DETERMINATION OF CERTIFIED RELIEVING CAPACITIES

1.0 GENERAL

To determine the relieving capacity that should appear on a pressure relief valve set at or between the minimum and maximum listed set pressures:

1.1 For the coefficient method – use the formula as applicable for the Code section and the coefficient and area listed for the particular design of the valve.

1.2 For the slope or flow factor method – calculate using the slope or flow factor given.

1.3 Valves certified by the single valve method or three valve average have the certified capacity listed.

2.0 PRESSURE RELIEF VALVES FOR POWER BOILERS (Section I):

The following steam calculations are also used for Power Operated Pressure Relief Valves.

2.1 Coefficient Method Formulas for Steam:

For nozzle…….. $W = (51.5\ APK)$

For flat seat (low lift)……. $W = (51.5\pi\ DLPK)$

For 45º seat……. $W = (51.5\pi\ DLPK)\ (.707)$

Where W = rated capacity, pounds dry saturated steam per hour

A = actual discharge area through the valve at developed lift, square inches

D = seat diameter, inches

K = certified coefficient

L = lift, inches

P = (stamped set pressure + 2 psi or 3%, whichever is greater) + 14.7 psia

For pressures over 1500 psi and up to 3200 psi the value W shall be multiplied by the Napier correction factor F_N (if the correction factor is greater than 1.0):

$F_N = (0.1906P – 1000)/(0.2292P – 1061)$

2.2 Slope Method Formula for Steam:

The values of the listed slopes have units of pounds per hour per psia.

W = slope x ((stamped set pressure + 2 psi or 3%, whichever is greater) + 14.7 psia)

For steam pressures over 1500 psi and up to 3200 psi the value W shall be multiplied by the Napier correction factor F_N (if the correction factor is greater than 1.0):

$F_N = (0.1906P – 1000)/(0.2292P – 1061)$

2.3 For superheated conditions the capacity shall be calculated by multiplying the capacity determined in 2.1 or 2.2 by the appropriate K_{sh} factor found in Section I table PG-68.7.

2.4 For pressures over 3200 psig the capacity shall be calculated by multiplying the capacity determined in 2.1 or 2.2 by the appropriate K_{sc} factor found in Section I, table PG-67.5. The Napier correction F_N is not used.

2.5 For economizers where the fluid being relieved is water, pressure relief valves shall have the capacity calculated as follows:

Flow Factor Method for Liquid (water):

$W = F \times \sqrt{(P - P_d)}$

Where W = rated capacity, GPM (water)

F = flow factor, GPM/$\sqrt{}$PSID

P = (stamped set pressure + 3 psi or 10%, whichever is greater) + 14.7 psia

Pd = pressure at discharge from valve, psia

The flow factor is a rating number for liquid service determined by test. It is equal to the capacity in gallons per minute divided by the square root of the differential flowing pressure.

Coefficient Method Formula for Water:

$W = 4.814AK \sqrt{w(P - P_d)}$

Where W = rated capacity, GPM (water)

A = nozzle throat area, square inches

K = certified coefficient

P = (stamped set pressure + 3 psi or 10%, whichever is greater) + 14.7 psia

Pd = pressure at discharge from valve, psia

w = 62.3058 lbm/ft^3, density @ 70ºF

3.0 PRESSURE RELIEF VALVES FOR NUCLEAR VESSELS (Section III):

3.1 Coefficient Method Formulas:

Steam:

For nozzle…….. W = (51.5 APK)

For flat seat (low lift)……. W = (51.5π DLPK)

For 45º seat……W = (51.5π DLPK) (.707)

For steam pressures over 1500 psi and up to 3200 psi the value W shall be multiplied by the Napier correction factor F_N (if the correction factor is greater than 1.0):

$F_N = (0.1906P – 1000)/(0.2292P – 1061)$

For Air…….. W = 18.331APK @ 60ºF and 14.7 psia
For Gas…….. W = CAPK $\sqrt{M/T}$
For liquid (water)…….. W = 4.814AK $\sqrt{w(P-P_d)}$

Where W = rated capacity, lb/hr (dry saturated steam), SCFM (air), lb/hr (gas or vapor), GPM (water)

A = actual discharge area through the valve at developed lift, square inches

C = constant for gas or vapor based on the ratio of specific heats C_p/C_v

D = seat diameter, inches

K = certified coefficient

L = lift, inches

M = molecular weight

P = (stamped set pressure + 3%) + 14.7 psia (for Class 1, 2, and 3 main steam safety valves)

- OR -

P = (stamped set pressure + 2.5 psi or 10%, whichever is greater) + 14.7 psia

(For air, gas, or steam valves other than main stream)

P_d = pressure at discharge from valve, psia

T = absolute temperature at inlet, ºR (degrees Fahrenheit + 460)

w = 62.3058 lbm/ft^3, density of water @ 70ºF

3.2 Slope Method Formula:

The values of slope given have the units of SCFM for air or pounds per hour per psia for steam.

W = slope x (set pressure + 3% + 14.7 psia), (for Class 1, 2. 3 main steam valves)

W = slope x [(set pressure + 3 psi or 10%, whichever is greater) + 14.7 psia], (For air, gas, or steam other than main stream)

For Liquid (water):

W = F x $\sqrt{}$ $(P – P_d)$ where F = flow factor, GPM/$\sqrt{}$PSID

The flow factor is a rating number for liquid service determined by test. It is equal

to the capacity in gallons per minute divided by the square root of the differential flowing pressure.

3.3 Valves less than 15 psig and Vacuum Relief Valves:

Consult ASME Code Section III subsections NC, ND, or NE for applicable capacity equations.

4.0 SAFETY AND SAFETY RELIEF VALVES FOR HEATING BOILERS (Section IV):

4.1 Coefficient Method Formula for steam:

For nozzle……..… W = (51.5 APK)

For flat seat……..…. W = (51.5π DLPK)

For 45º seat……..…….. W = (51.5π DLPK) (.707)

Where W = rated capacity, pounds dry saturated steam per hour

A = actual discharge area through the valve at developed lift, square inches

D = seat diameter, inches

K = certified coefficient

L = lift, inches

P = (15 + 33.3%) + 14.7 psia = 34.7 psia for 15 psi steam safety valves

- OR -

P = (stamped set pressure + 10%) + 14.7 psia for safety relief valves for hot water boilers

Note: Multiply steam capacity in lb/hr by 1000 to obtain capacity in BTU/Hr.

4.2 Slope Method Formula:

The values of slope have units of BTU per hour per psia or pounds per hour per psia. The capacity will have units of BTU/Hr or lb/hr based upon the units for slope.

W = slope x (set pressure + 10% + 14.7 psia)

5.0 PRESSURE RELIEF VALVES FOR PRESSURE VESSELS (Section VIII, Div. 1 & 2):

5.1 Coefficient Method Formula:

Steam:

For nozzle…….. W = (51.5 APK)

For flat seat (low lift)……. W = (51.5π DLPK)

For 45º seat……..….. W = (51.5π DLPK) (.707)

For steam pressures over 1500 psi and up to 3200 psi the value W shall be multiplied by the Napier correction factor F_N (if the correction factor is greater than 1.0):

$F_N = (0.1906P – 1000)/(0.2292P – 1061)$

For air: W = 18.331APK @ 60ºF and 14.7 psia

For Gas or Vapor: $W = CKAP \sqrt{M/T}$

For Liquid (water): $W = 4.814AK \sqrt{w(P – P_d)}$

Where W = rated capacity, lb/hr (dry saturated steam), SCFM (air), lb/hr (gas or vapor), GPM (water)

A = nozzle throat area, square inches

C = constant for gas or vapor based on ratio of specific heats C_p/C_v

(see Section VIII Div. 1, Appendix 11)

D = seat diameter, inches

K = certified coefficient

L = lift, inches

M = molecular weight

P = (stamped set pressure + 3 psia or 10%, whichever is greater) + 14.7 psia

- OR –

P = (stamped set pressure + 20%) + 14.7 psia for test per UG-131(c)(2)

Pd = pressure at discharge from valve, psia

T = absolute temperature at inlet, ºR (degrees Fahrenheit + 460)

w = 62.3058 lbm/ft^3, density @ 70ºF

5.2 Slope Method Formulas:

The values of slope given have units of SCFM/psia for air or lb per hour per psia for steam.

W = slope x [(set pressure + 3 psia or + 10%, whichever is greater) + 14.7 psia]

- OR –

W = slope x [(stamped set pressure + 20%) + 14.7 psia for test per UG-131(c)(2)]

For Liquid (water):

$W = F \times \sqrt{(P – P_d)}$ where F = flow factor, GPM/$\sqrt{PSID}$

The flow factor is a rating number for liquid service determined by test. It is equal to the capacity in gallons per minute divided by the square root of the differential flowing pressure.

5.3 Flow Resistance (Non-reclosing devices)

Device designs certified by the Flow Resistance method are not marked with a relieving capacity value. The certified flow resistance (K_{rg}, K_{rl}, K_{rgl}) is included on the nameplate and shall be used when determining total flow resistance of the pressure relief system and the flowing capacity it will relieve through the use of accepted engineering practices. The flow resistance subscripts “g,” “l,” or “gl” indicate that the device has been certified for gas (K_{rg}), liquid (K_{rl}), or both gases and liquids (K_{rgl}). Unless otherwise noted, the pressure drop across a certified non-reclosing device shall be calculated using dimensions for standard pipe (STD).

For pressure relief systems discharging directly to atmosphere which include a non-reclosing device installed within 8 pipe diameters of the vessel nozzle and having a discharge pipe no longer than 5 pipe diameters, system capacity can be determined from the equations found in 5.1 above using the listed minimum net flow area (MNFA) marked on the nameplate and an assumed coefficient of discharge equal to 0.62.