3.2.2 Globe Valve Stem Thrust

Globe valve's have several design features that greatly influence the force required to operate the valve. Globe valves can either be self opening or self closing, depending on the disc design and the direction of flow through the valve. An unbalanced disc globe valve is one where the full differential pressure acts across the valve disc. A balanced disc globe valve contains ports to equalize pressure above and below the disc. The design of the disc guides and seat determine if the differential pressure acts on an area defined by the seat diameter or the larger area defined by the guide outside diameter (referred to as seat-based or guide-based). Finally, the valve can be oriented in the piping system to produce over-disc flow or under-disc flow. Flow over the disc causes a differential pressure load which places the stem in tension (self closing), while flow under the disc places the stem in compression (self opening).

Figure 3-19 shows a Y-pattern globe valve design and identifies the location of the most common forces that resist or assist in valve operation. The required stem force to operate a globe valve is the sum of these forces. Positive values produce tension in the valve stem and negative values produce compression:

1. Differential pressure force - can be positive or negative depending on flow direction.

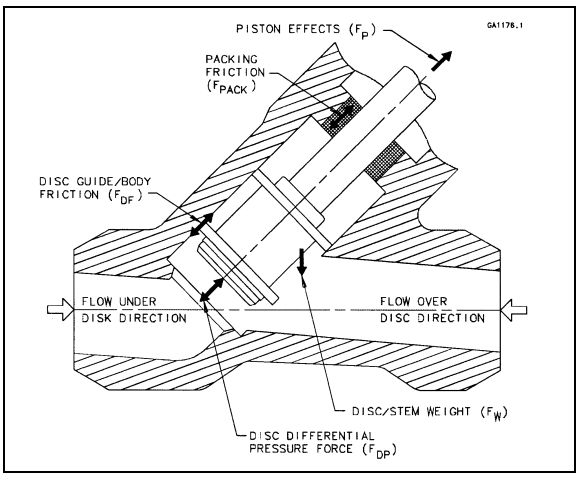

Figure 3-19 Y Pattern Globe Value Stem Thrust Components

2. Friction force between the disc and guide - resists valve disc movement, positive for opening and negative for closing.
3. Stem rejection force - pressure trying to expel the stem from the valve body - always negative.
4. Disc and stem weight - can be positive or negative depending on valve orientation.
5. Stem packing force - resists valve stem movement, positive for opening and negative for closing.
6. Torque reaction force - prevents stem rotation, positive for opening and negative for closing.

The most common safety-related globe valve applications encountered are larger diameter, unbalanced disc globe valves with significant differential pressure. In these applications, the differential pressure, stem rejection, and packing forces become first order and the other forces are typically ignored. The disc and guide friction, disc and stem weight, and torque reaction force, can be significant for small diameter valves, valves in low pressure systems, and balanced disc valves.

The required valve stem thrust to open a globe valve becomes:

$$F_{stem} = \pm F_{disc} - F_{rej} \pm F_{pack}$$

Equation (3-16)

Where,

F_{stem} = Required valve stem force (negative sign convention indicates compression or self opening)

$$F_{disc} = f\left(P_{up} - P_{down}\right)A_{DP}$$

$$F_{stem\ rej} = PA_{stem}$$

F_{pack} = Packing drag

In the above equations:

A_{DP} = Area for differential pressure calculation - seat or guide

A_{stem} = Area defined by the valve stem diameter

f = Disc factor

P_{up} = Upstream pressure

P_{down} = Downstream pressure

The differential pressure force, or disc force, is zero for balanced disc globe valves. For unbalanced discs, the area used in the calculation depends on valve design and position. In the zero stroke position (valve fully closed) the area defined by the seat diameter is used. For non-zero stem positions, the area will be the seat area for seat-based designs or the guide area for guide-based designs. A disc factor of 1.1 is often used when specific disc design information is unavailable. Figures 3-20 and 3-21 show examples of disc-based and guide -based disc designs.

The stem rejection force is calculated using the pressure acting on the valve stem. This pressure is the upstream pressure for unbalanced discs with over-disc flow or balanced discs with under-disc flow. The pressure will be the downstream pressure for unbalanced discs with under-disc flow or balanced discs with over-disc flow. The packing force is determined using the same methods as in gate valve calculations. It is often bounded by assuming a 1,000-lb_f per inch of stem diameter.

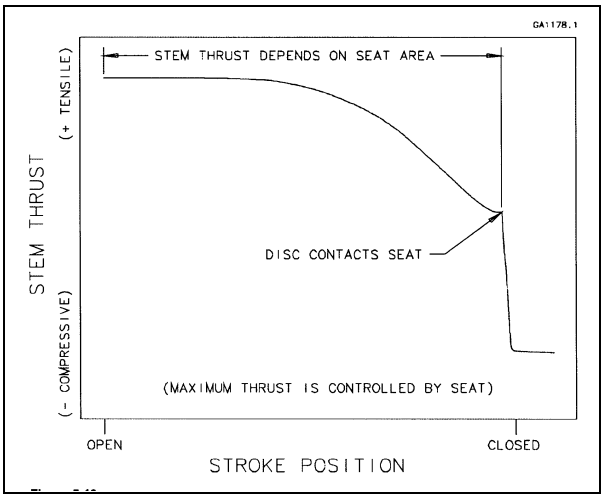

Figure 3-20 Typical Stem Thrust vs Stroke For Closing A Seat-based Globe Valve

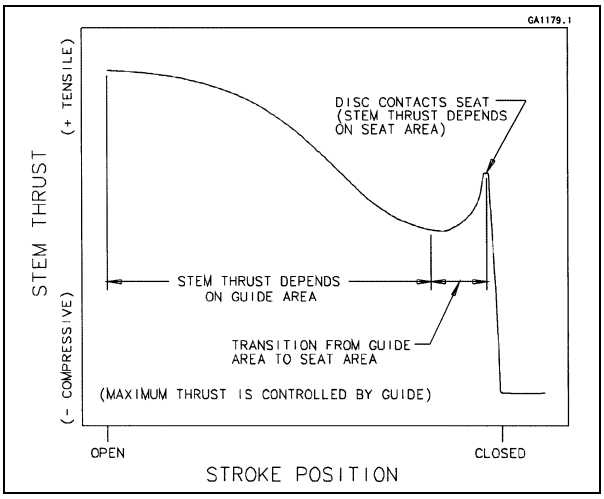

Figure 3-21 Typical Stem Thrust vs Stroke For Closing A Guide-based Globe Valve

The stem rejection force is calculated using the pressure acting on the valve stem. This pressure is the upstream pressure for unbalanced discs with over-disc flow or balanced discs with under-disc flow. The pressure will be the downstream pressure for unbalanced discs with under-disc flow or balanced discs with over-disc flow. The packing force is determined using the same methods as in gate valve calculations. It is often bounded by assuming a 1,000-lb_f per inch of stem diameter.

The calculations for determining the required globe valve stem force have been verified for water at less than 150°F. Beyond these conditions valve specific test data is preferred. Limited testing beyond these conditions have produced disc factors as high as 1.5.