FREE FIELD REFERENCE

47 Pipe Calculations Every Pipefitter Must Know

Every formula a pipefitter, boilermaker or piping engineer reaches for on a job site — with worked examples and the standard each one comes from.

Pipefitter Academy Pro — 44 offline calculators · ISO Assistant AI · 168 academy lessons

Contents

§1 — Offsets and travel

1 Simple 2D offset — travel

$$H = A / \sin(\beta)$$

A=200 mm, β=45° → H = 200/0.7071 ≈ 282.8 mm

`Geometry. App: Offset 2D`

2 Simple 2D offset — run

$$Run = A / \tan(\beta)$$

A=200, β=45° → Run = 200/1 = 200 mm

`Geometry. App: Offset 2D`

3 Spool length (travel − 2 take-outs)

$$Spool = H - 2 \cdot BOP \quad ; \quad BOP = R \cdot \tan(\beta/2)$$

R=152.4 mm (LR 4"), β=45° → BOP = 63.1 mm; Spool = 282.8 − 126.2 = 156.6 mm

`Geometry + ASME B16.9. App: Offset 2D / Cut List`

4 Rolling offset — travel

$$T = \sqrt{(Rise^2 + Lat^2 + Run^2)}$$

Rise=300, Lat=200, Run=500 → T = √(90 000+40 000+250 000) ≈ 618 mm

`3D Pythagorean. App: Offset 3D`

5 Rolling offset — roll angle

$$\theta\_roll = \arctan(Lat / Rise)$$

Lat=200, Rise=300 → 33.69°

`Trigonometry. App: Offset 3D (rise-lat-run mode)`

6 Rolling offset — fitting angle β

$$\beta = \arctan(\sqrt{(Rise^2 + Lat^2)} / Run)$$

Rise=300, Lat=200, Run=500 → √130 000 / 500 → β ≈ 35.8°

`Geometry. App: Offset 3D`

7 Compound angle (3D right triangle)

$$\alpha\_true = \arctan(\sqrt{(Rise^2 + Lat^2)} / Run)$$

For an inclined branch from a horizontal header

`Geometry. App: Compound Angles`

8 Pipe shrink/gain after bending

$$Gain = R \cdot (\tan(\beta/2) - \pi \cdot \beta/360) \ (\beta \text{ in degrees})$$

LR 90°, NPS 4": gain ≈ 23.5 mm vs. take-out

`Empirical. App: Shrink/Gain`

§2 — Elbows and bends

9 LR elbow center-to-face (take-out)

$$C2F = 1.5 \cdot NPS \cdot 25.4 \quad (mm)$$

NPS 6" → 1.5 × 6 × 25.4 = 228.6 mm

`ASME B16.9 Table. App: Elbow`

10 SR elbow center-to-face

$$C2F = 1.0 \cdot NPS \cdot 25.4 \quad (mm)$$

NPS 6" SR → 152.4 mm

`ASME B16.9. App: Elbow`

11 Arc length of elbow centreline

$$L = \pi \cdot R \cdot \theta / 180 \quad (\theta \text{ in degrees})$$

LR 4" 90° → π × 152.4 × 90/180 ≈ 239.4 mm

Geometry. App: Arc Development

12 Cut elbow at angle — segment length

$$L_{seg} = R \cdot \theta_{cut} \cdot \pi/180$$

LR 6" cut to 45° → 1.5 × 6 × 25.4 × 45 × π/180 ≈ 179.6 mm

Geometry. App: Cut Elbow

13 Miter elbow — segments needed

$$N = \lceil \theta_{total} / \theta_{per\_segment} \rceil + 1$$

90° elbow with 22.5° miters → 4 segments + end pieces

ASME B31.3 §306.3 limits. App: Miter Elbow

14 Miter MAWP limit (single cut)

$$P_a = SE \cdot (T - c)/r \cdot [1 / (1 + 0.643 \cdot \tan(\theta) \cdot \sqrt{r/(T-c)})]$$

Heavy-walled miters only — verify per B31.3 §304.2.3

ASME B31.3 §304.2. App: Miter + B31.3 module

15 Bend gain (rolled bends, no fitting)

$$Gain = 2 \cdot R \cdot \sin(\beta/2) - R \cdot \beta \cdot \pi/180$$

R=300, β=45° → 229.6 − 235.6 = −6 mm (slight loss)

Geometry. App: Shrink/Gain

16 BOP — backset for offset

$$BOP = R \cdot \tan(\beta/2)$$

LR 4", β=22.5° → 152.4 × 0.199 ≈ 30.3 mm

Geometry. App: every offset calculator

§3 — Branches and intersections

17 Cope (perpendicular branch) — saddle profile

$$y(\varphi) = Rb \cdot \sin(\varphi) - \sqrt{Ra^2 - (Rb \cdot \cos(\varphi))^2}$$

For each generatrix φ ∈ [0, 360°], y is the cut depth from a horizontal datum

Geometry. App: Cope

18 Branch on elbow (BOP) — geometry

Project branch axis onto elbow's torus → solve for intersection curve numerically

App computes 24-point template by default

Numerical geometry. App: Branch on Elbow

19 Reinforcement area (B31.3 §304.3.3)

$$A_{required} = th \cdot d1 \cdot (2 - \sin(\beta))$$

th = header thickness, d1 = branch inside diameter, β = branch angle

ASME B31.3 §304.3.3. App: B31.3 module

20 Tee — branch take-out

Run take-out: per B16.9 Table 6 ; Branch take-out: per same table

NPS 6×4 reducing tee → C-C run 178 mm; branch 92 mm

ASME B16.9 Table 6. App: Tee

21 Y-branch — symmetric split

$$L_{branch} = Z \cdot \sin(\beta/2) / \sin(180 - \beta)$$

For a 60° symmetric Y, branches develop at 30° from header axis

Geometry. App: Y-Branch

22 Pipe at angle through wall — chord on bore

$$C = D / \sin(\alpha) \quad (\alpha = \text{angle between pipe and wall normal})$$

D=168.3 mm at 60° → chord = 194.3 mm

Geometry. App: Pipe at Angle

§4 — Reductions and transitions

23 Concentric reducer length

L per B16.9 Table 9 (function of NPS pair)

NPS 6×4 → 152 mm; NPS 8×6 → 152 mm

ASME B16.9 Table 9. App: Reduction

24 Eccentric reducer — drop side

Drop = (D1 − D2) / 2 ; horizontal length per B16.9

NPS 6→4 eccentric: drop = (168.3 − 114.3)/2 = 27 mm bottom flat

ASME B16.9. App: Reduction

25 Cone development — slant height

$L_s = \sqrt{(D - d)^2 / 4 + h^2}$

D=300, d=150, h=200 → L_s = √(5 625+40 000) ≈ 213.6 mm

Geometry. App: Cone Dev

26 Cone development — sector angle

$\theta = (D \cdot 180) / R_{full}$; $R_{full} = D \cdot L_s / (D - d)$

Cone above → sector ≈ 252°

Geometry. App: Cone Dev

§5 — Flanges and gaskets

27 Flange bolt circle layout (XY)

$x_i = BCD/2 \cdot \cos(2\pi \cdot i/n)$; $y_i = BCD/2 \cdot \sin(2\pi \cdot i/n)$

CL 150 NPS 4" → BCD = 191.3 mm; 8 bolts

ASME B16.5 Table 2-3.4. App: Flange

28 Bolt spacing (chord between adjacent bolts)

$s = 2 \cdot (BCD/2) \cdot \sin(\pi/n)$

NPS 4" CL150 → s = 191.3 × sin(22.5°) ≈ 73.2 mm

Geometry. App: Flange

29 Flange CL150 max pressure @ 38°C, CS Gr.1.1

P_{max} = 19.6 barg (285 psig)

CL 300 → 51.1 barg; CL 600 → 102.1 barg

ASME B16.5 Table 2-1.1. App: Flange + Library

30 Bolt torque (rough rule of thumb)

$T = K \cdot F_b \cdot d_b$; $K \approx$ 0.20 dry / 0.15 lubed

M20 lubed, F_b=160 kN → T ≈ 480 N·m. Use manufacturer's exact value.

VDI 2230 / ASME PCC-1. App: companion to Flange

31 Gasket seating stress (basic)

y = required seating stress (per gasket vendor)

Spiral wound graphite: y ≈ 70 MPa typical

ASME B16.20 + vendor data. App: Reference

§6 — Pressure and thickness

32 Barlow's formula — internal pressure

$P = 2 \cdot S \cdot t / D$

A106-B (S=137 MPa) Sch40 NPS 4" (t=6.02, D=114.3) → P ≈ 14.4 MPa = 144 barg

Classical. App: Barlow

33 ASME B31.3 §304.1 — minimum thickness

$t = P \cdot D / (2 \cdot (SE \cdot W + P \cdot Y))$

P=25 barg, D=114.3, S=110 MPa @120°C, E=1, W=1, Y=0.4 → t ≈ 1.03 mm

ASME B31.3 §304.1. App: B31.3 module

34 Hydrostatic test pressure

$P\_test = 1.5 \cdot P\_design \cdot (S\_test / S\_design)$

P_design = 20 barg @ 250°C → P_test ≈ 30 barg adjusted

`ASME B31.3 §345. App: B31.3 module`

35 Corrosion allowance addition

$t\_required = t\_pressure + c$

CS in mildly corrosive service: c = 1.5–3.0 mm typical

`Project spec. App: B31.3 module`

36 Wall thickness tolerance (negative)

$t\_min\_supplied = t\_nominal \cdot (1 - tol/100)$

ASTM A106: tol = 12.5% → use 87.5% of nominal for B31.3 calcs

`ASTM A106 + ASME B31.3 §304.1.1. App: B31.3`

37 External pressure check (vacuum or jacketed)

Use ASME B31.3 §304.1.3 + B&PV Code Section VIII Div 1 UG-28

Often governing for thin large-diameter pipe under vacuum

`ASME B31.3 §304.1.3. App: B31.3 + external resources`

§7 — Supports and spans

38 MSS SP-69 — max span CS water service

L_max (m) per Table — function of NPS

NPS 4" CS water = 4.3 m ; NPS 6" = 5.2 m ; NPS 8" = 5.8 m

`MSS SP-69. App: Hanger Spacing`

39 Pipe weight (steel, water-filled)

$w\_total = w\_pipe + (\pi/4) \cdot ID^2 \cdot \rho\_fluid$

NPS 6" Sch40 (w_pipe = 28.3 kg/m) water-filled → ≈ 47.4 kg/m

`Geometry + ASME B36.10. App: Pipe Weight`

40 Hanger load (uniform distribution)

$F\_hanger = w\_total \cdot L\_span \cdot 1.1$ (safety)

NPS 6" water, 5 m span → F ≈ 261 kg per hanger

`Generic + project spec. App: Hanger Spacing`

41 Allowable deflection

$\delta\_max = L / 360$ (typical for piping)

5 m span → max sag ≈ 14 mm at midspan

`ASCE generic + MSS. App: Reference`

§8 — Welds, materials and tolerances

42 Bevel angle — V-groove preparation

$\alpha\_bevel = 30° \pm 2.5°$ per side ; root gap 2–3 mm

Standard for BW joints in CS pipe

`AWS D1.1 + B31.3. App: Weld Bevel`

43 PFI TB-10 — FDI (Fitting Difficulty Index)

FDI = base value per NPS × schedule × material modifier

NPS 12" XS SS = 28.8 FDI hours

`PFI TB-10. App: Productivity / Orçamentação`

44 A106-B max service temperature

T_max ≈ 425 °C (797 °F) — above, use P11/P22 or austenitic

Higher temps require Cr-Mo alloys or 300-series SS

`ASME B31.3 Appendix A. App: Reference + Academia`

45 Stainless sensitization range

450–850 °C: $Cr_{23}C_6$ precipitation → intergranular corrosion

Use L grades (304L/316L) for welded service to avoid

`Materials science. App: Academia M1`

46 Hi-Lo internal misalignment limit (BW)

> Hi-Lo ≤ 1.5 mm (or 25% of wall thickness, lesser)

Sch 40 NPS 4" (t=6.02): max ≈ 1.5 mm

`API 1104 + AWS D1.1. App: Reference`

47 Flange alignment tolerance

> Parallelism: ≤ 1 mm in 300 mm ; bolt-hole offset: ≤ 3 mm

Check with steel straight edge + feeler gauge before tightening

`ASME PCC-1. App: Reference`

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