Pipe Thrust Force at a Bend or Expansion Joint

Resultant thrust on a pipe bend or an unrestrained expansion joint from internal pressure and flow momentum, for anchor and thrust block design.

Method: Momentum equation on a pipe bend (Textbook fluid mechanics (White, Fluid Mechanics))

Input parameters

Unit system: SI

Parameter	Value	Unit
Internal pressure (gauge)	10.000	bar
Inside diameter (or effective diameter of the bellows)	200.00	mm
Bend angle (change of direction)	90.000	°
Volume flow	180.00	m³/h
Fluid density	998.00	kg/m³

Calculated results

Parameter	Value	Unit
Pressure thrust on one end p A (expansion joint)	31.416	kN
Momentum force on one end ρ Q v	0.079418	kN
Resultant on the bend 2 (pA + ρQv) sin(θ/2)	44.541	kN

Notes for this case

- The resultant acts along the bisector of the bend, outwards. Use the test pressure for anchors that must survive the hydrotest.

Formula and method

$$F_p = pA, \quad F_m = \rho Q v, \quad F_R = 2(pA + \rho Q v)\sin\frac{\theta}{2}$$

Variables

p	Internal pressure (gauge)	Pa
d	Inside diameter (or effective diameter of the bellows)	m
θ	Bend angle (change of direction)	rad
Q	Volume flow	m³/s
ρ	Fluid density	kg/m³
F_p	Pressure thrust on one end p A (expansion joint)	N
F_m	Momentum force on one end ρ Q v	N
F_R	Resultant on the bend 2 (pA + ρQv) sin(θ/2)	N

Method and standards

Force balance on the bend control volume.

Assumptions and limits

- Equal inlet and outlet sizes.

References

- Momentum equation on a pipe bend (Textbook fluid mechanics (White, Fluid Mechanics))

Report details

Report reference	FCC-724H-A114 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/piping/pipe-thrust-bend

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.