Instructions to Voters/Comments on API 520 Part I Ballot – "Reynolds Number for Liquids"

- Your comments should be limited to the **red-lines portions of the ballot only.**
- This ballot covers the API 520 TF action item 2024-10. This was initiated by RFI 10106.
- 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.
- Don't worry about formatting issues, particularly with the equations since these are a mess. These will be fixed during final editing.

Thanks to Craig Powers for assistance on this ballot.

Phil Henry
TF520 Chairman

Sizing, Selection, and Installation of Pressure-relieving Devices

Part I—Sizing and Selection

API STANDARD 520, PART I
TENTH EDITION, OCTOBER 2020

(Errata 1 incorporated into base document)

American Petroleum Institute

5 Procedures for Sizing

5.1 Determination of Relief Requirements

5.2 API Effective Area and Effective Coefficient of Discharge

5.3 Backpressure

5.4 Relieving Pressure

5.5 Development of Sizing Equations

5.6 Sizing for Gas or Vapor Relief

5.7 Sizing for Steam Relief

5.8 Sizing for Liquid Relief: Pressure-relief Valves Requiring Capacity Certification

5.8.1 General

5.8.1.1 The sizing equations for PRDs in liquid service provided in this section assume that the liquid is incompressible (i.e. the density of the liquid does not change as the pressure decreases from the relieving pressure to the total backpressure).

5.8.1.2 The ASME *Code* requires that capacity certification be obtained for PRVs designed for liquid service. The procedure for obtaining capacity certification includes testing to determine the certified coefficient of discharge for the liquid PRVs at 10 % overpressure.

5.8.1.3 Valves in liquid service that are designed in accordance with the ASME *Code*, which require a capacity certification, may be sized using Equation (33) or Equation (34). Note that the equations presented here can be used for preliminary sizing when effective values for area and coefficients of discharge are used and for final sizing when actual areas and certified coefficients of discharge are used.

In USC units:

$$A = \frac{Q}{38 K_d K_w K_c K_v} \sqrt{\frac{G_l}{P_1 - P_2}} \tag{33}$$

In SI units:

$$A = \frac{11.78 Q}{K_d K_w K_c K_v} \sqrt{\frac{G_l}{P_1 - P_2}} \tag{34}$$

where

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

Q is the required relieving capacity at the flowing temperature, U.S. gal/min (L/min);

K_d is the coefficient of discharge; for preliminary sizing, an effective coefficient of discharge can be used as follows:

— 0.65, when a PRV is installed with or without a rupture disk in combination;

— 0.62, when a PRV is not installed and sizing is for a rupture disk in accordance with 5.12.1.2.2;

K_w is the correction factor due to backpressure; if the backpressure is atmospheric, use a value for K_w of 1.0. Balanced bellows valves in backpressure service will require the correction factor determined from Figure 32. Conventional and pilot-operated valves require no special correction (see 5.3);

K_c is the combination correction factor for installations with a rupture disk upstream of the PRV (see 5.12.2); use the following values for the combination correction factor:

— 1.0, when a rupture disk is not installed;

— 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 correction factor due to viscosity; where the liquid has a viscosity of 100 cP (0.1 Pa-s) or less, the viscosity correction factor can be set to 1. For viscosities greater than 100 cP (0.1 Pa-s), the factor should be determined from Figure 38 or from Equation (35). This equation is applicable for $Re_L \geq 80$:

$$K_v = \left(\frac{170}{Re_L} + 1\right)^{-0.5} \quad (35)$$

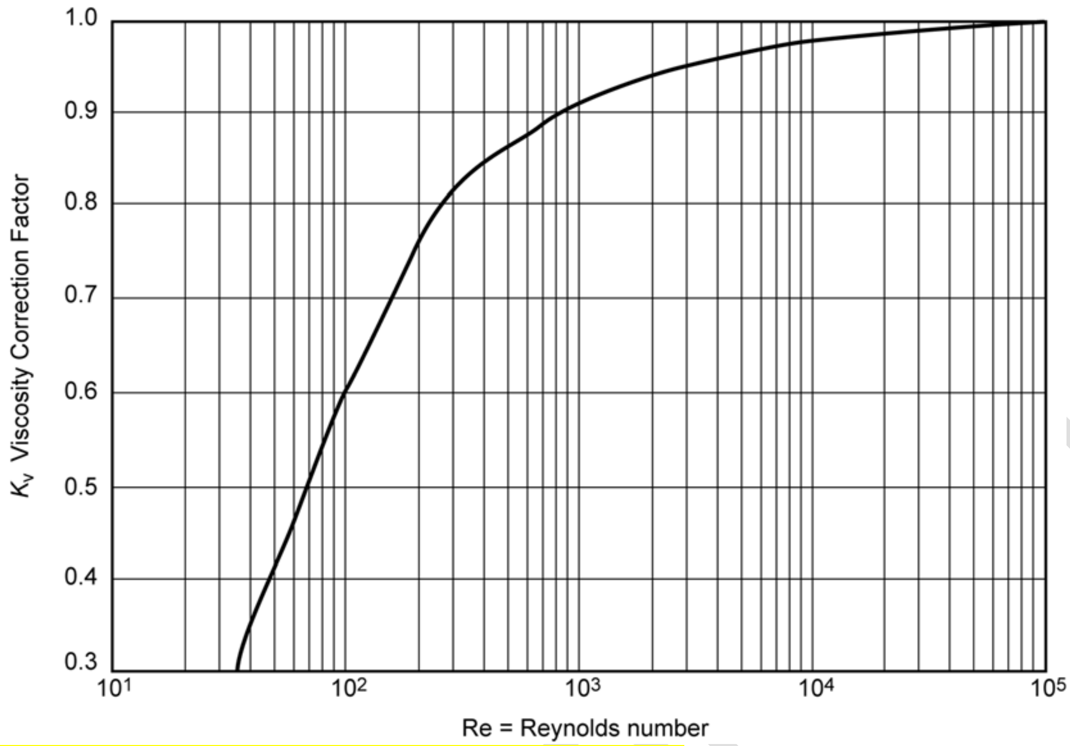
~~where~~

Re_L is the Reynolds Number for a liquid, see Equations (36) through (39);

G_l is the specific gravity of the liquid at the flowing temperature referred to water at standard conditions;

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

P_2 is the total backpressure, psig (kPag).



Editors Note: The X-axis label in Figure 38 needs to be updated to Re_L

Figure 38—Capacity Correction Factor, K_v, Due to Viscosity

5.8.1.4 When a PRV is sized for viscous liquid service, it should first be sized as if it were for a nonviscous type application (i.e. $K_v = 1.0$) so that a preliminary required discharge area, A_R, can be obtained from Equation (33) or Equation (34). The user is cautioned that the equations presented here may not be applicable for non-Newtonian applications (see 5.10). From the list of API 526 standard orifice sizes or the manufacturer's listing, the next orifice size, $A_{selected}$, larger than A_R should be chosen to calculate the Reynolds number, Re, from either of the following relationships.

In USC units:

$$\mathrm{Re}_L\ \mathrm{Re} = \frac{Q(2{,}800G_l)}{\mu\sqrt{A_{selected}}} \qquad (36)$$

or

$$\mathrm{Re}_L\ \mathrm{Re} = \frac{12{,}700Q}{U\sqrt{A_{selected}}} \qquad (37)$$

In SI units:

$$\mathrm{Re}_L\ \mathrm{Re} = \frac{Q(18{,}800G_l)}{\mu\sqrt{A_{selected}}} \qquad (38)$$

or

$$\mathrm{Re}_L\ \mathrm{Re} = \frac{85{,}220Q}{U\sqrt{A_{selected}}} \qquad (39)$$

where

Re_L is the Reynolds number for a liquid;

Q is the required relieving capacity at the flowing temperature in U.S. gal/min (L/min);

G_l is the specific gravity of the liquid at the flowing temperature referred to water at standard conditions;

μ is the absolute viscosity at the flowing temperature, centipoise;

$A_{selected}$ is the smallest standard orifice area that exceeds the preliminary area A_R, in.^{2} (mm^2); standard orifice sizes from API 526 or the manufacturer's table should be used;

U is the viscosity at the flowing temperature in Saybolt universal seconds.

Equation (37) and Equation (39) are not recommended for viscosities less than 100 Saybolt universal seconds.

5.8.1.5 After the Reynolds number, Re_L ~~Re~~, is determined, the factor K_v is obtained and applied in Equation (33) or Equation (34) to correct the preliminary required discharge area, A_R. If the corrected area exceeds the chosen standard orifice area, $A_{selected}$, the Reynolds number should be recalculated using the next larger standard orifice size and the value of K_v updated accordingly.

5.8.2 Example 5

5.8.2.1 In this example, the following relief requirements are given.

a) Required crude oil flow caused by blocked discharge, Q, of 1800 gal/min (6814 L/min).

b) The specific gravity, G_l, of the crude oil is 0.90. The viscosity of the crude oil at the flowing temperature is 2000 Saybolt universal seconds.

c) PRV set at 250 psig (1724 kPag), which is the design pressure of the equipment.

d) Backpressure is variable from 0 to 50 psig (345 kPag).

e) Overpressure of 10 %.

5.8.2.2 In this example, the following data are derived.

a) Relieving pressure, P1, of 1.10 × 250 = 275 psig (1896 kPag).

b) Backpressure of (50/250) × 100 = 20 %.

c) A balanced bellows valve was selected, since the backpressure is variable. From Figure 32, the backpressure capacity correction factor, $K_w = 0.97$.

d) The effective coefficient of discharge for preliminary sizing, $K_d = 0.65$.

5.8.2.3 Sizing first for no viscosity correction ($K_v = 1.0$), the size of the PRV is derived from Equation (32) as follows:

$$A_R = \frac{1{,}800}{38\times0.65\times0.97\times1.0\times1.0}\sqrt{\frac{0.90}{275-50}} = 4.752\ in.^2\ (3{,}066\ mm^2) \quad (40)$$

where

A_R is the required area of the PRV without any viscosity correction.

An area of 6.38 in.^{2} (4116 mm^2) using a P orifice is chosen for $A_{selected}$ from API 526.The Reynolds number, Re_L ~~Re~~, is then calculated using Equation (37).

$$Re_L \; \text{~~Re~~} = \frac{12{,}700 \times 1{,}800}{2{,}000\sqrt{6.38}} = 4{,}525 \qquad (41)$$

5.8.2.4 From Equation (34), the viscosity correction factor is determined, $K_v = 0.982$; therefore:

$$A = \frac{A_R}{K_v} = \frac{4.752}{0.982} = 4.84\ in.^2\ (3{,}122\ mm^2) \qquad (42)$$

5.9 Sizing for Liquid Relief: Pressure-relief Valves Not Requiring Capacity Certification

5.10 Special Considerations for Non-Newtonian Fluids

5.11 Sizing for Two-phase Liquid/Vapor Relief

5.12 Sizing for Rupture Disk Devices

5.13 Sizing for Open Flow Paths or Vents