# Bellows Pressure Thrust

Many factors come in to place when considering the design of a metal bellows (or expansion joint). One of the most important factors that can adversely affect the performance is the **pressure thrust force** of the media flowing through the system.

For an internally pressurized system:
The **pressure thrust force** for an internally pressurized system is equal to the effective cross sectional area of the bellows times the media pressure.
For a system with an internal vacuum:
The **pressure thrust force** is equal to the atmospheric pressure times the effective cross sectional area of the bellows.

The **pressure thrust force** of the system is a major influence to the design of the bellows & is a determining factor of any hardware required to react this force. All piping systems or duct systems undergo some **pressure thrust force** & with the addition of an unrestrained bellows, the flexibility introduced to the system will allow it to better absorb the forces acting on it & protect the system.

I. Definitions

| | |
|---|---|
| *$A_e$:* | *Bellows Effective Area* |
| *Dm:* | *Bellows Mean Diameter* |
| *F:* | *Pressure Thrust Force* |
| *ID:* | *Bellows Inside Diameter* |
| *p:* | *Pressure* |
| *OD:* | *Bellows Outside Diameter* |

II. Equations

(1) Effective Area: $A_e = \left(\frac{\pi}{4}\right) Dm^2$

(2) Mean Diameter: $Dm = \frac{ID+OD}{2}$

(3) Pressure Thrust Force: $F = p * A_e$

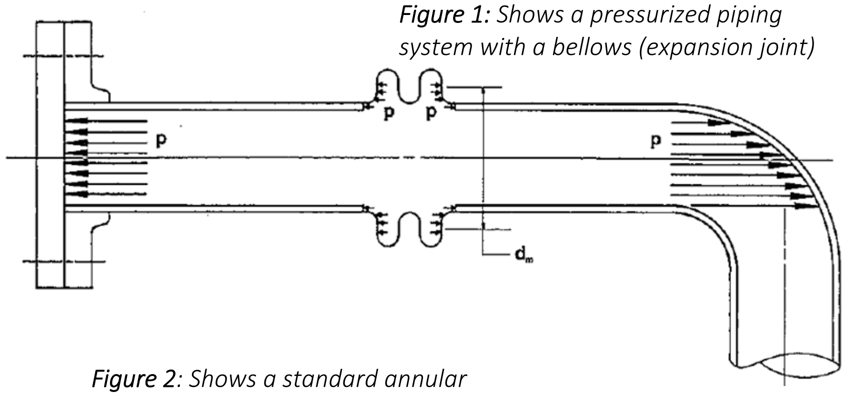
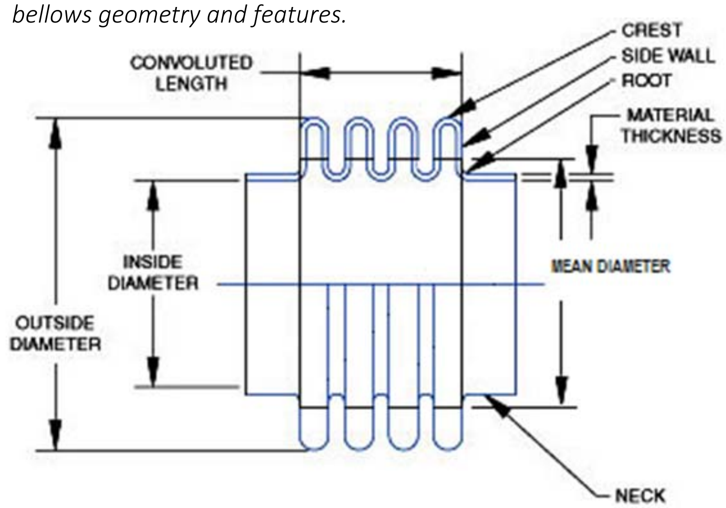



*Figure 1: Shows a pressurized piping system with a bellows (expansion joint)*

*Figure 2: Shows a standard annular bellows geometry and features.*



# BELLOWS EFFECTIVE AREA

## *What is a Bellows Effective Area?*

The effective area of a bellows (expansion joint), also known as the **bellows effective thrust area**, is the total cross sectional area of a bellows in which a media flows through. This area is calculated by using the mean diameter of the bellows convolutions due to the complex geometry. The effective area of a bellows can affect a variety of operating conditions such as: flow rate of the media, pressure inside the convolutions, allowable motions, etc.). The effective area of a bellows is directly related to the inner & outer diameter of the bellows. When designing a bellows component to accommodate for a required effective area, one must take these factors into account.

### III. Pressure Thrust Sample Calculations

Given a bellows with the following geometry with an internal pressure of 100 psi:

| Bellows Element Geometry: | | | |
|---|---|---|---|
| 1 | matl b | 321 SS | Bellows Material |
| 2 | OD | 6.100 | Bellows OD (in) |
| 3 | ID | 5.030 | Bellows ID (in) |
| 4 | span | 0.511 | Convolution Height (in) |
| 5 | n | 2 | Number of Plies |
| 6 | t | 0.012 | Individual Ply Thickness (in) |
| 7 | Lb | 6.300 | Bellows Live Length (in) |
| 8 | N | 16 | Number of Convolutions |
| 9 | Dm | 24.323 | Effective Area of Bellows (in^2) |

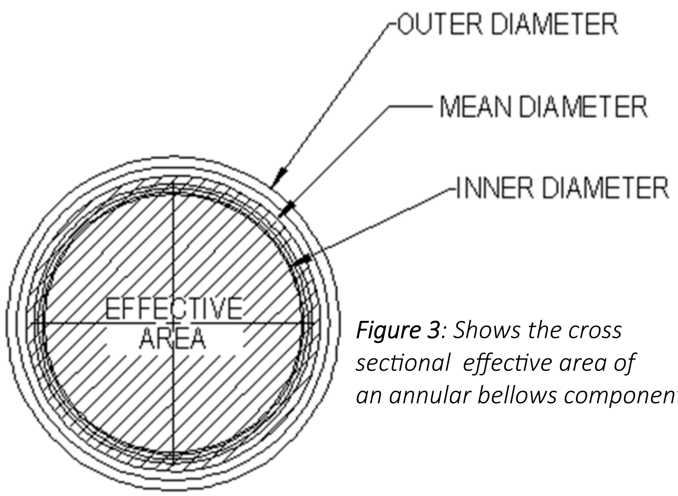



*Figure 3: Shows the cross sectional effective area of an annular bellows component.*

<u>To calculate the Bellows Effective Area</u>

(1) First, calculate the mean diameter of the bellows:

Mean Diameter: $Dm = \frac{ID+OD}{2}$ $\therefore$ $Dm = \frac{6.100+5.030}{2}$

$$Dm = 5.565\ in$$

(2) Next, calculate the effective area:

Effective Area: $A_e = \left(\frac{\pi}{4}\right) Dm^2$ $\therefore$ $A_e = \left(\frac{\pi}{4}\right)(5.565^2)$

$$\boldsymbol{A_e = 24.323\ in^2}$$

(3) Lastly, calculate the pressure thrust force:

Pressure Thrust Force: $F = pA_e$ $\therefore$ $F = (100psi)(24.323in^2)$

$$\boldsymbol{F = 2432.3\ lbs}$$