

OWNER

# Pressure Relief Devices and Tank Venting

Calculation

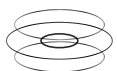


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## 1. OBJECTIVE

This calculation sizes the pressure relief devices for the and the venting for liquids tank T-101. It confirms that each relief valve meets the installation limits of API 520 Part II for inlet pressure loss, built-up back pressure and reaction force. It also sets the bores of the two restriction orifices that limit gas release into T-101 and into analyzer shelter B-101.

## 2. METHODOLOGY

TORUS first identified every section of station piping that can be isolated, and screened each for thermal overpressure. The screen heats the trapped gas at constant density from its densest credible state to the maximum metal or bath temperature. Any section that exceeds 1,440 psig needs a relief device, or an operating rule that keeps it from being blocked in.

For each device, TORUS evaluated the credible relieving cases and sized the valve for the largest load. Fire loads follow API 521. Thermal expansion loads follow the API 521 method,  $W = \beta \phi / c_p$ . Regulator failure loads follow ISA-75.01.01. Each relief area was then calculated with the API 520 Part I critical flow equation and matched to the next larger API 526 orifice.

Where two methods apply to the same case, the calculation reports both and uses the larger result. This occurs for the V-101 fire case, where the direct API 521 area formula and the API 520 area from the API 521 relief load differ by about 6 %.

T-101 venting follows API 2000 for normal inbreathing and outbreathing, and for emergency venting in fire and in the gas blow-by case.

Gas properties are calculated with the GERG-2008 equation of state (CoolProp 8.0). The specific heat ratio used in the API 520 equation is the ideal-gas value, as API 520 intends. The isentropic exponent used in the ISA-75.01 regulator equations is taken from the real-gas speed of sound ( $\kappa = \rho c^2 / p$ ), because at pipeline pressure the real-gas  $c_p / c_v$  overstates it by about 25 %.

## 3. DESIGN INPUTS

The inputs in Table 3-1 govern the calculation. Values taken from other project documents name that document.

Table 3-1: Design Inputs

| Input                                        | Value      | Source                     |
|----------------------------------------------|------------|----------------------------|
| Station design pressure and PSV set pressure | 1,440 psig | GEN-DB-001 Basis of Design |

| Input                                  | Value                                                                                            | Source                                               |
|----------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Fuel gas system set pressure (PSV-161) | 250 psig                                                                                         | Class 150 piping rated 285 psig                      |
| Fire-case normal state, V-101          | 1,150 psig, 45 °F                                                                                | Operating case C1, GEN-DB-001                        |
| V-101 shell                            | 42 in ID x 15 ft S/S, with NPS 24 x 14 ft liquid barrel                                          | PRO-CAL-005                                          |
| H-101 coil                             | 572 ft <sup>2</sup> , U = 64.6 Btu/h-ft <sup>2</sup> ·°F                                         | PRO-CAL-004                                          |
| H-101 bath high-high temperature       | 200 °F                                                                                           | PRO-CAL-004                                          |
| PCV-161 wide-open $C_v$ and $x_T$      | 0.6 and 0.7                                                                                      | Typical, vendor to confirm                           |
| Solar heat load on bare pipe           | 317 Btu/h-ft <sup>2</sup>                                                                        | GEN-DB-001                                           |
| T-101                                  | 100 bbl, 9 ft 6 in OD x 8 ft; design 16 oz/in <sup>2</sup> pressure, 1 oz/in <sup>2</sup> vacuum | MEC-DS-004                                           |
| Flash gas from V-101 liquids           | 750 scf per bbl dumped; 1,000 scf per stock-tank bbl                                             | Section 6.8 flash calculation; composition HOLD H-12 |
| LCV-104 design dump rate               | 30 gpm                                                                                           | PRO-CAL-005                                          |
| Gas composition                        | Design case, MW 18.46                                                                            | GEN-DB-001                                           |

## 4. ASSUMPTIONS

1. Discharge coefficient  $K_d = 0.975$ , with  $K_b = K_c = 1.0$ , for preliminary sizing. Final selection uses the vendor's certified capacity. *Verification required.*
2. The upstream lateral MAOP does not exceed 1,440 psig. A blocked outlet at V-101 therefore cannot exceed the set pressure and is not a relieving case. *Verification required (HOLD H-16).*
3. Fire exposure assumes adequate drainage and firefighting (environment factor  $F = 1.0$ ). All of V-101 lies within 25 ft of grade and is taken as exposed.
4. The unwetted carbon steel wall reaches 1,100 °F in fire.
5. The PSV-157 thermal load uses the coil heat transfer coefficient with full gas flow. With the coil blocked in, the gas film is in natural convection and the real load is lower, so the result is an upper bound.
6. The free liquid reaching V-101 is taken as a hydrocarbon condensate saturated with the design gas at case C1 conditions. Water, if present, flashes far less gas, so this is conservative for venting and emissions. The liquid composition is not known. *Verification required (HOLD H-12).*

## 5. REFERENCES

1. API Standard 520, Part I, 10th Edition (2020), Sizing and Selection of Pressure-relieving Devices.
2. API Standard 520, Part II, 7th Edition (2020), Installation of Pressure-relieving Devices.
3. API Standard 521, 7th Edition (2020), Pressure-relieving and Depressuring Systems.
4. API Standard 526, 7th Edition (2017), Flanged Steel Pressure-relief Valves.
5. API Standard 2000, 7th Edition (2014), Venting Atmospheric and Low-pressure Storage Tanks.
6. ASME Boiler and Pressure Vessel Code, Section VIII Division 1 and Section XIII (2023).
7. ANSI/ISA-75.01.01 (IEC 60534-2-1), Flow Equations for Sizing Control Valves.
8. 49 CFR 192.199, Requirements for design of pressure relief and limiting devices.
9. GEN-DB-001, Basis of Design.
10. PRO-CAL-004, Line Heater; PRO-CAL-005, Filter Separator; PRO-CAL-008, Blowdown and Vent System; PRO-CAL-010, Fuel Gas System.
11. MEA-CAL-004, Sampling System; SAF-RPT-003, Fire and Gas Detection.
12. PRO-DWG-109, P&ID Vent and Blowdown (Appendix A).

## 6. CALCULATION

### 6.1. BLOCKED-IN THERMAL SCREENING

Table 6-1 lists every section that can be isolated and the pressure it reaches when heated. Five of the six exceed the design pressure. The standby meter run is the one case that has no relief device. It is handled by an operating rule: the standby run is kept with its outlet valve open, so it is never isolated at both ends.

**Table 6-1: Thermal Screening of Isolatable Sections**

| Section                                    | Trapped at        | Heated to   | Final pressure | Protection                              |
|--------------------------------------------|-------------------|-------------|----------------|-----------------------------------------|
| Inlet section, V-101 and PR-101, after ESD | 1,150 psig, 45 °F | 150 °F      | 1,570 psig     | PSV-101                                 |
| Meter and heater section, after ESD        | 1,145 psig, 45 °F | 150 °F      | 1,560 psig     | PSV-101, open through the MOVs and FCVs |
| H-101 coil, HV-158A/B closed               | 1,145 psig, 45 °F | 200 °F bath | 1,760 psig     | PSV-157                                 |
| SDV-102 to SDV-103, after OPSS trip        | 1,290 psig, 18 °F | 150 °F      | 2,060 psig     | TSV-136                                 |
| Standby meter run, both ends closed        | 1,150 psig, 45 °F | 150 °F      | 1,570 psig     | Outlet valve kept open                  |



| Section                             | Trapped at        | Heated to                        | Final pressure | Protection    |
|-------------------------------------|-------------------|----------------------------------|----------------|---------------|
| Outlet lateral, lines 1041 and 1042 | 1,200 psig, 60 °F | 150 °F above grade, 75 °F buried | 1,360 psig     | None required |

## 6.2. PSV-101, V-101 EXTERNAL FIRE

V-101 is normally full of gas, with liquid only in its lower barrel, so the fire case is evaluated for an unwetted vessel and checked for the wetted barrel.

The relieving pressure includes the 21 % overpressure allowed in fire:

API 521 fire exposure; ASME XIII, 21 % fire overpressure

$$P_1 = 1.21 P_{set} + P_{atm} = 1.21(1440) + 14.1 = 1756.5 \text{ psia}$$

The gas heats at constant volume from its normal state ( $T_n = 504.7 \text{ R}$ ,  $P_n = 1,164.1 \text{ psia}$ ) to the relieving pressure:

API 521, unwetted vessel

$$T_1 = T_n \frac{P_1}{P_n} = 504.7 \times \frac{1756.5}{1164.1} = 761.5 \text{ R} \quad (301.8 \text{ °F})$$

The exposed area is the shell, heads and liquid barrel,  $A' = 178.7 + 31.2 + 94.2 = 304.1 \text{ ft}^2$ . With a wall temperature  $T_w = 1,560 \text{ R}$  and molecular weight  $M = 18.46$ , the relief load is:

API 521, relief load for a gas-filled vessel

$$W = 0.1406 \sqrt{MP_1} A' \frac{(T_w - T_1)^{1.25}}{T_1^{1.1506}} = 0.1406 \sqrt{18.46 \times 1756.5} (304.1) \frac{(798.2)^{1.25}}{761.5^{1.1506}} = 15,800 \text{ lb/h}$$

At the relieving conditions the ideal-gas specific heat ratio is  $k = 1.222$  and the compressibility  $Z = 0.964$ :

API 520-1, coefficient C

$$C = 520 \sqrt{k \left( \frac{2}{k+1} \right)^{\frac{k+1}{k-1}}} = 339.4$$

API 520-1, critical gas flow

$$A = \frac{W}{CK_d P_1 K_b K_c} \sqrt{\frac{T_1 Z}{M}} = \frac{15,800}{339.4(0.975)(1756.5)} \sqrt{\frac{761.5(0.964)}{18.46}} = 0.171 \text{ in}^2$$

API 521 also gives a direct area formula for this case,  $A = F' A' / \sqrt{P_1}$ , which with  $F' = 0.0222$  gives  $0.161 \text{ in}^2$ . That formula assumes ideal gas and carries a rounded temperature exponent. The larger value,  $0.171 \text{ in}^2$ , is used.

For the wetted liquid barrel ( $65.7 \text{ ft}^2$ ), with the API 521 minimum latent heat of 50 Btu/lb near the critical point:

API 521, wetted surface with adequate drainage

$$Q = 21,000 F A_{wet}^{0.82} = 21,000(1.0)(65.7)^{0.82} = 650,000 \text{ Btu/h}, \quad W = \frac{Q}{\lambda} = 13,000 \text{ lb/h}$$

This gives 0.153 in<sup>2</sup>, so the unwetted case governs.

**PSV-101 requires 0.171 in<sup>2</sup>. An API 526 E orifice (0.196 in<sup>2</sup>) is selected, with 14 % margin.**

A relief valve alone may not protect the unwetted wall of V-101 in a long fire, because the wall can overheat before the gas reaches the set pressure. The Owner should decide whether fire-case depressuring is required, to 50 % of design pressure within 15 minutes as API 521 suggests. If it is, BDV-181 must be automated. The present design uses manual blowdown.

### 6.3. PSV-157, H-101 COIL BLOCKED IN

If HV-158A and HV-158B close while the burner is firing, the gas trapped in the coil heats toward the bath trip temperature of 200 °F and would reach 1,760 psig. PSV-157 relieves the thermal expansion. At 10 % overpressure the relieving pressure is 1,598.1 psia, which the trapped gas reaches at 155.5 °F.

The heat transferred from the bath at that point is:

$$\phi = UA(T_{bath} - T_{rel}) = 64.6(572)(200 - 155.5) = 1.65 \times 10^6 \text{ Btu/h}$$

This is below the heater's absorbed rating of 4.49 MMBtu/h, so the rating does not cap it. With the cubical expansion coefficient  $\beta = 0.00266 \text{ /}^\circ\text{F}$  and  $c_p = 0.672 \text{ Btu/lb}\cdot^\circ\text{F}$  at relieving conditions:

API 521, thermal expansion

$$W = \frac{\beta \phi}{c_p} = \frac{0.00266 \times 1.65 \times 10^6}{0.672} = 6,510 \text{ lb/h}$$

With  $k = 1.257$  ( $C = 342.9$ ),  $Z = 0.880$  and  $T = 615.2 \text{ R}$ , the required area is 0.066 in<sup>2</sup>.

**PSV-157 requires 0.066 in<sup>2</sup>. An API 526 D orifice (0.110 in<sup>2</sup>) is selected. It is set on the coil outlet manifold.**

### 6.4. PSV-161, FUEL GAS REGULATOR FAILURE

PSV-161 protects the Class 150 fuel gas system if first-cut regulator PCV-161 fails wide open. The worst case is with preheater E-161 off, when the take-off gas is at 45 °F and densest. At 1,162.1 psia and 45 °F the isentropic exponent is  $\kappa = 1.428$ , so  $F_k = 1.020$  and the flow is choked:

ISA-75.01.01, compressible flow

$$x = \frac{1162.1 - 289.1}{1162.1} = 0.751 > F_k x_T = 0.714, \quad x = 0.714, \quad Y = 0.667$$

$$W = 63.3 C_v Y \sqrt{x P_1 \rho_1} = 63.3(0.6)(0.667) \sqrt{0.714(1162.1)(5.093)} = 1,650 \text{ lb/h}$$

With E-161 in service the load falls to 1,450 lb/h. The gas cools to -23 °F as it expands to the relieving pressure, where  $k = 1.299$ ,  $Z = 0.906$  and  $T = 436.6 \text{ R}$ . The required area is 0.078 in<sup>2</sup>.

**PSV-161 requires 0.078 in<sup>2</sup>. An API 526 D orifice (0.110 in<sup>2</sup>) is selected.**

Because PSV-161 relieves at -23 °F, below the station minimum design metal temperature of -20 °F, its body and outlet line 2"-V-1077-S1 shall be impact tested at -50 °F (ASTM A350 LF2 and A333 Grade 6) or stainless. The outlet line is NPS 2. An NPS 1 outlet would give more than 40 % built-up back pressure.

### 6.5. TSV-136, OUTLET SECTION IN SUN

After an overpressure trip, the section between SDV-102 and SDV-103 can be trapped at up to 1,290 psig, the highest pressure the overpressure protection allows (PRO-CAL-009), and at 18 °F in the heater-out upset. In full sun it would reach 2,060 psig. The solar load on its 40 ft<sup>2</sup> projected area is 12,800 Btu/h. With  $\beta = 0.00435 \text{ /}^\circ\text{F}$  and  $c_p = 0.785 \text{ Btu/lb} \cdot ^\circ\text{F}$ , the relief load is 71 lb/h, which needs 0.0006 in<sup>2</sup>.

**TSV-136 is a 3/4 x 1 in thermal relief valve with a 0.038 in<sup>2</sup> orifice, set at 1,440 psig, with its outlet expanded to NPS 1-1/2 into line 1074.**

### 6.6. PSV-141B AND RO-141A, ANALYZER SAMPLE SYSTEM

Restriction orifice RO-141A (1/32 in) limits the gas that can enter analyzer shelter B-101 if a sample tube breaks. At the normal sample pressure of 25 psig the break flow is 32 scf/h. The minimum shelter ventilation can dilute 126 scf/h, so this is acceptable.

An orifice limits flow, not pressure. If the probe regulator failed open, 1,150 psig would reach the sample components inside the shelter, and a break would release 1,100 scf/h. PSV-141B, set at 50 psig at the regulator outlet, prevents this. Its load is the regulator's wide-open flow, with  $\kappa = 1.410$  at 1,150 psig and 60 °F:

ISA-75.01.01, compressible flow

$$W = 63.3(0.06)(0.667) \sqrt{0.705(1164.1)(4.80)} = 159 \text{ lb/h (3,250 scf/h)}$$

At 55 psig and 60 °F this needs 0.036 in<sup>2</sup>. With PSV-141B relieving, a break inside B-101 releases 57 scf/h through RO-141A, within the ventilation's dilution capacity.

**PSV-141B is a 1/2 x 1/2 in relief valve with at least 0.040 in<sup>2</sup> effective area, set at 50 psig, discharging through 1/2"-V-1121-T1 to header 1120.**

## 6.7. RELIEF VALVE INSTALLATION CHECKS

Inlet loss, back pressure and reaction force were calculated at the rated capacity of each selected orifice. Table 6-2 shows that every valve is within the API 520 Part II limits. Flow is subsonic in header 1070 and the stack. The PSV-101 and PSV-157 outlet lines reach sonic velocity where they join the header, and the back pressure figures include this.

**Table 6-2: Relief Valve Installation Checks**

| Valve   | Inlet loss, % of set | Built-up back pressure, % of set | Back pressure limit, % of set | Reaction force, lbf |
|---------|----------------------|----------------------------------|-------------------------------|---------------------|
| PSV-101 | 0.1                  | 4.9                              | 21                            | 758                 |
| PSV-157 | 0.8                  | 7.5                              | 10                            | 449                 |
| PSV-161 | 0.7                  | 5.4                              | 10                            | 63                  |
| TSV-136 | 0.5                  | 5.1                              | 10                            | 101                 |

Note 1: Reaction force is for open discharge at the valve outlet,  $F = (W/366)\sqrt{(kT/((k+1)M))} + A_o P_2$ , per API 520 Part II.

## 6.8. FLASH GAS FROM V-101 LIQUIDS

Liquid dumped from V-101 is saturated with gas at separator pressure and releases that gas when it reaches the atmospheric tank. The free liquid is a hydrocarbon condensate of unknown composition, so TORUS represented it by a single heavy component (C7, C8 or C10), saturated it with the design gas at the case C1 separator conditions (1,150 psig, 45 °F), and flashed the saturated liquid to the tank at 14.1 psia and 60 °F. Both flashes used the Peng-Robinson equation of state with successive substitution on the fugacity ratios. Table 6-3 gives the results per barrel of stock-tank liquid, the basis for emissions and for the tank throughput limit, and per barrel of liquid as it leaves V-101, the basis for the venting rate while LCV-104 dumps.

**Table 6-3: Flash Gas Released in T-101**

| Heavy end      | Methane in separator liquid, mol % | Flash gas, scf per stock-tank bbl | Flash gas, scf per bbl dumped | Flash gas MW |
|----------------|------------------------------------|-----------------------------------|-------------------------------|--------------|
| C7 (n-heptane) | 39                                 | 1,170                             | 741                           | 25.6         |
| C8 (n-octane)  | 38                                 | 962                               | 658                           | 23.6         |
| C10 (n-decane) | 38                                 | 769                               | 564                           | 22.7         |

A published black-oil correlation gives 607 to 848 scf per stock-tank barrel for these conditions. The equation-of-state results are higher because the correlations are fitted to crude oils, which are heavier than a pipeline condensate. TORUS adopted **1,000 scf per stock-tank bbl** for emissions, the C8 result rounded up, because C8 is typical of the heavy end carried in dehydrated residue gas. For the venting

rate it adopted **750 scf per bbl dumped**, the highest of the three results rounded up, with a flash gas molecular weight of 25.6. Both values stay provisional until the liquid composition is known (HOLD H-12). At the 350 bbl/yr enforceable throughput limit the flash gas is about 350,000 scf/yr.

**Design flash factor: 1,000 scf per stock-tank bbl for emissions, 750 scf per bbl of liquid dumped for venting.**

## 6.9. T-101 VENTING

T-101 receives liquids from V-101 through LCV-104, and liquid from the pig receiver. Normal outbreathing is dominated by gas flashing from the liquid as it enters the tank. The emergency case is fire, which exceeds the LCV-104 gas blow-by case now that RO-104 limits the blow-by. Table 6-4 summarizes the venting requirement.

**Table 6-4: T-101 Venting Requirement**

| Case                                       | Basis                                               | Venting, SCFH air |
|--------------------------------------------|-----------------------------------------------------|-------------------|
| Thermal outbreathing                       | Y = 0.32, tank volume 16.1 m <sup>3</sup>           | 145               |
| Liquid inflow, doubled for flashing liquid | 30 gpm                                              | 481               |
| Flash gas during dump                      | 750 scf/bbl at 42.9 bbl/h                           | 30,200            |
| <b>Normal outbreathing</b>                 |                                                     | <b>30,900</b>     |
| Thermal inbreathing                        | C = 6.5                                             | 1,690             |
| Pump-out by vacuum truck                   | 400 gpm                                             | 3,210             |
| <b>Normal inbreathing</b>                  |                                                     | <b>4,900</b>      |
| External fire                              | Wetted area 239 ft <sup>2</sup> , hexane properties | 253,000           |
| LCV-104 gas blow-by, limited by RO-104     |                                                     | 131,000           |
| <b>Emergency venting</b>                   | Larger of fire and blow-by                          | <b>253,000</b>    |

The fire heat input for a wetted area between 200 and 1,000 ft<sup>2</sup> is:

API 2000, emergency venting in fire

$$Q = 199,300 A^{0.566} = 199,300(239)^{0.566} = 4.42 \times 10^6 \text{ Btu/h}$$

which, for hexane vapor, requires 253,000 SCFH of air-equivalent venting. At a 0.5 psi differential and a discharge coefficient of 0.6 this needs a clear opening of 9.3 in.

**PVRV-193 is NPS 6 (typical capacity about 45,000 SCFH air with its arrestor at 1 oz/in<sup>2</sup> overpressure, vendor to confirm), set at 8 oz/in<sup>2</sup> pressure and 0.4 oz/in<sup>2</sup> vacuum, with flame arrestor FA-193. Emergency vent EV-193 is a 16 in relief manway set at 12 oz/in<sup>2</sup>.**

## 6.10. RO-104, V-101 LIQUID LINE BLOW-BY LIMITER

RO-104, in line 1060 downstream of LCV-104, must pass the 30 gpm design dump yet limit gas blow-by if LCV-104 fails open. Table 6-5 compares three standard bores. The 3/8 in bore cannot pass the design dump. The 7/16 in bore passes it and limits blow-by to 131,000 SCFH air, which EV-193 can vent while SDV-106 closes on low-low level.

**Table 6-5: RO-104 Bore Selection**

| Bore, in | Orifice $C_v$ | Liquid flow at case C5, gpm | Gas blow-by, lb/h | Gas blow-by, SCFH air |
|----------|---------------|-----------------------------|-------------------|-----------------------|
| 3/8      | 2.56          | 25.5                        | 6,500             | 106,000               |
| 7/16     | 3.49          | 31.1                        | 8,000             | 131,000               |
| 1/2      | 4.56          | 35.6                        | 9,180             | 150,000               |

RO-104 bore is 7/16 in.

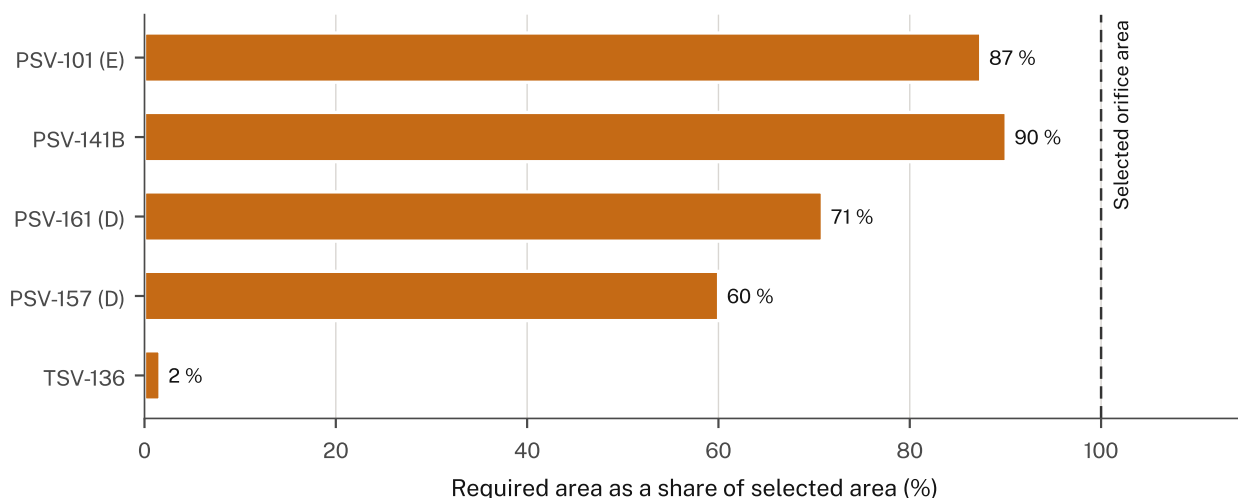
## 7. RESULTS AND CONCLUSIONS

Table 7-1 gives the selected relief devices. Figure 7-1 compares the required area of each valve with the area of the orifice selected. Two valves carry little margin: PSV-101 (87 %) and PSV-141B (90 %). Both selections should be confirmed against the vendor's certified capacity before purchase.

**Table 7-1: Relief Device Summary**

| Tag      | Protects                | Governing case                 | Set                   | Load             | Required area, in <sup>2</sup> | Selected                                 |
|----------|-------------------------|--------------------------------|-----------------------|------------------|--------------------------------|------------------------------------------|
| PSV-101  | V-101 and inlet section | External fire, unwetted        | 1,440 psig            | 15,800 lb/h      | 0.171                          | API 526 E, 0.196 in <sup>2</sup>         |
| PSV-157  | H-101 coil              | Coil blocked in, burner firing | 1,440 psig            | 6,510 lb/h       | 0.066                          | API 526 D, 0.110 in <sup>2</sup>         |
| PSV-161  | Fuel gas system         | PCV-161 fails open             | 250 psig              | 1,650 lb/h       | 0.078                          | API 526 D, 0.110 in <sup>2</sup>         |
| TSV-136  | SDV-102 to SDV-103      | Solar heating                  | 1,440 psig            | 71 lb/h          | 0.0006                         | Thermal relief, 0.038 in <sup>2</sup>    |
| PSV-141B | Analyzer sample system  | Probe regulator fails open     | 50 psig               | 159 lb/h         | 0.036                          | 1/2 x 1/2 in, 0.040 in <sup>2</sup> min. |
| PVRV-193 | T-101, normal           | Flash during dump              | 8 oz/in <sup>2</sup>  | 30,900 SCFH air  |                                | NPS 6                                    |
| EV-193   | T-101, emergency        | External fire                  | 12 oz/in <sup>2</sup> | 253,000 SCFH air | 9.3 in opening                 | 16 in manway                             |

**Figure 7-1. Required Relief Area as a Share of the Selected Orifice**



TORUS draws the following conclusions:

1. The devices in Table 7-1 provide the relief protection 49 CFR 192.199 requires for the station.
2. PSV-161 and its outlet line shall be low-temperature materials, because the valve relieves at -23 °F.
3. The standby meter run shall be operated with its outlet valve open. A run blocked in at both ends reaches 1,570 psig in sun and has no relief device.
4. The outlet lateral needs no thermal relief. Trapped at 1,200 psig, it reaches 1,360 psig, below its 1,440 psig design pressure.
5. T-101 needs emergency vent EV-193 in addition to PVRV-193, because the PVRV alone cannot pass the fire case or the LCV-104 blow-by case.
6. The Owner should decide on fire-case depressuring of V-101 (Section 6.2). If it is required, BDV-181 must be automated.

The following items remain open: the upstream lateral MAOP (HOLD H-16), the liquid composition and flash factor (HOLD H-12), and certified valve capacities and regulator  $C_v$  values from the vendors (HOLD H-15).

## APPENDIX A. P&ID VENT AND BLOWDOWN



VS-101

VENT STACK

NPS 8 x 25 FT ABOVE GRADE, HELICAL STRAKES ON TOP 8 FT  
(PRO-CAL-008)  
SPEC S1: CLASS 150 304L / 316L SS, MIN. DESIGN -150 F  
OPEN VERTICAL DISCHARGE, NO RAIN CAP FLAPPER

HEADER 1070

STATION VENT HEADER

8"-V-1070-S1, CLASS 150 STAINLESS  
OPEN TO ATMOSPHERE THROUGH VS-101, NO BLOCK VALVES  
SLOPE 1:200 MIN. CONTINUOUS TO VS-101

NOTES

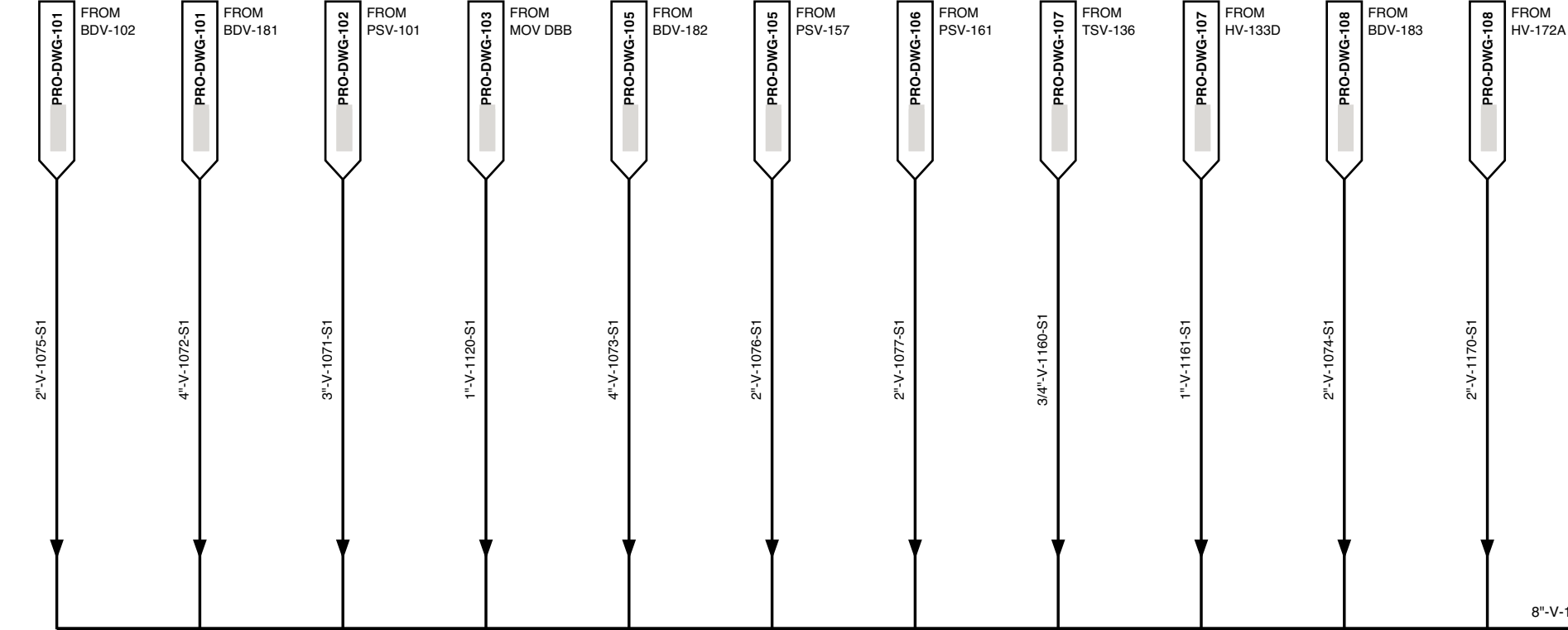
- HEADER 1070, VS-101 AND ALL BRANCHES DOWNSTREAM OF THEIR PSV / TSV OR RO ARE SPEC S1: CLASS 150 304/304L OR 316/316L STAINLESS, MIN. DESIGN -150 F. GAS DOWNSTREAM OF THE ROS REACHES -121 F. A6 / S1 SPEC BREAKS ARE AT THE RO AND PSV OUTLETS ON THE SOURCE SHEETS. NO BLOCK VALVES IN THE HEADER OR STACK.
- BRANCHES CONNECT TO THE TOP OF THE HEADER (45 DEG LATERAL WHERE PRACTICAL). HEADER SELF-DRAINS TO THE VS-101 BASE; NO POCKETS.
- VS-101 NPS 8 x 25 FT WITH HELICAL STRAKES ON THE TOP 8 FT, CONFIRMED BY PRO-CAL-008. LOCATION PER PLOT PLAN MEC-DWG-001.
- BLOW DOWN ONE SECTION AT A TIME (O&M PROCEDURE REQUIREMENT). SIMULTANEOUS BLOWDOWN OF SECTIONS WOULD NEED A 43 FT STACK. BLOWDOWNS ARE MANUAL AFTER AN ESD; NO AUTOMATIC BLOWDOWN (BASIS 9.3).
- NO SNUFFING STEAM. A 1 IN PLUGGED CONNECTION AT THE STACK BASE ALLOWS NITROGEN PURGE OR PORTABLE SNUFFING OF A LIGHTNING-IGNITED VENT.
- STACK BASE DRAIN HV-180A (2 IN, NC, PLUGGED) DRAINS RAINWATER / CONDENSATE INTO A PORTABLE COLLECTION PAN, EMPTIED BY VACUUM TRUCK. THERE IS NO DRAIN LINE TO T-101 (LINE 1180 DELETED).
- LINES 1072 AND 1073 ARE NPS 4; PSV-161 DISCHARGES THROUGH NEW LINE 2"-V-1077-S1 (REPLACES 1150). BACKPRESSURE PER PRO-CAL-007.

D

C

B

A

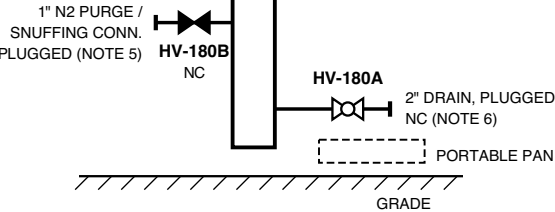


BRANCHES ENTER TOP OF HEADER (NOTE 2)  
SLOPE 1:200 TO VS-101

VENT HEADER BRANCH SCHEDULE

| LINE           | SOURCE  | SERVICE                                  | FROM DWG    |
|----------------|---------|------------------------------------------|-------------|
| 2"-V-1075-S1   | BDV-102 | PR-101 BARREL VENT (RO-102)              | PRO-DWG-101 |
| 4"-V-1072-S1   | BDV-181 | INLET SECTION BLOWDOWN (RO-181)          | PRO-DWG-101 |
| 3"-V-1071-S1   | PSV-101 | V-101 RELIEF, FIRE CASE, SET 1,440 PSIG  | PRO-DWG-102 |
| 1"-V-1120-S1   | MOV DBB | METER SKID DBB BODY BLEEDS               | PRO-DWG-103 |
| 4"-V-1073-S1   | BDV-182 | METER / HEATER SECTION BLOWDOWN (RO-182) | PRO-DWG-105 |
| 2"-V-1076-S1   | PSV-157 | H-101 COIL RELIEF, SET 1,440 PSIG        | PRO-DWG-105 |
| 2"-V-1077-S1   | PSV-161 | FUEL GAS RELIEF, SET 250 PSIG            | PRO-DWG-106 |
| 3/4"-V-1160-S1 | TSV-136 | THERMAL RELIEF SDV-102 / SDV-103         | PRO-DWG-107 |
| 1"-V-1161-S1   | HV-133D | LINE 1033 MAINTENANCE VENT               | PRO-DWG-107 |
| 2"-V-1074-S1   | BDV-183 | OUTLET SECTION BLOWDOWN (RO-183)         | PRO-DWG-108 |
| 2"-V-1170-S1   | HV-172A | OUTLET LATERAL BLOWDOWN (RO-172B)        | PRO-DWG-108 |

CAUTION: BLOW DOWN ONE SECTION AT A TIME (NOTE 4).  
VS-101 IS SIZED FOR ONE BLOWDOWN SOURCE; SIMULTANEOUS BLOWDOWN NEEDS A 43 FT STACK.



NOTES / REFERENCES  
REF: PRO-DWG-100 SH 1-2 (LEGEND)  
REF: GEN-DB-001 SECTIONS 8, 9.3, 10  
REF: PRO-CAL-008 BLOWDOWN AND VENT STACK  
REF:

| REVISIONS |            |                         |            |
|-----------|------------|-------------------------|------------|
| REV       | DATE       | DESCRIPTION             | BY CHK APP |
| A         | 2026-09-29 | ISSUED FOR REVIEW (IFR) |            |

PRELIMINARY - ISSUED FOR REVIEW - NOT FOR CONSTRUCTION

ENGINEER OF RECORD SEAL

NOT SEALED  
PRELIMINARY  
PE NO. \_\_\_\_\_

PROJECT

120 MMSCFD RECEIPT INTO  
COUNTY,  
DISCIPLINE: PROCESS  
SCALE: NTS

P&ID VENT AND BLOWDOWN

VENT HEADER 1070 AND VENT STACK VS-101  
DRAWN: \_\_\_\_ CHECKED: \_\_\_\_ APPROVED: \_\_\_\_  
DWG NO. PRO-DWG-109  
SHEET 1 OF 1 REV A