Approximate Sizing Guide for Temperature Compensating Units

This guide provides some basic information so that temperature compensating units (TCU) can be correctly sized. The TCU acts as an expanding joint between the valve and IB & IS gearboxes. In normal service the preload within the TCU prevents any movement, as this would be higher than the maximum stem thrust. Upon elevated temperatures producing thermal expansion of the valve stem, the TCU would expand due to additional thrust from the valve stem, above that which would normally be seen. The valve stem passes through the TCU with no direct interaction.

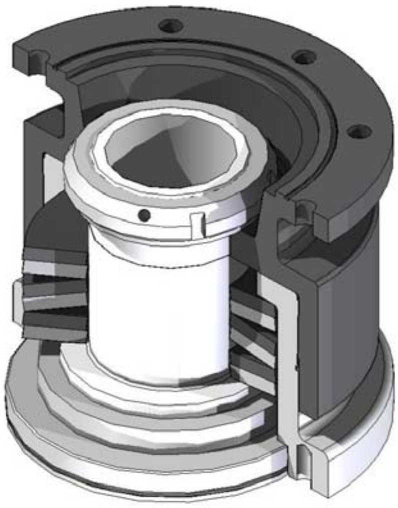


Fig.1. TCU cutaway

Fig.1. shows a cutaway view of a typical TCU. Due to the variety of both sizes and valve parameters, TCUs are customised to meet the load and expansion requirements of the valve stem. (This involves changing spring configuration and preload). Fig.2. shows the arrangement of a TCU.

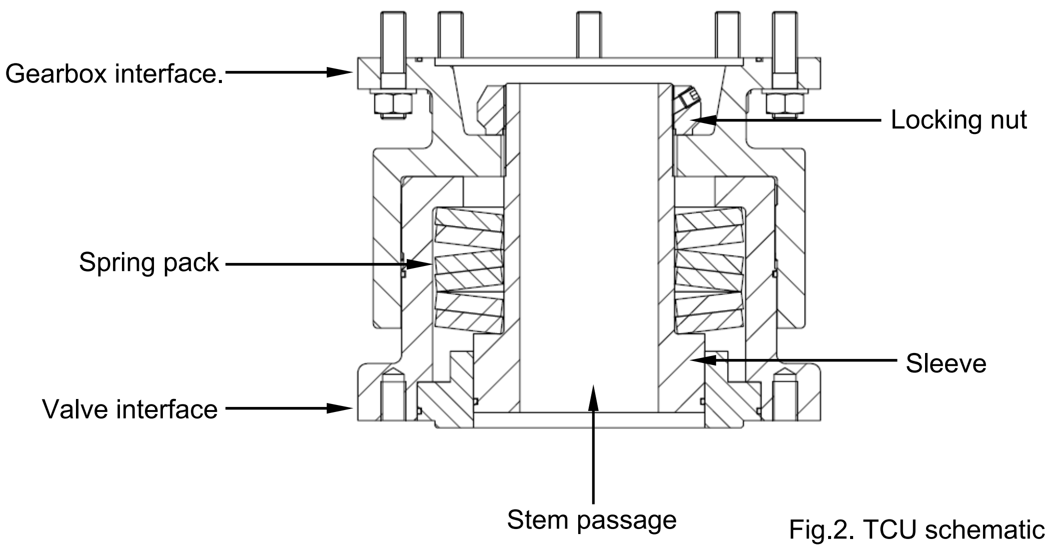


Fig.2. TCU schematic

Three principal valve parameters are required to size a TCU. These are:

- Valve seating thrust (F_{SEAT})
- Maximum allowable stem thrust (F_{MAST})
- Required stem expansion (x)

Example. Fig.3. shows the typical characteristics of a TCU. The valve has a seating thrust (F_{SEAT}) of 15kN, requires a stem expansion (x) of approximately 2mm and has a maximum allowable stem thrust (F_{MAST}) of 40kN. Can the TCU accommodate this?

1. Firstly the shallowest curve is chosen
2. The seating thrust of the valve is traced horizontally to the spring curve
3. Tracing vertically down, this then gives the spring preload travel.
4. Adding the stem expansion required to the preload travel gives the total spring travel.
5. At this travel, the corresponding stem load (F_{APP}) can be found by tracing up to the curve and across to the Load axis. (If the vertical trace does not meet this curve, the next steeper spring curve must be chosen, if applicable)

In this example, the TCU can accommodate this expansion as the maximum applied stem thrust is lower than both the maximum allowable stem thrust and maximum gearbox thrust. The maximum stem expansion (x_{max}) can also be found using this method.

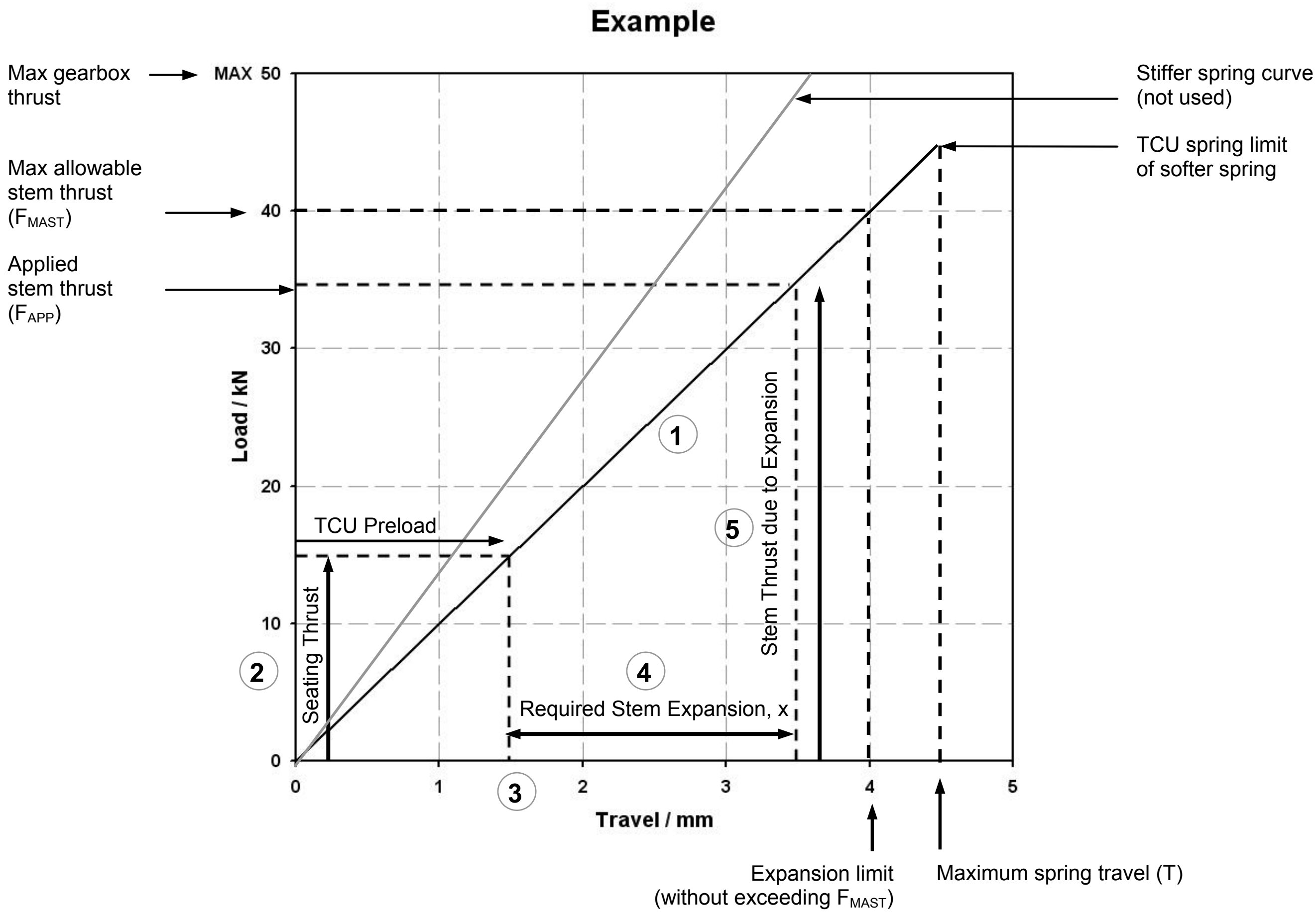
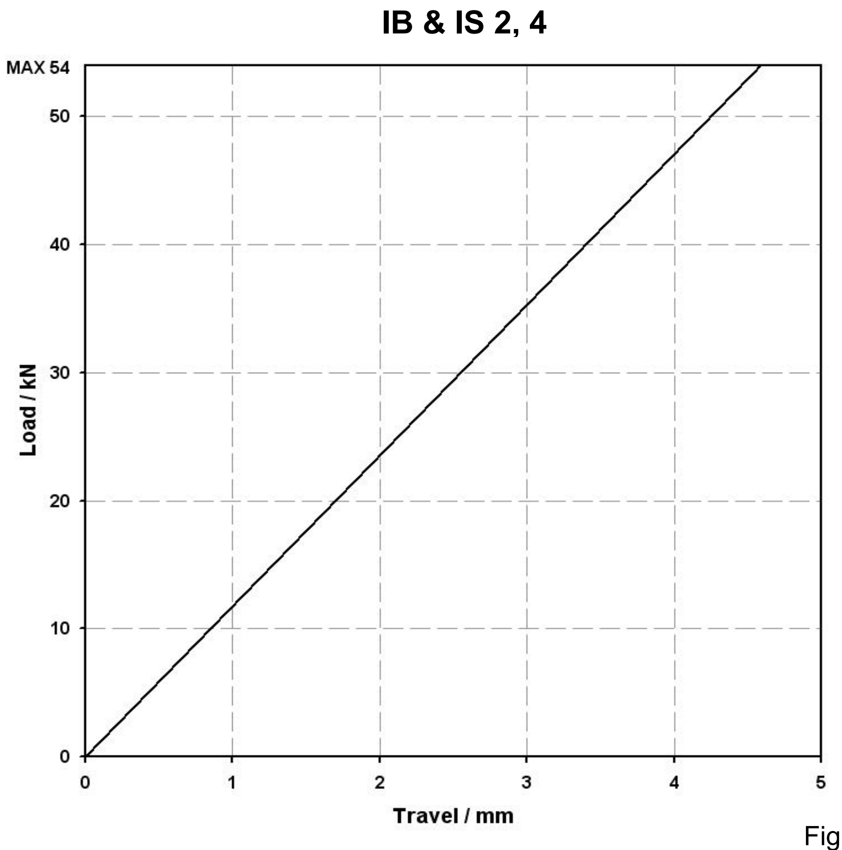


Fig.3. Example TCU curve

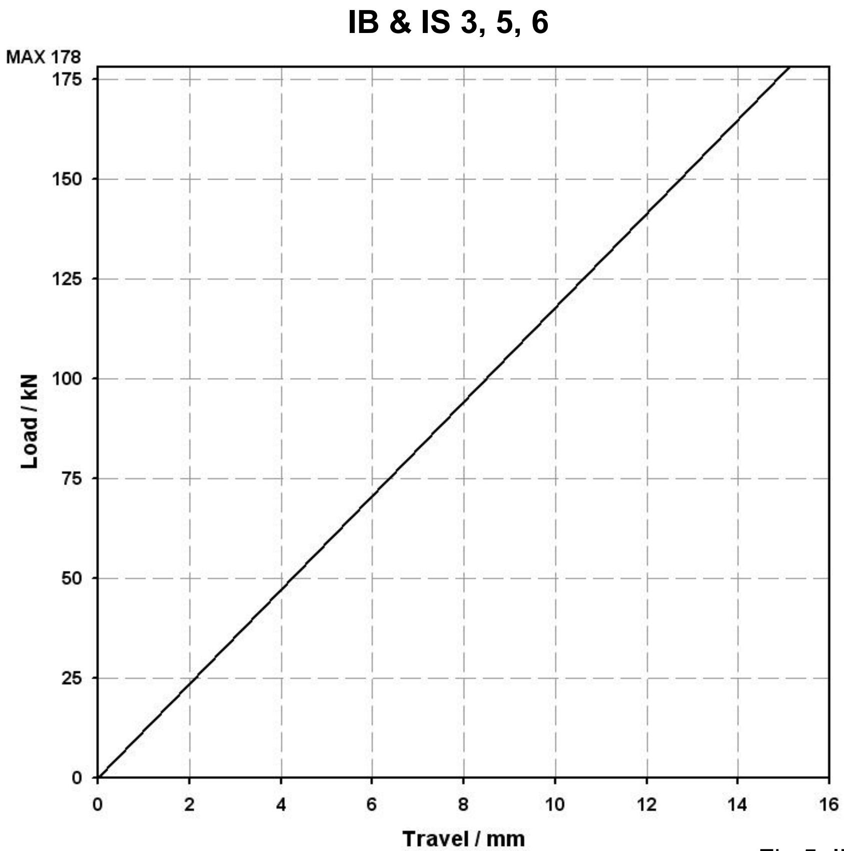
The following figures show the available characteristics for TCUs of different gearbox sizes. In cases where multiple spring configurations are present, it is advisable to use the gentlest curve as spring configurations with steeper curves increase the load on the stem for any given expansion. Steeper curves are listed, as these spring configurations have a higher load capacity. For each spring curve the spring thickness (e.g. 12mm), configuration (e.g. 5x1; 5 springs in series), spring pack constant (k) and maximum travel (T) is also listed.



Spring Arrangement:

12mm (5x1)
$k=11.8kNmm^{-1}$ T=4.6mm

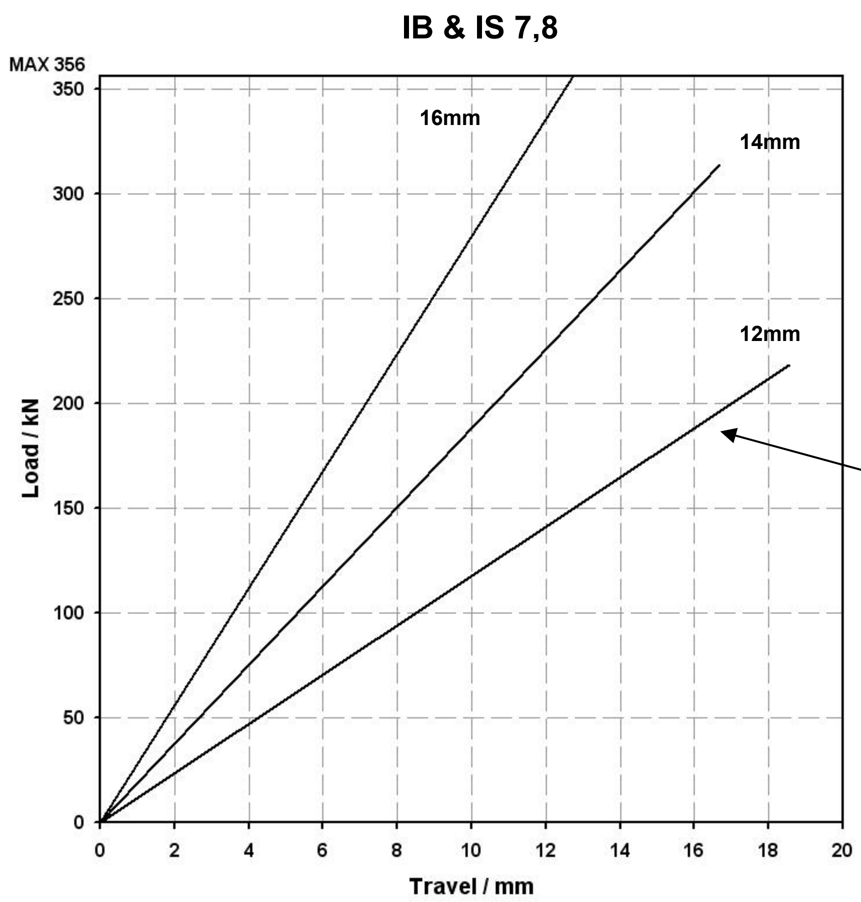
Fig.4. IB & IS 2, 4 TCU Characteristic



Spring Arrangement:

12mm (5x1)
$k=11.8kNmm^{-1}$ T=15.1mm

Fig.5. IB & IS 3, 5, 6 TCU Characteristic



Spring Arrangements:

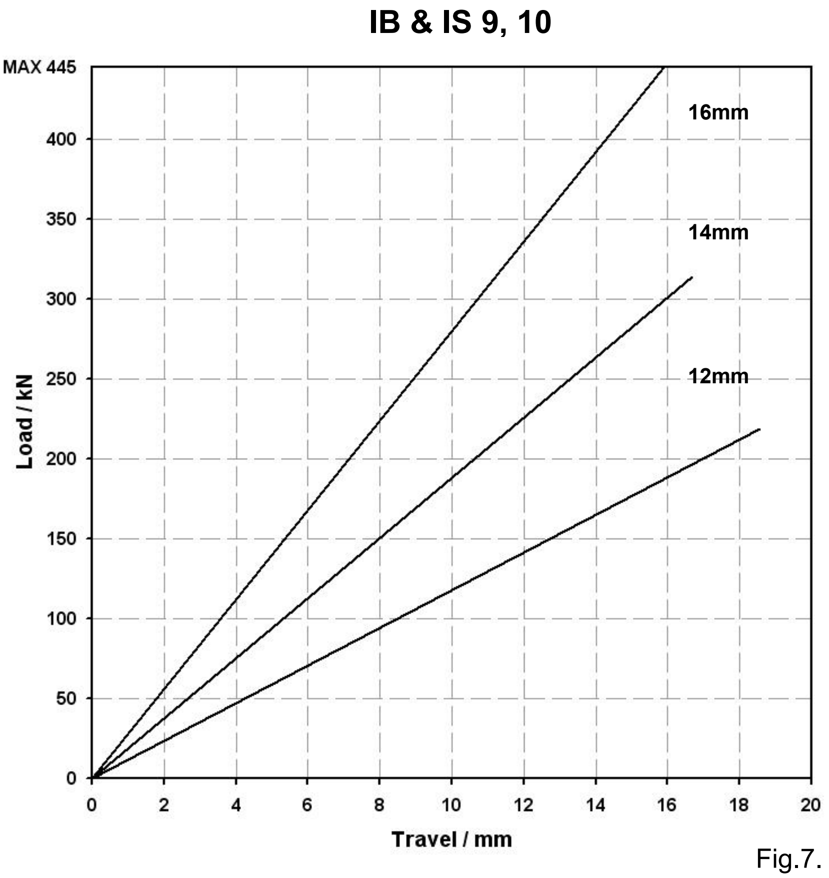
16mm (5x1)
k=28.0kNmm^{-1} T=12.7mm

14mm (5x1)
k=18.8kNmm^{-1} T=16.7mm

12mm (5x1)
k=11.8kNmm^{-1} T=18.6mm

Use this spring curve first…

Fig.6. IB & IS 7, 8 TCU Characteristics



Spring Arrangements:

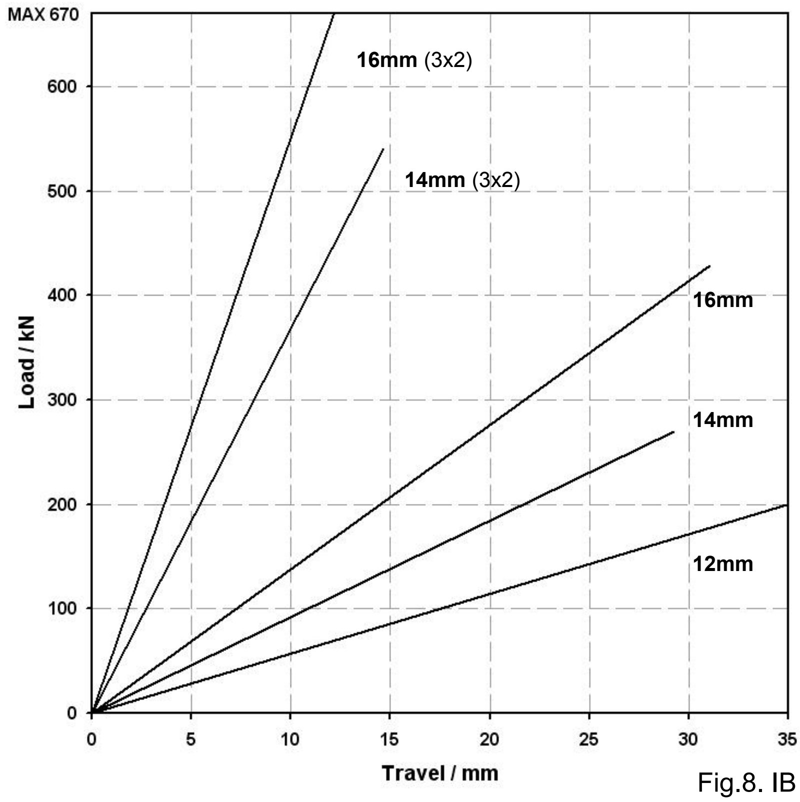
16mm (5x1)
k=28.0kNmm^{-1} T=15.9mm

14mm (5x1)
k=18.8kNmm^{-1} T=16.7mm

12mm (5x1)
k=11.8kNmm^{-1} T=18.6mm

Fig.7. IB & IS 9, 10 TCU Characteristics

IB & IS 11, 12



Spring Arrangements:

16mm (3x2)
k=55.1kNmm^{-1} T=12.1mm

14mm (3x2)
k=36.9kNmm^{-1} T=14.6mm

16mm (5x1)
k=13.8kNmm^{-1} T=31.0mm

14mm (5x1)
k=9.2kNmm^{-1} T=29.2mm

12mm (5x1)
k=5.7kNmm^{-1} T=35.0mm

Fig.8. IB & IS 11, 12 TCU Characteristics

In addition to the graphical method, for any spring configuration, parameters can be found mathematically; however the total spring travel must be checked to ensure that it is lower than the maximum travel available or the result will be invalid. The maximum stem expansion is found from the following equation:

$$x_{MAX} = T - \left(\frac{F_{SEAT}}{k}\right)$$

x_{MAX} = Maximum stem expansion (mm)
T = Maximum spring pack travel (mm)
F_{SEAT} = Valve seating thrust (kN)
k = Spring constant (kNmm^{-1})

The following equation finds the applied stem thrust for a given expansion:

$$F_{APP} = F_{SEAT} + kx$$

F_{APP} = Applied stem thrust (kN)
F_{SEAT} = Valve seating thrust (kN)
k = Spring constant (kNmm^{-1})
x = Required stem expansion (mm)

To validate, ensure that:

$$T > \frac{F_{SEAT}}{k} + x$$

or $F_{APP} < F_{MAST}$

T = Maximum spring pack travel (mm)
F_{SEAT} = Valve seating thrust (kN)
k = Spring constant (kNmm^{-1})
x = Required stem expansion (mm)
F_{APP} = Applied stem thrust (kN)
F_{MAST} = Maximum allowable stem thrust (kN)

(This document acts only as a guide and Rotork Gears should be contacted regarding specific requirements or proposals.).