Calculation process for the safety of cylinders against buckling

- When you enter the force of pressure [$\mathbf{F_d}$] the system computes the required piston diameter without taking friction and efficiency into account.

- When you enter force of pressure [$\mathbf{F_d}$], stroke length and installation angel [α], the safety against buckling [υ] is computed.
  On the basis of this calculation, a selection list of cylinders is created that feature a safety factor against buckling [υ] of at least υ = 2,5.

- The calculation of the cylinder is based on the system pressure. The cylinder can also be selected on the basis of the load pressure. However, for this, it must be ensured that the pressure in the cylinder chamber (pressure side) is not higher than the load pressure.

- The calculation carried out by the program refers to the installation position according to the installation angle [α] entered.

- The recommendation of saftey against buckling of υ = 3,5 given in the catalogue is a figure based on experience that has proven successful in the industrial use of cylinders.

- Depending on the application and the experience of the user, a safety factor up to min. υ = 2,5 can be selected. Due to the possibility of safety risks involved, the selected safety factor should not be less than υ = 2,5.

Calculation steps:

- Pressure stresses and bending stresses acting on the extended piston rod at critical places are calculated on the basis of the computed force of pressure [$\mathbf{F_d}$], the line load [**q**] and the deflection of the cylinder [$\mathbf{f_m}$] (bending) as well as the installation angle [α].

- In a next step, the total stress [σ_{total}] is calculated for the selected cylinder:

$$\sigma_{total} = \sigma_d + \sigma_b + \sigma_{bd}$$

  [σ_{total}] Total stress
  [σ_d] Compressive stress due to force of pressure
  [σ_b] Bending stress under own weight
  [σ_{bd}] Bending stress due to force of pressure and deflection

- The permitted buckling stress of the piston rod [σ_s] is calculated with the help of Euler´s equation taking into account the mounting style of the cylinder, the tensile yield strength of the piston rod material [σ_k] and the slenderness [λ].

- In the last calculation step, the selected cylinder´s safety against buckling [υ] is checked.

$$\upsilon = \sigma_k / \sigma_{total}$$

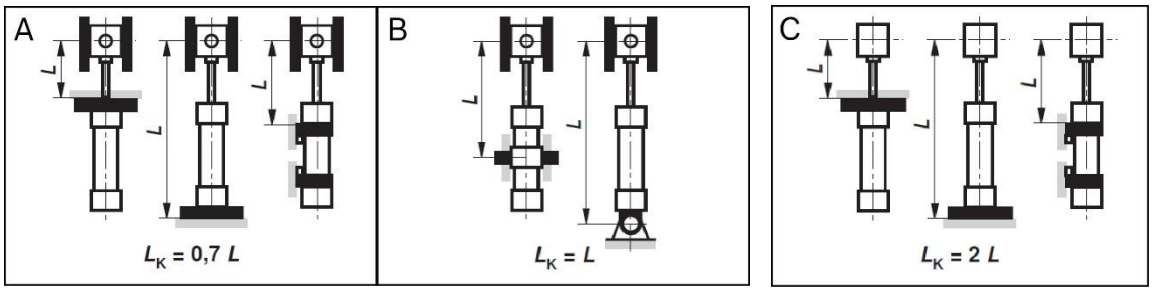
  [υ] Safety against buckling
  [σ_k] Permitted buckling stress of the piston rod
  [σ_{total}] Total stress

Influence of the mounting style on the buckling length (safety against buckling)

The examples in the figures show, which effect factor „L_K“ has on the calculation of the buckling length (safety against buckling) relating to the individual mounting styles and in the case of a “guided load” (examples “A” and “B”) and a “non-guided load” (example “C”)

Examples of cylinder with guided load (images A and B)

Example of cylinder with non-guided load (image C)



Installation length with and without stop tube for various mounting styles

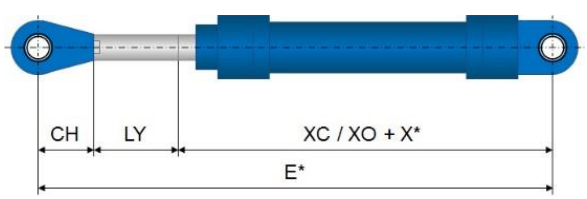
- If the standard installation length of a cylinder is to be increased, then the piston rod can be lengthened by the dimension „LY“ (piston rod extension).

Entry in the box „Input the installation length (retracted)“

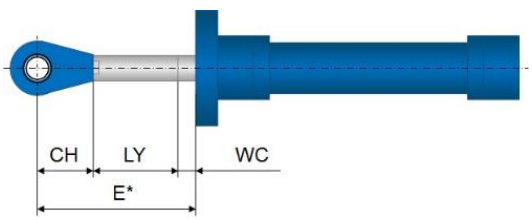
All mounting styles (except for MT4)
- If the installation length of a cylinder is longer than the standard installation length, the difference between the specified installation length and the standard installation length can be compensated for by a „**LY**“ piston rod extension.
- For cylinders without a self-aligning clevis, the installation dimension is shortened by dimension „**CH**“.

Mounting style „MT4“:
- If the specified installation length is longer than dimension „**XV max**.“ plus dimension „**CH**“, a „**LY**“ piston rod extension can be added to comply with the specified dimension.
- For cylinders without a fitted self-aligning clevis, the installation dimension shortens by dimension „**CH**“

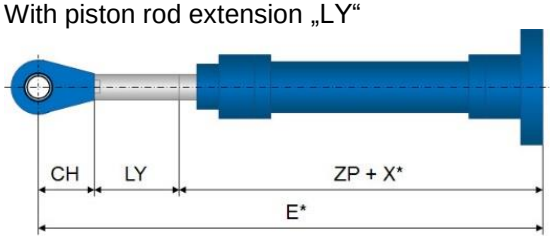
Valid for mounting styles MP3 and MP5
With piston rod extension „LY“



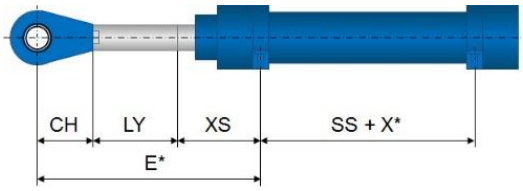
Valid for mounting styles MF1 and MF3
With piston rod extension „LY“



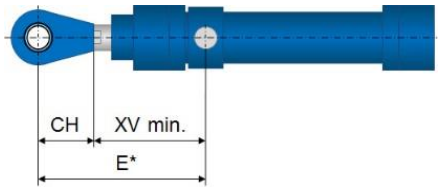
Valid for mouting styles MF2 and MF4
With piston rod extension „LY“



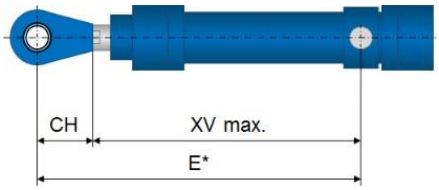
Valid for mounting style MS2
With piston rod extension „LY“



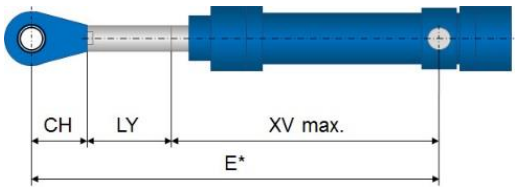
Valid for mounting style MT4
Minimum trunnion offset „XV min.“
Without piston rod extension „LY“



Maximum trunnion offset „XV max.“
Without piston rod extension „LY“



With piston rod extension „LY“



X* = Stroke length
E* = Installation dimension

By analogy, the same procedure can be applied for the tie-rod cylinder series in relation to the cylinder series and the mounting style!

Spherical bearing check

Application

- Quasi-static:
  low cycle number for the life expectancy with very slow increase of pressure speeds and pressure drop speeds, low pressure differences between min and max. pressure in the respective cylinder chambers and low stroke speed.

- Dynamic:
  Cycling loading or alternating load with higher cycle result for the life expectancy with quicker increase of pressure speeds and pressure drop speeds, higher pressure differences between min. and max. pressure in the respective cylinder chambers and low stroke speed.

Load rating

The allowed load rating can be smaller under circumstances with alternating laod for the swivel head than the allowed max. cylinder force. The producer deviate the load rating from the material characteristics of the used corresponding material of swivel head. They are not standard and can be different according to producer.

Clamping screws

The used clamping screws are not standard and can be different according to swivel head from the producer, therefore also their necessary tightening torque. The statements in our data sheets refer to screws according to ISO 4762-10.9.

Note

- Should the swivel head not be in the scope of delivery of the cylinder, the allowed load rating and the necessary tightening torque of the clamping screws from the producer has always to be checked according to use case.

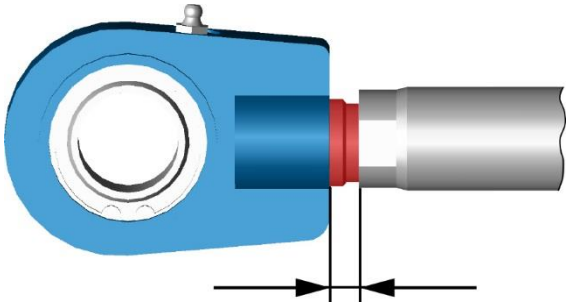
- The security factors stated in the calculation refer to the static load rating of the swivel head casing. The spherical bearing are not considered in the interpretation, because for this more detailed information from the application are necessary. Calculation / dimensioning support on inquiry possibly.

Notes regarding the service strength calculation for the piston rod end.

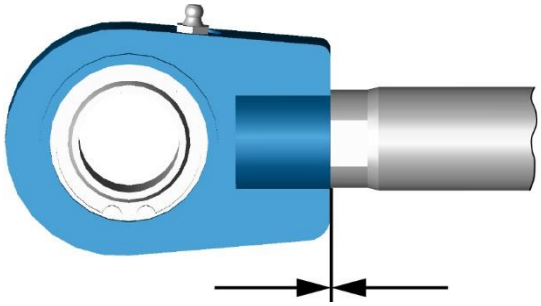
The given number of load cycles only relate to the customer side piston rod thread (catalogue dimension “KK”). The calculation is based on the FKM guide line (FKM: Forschungskuratorium Maschinenbau). It is only valid for operation without any shear forces, friction forces and takes into account the Bosch Rexroth specific material and manufacturing technologies.
The results of the calculation are therefore not transferable.

When a minimum number of load cycles has been applied this is then subsequently applied in the selection process so that it is ensured that only cylinders are displayed whose number of load cycles exceeds the applied value. Alternatively the number of load cycles can be shown for information purposes.

A decision was taken in six load cases. For this a deciding factor is the cylinders direction of operation (pulling, pushing or both) as well as the connection to the mating part (interface to the machine) to the piston rod (e.g.: is the self–aligning clevis in contact with the piston rod or not).



The self-aligning clevis is not
in contact with the piston rod shoulder



The self-aligning clevis is
in contact with the piston rod shoulder

The service strength of further components is not taken into account. These can however lead to a further reduction in the number of permissible load cycles. The permissible number of load cycles for these components (e.g. trunnions) are affected by numerous factors that are unknown to us and influenced by the customer and cannot regretfully therefore be made available in the same form.

With operating pressures greater than the nominal 50% of nominal pressure or when the cylinder is operating under shock load conditions and the total load cycles are greater than 10^4 the mounting elements have to be checked with regard to their fatigue strength or the required service strength.

If its not possible to assign the load cases, please contact Bosch Rexroth: technik.zylinder@boschrexroth.de