



# HC3

## HYDRAULIC CYLINDERS

# HCK3

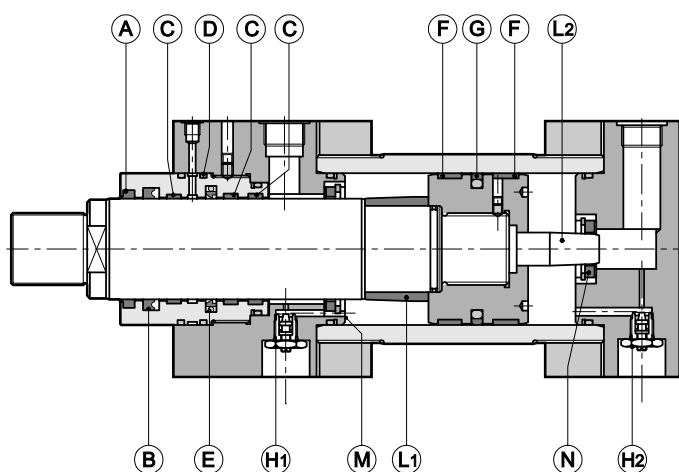
## HYDRAULIC CYLINDERS

### ATEX 2014/34/UE

### SERIES 10

ISO 6022  
DIN 24333

#### DESCRIPTION



— Double acting cylinders constructed in compliance with ISO 6022 and DIN 24333.

— The materials used to make these cylinders are particularly resistant and make them suitable for applications in the iron and steel sector.

— The cylinder is available with 5 different mounting styles as well as a range of accessories to meet all application requirements.

- A - scraper ring
- B - piston rod seal
- C - guide ring
- D - drain seal (O-Ring)
- E - piston rod seal
- F - guide ring
- G - piston seal
- H1 - front cushioning adjustment screw
- H2 - rear cushioning adjustment screw
- L1 - front cushion
- L2 - rear cushion
- M - front cushioning bushing
- N - rear cushioning bushing

ATEX 2014/34/UE rated version for installation in potentially explosive atmospheres is now available. The standard version of cylinders is ATEX II 2GD classified, whereas cylinders with proximity sensors are ATEX II 3GD classified. The declaration of conformity to the up mentioned standards is always supplied with the cylinder. See paragraph 3 for details.

#### PERFORMANCES

|                                                 |     |                                           |
|-------------------------------------------------|-----|-------------------------------------------|
| Nominal operating pressure (continuous service) | bar | 250                                       |
| Maximum operating pressure                      | bar | 320                                       |
| Maximum speed (standard)                        | m/s | 0,5                                       |
| Maximum stroke (standard)                       | mm  | 5000                                      |
| Fluid temperature range (standard)              | °C  | -20 / +80                                 |
| Fluid viscosity range                           | cSt | 10 ÷ 400                                  |
| Fluid contamination degree                      |     | According to ISO 4406:1999 class 20/18/15 |
| Recommended viscosity                           | cSt | 25                                        |

Архангельск (8182)63-90-72  
Астана (7172)727-132  
Астрахань (8512)99-46-04  
Барнаул (3852)73-04-60  
Белгород (4722)40-23-64  
Брянск (4832)59-03-52  
Владивосток (423)249-28-31  
Волгоград (844)278-03-48  
Вологда (8172)26-41-59  
Воронеж (473)204-51-73  
Екатеринбург (343)384-55-89  
Иваново (4932)77-34-06

Ижевск (3412)26-03-58  
Иркутск (395)279-98-46  
Казань (843)206-01-48  
Калининград (4012)72-03-81  
Калуга (4842)92-23-67  
Кемерово (3842)65-04-62  
Киров (8332)68-02-04  
Краснодар (861)203-40-90  
Красноярск (391)204-63-61  
Курск (4712)77-13-04  
Липецк (4742)52-20-81

Магнитогорск (3519)55-03-13  
Москва (495)268-04-70  
Мурманск (8152)59-64-93  
Набережные Челны (8552)20-53-41  
Нижний Новгород (831)429-08-12  
Новокузнецк (3843)20-46-81  
Новосибирск (383)227-86-73  
Омск (3812)21-46-40  
Орел (4862)44-53-42  
Оренбург (3532)37-68-04  
Пенза (8412)22-31-16

Пермь (342)205-81-47  
Ростов-на-Дону (863)308-18-15  
Рязань (4912)46-61-64  
Самара (846)206-03-16  
Санкт-Петербург (812)309-46-40  
Саратов (845)249-38-78  
Севастополь (8692)22-31-93  
Симферополь (3652)67-13-56  
Смоленск (4812)29-41-54  
Сочи (862)225-72-31  
Ставрополь (8652)20-65-13

Сургут (3462)77-98-35  
Тверь (4822)63-31-35  
Томск (3822)98-41-53  
Тула (4872)74-02-29  
Тюмень (3452)66-21-18  
Ульяновск (8422)24-23-59  
Уфа (347)229-48-12  
Хабаровск (4212)92-98-04  
Челябинск (351)202-03-61  
Череповец (8202)49-02-64  
Ярославль (4852)69-52-93

Киргизия (996)312-96-26-47

Россия (495)268-04-70

Казахстан (772)734-952-31

## 1 - CHARACTERISTICS

### 1.1 - Bores and piston rods

Ø 50 to Ø 400 mm bores are available to enable a vast choice according to required force.

Two piston rod diameters are available for each bore:

- reduced piston rod with area ratio 1:1.65
- standard piston rod with area ratio 1:2

### 1.2 - Cushionings

On request, gradual and adjustable cushioning devices can be fitted in the front and/or rear ends of the cylinder without affecting overall dimensions.

The special design of the cushions ensures optimal repeatability also in the event of variations in fluid viscosity.

Cushioning devices are always recommended as they ensure impact-free stopping even at high speed thus reducing pressure surges and impact transferred to the mounting supports.

The cylinder ends of bores higher than 160mm with cushioning can have an additional port connected directly with the braking chamber. This connection must be used in case of application, near the cylinder, of a pressure relief valve set at 350 bar, to limit overpressures during braking. For further information and for the order identification code, please consult our technical office.

The table below shows cushioning cone lengths:

| Bore (mm)              | 50 | 63 | 80 | 100 | 125 | 140 | 160 | 180 | 200 | 250 | 320 | 400 |
|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Front cone length (mm) | 38 | 40 | 50 | 50  | 60  | 60  | 75  | 75  | 80  | 100 | 100 | 110 |
| Rear cone length (mm)  | 34 | 42 | 58 | 49  | 64  | 64  | 68  | 73  | 69  | 101 | 99  | 108 |

### 1.3 - Connections

The cylinders are supplied as standard with cylindrical BSP threads and spot facing for seal rings in compliance with ISO 1179.

Connections which are oversized compared to those shown in the dimensional tables are available upon request. For further information and for the order identification code, please consult our technical office.

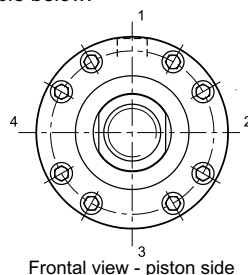
For correct cylinder operation, fluid velocity must not exceed 5 m/s.

### 1.4 - Connection position

Standard positions of the oil ports, cushioning adjustment screws, breathers, optional external drain and optional end-stroke proximity sensors, are indicated in the table below.

Connection positions different from the standard are available upon request. As a consequence, the other options positions will be rotated.

For special requests, please consult our technical office.



|                              | POSITION |
|------------------------------|----------|
| Connections                  | 1        |
| Cushioning adjustment        | 3        |
| Breathers                    | 4        |
| Drainage                     | 1        |
| Proximity end stroke         | 2        |
| Optional port (see par. 1.2) | 4        |

### 1.5 - Seals

The table below illustrates seal characteristics in relation to hydraulic fluid and operating temperatures.

| Type | Seal type                                        | Seal material           | Hydraulic fluid             | Minimum pressure [bar] | Operating pressure [°C] | Max speed [m/s] |
|------|--------------------------------------------------|-------------------------|-----------------------------|------------------------|-------------------------|-----------------|
| K    | Standard                                         | nitrile<br>polyurethane | mineral oil                 | 10                     | -20 / +80               | 0,5             |
| M    | Low friction                                     | nitrile<br>PTFE         | Mineral oil<br>Water glycol | 20<br>(note)           | -20 / +80               | 15              |
| V    | high temperature<br>and / or<br>aggressive fluid | Viton<br>PTFE           | Special fluids              | 10                     | -20 / +150              | 1               |

**NOTE:** for lower pressure use consult our technical office.

### 1.6 - Strokes

Standard cylinders are available with strokes up to 5000 mm. Longer cylinder strokes can be supplied on request.

Stroke tolerances are:

- 0 + 1 mm for strokes up to 1000 mm
- 0 + 4 mm for strokes up to 5000 mm.

### 1.7 - Spacers

In the case of cylinder strokes above 1000 mm we recommend the use of spacers which can be inserted to reduce loads on the piston rod bushing and prevent the piston from sticking.

Spacers are constructed in hardened and tempered steel with PTFE facing.

Every spacer is 50 mm long. We recommend to insert 1 spacer for strokes from 1001 to 1500 mm, with an increment of 1 spacer for every 500 mm stroke.

You must remember that the overall length of the cylinder increases according to the number of inserted spacers (50 mm for each spacer).

### 1.8 - Drainage

A connection for external drainage on the front end (even on the back end for double-rod cylinders) can be supplied upon request, for fluid drops recovery of the first seal of the rod, without any modification to the overall dimensions.

Connection: 1/8" BSP for bore up to Ø 100 included - 1/4" BSP for higher bores.

### 1.9 - Breathers

On request cylinder ends can be supplied with breathers for the elimination of air. This is necessary when the entire stroke is not used or when connections are not facing upwards.

### 1.10 - Surface finish

The cylinders are supplied painted with Duplomatic black opaque colour with a paint thickness of 40µ. The rod is chromed.

### 2 - IDENTIFICATION CODE

K = Explosion-proof version according to ATEX 2014/34/UE (paragraph 3). Omit if not required.

|    |   |   |   |   |   |   |   |   |   |   |   |   |    |
|----|---|---|---|---|---|---|---|---|---|---|---|---|----|
| HC | 3 | - | / | / | - | - | - | - | / | - | / | / | 10 |
|----|---|---|---|---|---|---|---|---|---|---|---|---|----|

Series  
(indicate for  
spare parts  
requests)

Dimension XV  
for "L" mounting  
(omit for other  
mounting styles)

N. of spacers multiple of 50  
mm (omit if not required)  
(see par. 1.7)

Back end connection position (1-4)  
(see par. 1.4)

Front end connection position (1-4)  
(see par. 1.4)

Drainage for second rod. Omit if not required  
(see par. 1.8)

0 = without drainage  
E = external drainage with connection  
on the back end

Drainage (see par. 1.8)

0 = without drainage  
E = external drainage with connection on the front end

Breathers (see par. 1.9)

0 = without breathers  
S = front and back breathers

Cushioning (see par. 1.2):

0 = without cushioning      1 = front  
2 = back      3 = front and back

Seals (see par. 1.5):

K = standard (nitrile + polyurethane)  
M = low friction (nitrile + PTFE)  
V = high temperature (viton + PTFE)

Stroke (mm) - For cylinders with spacers indicate the working stroke.

Double rod threading (omit if not required).  
See single rod for dimensions

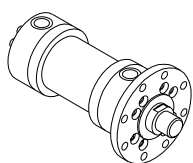
Double rod (omit if not required)

See single rod for dimensions. Not available with mounting style B-D-F.

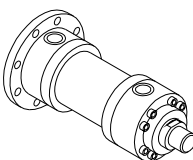
Rod threading: Male thread (standard)

W = Female thread (see par. 4)

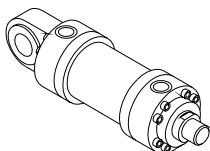
#### MOUNTING STYLE



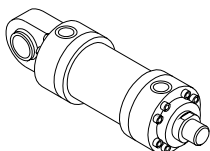
A = Front flange (MF3)



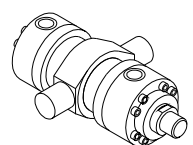
B = Rear flange (MF4)



D = Male clevis (MP3)



F = Spheric swivel (MP5)



L = Mid swinging (MT4)

\* Bores not  
considered by  
the standard  
ISO 6022

| Ø rod (mm) |     | Rods available for each bore |    |    |     |     |      |     |      |     |     |     |     |  |  |
|------------|-----|------------------------------|----|----|-----|-----|------|-----|------|-----|-----|-----|-----|--|--|
| 32         | 36  | •                            |    |    |     |     |      |     |      |     |     |     |     |  |  |
| 40         | 45  |                              | •  |    |     |     |      |     |      |     |     |     |     |  |  |
| 50         | 56  |                              |    | •  |     |     |      |     |      |     |     |     |     |  |  |
| 63         | 70  |                              |    |    | •   |     |      |     |      |     |     |     |     |  |  |
| 80         | 90  |                              |    |    |     | •   |      |     |      |     |     |     |     |  |  |
| 90         | 100 |                              |    |    |     |     | •    |     |      |     |     |     |     |  |  |
| 100        | 110 |                              |    |    |     |     |      | •   |      |     |     |     |     |  |  |
| 110        | 125 |                              |    |    |     |     |      |     | •    |     |     |     |     |  |  |
| 125        | 140 |                              |    |    |     |     |      |     |      | •   |     |     |     |  |  |
| 160        | 180 |                              |    |    |     |     |      |     |      |     | •   |     |     |  |  |
| 200        | 220 |                              |    |    |     |     |      |     |      |     |     | •   |     |  |  |
| 250        | 280 |                              |    |    |     |     |      |     |      |     |     |     | •   |  |  |
| Bore (mm)  |     | 50                           | 63 | 80 | 100 | 125 | 140* | 160 | 180* | 200 | 250 | 320 | 400 |  |  |

### 3 - ATEX 2014/34/UE RATED VERSION

ATEX 2014/34/UE rated version cylinders for installation in potentially explosive atmospheres are now available. The standard version of cylinders is ATEX II 2GD classified, whereas cylinders with proximity sensors are ATEX II 3GD classified.

The supply is always delivered accompanied by:

- the ATEX declaration of conformity
- the operating and maintenance user manual, where are described all the information for the proper use of cylinders in potentially explosive environments.

TYPE EXAMINATION CERTIFICATE N°: **CEC 10 ATEX 138**

#### 3.1 - Identification code

To order the ATEX-rated version, simply insert the letter K in the initial part of the identification code. The description becomes HCK3-.\*.

For cylinders without end-stroke proximity sensors please order with the identification code shown at paragraph 2.

Example: HCK3C-200/125-350-K3-S-0-11/20

For cylinders equipped with end-stroke proximity sensors please refer to the identification code shown at paragraph 16.1.

Example: HCK3F-FP22-80/56-225-K3-S-0-11/20

The ATEX-rated cylinders equipped with end-stroke proximity sensors are compliant with the specifications listed paragraph 16; Also the same prescriptions described in that paragraph are effective. (NB: for bores Ø125 and Ø400 feasibility contact our technical department).

The proximity sensors are compliant with the description and the wiring diagram shown at the paragraph 16.2.

#### 3.2 - Classification

Cylinders without end-stroke proximity sensors have this ATEX mark:

II 2GD ck IIC T4 (-20°C Ta +80°C)

EX: Specific marking of explosion protection as ATEX 2014/34/UE directive and related technical specification requests.

II: Group II for surface plants

2: Category 2 high protection, eligible for zone 1 for gases and zone 21 for dust (automatically be eligible for zone 2 category 3 for gases and zone 22 for dust)

GD: for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures.

ck: protection by constructional safety and by liquid immersion

IIC: Gas group  
(automatically eligible for group IIA and IIB)

T4: Temperature class for gas (max surface temperature)  
-20°C Ta +80°C: Ambient temperature range

Cylinders with end-stroke proximity sensors have this ATEX mark:

II 3GD ck IIC T4 (-20°C Ta +80°C)

EX: Specific marking of explosion protection as ATEX 2014/34/UE directive and related technical specification requests

II: Group II for surface plants

3: Category 3 standard protection, eligible for zone 2 for gases (zone 22 for dust)

GD: for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures.

ck: protection by constructional safety and by liquid immersion

IIC: Gas group  
(automatically eligible for group IIA and IIB)

T4: Temperature class for gas (max surface temperature)  
-20°C Ta +80°C: Ambient temperature range

#### 3.3 - Operating temperatures

The operating ambient temperature must be between -20°C and +80 °C.

The fluid temperature for the standard version seals (K) and for low friction seals (M) must be between -20°C and +80°C, as for viton (V) seals must be between -20°C and +120 °C.

The actuators are T4 (T135° C) class temperature classified, so they are eligible for operation also at higher class temperature (T3, T2, T1 (T200° C).

#### 3.4 - Admitted velocities

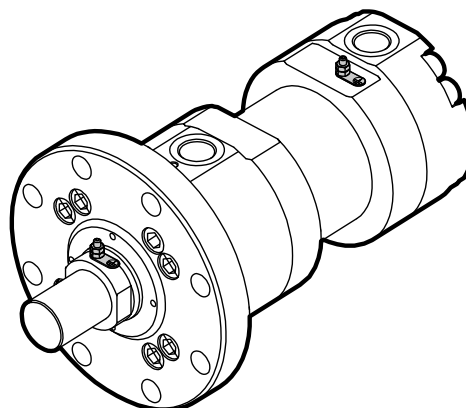
The maximum permissible speed is 0.5 m/s for standard cylinder seals (K) and 1 m/s for actuators with low friction seals (M) or Viton (V).

#### 3.5 - Connectors

The connectors for the end-stroke proximity are available upon request. They are metal, to be wired. The ordering code is **0680961**. One connector per sensor is needed.

#### 3.6 - Grounding points

The ATEX certified actuators are supplied with two grounding points, one on the rear head and one on the rod, for the wire of the cylinder with the ground (M4 screws).



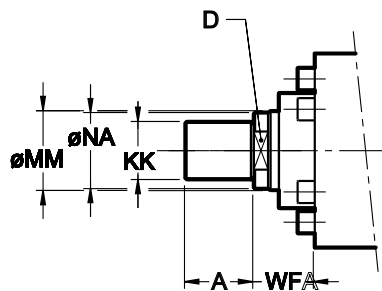
The bottom grounding point must always be connected whereas the connection of the rod grounding point can be avoided in case the whole mechanical stroke is covered during the cylinder operating phase (from the mechanical stop on the cylinder head to the mechanical stop on the bottom), or in case the rod has already been grounded through the mechanical connection between the rod itself and the machine/plan it is installed on.

In order to verify such a condition it is necessary to test the equipotentiality of the parts and a maximum resistance equal to 100Ω as per the EN13463-1 norm.

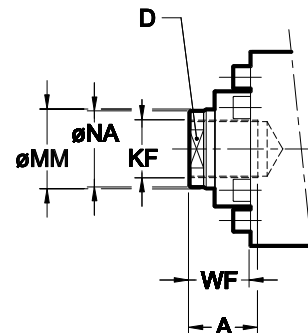
## 4 - OVERALL AND MOUNTING DIMENSIONS

dimensions in mm

Standard = male thread



W = female thread



\* For bores Ø 180 (piston rod Ø 110) and higher, the rod has 4 holes at 90° realized on Ø NA and of Ø shown in the table.

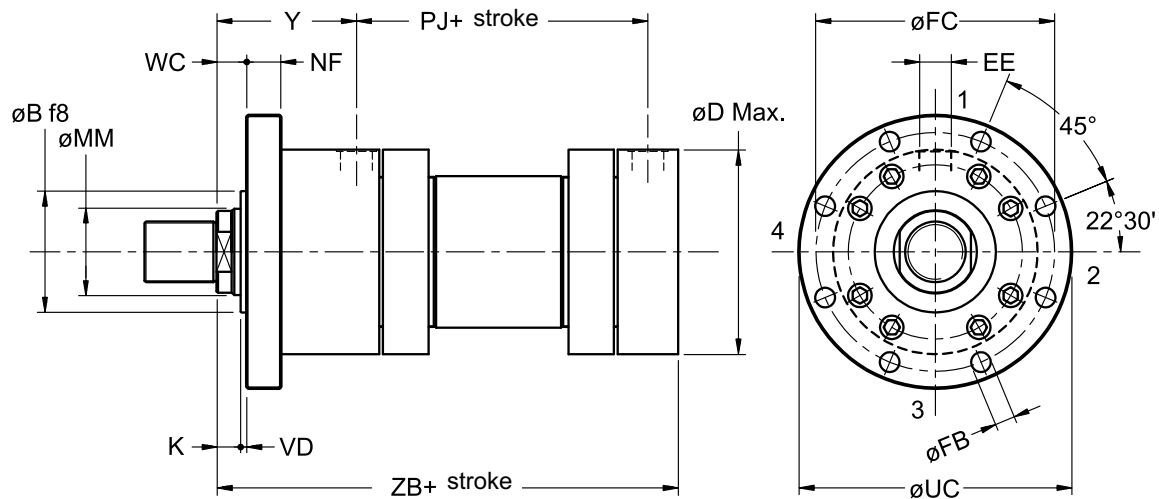
A pin wrench UNI 6752 - DIN 1810 must be used.

| Bore | MM<br>Ø rod | KK     | Ø NA | KF     | A   | D     | WF  |
|------|-------------|--------|------|--------|-----|-------|-----|
| 50   | 32          | M27x2  | 31   | -      | 36  | 28    | 47  |
|      | 36          |        | 35   | M27x2  |     | 32    |     |
| 63   | 40          | M33x2  | 38   | -      | 45  | 34    | 53  |
|      | 45          |        | 43   | M33x2  |     | 36    |     |
| 80   | 50          | M42x2  | 48   | -      | 56  | 43    | 60  |
|      | 56          |        | 54   | M42x2  |     | 46    |     |
| 100  | 63          | M48x2  | 60   | -      | 63  | 53    | 68  |
|      | 70          |        | 67   | M48x2  |     | 60    |     |
| 125  | 80          | M64x3  | 77   | -      | 85  | 65    | 76  |
|      | 90          |        | 87   | M64x3  |     | 75    |     |
| 140  | 90          | M72x3  | 87   | -      | 90  | 75    | 76  |
|      | 100         |        | 96   | M72x3  |     | 85    |     |
| 160  | 100         | M80x3  | 96   | -      | 95  | 85    | 85  |
|      | 110         |        | 106  | M80x3  |     | 95    |     |
| 180  | 110         | M90x3  | 106  | -      | 105 | 95    | 95  |
|      | 125         |        | 121  | M90x3  |     | Ø 12* |     |
| 200  | 125         | M100x3 | 121  | -      | 112 | Ø 12* | 101 |
|      | 140         |        | 136  | M100x3 |     | Ø 12* |     |
| 250  | 160         | M125x4 | 155  | -      | 125 | Ø 15* | 113 |
|      | 180         |        | 175  | M125x4 |     | Ø 15* |     |
| 320  | 200         | M160x4 | 195  | -      | 160 | Ø 15* | 136 |
|      | 220         |        | 214  | M160x4 |     | Ø 15* |     |
| 400  | 250         | M200x4 | 245  | -      | 200 | Ø 20* | 163 |
|      | 280         |        | 270  | M200x4 |     | Ø 20* |     |

## 5 - OVERALL AND MOUNTING DIMENSIONS ISO MF3

### A FRONT FLANGE

dimensions in mm



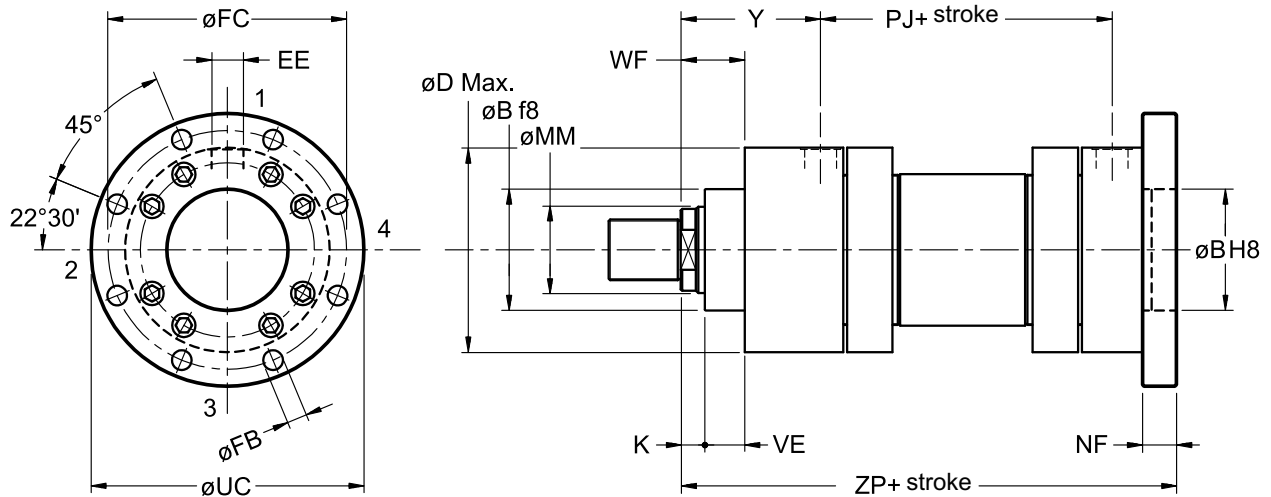
**NOTE:  $\varnothing 400$  bore has 12 equally spaced  $\varnothing FB$  holes in the mounting flange**

| Bore | MM<br>$\varnothing rod$ | $\varnothing B$<br>f8 | $\varnothing D$<br>max | EE<br>BSP | $\varnothing FB$ | $\varnothing FC$ | K  | NF  | PJ  | $\varnothing UC$ | VD | WC | Y   | ZB  |
|------|-------------------------|-----------------------|------------------------|-----------|------------------|------------------|----|-----|-----|------------------|----|----|-----|-----|
| 50   | 32<br>36                | 63                    | 105                    | 1/2"      | 13,5             | 132              | 18 | 25  | 120 | 155              | 4  | 22 | 98  | 244 |
| 63   | 40<br>45                | 75                    | 122                    | 3/4"      | 13,5             | 150              | 21 | 28  | 133 | 175              | 4  | 25 | 112 | 274 |
| 80   | 50<br>56                | 90                    | 145                    | 3/4"      | 17,5             | 180              | 24 | 32  | 155 | 210              | 4  | 28 | 120 | 305 |
| 100  | 63<br>70                | 110                   | 175                    | 1"        | 22               | 212              | 27 | 36  | 171 | 250              | 5  | 32 | 134 | 340 |
| 125  | 80<br>90                | 132                   | 210                    | 1"        | 22               | 250              | 31 | 40  | 205 | 290              | 5  | 36 | 153 | 396 |
| 140  | 90<br>100               | 145                   | 255                    | 1. 1/4"   | 26               | 300              | 31 | 40  | 208 | 340              | 5  | 36 | 181 | 430 |
| 160  | 100<br>110              | 160                   | 270                    | 1. 1/4"   | 26               | 315              | 35 | 45  | 235 | 360              | 5  | 40 | 185 | 467 |
| 180  | 110<br>125              | 185                   | 300                    | 1. 1/4"   | 33               | 365              | 40 | 50  | 250 | 420              | 5  | 45 | 205 | 505 |
| 200  | 125<br>140              | 200                   | 330                    | 1. 1/4"   | 33               | 385              | 40 | 56  | 278 | 440              | 5  | 45 | 220 | 550 |
| 250  | 160<br>180              | 250                   | 410                    | 1. 1/2"   | 39               | 475              | 42 | 63  | 325 | 540              | 8  | 50 | 260 | 652 |
| 320  | 200<br>220              | 320                   | 500                    | 2"        | 45               | 600              | 48 | 80  | 350 | 675              | 8  | 56 | 310 | 764 |
| 400  | 250<br>280              | 400                   | 628                    | 2"        | 45<br>NOTE       | 720              | 53 | 100 | 360 | 800              | 10 | 63 | 333 | 775 |

## 6 - OVERALL AND MOUNTING DIMENSIONS ISO MF4

### B BACK FLANGE

dimensions in mm



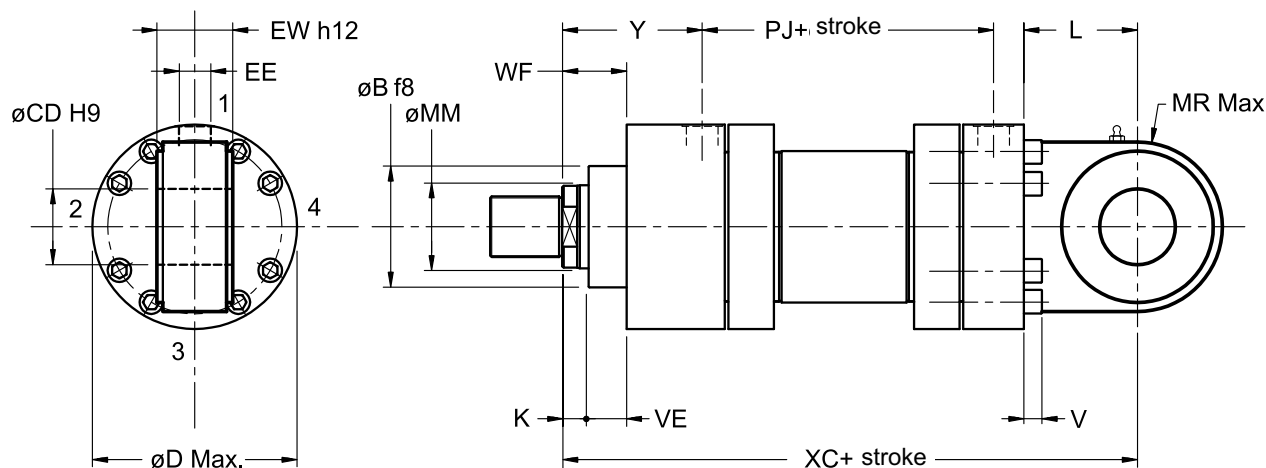
NOTE: Ø 400 bore has 12 equally spaced ØFB holes in the mounting flange

| Bore | MM<br>Ø rod | ØB<br>f8 | ØD<br>max | EE<br>BSP | ØFB        | ØFC | K  | NF  | PJ  | ØUC | VE  | WF  | Y   | ZP  |
|------|-------------|----------|-----------|-----------|------------|-----|----|-----|-----|-----|-----|-----|-----|-----|
| 50   | 32<br>36    | 63       | 105       | 1/2"      | 13,5       | 132 | 18 | 25  | 120 | 155 | 29  | 47  | 98  | 265 |
| 63   | 40<br>45    | 75       | 122       | 3/4"      | 13,5       | 150 | 21 | 28  | 133 | 175 | 32  | 53  | 112 | 298 |
| 80   | 50<br>56    | 90       | 145       | 3/4"      | 17,5       | 180 | 24 | 32  | 155 | 210 | 36  | 60  | 120 | 332 |
| 100  | 63<br>70    | 110      | 175       | 1"        | 22         | 212 | 27 | 36  | 171 | 250 | 41  | 68  | 134 | 371 |
| 125  | 80<br>90    | 132      | 210       | 1"        | 22         | 250 | 31 | 40  | 205 | 290 | 45  | 76  | 153 | 430 |
| 140  | 90<br>100   | 145      | 255       | 1. 1/4"   | 26         | 300 | 31 | 40  | 208 | 340 | 45  | 76  | 181 | 465 |
| 160  | 100<br>110  | 160      | 270       | 1. 1/4"   | 26         | 315 | 35 | 45  | 235 | 360 | 50  | 85  | 185 | 505 |
| 180  | 110<br>125  | 185      | 300       | 1. 1/4"   | 33         | 365 | 40 | 50  | 250 | 420 | 55  | 95  | 205 | 550 |
| 200  | 125<br>140  | 200      | 330       | 1. 1/4"   | 33         | 385 | 40 | 56  | 278 | 440 | 61  | 101 | 220 | 596 |
| 250  | 160<br>180  | 250      | 410       | 1. 1/2"   | 39         | 475 | 42 | 63  | 325 | 540 | 71  | 113 | 260 | 703 |
| 320  | 200<br>220  | 320      | 500       | 2"        | 45         | 600 | 48 | 80  | 350 | 675 | 88  | 136 | 310 | 830 |
| 400  | 250<br>280  | 400      | 628       | 2"        | 45<br>NOTE | 720 | 53 | 100 | 360 | 800 | 110 | 163 | 333 | 855 |

## 7 - OVERALL AND MOUNTING DIMENSIONS ISO MP3

**D MALE CLEVIS**  
(with bushing)

dimensions in mm

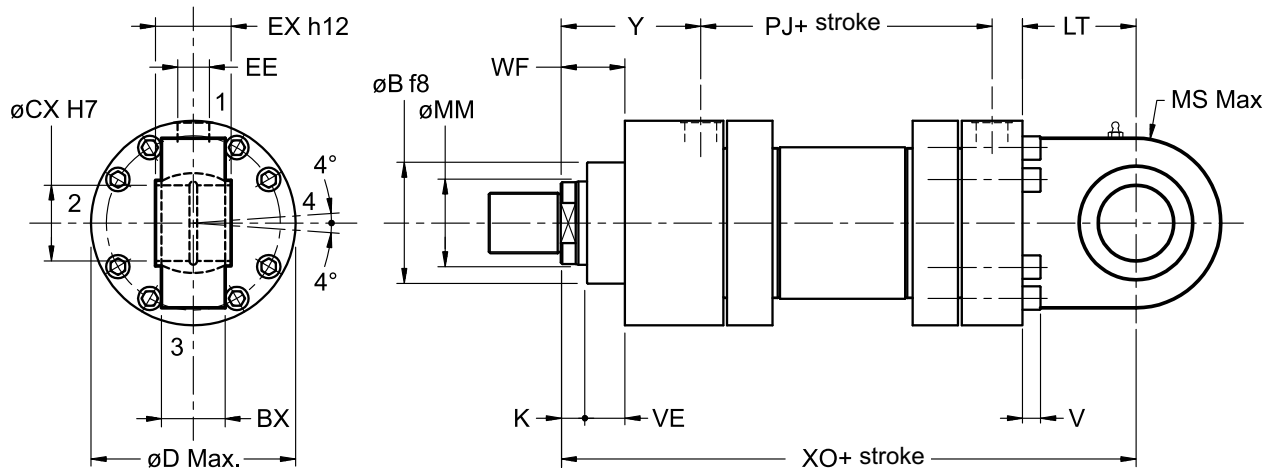


| Bore | MM<br>Ø rod | Ø B<br>f8 | Ø CD<br>H9 | Ø D<br>max | EE<br>BSP | EW<br>h12 | K  | L   | MR<br>max | PJ  | V  | VE  | WF  | XC   | Y   |
|------|-------------|-----------|------------|------------|-----------|-----------|----|-----|-----------|-----|----|-----|-----|------|-----|
| 50   | 32<br>36    | 63        | 32         | 105        | 1/2"      | 32        | 18 | 61  | 35        | 120 | 8  | 29  | 47  | 305  | 98  |
| 63   | 40<br>45    | 75        | 40         | 122        | 3/4"      | 40        | 21 | 74  | 50        | 133 | 10 | 32  | 53  | 348  | 112 |
| 80   | 50<br>56    | 90        | 50         | 145        | 3/4"      | 50        | 24 | 90  | 61.5      | 155 | 12 | 36  | 60  | 395  | 120 |
| 100  | 63<br>70    | 110       | 63         | 175        | 1"        | 63        | 27 | 102 | 72.5      | 171 | 16 | 41  | 68  | 442  | 134 |
| 125  | 80<br>90    | 132       | 80         | 210        | 1"        | 80        | 31 | 124 | 90        | 205 | 16 | 45  | 76  | 520  | 153 |
| 140  | 90<br>100   | 145       | 90         | 255        | 1.1/4"    | 90        | 31 | 150 | 113       | 208 | 24 | 45  | 76  | 580  | 181 |
| 160  | 100<br>110  | 160       | 100        | 270        | 1.1/4"    | 100       | 35 | 150 | 125       | 235 | 24 | 50  | 85  | 617  | 185 |
| 180  | 110<br>125  | 185       | 110        | 315        | 1.1/4"    | 110       | 40 | 185 | 147.5     | 250 | 27 | 55  | 95  | 690  | 205 |
| 200  | 125<br>140  | 200       | 125        | 330        | 1.1/4"    | 125       | 40 | 206 | 160       | 278 | 24 | 61  | 101 | 756  | 220 |
| 250  | 160<br>180  | 250       | 160        | 410        | 1.1/2"    | 160       | 42 | 251 | 200       | 325 | 27 | 71  | 113 | 903  | 260 |
| 320  | 200<br>220  | 320       | 200        | 510        | 2"        | 200       | 48 | 316 | 250       | 350 | 36 | 88  | 136 | 1080 | 310 |
| 400  | 250<br>280  | 400       | 250        | 628        | 2"        | 250       | 53 | 300 | 320       | 360 | 42 | 110 | 163 | 1075 | 333 |

## 8 - OVERALL AND MOUNTING DIMENSIONS ISO MP5

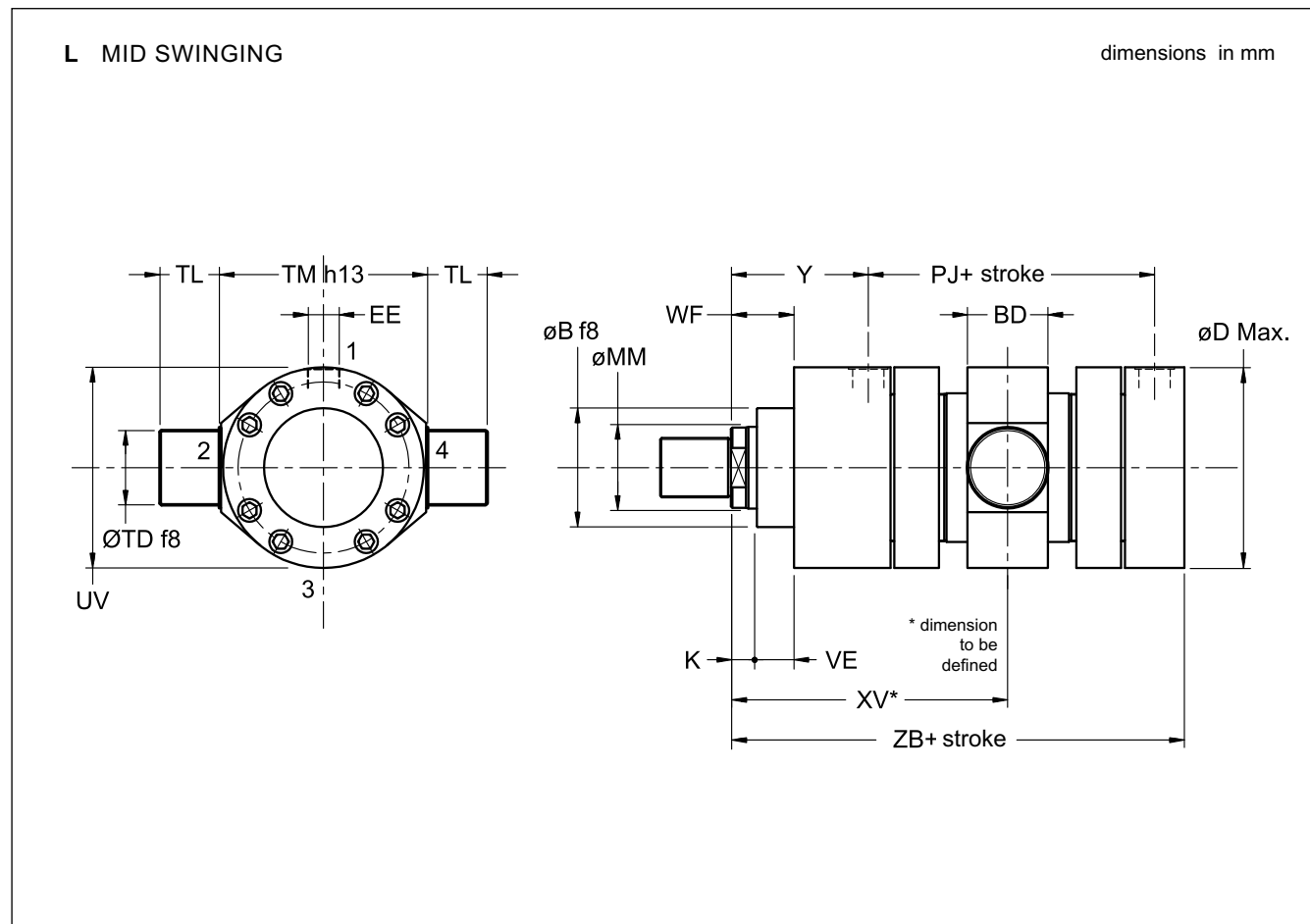
### F SPHERIC SWIVEL

dimensions in mm



| Bore | MM<br>$\phi$ rod | $\phi B$<br>f8 | BX  | $\phi CX$<br>H7 | $\phi D$<br>max | EE<br>BSP | EX<br>h12 | K  | LT  | MS<br>max | PJ  | V  | VE  | WF  | XO   | Y   |
|------|------------------|----------------|-----|-----------------|-----------------|-----------|-----------|----|-----|-----------|-----|----|-----|-----|------|-----|
| 50   | 32<br>36         | 63             | 27  | 32              | 105             | 1/2"      | 32        | 18 | 61  | 40        | 120 | 8  | 29  | 47  | 305  | 98  |
| 63   | 40<br>45         | 75             | 35  | 40              | 122             | 3/4"      | 40        | 21 | 74  | 50        | 133 | 10 | 32  | 53  | 348  | 112 |
| 80   | 50<br>56         | 90             | 40  | 50              | 145             | 3/4"      | 50        | 24 | 90  | 63        | 155 | 12 | 36  | 60  | 395  | 120 |
| 100  | 63<br>70         | 110            | 50  | 63              | 175             | 1"        | 63        | 27 | 102 | 71        | 171 | 16 | 41  | 68  | 442  | 134 |
| 125  | 80<br>90         | 132            | 60  | 80              | 210             | 1"        | 80        | 31 | 124 | 90        | 205 | 16 | 45  | 76  | 520  | 153 |
| 140  | 90<br>100        | 145            | 65  | 90              | 255             | 1.1/4"    | 90        | 31 | 150 | 113       | 208 | 24 | 45  | 76  | 580  | 181 |
| 160  | 100<br>110       | 160            | 70  | 100             | 270             | 1.1/4"    | 100       | 35 | 150 | 112       | 235 | 24 | 50  | 85  | 617  | 185 |
| 180  | 110<br>125       | 185            | 80  | 110             | 300             | 1.1/4"    | 110       | 40 | 185 | 147.5     | 250 | 27 | 55  | 95  | 690  | 205 |
| 200  | 125<br>140       | 200            | 102 | 125             | 330             | 1.1/4"    | 125       | 40 | 206 | 160       | 278 | 24 | 61  | 101 | 756  | 220 |
| 250  | 160<br>180       | 250            | 130 | 160             | 410             | 1.1/2"    | 160       | 42 | 251 | 200       | 325 | 27 | 71  | 113 | 903  | 260 |
| 320  | 200<br>220       | 320            | 162 | 200             | 500             | 2"        | 200       | 48 | 316 | 250       | 350 | 36 | 88  | 136 | 1080 | 310 |
| 400  | 250<br>280       | 400            | 192 | 250             | 628             | 2"        | 250       | 53 | 300 | 320       | 360 | 42 | 110 | 163 | 1075 | 333 |

## 9 - OVERALL AND MOUNTING DIMENSIONS ISO MT4

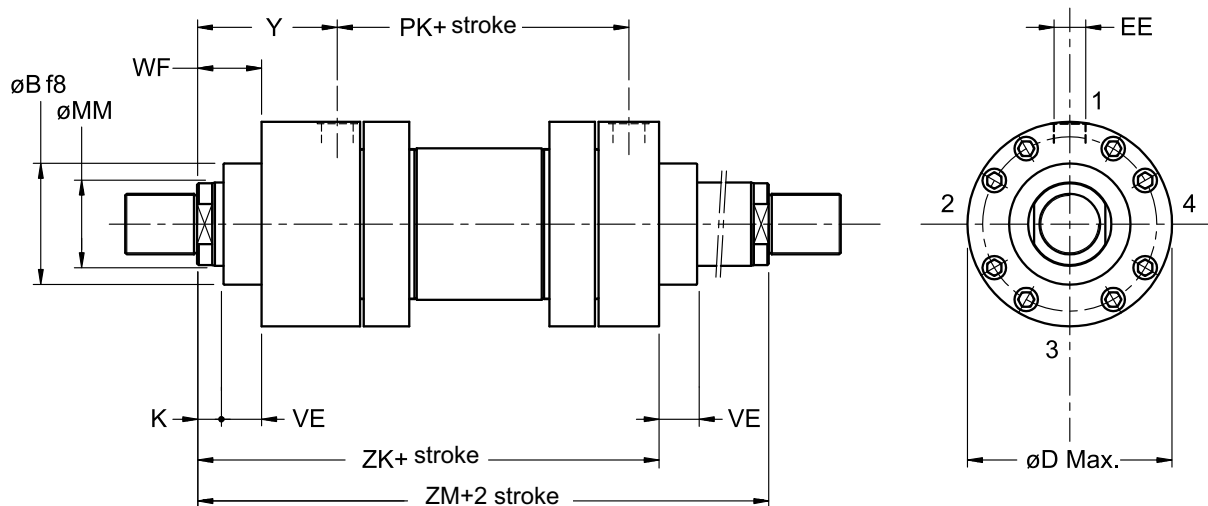


| Bore | MM<br>$\varnothing$ rod | $\varnothing B$<br>f8 | BD  | stroke<br>mm | $\varnothing D$<br>max | EE<br>BSP | K  | PJ  | $\varnothing TD$<br>f8 | TL  | TM<br>h13 | $\varnothing UV$ | VE  | WF  | XV<br>min | XV<br>max<br>+ stroke | Y   | ZB  |
|------|-------------------------|-----------------------|-----|--------------|------------------------|-----------|----|-----|------------------------|-----|-----------|------------------|-----|-----|-----------|-----------------------|-----|-----|
| 50   | 32<br>36                | 63                    | 38  | 45           | 105                    | 1/2"      | 18 | 120 | 32                     | 25  | 112       | 105              | 29  | 47  | 180       | 144                   | 98  | 244 |
| 63   | 40<br>45                | 75                    | 48  | 45           | 122                    | 3/4"      | 21 | 133 | 40                     | 32  | 125       | 122              | 32  | 53  | 195       | 160                   | 112 | 274 |
| 80   | 50<br>56                | 90                    | 58  | 60           | 145                    | 3/4"      | 24 | 155 | 50                     | 40  | 150       | 145              | 36  | 60  | 220       | 175                   | 120 | 305 |
| 100  | 63<br>70                | 110                   | 73  | 80           | 175                    | 1"        | 27 | 171 | 63                     | 50  | 180       | 175              | 41  | 68  | 245       | 185                   | 134 | 340 |
| 125  | 80<br>90                | 132                   | 88  | 95           | 210                    | 1"        | 31 | 205 | 80                     | 63  | 224       | 210              | 45  | 76  | 290       | 220                   | 153 | 396 |
| 140  | 90<br>100               | 145                   | 98  | 115          | 255                    | 1. 1/4"   | 31 | 208 | 90                     | 70  | 265       | 255              | 45  | 76  | 330       | 240                   | 181 | 430 |
| 160  | 100<br>110              | 160                   | 108 | 115          | 270                    | 1. 1/4"   | 35 | 235 | 100                    | 80  | 280       | 270              | 50  | 85  | 340       | 255                   | 185 | 467 |
| 180  | 110<br>125              | 185                   | 118 | 150          | 300                    | 1. 1/4"   | 40 | 250 | 110                    | 90  | 320       | 315              | 55  | 95  | 390       | 270                   | 205 | 505 |
| 200  | 125<br>140              | 200                   | 133 | 180          | 330                    | 1. 1/4"   | 40 | 278 | 125                    | 100 | 335       | 330              | 61  | 101 | 430       | 280                   | 220 | 550 |
| 250  | 160<br>180              | 250                   | 180 | 220          | 410                    | 1. 1/2"   | 42 | 325 | 160                    | 125 | 425       | 410              | 71  | 113 | 505       | 320                   | 260 | 652 |
| 320  | 200<br>220              | 320                   | 220 | 280          | 500                    | 2"        | 48 | 350 | 200                    | 160 | 530       | 510              | 88  | 136 | 590       | 380                   | 310 | 764 |
| 400  | 250<br>280              | 400                   | 270 | 420          | 628                    | 2"        | 53 | 360 | 250                    | 200 | 630       | 628              | 110 | 163 | 675       | 340                   | 333 | 775 |

### 10 - OVERALL AND MOUNTING DIMENSIONS

#### DOUBLE ROD

dimensions in mm



For other dimensions and mounting styles please see single rod cylinder tables.

Not available for mounting styles B - D - F.

| Bore | MM<br>$\varnothing$ rod | K  | $\varnothing D$<br>max | EE<br>BSP | PK  | VE  | WF  | Y   | ZM  | ZK  |
|------|-------------------------|----|------------------------|-----------|-----|-----|-----|-----|-----|-----|
| 50   | 32<br>36                | 18 | 105                    | 1/2"      | 126 | 29  | 47  | 98  | 322 | 275 |
| 63   | 40<br>45                | 21 | 122                    | 3/4"      | 134 | 32  | 53  | 112 | 358 | 305 |
| 80   | 50<br>56                | 24 | 145                    | 3/4"      | 153 | 36  | 60  | 120 | 393 | 333 |
| 100  | 63<br>70                | 27 | 175                    | 1"        | 165 | 41  | 68  | 134 | 433 | 365 |
| 125  | 80<br>90                | 31 | 210                    | 1"        | 204 | 45  | 76  | 153 | 510 | 434 |
| 140  | 90<br>100               | 31 | 255                    | 1. 1/4"   | 208 | 45  | 76  | 181 | 570 | 494 |
| 160  | 100<br>110              | 35 | 270                    | 1. 1/4"   | 225 | 50  | 85  | 185 | 595 | 510 |
| 180  | 110<br>125              | 40 | 300                    | 1. 1/4"   | 250 | 55  | 95  | 205 | 660 | 565 |
| 200  | 125<br>140              | 40 | 330                    | 1. 1/4"   | 271 | 61  | 101 | 220 | 711 | 610 |
| 250  | 160<br>180              | 42 | 410                    | 1. 1/2"   | 308 | 71  | 113 | 260 | 828 | 715 |
| 320  | 200<br>220              | 48 | 500                    | 2"        | 350 | 88  | 136 | 310 | 970 | 834 |
| 400  | 250<br>280              | 53 | 628                    | 2"        | 360 | 110 | 163 | 333 | 975 | 812 |

**NOTE:** Double rod cylinders are developed with two separate rods, fixed together by means of threading.

Because of this mounting style, the rod with female threading is less resistant than the other. To simplify the identification of the more resistant rod, the "M" marking is stamped on its end.

We recommend the use of the weaker rod for the less demanding applications.

### 11 - ROD DIAMETER SELECTION

To ensure adequate stability, cylinders must be calculated for maximum compressive load according to the following simplified procedure:

- Refer to the table to identify the stroke factor according to the mounting style.
- To calculate the reference length, multiply the working stroke by the stroke factor.

- To calculate the thrust force, multiply the total cylinder area by the operating pressure.

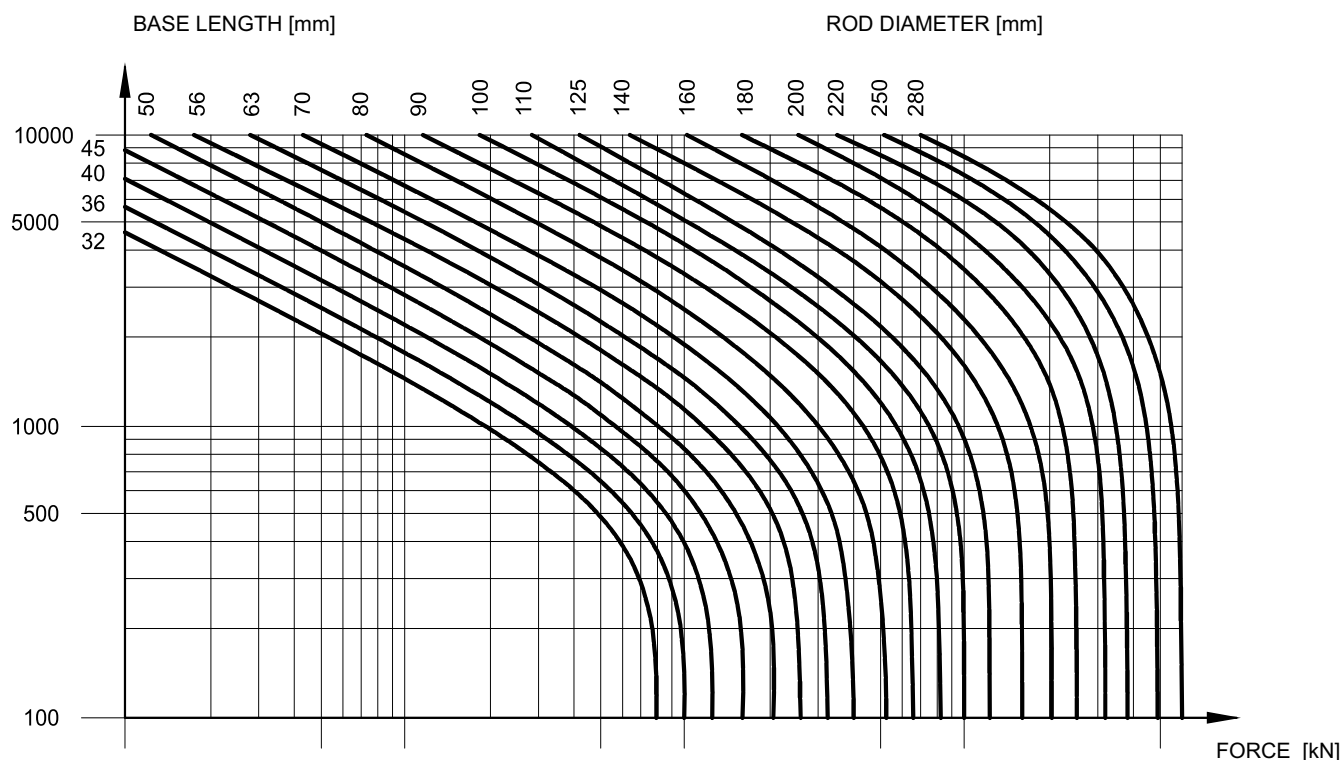
- On the diagram, find the point of intersection between the thrust force and reference length.

- Identify the minimum rod diameter on the curve above the previous point of intersection.

Cylinders with rod diameters smaller than the value plotted in the diagram will not guarantee sufficient rigidity.

| Mounting style | Rod connection             | Mounting | Stroke factor |
|----------------|----------------------------|----------|---------------|
| A              | Fixed and supported        |          | 2             |
|                | Fixed and rigidly guided   |          | 0.5           |
|                | Jointed and rigidly guided |          | 0.7           |
| B              | Fixed and supported        |          | 4             |
|                | Fixed and rigidly guided   |          | 1             |
|                | Jointed and rigidly guided |          | 1.5           |

| Mounting style | Rod connection             | Mounting | Stroke factor |
|----------------|----------------------------|----------|---------------|
| D - F          | Jointed and supported      |          | 4             |
|                | Jointed and rigidly guided |          | 2             |
| L              | Jointed and supported      |          | 3             |
|                | Jointed and rigidly guided |          | 1.5           |



### 12 - THEORETICAL FORCES

Push force

$$F_s = P \cdot A_t$$

Pull force

$$F_t = P \cdot A_a$$

$F_s$  = Force (extension) in N

$F_t$  = Force (retraction) in N

$A_t$  = Total area in mm<sup>2</sup>

$A_a$  = Annular area in mm<sup>2</sup>

$P$  = Pressure in MPa

1 bar = 0.1 MPa

1 kgf = 9.81 N

| Bore<br>mm | Ø rod<br>mm | Total area<br>mm <sup>2</sup> | Annular area<br>mm <sup>2</sup> |
|------------|-------------|-------------------------------|---------------------------------|
| 50         | 32<br>36    | 1964                          | 1159<br>946                     |
| 63         | 40<br>45    | 3117                          | 1861<br>1527                    |
| 80         | 50<br>56    | 5027                          | 3063<br>2564                    |
| 100        | 63<br>70    | 7854                          | 4737<br>4006                    |
| 125        | 80<br>90    | 12272                         | 7245<br>5910                    |
| 140        | 90<br>100   | 15394                         | 9032<br>7540                    |
| 160        | 100<br>110  | 20106                         | 12252<br>10603                  |
| 180        | 110<br>125  | 25447                         | 15943<br>13175                  |
| 200        | 125<br>140  | 31416                         | 19144<br>16022                  |
| 250        | 160<br>180  | 49087                         | 28981<br>23640                  |
| 320        | 200<br>220  | 80425                         | 49009<br>42412                  |
| 400        | 250<br>280  | 125664                        | 76576<br>64089                  |

### 13 - THEORETICAL VELOCITIES

#### Configuration 1

The diagram illustrates a conventional cylinder application: the fluid is delivered by means of a directional control valve in alternation to the front chamber while the rear chamber is connected to tank and vice versa.

To calculate velocity and force, proceed as follows:

Velocity (extension)

$$V = \frac{Q \cdot 1000}{A_t \cdot 60}$$

Velocity (retraction)

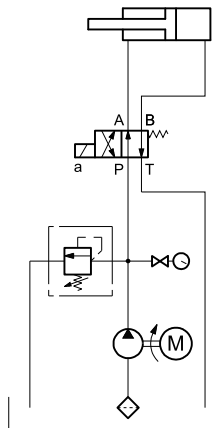
$$V = \frac{Q \cdot 1000}{A_a \cdot 60}$$

Force (extension)

$$F = P \cdot A_t$$

Force (retraction)

$$F = P \cdot A_a$$



#### Configuration 2

When the system requires high velocity with relatively low forces, we recommend using a regenerative circuit. Diagram 2 illustrates the simplest version of this type of set-up.

The annular chamber is permanently connected to the pump while the full bore end is connected alternately to the pump, in which case the piston rod extends as a result of the differential areas (both chambers are supplied at the same pressure), and to tank, in which case the piston rod retracts.

Velocity (extension)

$$V = \frac{Q \cdot 1000}{A_s \cdot 60}$$

Velocity (retraction)

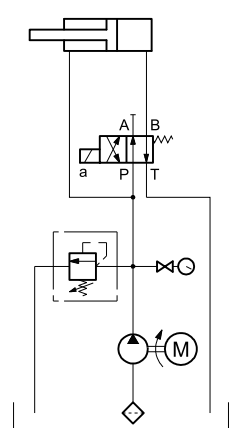
$$V = \frac{Q \cdot 1000}{A_a \cdot 60}$$

Force (extension)

$$F = P \cdot A_s$$

Force (retraction)

$$F = P \cdot A_a$$



$V$  = Velocity in m/s

$Q$  = Flow rate in l/min

$A_t$  = Total area (piston bore) in mm<sup>2</sup>

$A_a$  = Annular area ( $A_t - A_s$ ) in mm<sup>2</sup>

$F$  = Force in N

$P$  = Pressure in MPa

$A_s$  = Rod area ( $A_t - A_a$ ) in mm<sup>2</sup>

$Q_d$  = Flow rate through directional control valve ( $Q$ +return flow rate from small chamber) in l/min

1 bar = 0.1 MPa

1 kgf = 9.81 N

**NOTE:** In the case of regenerative circuits, the sizing of the directional control valve is fundamental. Flow rate through the directional control valve is calculated according to the following formula:

$$Q_d = \frac{V \cdot A_t \cdot 60}{1000}$$



## 14 - MASSES

| Bore | Ø rod      | Mass for null stroke |              |              | Mass for 10 mm stroke |
|------|------------|----------------------|--------------|--------------|-----------------------|
|      |            | Mounting style       |              |              |                       |
|      |            | A -B                 | D - F        | L            |                       |
| mm   | mm         | kg                   | kg           | kg           | kg                    |
| 50   | 32<br>36   | 14                   | 16           | 17           | 0,2                   |
| 63   | 40<br>45   | 28                   | 27           | 27           | 0,3                   |
| 80   | 50<br>56   | 39                   | 38           | 39           | 0,5                   |
| 100  | 63<br>70   | 61                   | 62           | 63           | 0,6<br>0,7            |
| 125  | 80<br>90   | 103<br>104           | 107<br>108   | 110          | 0,9<br>1              |
| 140  | 90<br>100  | 164                  | 173          | 175          | 1,1<br>1,2            |
| 160  | 100<br>110 | 198<br>199           | 210          | 208<br>209   | 1,6<br>1,7            |
| 180  | 110<br>125 | 289                  | 296<br>297   | 298<br>299   | 2<br>2,2              |
| 200  | 125<br>140 | 356<br>357           | 365<br>366   | 364<br>365   | 2,2<br>2,4            |
| 250  | 160<br>180 | 666<br>667           | 698<br>700   | 685<br>687   | 3,2<br>3,6            |
| 320  | 200<br>220 | 1200<br>1250         | 1314<br>1365 | 1259<br>1310 | 5,1<br>5,6            |
| 400  | 250<br>280 | 2180<br>2250         | 2259<br>2330 | 2249<br>2320 | 7<br>7,5              |

## 15 - SEAL KIT IDENTIFICATION CODE

|                                 |  |  |  |  |  |  |  |  |                                                                                                                                                  |  |  |
|---------------------------------|--|--|--|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| <b>S K / H C 3 - / / - / 10</b> |  |  |  |  |  |  |  |  |                                                                                                                                                  |  |  |
| Seal kit                        |  |  |  |  |  |  |  |  | Series no. indicated on cylinder                                                                                                                 |  |  |
| Bore (mm)                       |  |  |  |  |  |  |  |  | Seals:<br><b>K</b> = standard (nitrile + polyurethane)<br><b>M</b> = low friction (nitrile + PTFE)<br><b>V</b> = high temperature (viton + PTFE) |  |  |
| Rod (mm)                        |  |  |  |  |  |  |  |  | Double rod (omit if not required)                                                                                                                |  |  |

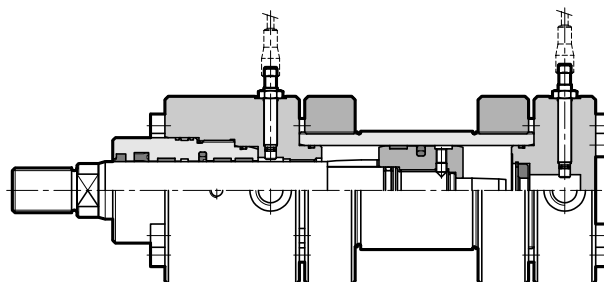
**NOTE:** the seal kit includes all the seals of a full-options cylinder (cushionings and external drain).

### 16 - END-STROKE PROXIMITY SENSORS

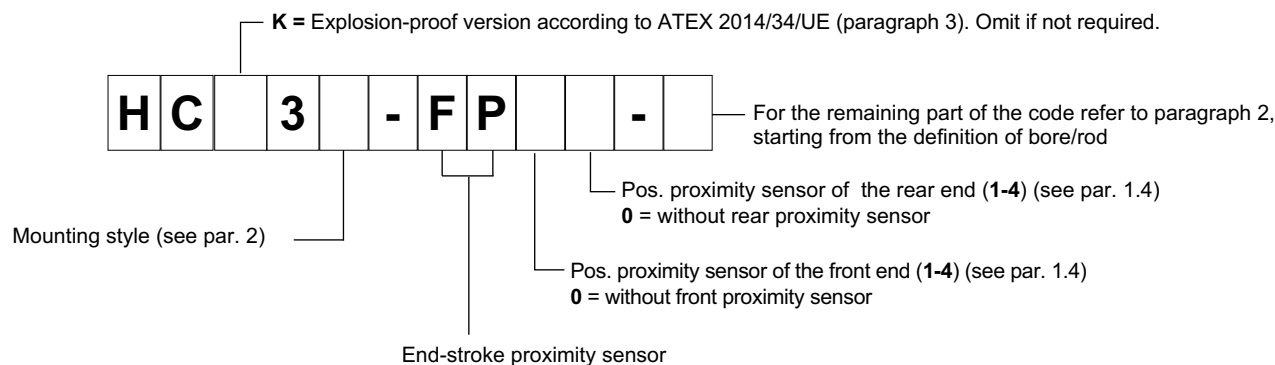
Upon request, cylinders can be supplied with end-stroke proximity sensors type PNP, with normally open output. They are mounted on the front and rear end of the cylinder and they supply an electric signal when the piston rod reaches the stroke end. They are available for all cylinder mounting styles, on both ends and for every available bore.

In order to ensure the correct functioning of the system, cylinders must be equipped with cushionings.

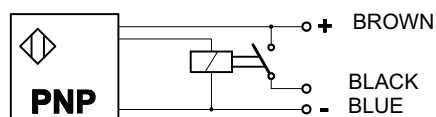
These sensors can be only used to provide the switching signal and not to control voltage loads.



#### 16.1 - Identification code



#### 16.2 - Technical characteristics and electrical connection



|                                                              |                                                    |                            |
|--------------------------------------------------------------|----------------------------------------------------|----------------------------|
| Rated voltage                                                | VDC                                                | 24                         |
| Power supply voltage range                                   | VDC                                                | 10 ÷ 30                    |
| Absorbed current                                             | mA                                                 | 200                        |
| Output                                                       | normally open contact                              |                            |
| Electric protection                                          | polarity inversion<br>short circuit<br>overvoltage |                            |
| Electric connection                                          | with connector                                     |                            |
| Maximum operating pressure                                   | bar                                                | 500                        |
| Operating temperature range                                  | °C                                                 | -25 / +80                  |
| Class of protection according IEC EN 60529 (atmospheric ag.) |                                                    | IP 68                      |
| Piston position LED ( <b>NOTE</b> )                          |                                                    | NO (it's on the connector) |

#### 16.3 - Connectors

Connectors for proximity sensors must be ordered separately, by specifying the code: **ECM3S/M12L/10**

**NOTE: These connectors are not suitable for ATEX-rated cylinders. The connectors for the ATEX-rated cylinders are described at paragraph 3.5.**

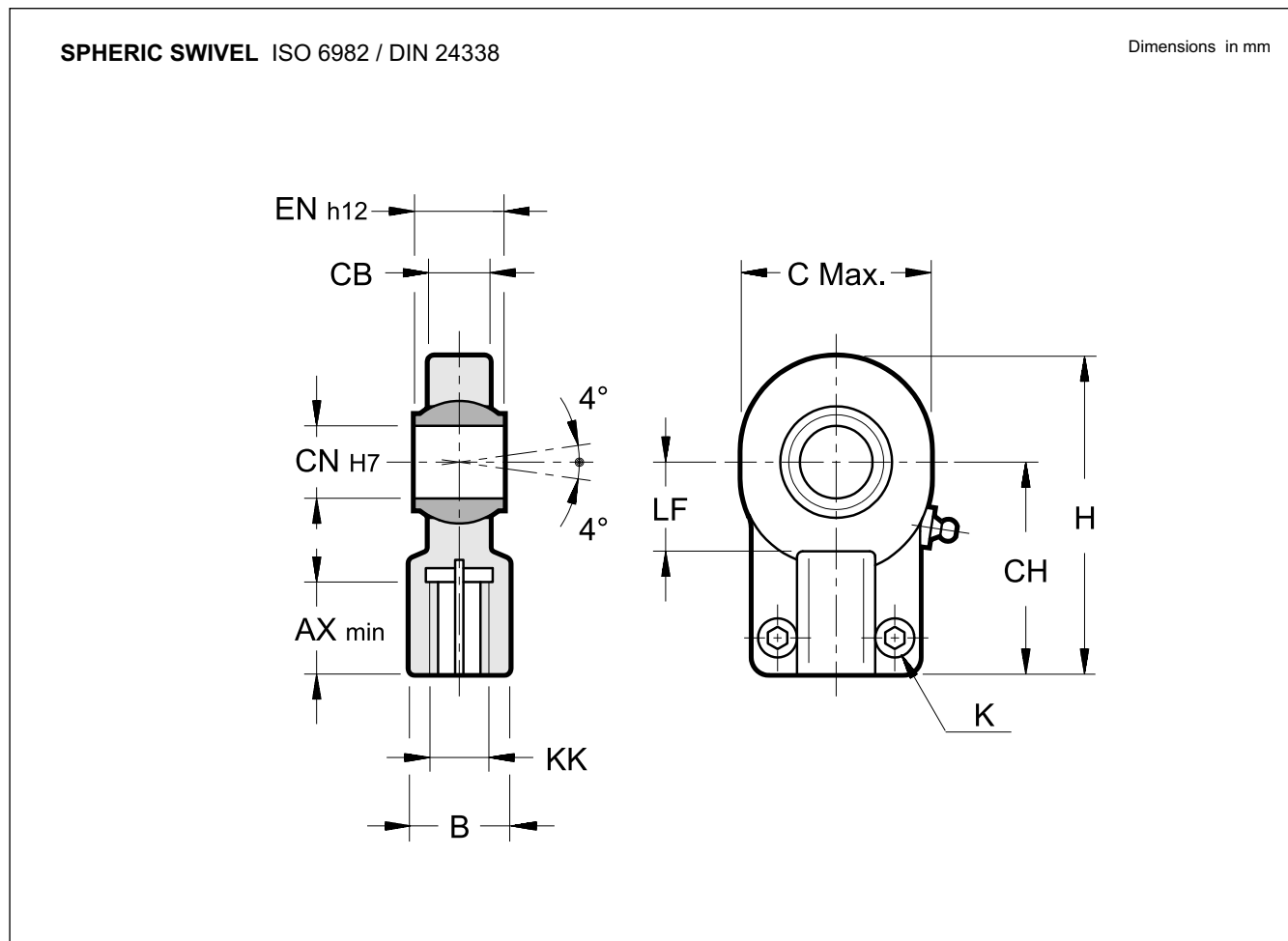
Connector: pre-wired connector M12 - IP68  
Cable: with 3 conductors 0.34 mm<sup>2</sup> - length 5 mt.  
Cable material: polyurethane resin (oil resistant)

The connector has two LEDs, one green and one yellow.

**GREEN:** Connector power supply.  
The LED burn when the connector is supplied.

**YELLOW:** position signal.  
ON - piston at stroke end  
OFF - piston not at stroke end

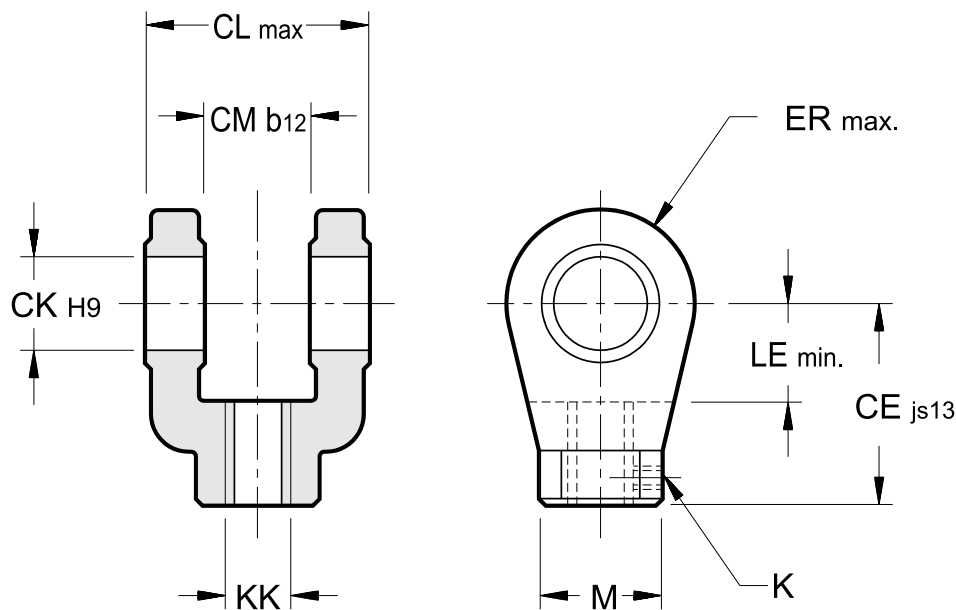
## 17 - OVERALL AND MOUNTING DIMENSIONS



| Type    | Ø cylinder bore | AX min | B   | C max | CB  | CH  | Ø CN H7 | EN h12 | H   | KK     | LF  | BOLT K UNI 5931 | Torque Nm | Max load kN | Mass Kg |
|---------|-----------------|--------|-----|-------|-----|-----|---------|--------|-----|--------|-----|-----------------|-----------|-------------|---------|
| LSF-36  | 50              | 37     | 38  | 71    | 28  | 80  | 32      | 32     | 119 | M27x2  | 32  | M10x25          | 49        | 67          | 1.17    |
| LSF-45  | 63              | 46     | 47  | 90    | 33  | 97  | 40      | 40     | 146 | M33x2  | 41  | M10x30          | 49        | 100         | 2.15    |
| LSF-56  | 80              | 57     | 58  | 109   | 41  | 120 | 50      | 50     | 180 | M42x2  | 50  | M12x35          | 86        | 156         | 3.75    |
| LSF-70  | 100             | 64     | 70  | 132   | 53  | 140 | 63      | 63     | 212 | M48x2  | 62  | M16x40          | 210       | 255         | 7       |
| LSF-90  | 125             | 86     | 90  | 170   | 67  | 180 | 80      | 80     | 271 | M64x3  | 78  | M20x50          | 410       | 400         | 13.8    |
| LSF-100 | 140             | 91     | 100 | 185   | 72  | 195 | 90      | 90     | 296 | M72x3  | 85  | M20x60          | 410       | 490         | 19.1    |
| LSF-110 | 160             | 96     | 110 | 224   | 84  | 210 | 100     | 100    | 322 | M80x3  | 98  | M24x60          | 710       | 610         | 25      |
| LSF-125 | 180             | 106    | 125 | 235   | 88  | 235 | 110     | 110    | 364 | M90x3  | 105 | M24x60          | 710       | 655         | 32      |
| LSF-140 | 200             | 113    | 135 | 290   | 102 | 260 | 125     | 125    | 405 | M100x3 | 120 | M24x70          | 710       | 950         | 46      |
| LSF-180 | 250             | 126    | 165 | 346   | 130 | 310 | 160     | 160    | 480 | M125x4 | 150 | M24x80          | 710       | 1370        | 82.5    |
| LSF-220 | 320             | 161    | 215 | 460   | 162 | 390 | 200     | 200    | 620 | M160x4 | 195 | M30x100         | 1500      | 2120        | 168     |

## 18 - OVERALL AND MOUNTING DIMENSIONS

### FEMALE CLEVIS ISO 8133



Dimensions in mm

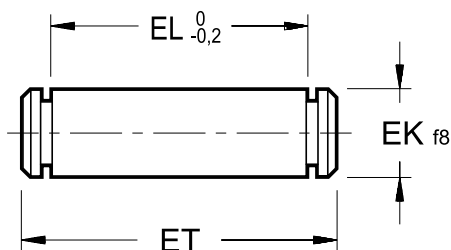
| Type    | Ø cylinder bore | M  | CE   | Ø CK | CL  | CM  | ER  | KK    | LE  | K bolt | Max load kN | Mass kg |
|---------|-----------------|----|------|------|-----|-----|-----|-------|-----|--------|-------------|---------|
|         |                 | CH | js13 | H9   | max | b12 | max |       | min |        |             |         |
| FRC-36  | 50              | 40 | 75   | 28   | 83  | 40  | 34  | M27x2 | 39  | M6x6   | 80          | 1.8     |
| FRC-45  | 63              | 56 | 99   | 36   | 103 | 50  | 50  | M33x2 | 54  | M8x8   | 125         | 3.7     |
| FRC-56  | 80              | 56 | 113  | 45   | 123 | 60  | 53  | M42x2 | 57  | M8x8   | 200         | 5.6     |
| FRC-70  | 100             | 75 | 126  | 56   | 143 | 70  | 59  | M48x2 | 63  | M12x12 | 320         | 9.3     |
| FRC-90  | 125             | 95 | 168  | 70   | 163 | 80  | 78  | M64x3 | 83  | M12x12 | 500         | 20      |
| FRC-110 | 160             | 95 | 168  | 70   | 163 | 80  | 78  | M80x3 | 83  | M12x12 | 500         | 20      |

## 19 - OVERALL AND MOUNTING DIMENSIONS

### FEMALE CLEVIS ISO 8133

with spring retainers

Dimensions in mm



| Type   | Ø EK f8 | EL 0 / -0.2 | ET  | Mass kg |
|--------|---------|-------------|-----|---------|
| PNF-36 | 28      | 87          | 96  | 0.5     |
| PNF-45 | 36      | 107         | 120 | 1       |
| PNF-56 | 45      | 129         | 144 | 1.8     |
| PNF-70 | 56      | 149         | 164 | 3.2     |
| PNF-90 | 70      | 169         | 187 | 5.6     |

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