Instructions to Voters/Comments on API 520 Part I Ballot – "Kp for Sub-cooled Liquid in Annex B and C"

1st Ballot

- This is the 1st Ballot for this work item. It covers AI 2019-22 and updates Annex B and C to include the Kp factor in the two-phase sizing procedure for sub-cooled liquid where the PRV is not certified for liquid.
- This ballot only includes the changes that occurred when resolving the comments from the 2nd Ballot.
- Your comments should be limited to the **red-lines portions of the ballot only.**
- Don't worry about formatting issues, particularly with the equations since these are a mess. These will be fixed during final editing.
- If you are voting negative, please indicate which of your comment or comments are the reason for your negative vote. API's Balloting system will categorize all of your comments as Negative.

Thanks to Casey Houston and his work group for their efforts.

Phil Henry
API 520 Task Force Chair

Annex B
(informative)

Review of Flow Equations Used in Sizing Pressure-relief Devices

B.1 Development of Flow Equations

B.1.1 General

B.1.2 General Applicability

B.1.3 Numerical Integration Example

B.1.4 Capacity Corrections

B.1.4.1 Once the theoretical mass flux through the nozzle has been determined, various correction factors are employed to derive an expression for the PRV rated capacity corrected for the actual overpressure. These correction factors may include coefficients of discharge (K_d), backpressure correction factors (K_b and K_w), viscosity correction factors (K_v), overpressure correction factors (Kp), and combination capacity correction factors (K_c) depending on the applicability of those correction factors. A general expression for the PRV sizing equation is shown in Equation (B.5).

$$W = GA\Pi[K] \tag{B.5}$$

where

G is the theoretical mass flux through the nozzle, lb/s•ft^2 (kg/s•m^2);

W is the mass flow through the PRV, lb/s (kg/s);

A is the discharge area of the PRV, ft^2 (m^2);

$\Pi[K]$ is the product of all applicable correction factors (no units).

Remainder of Annex B remains unchanged

Annex C
(informative)

Sizing for Two-phase Liquid/Vapor Relief

C.1 Sizing for Two-phase Liquid/Vapor Relief

C.2 Sizing Methods

C.2.1 Sizing by Direct Integration of the Isentropic Nozzle Flow

C.2.1.1 General

Paragraphs 2.1.1.1 through 2.1.1.6 remains unchanged

C.2.1.2 Pressure Relief Valves Requiring Capacity Certification

Once the value for the mass flux has been determined, the required orifice area can be calculated using Equation (C.9) or Equation (C.10).

In USC units:

$$\mathrm{A} = \frac{0.04\mathrm{W}}{\mathrm{K_d K_b K_c K_v G}} \tag{C.9}$$

In SI units:

$$\mathrm{A} = \frac{277.8W}{K_d K_b K_c K_v G} \tag{C.10}$$

where

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

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

K_d is the coefficient of discharge; for a preliminary sizing estimation, an effective coefficient of discharge of 0.85 can be used for a two-phase mixture or saturated liquid entering the PRV inlet. For the case of a subcooled liquid entering the PRV inlet, a coefficient of discharge equal to 0.65 is consistent with the single-phase method in Equation (33) and Equation (34). Note that a value of 0.65 may result in a conservative valve size for liquids that are only slightly subcooled; the user may select other methods for determining a coefficient of discharge [8, 9, 10];

K_b is the backpressure correction factor for vapor that should be obtained from the valve manufacturer; for a preliminary sizing estimation, use Figure 31. 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 5.12.2);

- 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; for two-phase flows where the liquid has a viscosity of 100 cP (0.1 Pa-s) or less, the viscosity correction factor can be set to 1.0;

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

C.2.1.3 Example

C.2.1.4 Pressure Relief Valves not Requiring Capacity Certification

Equation (C.9) and Equation (C.10) are modified as shown in Equation (C.xx) and Equation (C.yy) to handle liquid service PRVs that have never been certified (see 5.9 for a discussion on noncertified PRVs):

In USC units:

$$A = \frac{0.04 \times W}{K_d K_b K_c K_v G} \times \frac{\sqrt{P_1 - P_2}}{K_p \sqrt{1.25 \times P_s - P_2}} \qquad \text{(C.xx)}$$

In SI units:

$$A = \frac{277.8 \times W}{K_d K_b K_c K_v G} \times \frac{\sqrt{P_1 - P_2}}{K_p \sqrt{1.25 \times P_s - P_2}} \qquad \text{(C.yy)}$$

where

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

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

K_d is the coefficient of discharge and shall be 0.62;

K_b is the backpressure correction factor;

K_c is the combination correction factor;

K_v is the viscosity correction factor;

K_p is the correction factor due to overpressure; at 25% overpressure, $K_p = 1.0$. For overpressures other than 25%, K_p is determined from Figure 39;

P_s is the set pressure, psig (Pag);

P_1 is the upstream relieving pressure, psig (Pag); this is the set pressure plus allowable overpressure;

P_2 is the total backpressure, psig (Pag).

C.2.2 Sizing for Subcooled Liquid at the Pressure-relief Valve Inlet Using the Omega Method

Section C.2.2 remains unchanged

C.2.3 Sizing for Subcooled Liquid at the Pressure-relief Valve Inlet Using the Omega Method

C.2.3.1 Pressure-relief Valves Requiring Capacity Certification

C.2.3.2 Example

C.2.3.3 Pressure-relief Valves Not Requiring Capacity Certification

~~If the PRV is one that was never certified in liquid service (see 5.9 for a discussion on noncertified PRVs), then the area calculated using Equation (C.45) or Equation (C.46) needs to be adjusted to account for the higher overpressures required to get the valve to go to full lift.~~ Equation (C.45) and Equation (C.46) are modified as shown in Equation (C.56) and Equation (C.57) to handle liquid service PRVs that have never been certified (see 5.9 for a discussion on noncertified PRVs):

In USC units:

$$A = 0.3208 \frac{Q \rho_{l1}}{K_d K_b K_c K_v G} \times \frac{\sqrt{P_1 - P_2}}{K_p \sqrt{1.25 P_s - P_2}} \qquad \text{(C.56)}$$

In SI units:

$$A = 16.67 \frac{Q \rho_{l1}}{K_d K_b K_c K_v G} \times \frac{\sqrt{P_1 - P_2}}{K_p \sqrt{1.25 P_s - P_2}} \qquad \text{(C.57)}$$

where

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

Q is the volumetric flow rate, gal/min (L/min);

ρ_{l1} is liquid density at the PRV inlet, lb/ft^3 (kg/m^3);

K_d is the effective coefficient of discharge and shall be 0.62;

K_b is the backpressure correction factor; K_c is the combination correction factor; K_v is the viscosity correction factor;

K_p is the correction factor due to overpressure; at 25 % overpressure, $K_p = 1.0$. For overpressures other than 25 %, K_p is determined from Figure 39;

P_s is the set pressure, psig (Pag);

P_1 is the upstream relieving pressure, psig (Pag); this is the set pressure plus allowable overpressure;

P_2 is the total backpressure, psig (Pag).