



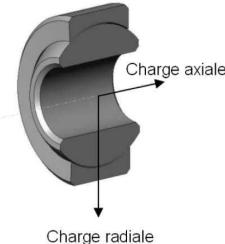
Calculations

Static loading

The **basic static loading** C_0 is given in the tables of dimensions. For a rod-end bearing, it is limited by the strength of the mount.

The values given in the Unibal standard programme tables are calculated from the elastic limit of the mount material (C_{se}) taking a safety factor into account:

$$C_0 = \frac{C_{se}}{1.25}$$



In the case of a spherical bearing, the basic static loading C_0 is calculated using the following formula:

$$C_0 = d_k \times C \times 0.85 \times X$$

d_k : diameter of the inner bush sphere (mm)

C : width of the mount (mm)

X : Stress admissible by the material (daN.mm⁻²)

Fatigue resistance: Please note that values given in the tables of dimensions are for occasional static loadings. Ask us where fatigue resistance is required.

Axial static loading

The following table gives the values for the axial static loading not to be exceeded for spherical and rod-end bearings.

Standard series, .40, .45, .50,.51 and .52	Limit axial static loadings F_a adm.
SME/SFE/SMEM/SSE	8% C_0
SM/SF SMG/SFG SS/SSA	20% C_0

C_0 : Basic static loading (see tables of dimensions pages 24 to 47)

In the case of rod-end bearings, it must also be ensured that the thread is properly located so as to prevent any risk of buckling or stripping of the rod-end bearing shank.

In the case of spherical bearings (SS, SSA, SSE), attention must be paid to maintaining the cage axially (see assembly instructions chapter, page 23)



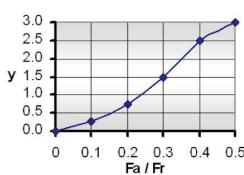
Checking the application

Proceed as follows to check the choice of a spherical bearing:

- Calculate and check whether the pressure is within the allowable limits
- Calculate and check whether the velocity is within the allowable limits
- Calculate the PV factor (Pressure x Velocity) and check the allowable limit

Series	Slip contact		Max. allowable pressure (daN · mm ⁻²)	Max. allowable velocity (m · min ⁻¹)	Maximum allowable PV
	Int. bush	Ext. bush			
.40	Steel	Bronze	5	5	3.5
		Steel	10	4	3.5
		Uniflon® E	15	4	4.5
.45	Steel	Bronze	5	2.5	3
		Uniflon® E	15	4	4.5
		Stainless steel	10	4.5	3
.50	Steel	Bronze	5	4.5	3.5
		Stainless steel	10	4.5	4
		Uniflon® E	15	4	4.5

Calculating specific pressure



Coefficient of axial loading **y** and equivalent dynamic loading:

- Our spherical bearings are designed to withstand radial loadings (Fr). But the combination with an axial loading (Fa) is sometimes inevitable and spherical bearings are able to accommodate it to a certain extent. So the equivalent dynamic loading F must be calculated taking into account a correction factor y for that axial loading. The table opposite gives the value of y for different Fa / Fr ratios.

$$F = Fr + (y \times Fa)$$

Normal case: $F = Fr$

Checking the average pressure according to the force exercised on the friction surface.

$$P = \frac{F}{d_K \times C \times 0.85}$$

P: pressure (daN.mm⁻²)

F: total dynamic loading (daN)

Fr: radial dynamic loading (daN)

Fa: axial dynamic loading (daN)

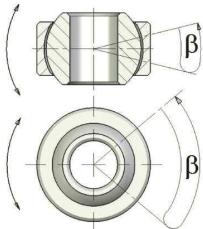
d_K: diameter of the inner sphere bush (mm)

C: width of the mount or cage (mm)



Calculating the slip velocity on contact

Checking the maximum friction velocity between the inner bush and outer bush.



$$V = \frac{d_K \times \beta \times f}{114'600}$$

- V: velocity ($m \cdot min^{-1}$)
 d_K: diameter of the inner bush sphere (mm)
 β: angle of oscillation complete (degrees)
 f: frequency of oscillation (Hz)

PV factor

$$PV = P \times V$$

P: pressure (daN.mm⁻²) V: velocity ($m \cdot min^{-1}$)

Calculating life

If your application requires the play or torque of the spherical bearing to be controlled throughout its life, please ask us.

$$D_h = \frac{c_1 \cdot c_2 \cdot c_3 \cdot c_4 \cdot c_5 \cdot c_6 \cdot c_7 \cdot c_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot f}$$

$$D = \frac{c_1 \cdot c_2 \cdot c_3 \cdot c_4 \cdot c_5 \cdot c_6 \cdot c_7 \cdot c_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot 0.0167}$$

- D_h : life in hours (h)
 D : life (number of oscillations or complete rotations)
 C : Width of the cage or rod (P24 to 47)
 K : Constant given by the table opposite
 F : radial dynamic loading (daN)
 β : angular distance run per cycle (degrees)
 f : frequency of oscillations (osc/min)
 c₁ : coefficient of pressure (p.12)
 c₂ : coefficient of velocity (p.12)
 c₃ : coefficient of angle (p.13)
 c₄ : coefficient of strain (p.13)
 c₅ : coefficient of alternate loadings (p.13)
 c₆ : coefficient of maintenance (p.13)
 c₇ : coefficient of temperature (p.13)
 c₈ : coefficient of vibration (c₈ = 1 or 0.8)
 If parts have to withstand vibrations greater than 60 vibr./min.,
 use a coefficient c₈ of 0.8.
 X : Coefficient of safety (min.=0.7, max.=1)
 According to your estimate of external influences, unknowns
 and their importance from the functional point of view (abrasive
 environment, corrosion, etc.), use a coefficient X of 0.7 to 1.0

Type	Constant K
SMG, SFG	85
SMG..20, SFG..20	85
SMG..40, SFG..40	70
SMG..45, SFG..45	80
SMGM..50 / 51 / 52	
	105
SME, SFE	105
SME..40, SFE..40	100
SME..45, SFE..45	110
SMEM..50 / 51 / 52	
	85
SS	70
SS..45	
	75
SSA	70
SSA..45	80
SSA..50	
	105
SSE	100
SSE..45	110
SSE..50	



Determining calculation coefficients

The life of a spherical bearing or rod is the maximum number of running hours or oscillations before play appears that does not allow the spherical bearing to fulfil its function.

The life is a function of the dynamic strain and of the various parameters of the application.

- Pressure
- Velocity (angle and frequency of oscillations)
- Strain (continuous, pulsating, alternate loadings)
- Temperature
- Vibrations

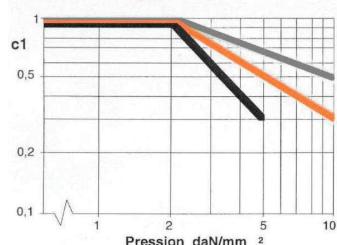
Calculation formulas, worked out from trials conducted on our test benches, enable you to determine the life in accordance with your application.

In the case of a pulsating or alternate loading, the value to use for F is the absolute maximum value reached.

To determine it correctly, all possible data should be taken into consideration – no unknowns should remain that could invalidate the result.

For specific uses in a particular environment (corrosion, vibration, aggressive ambient environment, abrasive dust, etc.), please ask us.

Coefficient de pression c1



Slip

Steel / bronze

SMG, SFG
SMG..40, SFG..40
SMG..45, SFG..45

SS
SS..45

Slip

Steel / Steel

SMGM..50
SMGM..51
SMGM..52

SSA
SSA..45
SSA..50

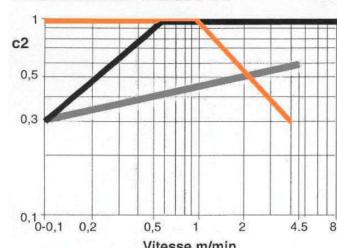
Slip

Steel / Uniflon®

SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52

SSE
SSE..45
SSE..50

Coefficient de vitesse c2



Slip

Steel / bronze

SMG, SFG
SMG..40, SFG..40
SMG..45, SFG..45

SS
SS..45

Slip

Steel / Steel

SMGM..50
SMGM..51
SMGM..52

SSA
SSA..45
SSA..50

Slip

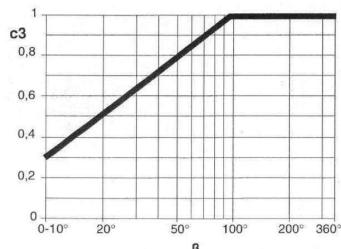
Steel / Uniflon®

SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52

SSE
SSE..45
SSE..50



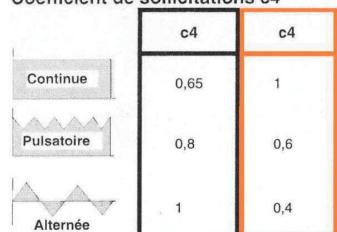
Coefficient d'angle c3



Slip	Slip
Steel / bronze	Steel / Steel
SMG, SFG	SMGM..50
SMG..40, SFG..40	SMGM..51
SMG..45, SFG..45	SMGM..52
SS	SSA
SS..45	SSA..45
	SSA..50

Slip
Steel / Uniflon®
Coef. c3=1
SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52
SSE
SSE..45
SSE..50

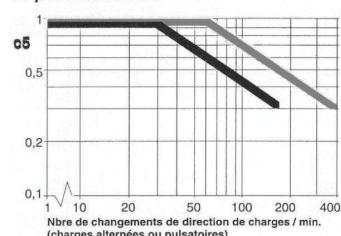
Coefficient de sollicitations c4



Slip	Slip
Steel / bronze	Steel / Steel
SMG, SFG	SMGM..50
SMG..40, SFG..40	SMGM..51
SMG..45, SFG..45	SMGM..52
SS	SSA
SS..45	SSA..45
	SSA..50

Slip
Steel / Uniflon®
SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52
SSE
SSE..45
SSE..50

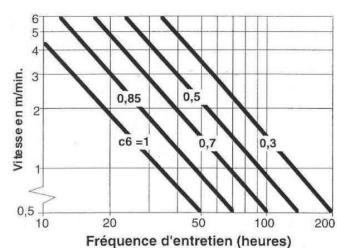
Coefficient de charges alternées et pulsatoires c5



Slip	Slip
Steel / bronze	Steel / Uniflon®
SMG, SFG	SME, SFE
SMG..40, SFG..40	SME..40, SFE..40
SMG..45, SFG..45	SME..45, SFE..45
SS	SSE
SS..45	SSE..45
	SSE..50

Slip
Steel / Steel
SMGM..50
SMGM..51
SMGM..52
SSE
SSA..45
SSA..50

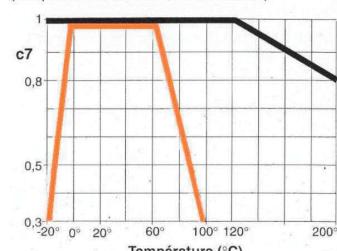
Coefficient d'entretien c6



Slip	Slip
Steel / bronze	Steel / Steel
SMG, SFG	SMGM..50
SMG..40, SFG..40	SMGM..51
SMG..45, SFG..45	SMGM..52
SS	SSA
SS..45	SSA..45
	SSA..50

Slip
Steel / Uniflon®
Coef. c6=1
SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52
SSE
SSE..45
SSE..50

Coefficient de température c7
(Température ambiante du lieu de travail)



Slip	Slip
Steel / bronze	Steel / Steel
SMG, SFG	SMGM..50
SMG..40, SFG..40	SMGM..51
SMG..45, SFG..45	SMGM..52
SS	SSA
SS..45	SSA..45
	SSA..50

Slip
Steel / Uniflon®
SME, SFE
SME..40, SFE..40
SME..45, SFE..45
SMEM..50 / 51 /52
SSE
SSE..45
SSE..50



Examples of dynamic calculations

Calculation n°1: Steel / Bronze

On a machine, an automatic loading system requires size 12 rod-end bearings

1) Data

Type and size wanted:	SMG12
Dynamic radial loading:	180 daN
Type of strain:	continuous
Angle of oscillation:	± 45° ($\beta = 180^\circ$)
Frequency:	125 osc./min
Maintenance:	1 lubrication / 18h
Ambient temperature:	50°C
Life wanted:	7,000,000 osc.

2) Checking the pressure, velocity and PV factor

$$P = \frac{F}{d_K \times C \times 0.85} = \frac{180}{22.23 \times 12 \times 0.85} = 0.79 \text{ daN/mm}^2$$

$$V = \frac{D_K \times \beta \times f}{114'600} = \frac{22.23 \times 180 \times 125}{114'600} = 4.36 \text{ m/min}$$

$$PV = P \times V = 0.79 \times 4.36 = 3.46$$

After checking the values obtained in table 1, we find that the maximum admissible PV factor is 3.5, the limit admissible velocity is 5 m/min. and the pressure maximum admissible is 5 daN/mm²

So we can continue the calculation.

3) Calculating the life

K: table p.11	Constant SMG12	85
c1: coef. p.12	Pressure: 0.79	1
c2: coef. p.12	Velocity: 4.36	1
c3: coef. p.13	Angle $\beta = 180^\circ$	1
c4: coef. p.13	Continuous loading	0.65
c5: coef. p.13	Not applicable	1
c6: coef. p.13	1 lubrication/ 18h	0.8
c7: coef. p.13	50°C	1
c8: coef. p.11	Not applicable	1
X: coef. p.11		1

Life:

$$D = \frac{C_1 \cdot C_2 \cdot C_3 \cdot C_4 \cdot C_5 \cdot C_6 \cdot C_7 \cdot C_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot 0.0167}$$

$$D = \frac{1 \cdot 1 \cdot 1 \cdot 0.65 \cdot 1 \cdot 0.8 \cdot 1 \cdot 1 \cdot 1 \cdot 12 \cdot 85 \cdot 10^7}{180 \cdot 180 \cdot 0.0167}$$

D = 9,800,000 oscillations (> 7,000,000 osc.)
Type SMG12 is entirely suitable for this application.

Calculation n°2: Steel / Steel

You want to fit the tower of a crane with size 16 rod-end bearings. What will the life stress surfaces below be?

1) Data

Type and size wanted:	Gr. 16 Type?
Dynamic radial loading:	2,500 daN with impacts
Type of strain:	alternating
Angle of oscillation:	± 30° ($\beta = 120^\circ$)
Frequency:	0.5 osc./min
Maintenance:	liberal lubrication
Ambient temperature:	120 to 180°C
Life wanted:	10,000h

2) Checking the pressure, velocity and PV factor

$$P = \frac{F}{d_K \times C \times 0.85} = \frac{2,500}{28.58 \times 15 \times 0.85} = 6.9 \text{ daN/mm}^2$$

$$V = \frac{D_K \times \beta \times f}{114'600} = \frac{28.58 \times 120 \times 0.5}{114'600} = 0.015 \text{ m/min}$$

$$PV = P \times V = 6.9 \times 0.015 = 0.1$$

We have to choose a rod-end bearing withstanding 10daN/mm², so steel /steel friction. Type SMGM 16.50 does not withstand very high velocities, but in this application, the velocity is very low. An SMGM 16.50 is particularly suited to this application.

3) Calculating the life

K: table p.11	Constant SMGM 16.50	80
c1: coef. p.12	Pressure: 6.9	0.6
c2: coef. p.12	Velocity: 0.01	0.3
c3: coef. p.13	Angle $\beta = 120^\circ$	1
c4: coef. p.13	Alternating loading	1
c5: coef. p.13	0.5 osc./min	1
c6: coef. p.13	Liberal lubrication	1
c7: coef. p.13	180°C	0.85
c8: coef. p.11	Not applicable	1
X: coef. p.11	Impacts	0.9

Life:

$$D_h = \frac{C_1 \cdot C_2 \cdot C_3 \cdot C_4 \cdot C_5 \cdot C_6 \cdot C_7 \cdot C_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot f}$$

$$D_h = \frac{0.6 \cdot 0.3 \cdot 1 \cdot 1 \cdot 1 \cdot 0.85 \cdot 1 \cdot 0.9 \cdot 15 \cdot 80 \cdot 10^7}{2500 \cdot 120 \cdot 0.5}$$

D_h = 11,000 hours (> 10,000 h)
It is wise to choose an SMGM16.50 rod-end bearing for this lifting system.

NB: use grease that withstands the 180°C working temperature



Calculation n°3: Steel / Uniflon ® E

An SF..30 rod-end bearing is going to be used for the transmission on a fairground ride. It must be able to run maintenance-free. What type should be used?

1) Data

Type and size wanted:	Gr. 30 Type SF..
Dynamic radial loading:	2,500 daN
Type of strain:	alternating
Angle of oscillation:	$\pm 1.5^\circ (\beta = 6^\circ)$
Frequency:	80 osc./min
Maintenance:	self-lubricating
Ambient temperature:	0 to 45°C, dust
Life wanted:	3,000 h

2) Checking the pressure, velocity and PV factor

$$P = \frac{F}{d_K \times C \times 0.85} = \frac{2,500}{50.8 \times 25 \times 0.85} = 2.32 \text{ daN/mm}^2$$

$$V = \frac{D_K \times \beta \times f}{114'600} = \frac{50.8 \times 6 \times 80}{114'600} = 0.21 \text{ m/min}$$

$$PV = P \times V = 2.32 \times 0.21 = 0.49$$

After checking the values obtained in table 1, we find that the pressure, velocity and PV factor are below the maximum admissible values. Checking the static loading of an SFE30: 5,130 daN, which is thus greater than the loading stated. So the SFE30 is suitable for this application.

3) Calculating the life

K: table p.11	Constant SFE30	105
c1: coef. p.12	Pressure: 2.32	1
c2: coef. p.12	Velocity: 0.21	1
c3: coef. p.13	Angle $\beta = 6^\circ$	1
c4: coef. p.13	Alternating loading	0.4
c5: coef. p.13	80 osc./min	0.5
c6: coef. p.13	self-lubricating	1
c7: coef. p.13	0 to 45°C	1
c8: coef. p.11	Not applicable	1
X: coef. p.11	Dusty	0.8

Life:

$$D_h = \frac{C_1 \cdot C_2 \cdot C_3 \cdot C_4 \cdot C_5 \cdot C_6 \cdot C_7 \cdot C_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot f}$$

$$D_h = \frac{1 \cdot 1 \cdot 1 \cdot 0.4 \cdot 0.5 \cdot 1 \cdot 1 \cdot 1 \cdot 0.8 \cdot 25 \cdot 105 \cdot 10^7}{2500 \cdot 6 \cdot 80}$$

$$D = 3,500 \text{ hours } (> 3,000 \text{ h.})$$

The Unibal SFE30 rod-end bearing will ensure that the ride runs correctly.

Calculation n°4: Steel / Steel

Several type SSA 3.45 spherical bearings are fitted to scale models (model boats). Despite the corrosive environment and stresses, these Unibals must withstand 300,000 oscillations.

1) Data

Type and size wanted:	SSA 3.45
Dynamic radial loading:	190 daN
Type of strain:	continuous
Angle of oscillation:	$\beta = 360^\circ$
Frequency:	20 rpm
Maintenance:	liberal lubrication
Ambient temperature:	5 to 30°C
Life wanted:	300,000 osc.

2) Checking the pressure, velocity and PV factor

$$P = \frac{F}{d_K \times C \times 0.85} = \frac{190}{7.93 \times 4.5 \times 0.85} = 6.26 \text{ daN/mm}^2$$

$$V = \frac{D_K \times \beta \times f}{114'600} = \frac{7.93 \times 360 \times 20}{114'600} = 0.50 \text{ m/min}$$

$$PV = P \times V = 6.26 \times 0.5 = 3.12$$

After checking the values obtained, we find that the velocity and PV factor are acceptable. As concerns pressure, an SSA 3.45 withstands pressure of 10 daN/mm². The admissible static loading is much greater than 190 daN. So we now have to check the required number of oscillations.

3) Calculating the life

K: table p.11	Constant SSA 3.45	70
c1: coef. p.12	Pressure: 6.26	0.62
c2: coef. p.12	Velocity: 0.5	0.35
c3: coef. p.13	Angle $\beta = 360^\circ$	1
c4: coef. p.13	Continuous loading	0.65
c5: coef. p.13	Not applicable	1
c6: coef. p.13	Liberal lubrication	1
c7: coef. p.13	5 to 30°C	1
c8: coef. p.11	Not applicable	1
X: coef. p.11		1

Life:

$$D = \frac{C_1 \cdot C_2 \cdot C_3 \cdot C_4 \cdot C_5 \cdot C_6 \cdot C_7 \cdot C_8 \cdot X \cdot C \cdot K \cdot 10^7}{F \cdot \beta \cdot 0.0167}$$

$$D = \frac{0.62 \cdot 0.35 \cdot 1 \cdot 0.65 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 4.5 \cdot 70 \cdot 10^7}{190 \cdot 360 \cdot 0.0167}$$

$$D_h = 389,000 \text{ osc. } (> 300,000 \text{ osc.})$$

According to the calculation performed, SSA 3.45 spherical bearings are suitable for this application.