Technical features

Nadella linear systems

With this line of products, NADELLA confirms the aim to provide manufacturing solutions tailored to the user's needs in order to achieve simple automation at a low cost.
The process under way of transferring production automation and relevant handling onto increasingly heavier and cumbersome units has prompted us to seek original and flexible components for the different commodity sectors.
We have accumulated sound working experience in the following sectors:

- marble-working machinery
- foundry machinery
- metal sheet working machinery
- special lifting machines
- pick up
- automatic warehouses
- textile machines
- machine tool protections and utilities
- oxygen cutting machines

Our Technical Department works with Customers and recommends the best component choice by making the calculations needed to determine the best life.

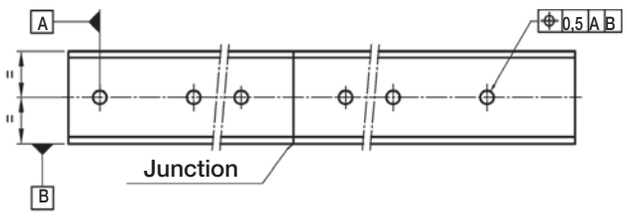
Guides

Length
The maximum length of each single guide component is shown on the dimensional tables.
The standard lengths of the rails are determined by adding the product of the fixing hole centre distance and the number of holes to twice the end dimension (see dimensional tables).

Length	≥ 150 < 420	≥ 420 < 1.050	≥ 1.050 < 2.040	≥ 2.040 < 4.020	≥ 4.020 < 5.280
Length tolerance	± 0,5	± 0,8	± 1,2	± 2	± 2,5

Joints
For strokes of greater length, the guide components can be joined after grinding the end faces (suffix R or RR). To maintain the hole centre distance tolerance, when ordering always specify the number of individual rails making one continuous length.
Please specify in the order when rails have to be matched. The junctions are marked (letters and numbers) to avoid a mix-up of different rails.

Fixing holes
The guides are available with standard holes, as shown in dimensional tables, with special hole layout or without holes (see order code referencing) Standard tolerance for hole position is ± 0,25 mm.



The standard boring layout is designed to fit most common application requirements, but connection strength has to be evaluated on the application case.

Steel guides

General
Steel rails are made of bearing steel to give best stability and durability. Raceways are induction hardened to achieve 58 HRC hardness minimum. The rail core remains soft to allow easy machining.
Rails can be provided with different finishes to meet specific application requirements.
Guide rails MT type. Profile is produced by cold drawing process, raceways are induction hardened and sandblasted to improve surface strength and finish.
Guide rails M type. Profile is usually produced by cold drawing process, induction hardened on raceways and ground to improve surface finish and profile geometry and to remove the partially decarburised surface (0.1 mm max on cold drawn rails ..MT). Ground rails have to be used when there are high loads, heavy-duty cycles or when there is a high accuracy requirement.
Guide rails MC type (flat rail GP..MC only). MC rails are induction-hardened on every side and finished by-a-rough grinding.

Options
Corrosion protection
For use in oxidising environments or in the presence of corrosive agents, the guides are available with chemical nickel-plating protective anticorrosion treatment (suffix NW.).
This treatment features substantial mechanical characteristics together with a resistance to salty mist corrosion superior to that of hard chrome. On request many rails are available in stainless-steel version (suffix NX)

Circular rail
On request circular rails can be provided. Circular rails can be used as an alternative to rotating devices or as junction between straight rails.

Technical features
Standard rail straightness (for non-mounted rails) is 0.5 mm/m max. Higher accuracy can be supplied on request.

Technical features

Temperature
Standard operating temperature range is –20°C up to 150°C. In lower or higher temperature applications please contact Nadella Technical Service. Special care is required if guide rollers are operating at maximum temperature.

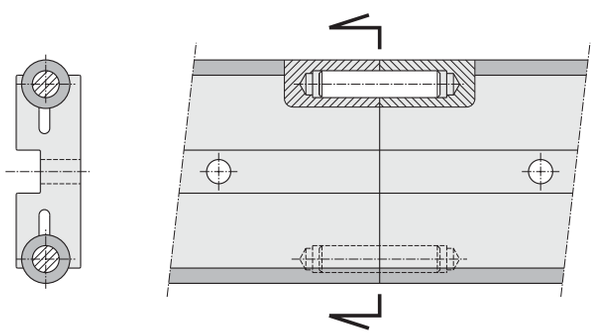
Aluminium guides

General
Made by joining an aluminium alloy support element and hardened steel rods that form the sliding surfaces.
The best features of the two materials and relevant working technologies are combined to give the lightness of the alloy and the hardness and surface finish of the rods.
Guides of this type can be used for structural functions; they have a high moment of inertia that enables them to be used in many applications as carrying structures.
Aluminium extruded profiles are stabilised and anodised.
Sliding rods are induction hardened and ground.

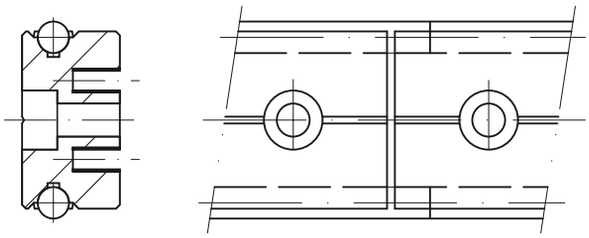
Options
Corrosion protection
For use in oxidising environments or in the presence of corrosive agents, the guides of this series can feature stainless-steel bars (suffix NX).

Chromium-plated rods
Optional chromium-plated rods are available (suffix CH); the thickness of the chromium plating is 10 ± 5 µm with hardness ≥ 800 HV.
Please check option availability in dimensional tables.

Joints
In case rail made by multiple C-DC or LM rails the most efficient joint can be realized with the insertion of a dowel pin inside the rods. This solution allows for simple assembly at the site and maintains alignment under load.



For rails FWS the joint can be realised by protruding the rods of one rail in order to engage them in the profile of the next rail. In the final configuration there will be a small gap between the aluminium profiles (see next drawing).



Technical features
Standard rails straightness (for non mounted rails) is 0.5 mm/m maximum. Higher accuracy can be supplied on request.

Temperature
Standard operating temperature range is –20°C up to 70°C. Applications with frequent temperature variation should be avoided. For operating conditions outside the given range please contact Nadella Technical Service.

Guide rollers

General
Nadella provide a wide range of guide rollers to be able to meet different technical and economic requirements.
All guide rollers are produced in concentric and eccentric versions to allow backlash adjustment during assembly on final equipment. Eccentric rollers are identified by additional R in the code.

The sides of the races of the guide roller are slightly convex. Besides reducing rolling friction, this also permits offsetting slight guide flexing or small assembly alignment errors.

Guide rollers are fitted with seals or shields for bearing protection and lubricant retention as described in dimensional tables.

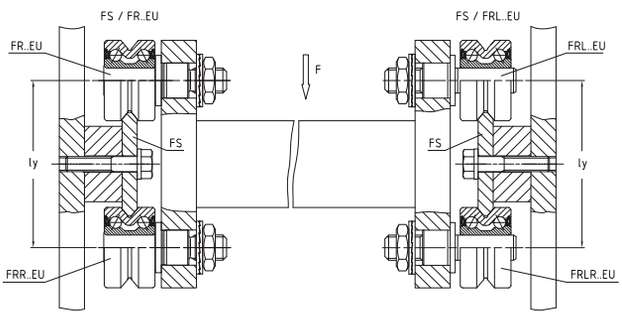
Guide rollers based on **needle or tapered roller bearings** (FRN..EI,RK..,PK..) are recommended for critical applications with heavy axial loads and/or shock loading. Guide rollers based on **ball bearings** (FR..EU, PFV, RCL) are more suitable for lighter loads or high dynamic systems.

The carriages based on Rolbloc's system are recommended for applications with heavy loads, high frequency of work and aggressive environment (dust, abrasive).

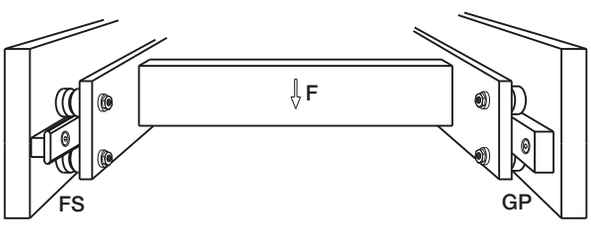
When mounting guide rails opposite to each other with connected carriages, as shown in the next sketch, a high level of parallelism between the guide rails is required when axially rigid rollers are used.
To avoid operating problems it is recommended to use axial rigid fixed rollers on one carriage e.g. FR.. EU/FRR…EU and axial movable rollers on the other

Technical features

carriage e.g. FRL..EU/FRLR..EU
Movable rollers allow a little misalignment between the opposite mounted guide rails.



Another solution is to use one profiled guide rail e.g. FS and on the opposite side a flat rail e.g. GP in connection with rollers GC or PK.



Technical features

Lubrication
Guide roller FRN..EI permits bearing relubrication. All other guide rollers are long life lubricated.

Temperature
Guide roller should not operate at constant temperature above 80°C. For short durations 100°C can be accepted. For higher temperature please see the “option section”.

Speed limit
Max velocity has to be determined for each application relevant to the guide roller type, size and load conditions. As general value, in normal conditions maximum speed is 4 m/sec but, with the correct chose of the components, the speed can reach 10 m/s. Contact Nadella Technical service in case of specific request.

Options

Corrosion protection
For uses in oxidising environments or in the presence of corrosive agents, the guide rollers are available in stainless steel (suffix NX) the guide rollers with tapered rollers (RKU, RKY/X, FKU, FKY/X) and needles (FRN) are equipped with standard bearings. Check in the dimensional table component availability.

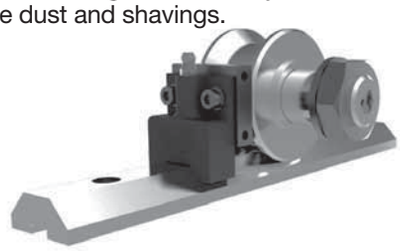
High temperature
On request guide rollers can be equipped with Viton seals to operate at temperature up to 120° (suffix V). Check in the dimensional table component availability.

Accessories

Tables and carriages
Standard table and carriages for C-DC and LM systems incorporate a black anodised aluminium plate fitted with guide rollers.

Wipers
Standard wipers NAID for C-DC rails are made from NBR compound moulded on a steel plate.

Lubricators
Are composed by two main parts: a plastic box with the same shape profile of the rail, and a lubricated felt; the felt is slightly pressed on the raceways by a spring. The plastic box, that drags the raceways, works as a wiper, and remove dust and shavings.



The plastic box can be mounted directly on the guide rollers plate by the appropriate aluminium plate included in the kit.

In the lubricators for guide rollers size 52 or higher, the grease nipple allows an easy connection with a re-lubrication system.

For the simply lubrication of the rails you can use one lubricator only on each raceway; in order to wipe the raceways it is better to mount two lubricators, before and after the carriage.

The lubricators are supplied with the felt already lubricated.

Use in dirty environment
Due to the design cam rollers with profile are especially adapted to the use in rough and dirty environment. This properly has proved true in many applications such as welding plants, steel and grinding machines and is superior to recirculating ball bearing guides in continuous operation.

Technical features

Lubrication

Bearing lubrication
All the guide rollers, except for the FRN..EI, based on needle bearings, are equipped with long life lubricated bearings. This means that the grease inside the bearing is enough for the entire life of the roller guide. The roller guide type FRN..EI, with needle bearings, accommodates the re-lubrication of the bearings.

Rail lubrication
Rails must be lubricated. This allows reducing the friction, to reach the calculated lifetime of the system and to work at high speed.

No or insufficient lubrication will cause rapid deterioration. The typical signal of tribocorrosion is the presence of a red/dark oxide and rapid wearing of the rail and guide rollers.

The lubrication of the rail, the working environment and the load must be considered all together for a correct estimation of the lifetime of the guide system.

Generally speaking, for application with low duty frequency, a periodic relubrication with a grease or with a viscous oil will sufficiently maintain the lubrication film. The re-lubrication interval depends on the application and must always be tested in the real working conditions. In a system with ground rails and short stroke without lubricators, you can consider a re-lubrication interval every 100,000 cycles. Increasing the load, speed or stroke, or using an under sized bearing will increase lubrication demand and result in a shorter lubrication interval. For a constant lubrication we suggest the use of felt lubricators to ensure a constant layer of lubricant between guide rollers and raceways. Felt lubricators enlarge the lubrication interval more than ten times.

The recommended lubricants are greases and oil for bearings, linear rails or chains, with a high viscosity of the basic oil and with EP additives, in order to separate the metallic surfaces even with low speed.

Assembly instructions

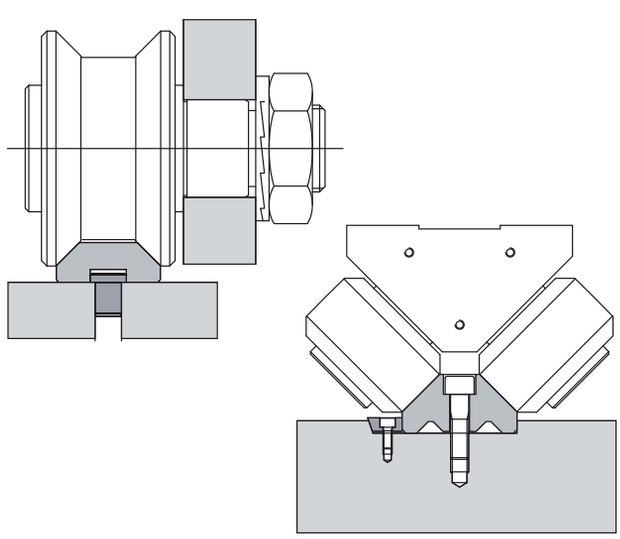
Guide rollers
The eccentric guide rollers allows the preload or clearance of the carriage to be adjusted independently of the guide roller mounting hole positioning tolerance or the distance between the rails.
Recommended mounting hole tolerance is H7.
When adjusting the eccentric guide roller care has to be taken to avoid excessive preload. Excessive preload can reduce the life of the linear system.
Set the preload turning the guide roller counterclockwise so that any movement caused by vibration will cause the nut to be tightened. Ensure the preload is not increased when tightening the nut.
A simple way of setting a roller preload is as follows:

1 move the slider on the guide, holding the roller being adjusted with two fingers to prevent it from rotating
2 increase the preload by means of the wrench
3 repeat step 1 making sure the roller slides without rolling
4 when it is no longer possible to prevent roller rolling, slightly decrease the preload and fully tighten the lock nut, thereby setting the position of the eccentric.

When correctly adjusted it is just possible to cause the guide roller to slip on the guide rail when a torque is applied to the roller.

Guides
For single guide rail type FS, FWS, DC and LM no special assembly instructions are necessary. For multiple parallel rails parallelism has to be checked to avoid guide rollers overload or excessive carriage play. When constant preload is required parallelism error has to be lower that 0.050 mm.

Connection between the rail and the mounting surface has to be designed accordingly with the operating condition to ensure proper product positioning and functionality.
The direction and intensity of the load, the number and strength of the screws, the geometry of mounting surfaces, use of pins or wedges have to be evaluated to fully utilize the linear guide load capacity.



Carriages
Carriages are supplied with concentric guide rollers nut tighten already. Eccentric guide rollers have to be set and tighten during final assembly operation by customer.

Technical features

Calculation procedure

Calculation is carried out in two steps, first defining the forces on the most heavily loaded roller and then estimating the safety factors and life.

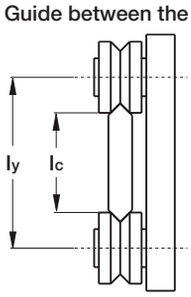
Calculating the loads on the guide rollers

In the case of complex load situations, with forces acting in different directions, calculating the reactions on the rollers is difficult and hard to simplify.
In the event of the applied load having a direction parallel to one of the co-ordinate axes, the radial Pr and axial Pa components of the reactions on the most loaded roller can be obtained using elementary formulas.
With reference to the diagrams shown, we obtain the load components on the rollers relevant for checking and calculating the life, applying the following methods.

Angle α in the formulas is half the groove angle. Look in the dimensional table notes for the correct value.

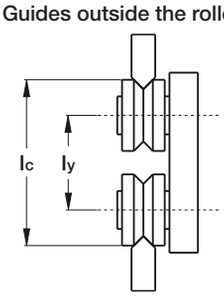
Distance I_C is the effective contact distance. With the exception of ROLBLOC system the correct value is calculated as the guide rollers centre distance across the rail plus or minus the outer guide roller diameter De, depending if the guide is outside or between the rollers.

Guide between the rollers



$I_C = I_y - De$

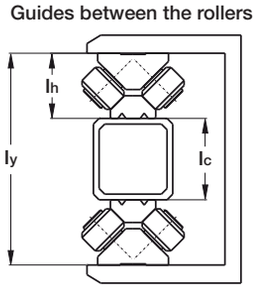
Guides outside the rollers



$I_C = I_y + De$

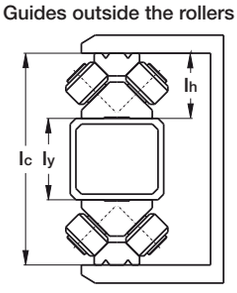
In case of ROLBLOC the distance I_C is the distance between the rails basis.

Guides between the rollers



$I_C = I_y - 2 \cdot I_h$

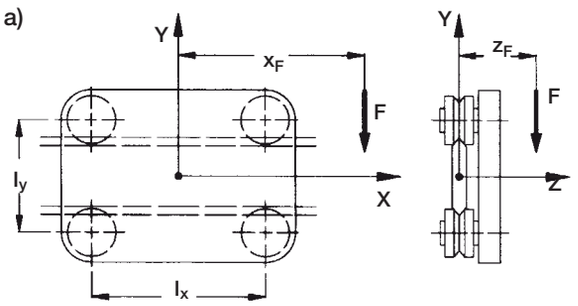
Guides outside the rollers



$I_C = I_y + 2 \cdot I_h$

Diagram a)
load F applied parallel to axis Y

a)

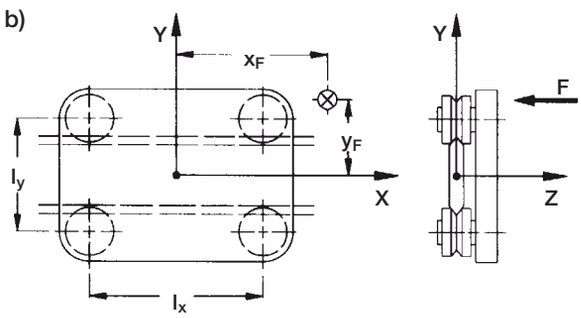


$$Pa = \frac{F \cdot z_F}{2 \cdot I_C}$$

$$Pr = \frac{F \cdot (I_X + 2 \cdot x_F)}{2 \cdot I_X} + \frac{F \cdot z_F \cdot \tan \alpha}{2 \cdot I_C}$$

Diagram b)
load F applied parallel to axis Z

b)

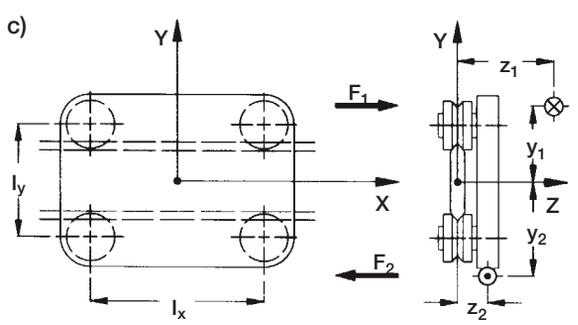


$$Pa = \frac{F}{4} + \frac{F \cdot x_F}{2 \cdot I_X} + \frac{F \cdot y_F}{2 \cdot I_C}$$

$$Pr = Pa \cdot \tan \alpha$$

Diagram c) load F applied parallel to axis X

c)



Technical features

In this case the external load F_1, applied at the point of co-ordinate y_1 z_1, should be considered together with reaction $F_2 = -F_1$, applied at the point of co-ordinate y_2 z_2. Calling Δy the absolute value of y_2-y_1 and Δz the absolute value of z_2-z_1, the following formula is used:

$$Pa = \frac{F_1 \bullet \Delta z}{2 \bullet I_x}$$

$$Pr = \frac{F_1}{I_x} \bullet \left(\frac{\Delta z \ \tan \alpha}{2} + \Delta y \right)$$

Guide roller calculation

In the table for each roller the following data is specified:

C_w basic dynamic load, it is the radial load [N] that applied to the guide roller gives 100 km nominal life*.

F_r limit radial load, it is the maximum radial load [N] that can be applied on the guide roller; for the guide wheels is the limit radial load of the wheel.

F_a limit axial load, it is the maximum axial load [N] that can be applied on the guide roller; for the guide wheels is the limit axial load of the wheel.

X and Y coefficients to define the equivalent load for bearing life.

α is the contact angle dependent on the guide roller type.

Rollers FRN..EI work as combined bearings, the basic dynamic load is defined as:

C_{wr} basic radial dynamic load, it is the radial load [N] that applied to the guide roller gives 100 km nominal life*.

C_{wa} basic axial dynamic load, it is the axial load [N] that applied to the guide roller gives 100 km nominal life*.

Note*: ISO 281 states 'the nominal life will be exceeded by 90% of bearings before the first sign of material fatigue'.

Nominal life calculation

System life is the minimum life of either the bearings in the guide roller or the rail/roller contact surfaces.

For the rail/roller surface see the lubrication paragraph. For the bearings life proceed as follows.

The loads Pr and Pa are calculated for ideal condition. However, in practice, because of the structure and operating conditions a better calculation and life estimation is performed using overload factor f_w as follows:

1.0 – 1.2	smooth operation at low speed at constant load without shocks
1.2 – 1.5	smooth operation with load variation
1.5 – 2.0	operation with small shocks and vibrations
2.0 ~ 4.0	high acceleration, shocks and vibrations

Once P_a and P_r has been defined we can proceed to calculate the equivalent load P_{eq} (not for FRN..EI).

$$P_{eq} = X\,P_r + Y\,P_a \quad [N]$$

Coefficients X and Y can be obtained from guide rollers tables.
In case of pure radial guide roller as PK and GC or floating bearings FRL, RAL, RKXL, RKUL.

$$P_{eq} = P_r \quad [N]$$

Nominal bearing life:

$$L_{10} = 100 \left(\frac{C_w}{P_{eq} \bullet f_w} \right)^p \quad [km]$$

Where coefficient p is:

p = 3 for ball bearing guide rollers
(FR..EU, RCL.., PFV.., RAL, MBL)

p = 10/3 for roller bearing guide rollers
(PK.., RKY, RKX, ROLBLOC, GC, FRL..)

In case of guide rollers based on needle bearings type FRN..EI nominal bearing life is calculated as the minimum between:

$$L_{10} = 100 \left(\frac{C_{wr}}{P_r \bullet f_w} \right)^{10/3} \quad [km]$$

and

$$L_{10} = 100 \left(\frac{C_{wa}}{P_a \bullet f_w} \right)^{10/3} \quad [km]$$

Checking the guide roller max load

The values of the radial limit loads Fr and axial limit loads Fa shown in the catalogue refer to extreme operating conditions, meaning:
$P_a = 0$ (pure radial load)
$P_r = P_a \tan \alpha$ (maximum axial load)

Technical features

In intermediate cases, when the ratio is included between the extreme values, the equivalent limit load F_k to be considered must be calculated according to ratio $k = P_a/P_r$.

$$F_k = \frac{F_r \bullet F_a}{k \bullet F_r + (1 - k \tan \alpha) \bullet F_a} \; [N]$$

To check the strength of the guide roller, in relation to the limit load, the safety factor has to be greater than 1

$$Fk/Pr > 1$$

Note: in the following common cases it is not necessary to calculate F_k and the evaluation can be completed easily. Rollers that allow axial movement (FRL, PK, RKYL, RKUL, GC) don't support axial loads.

In case of loads acting in the guide roller plane (F_x or F_y acting with Z=0) the axial load is also zero (0) (see calculation example n° 3).
In these cases it has to be

$$F_r/P_r > 1$$

In case of load F_z acting perpendicular at guide roller plane the axial load is maximum (example n° 4).

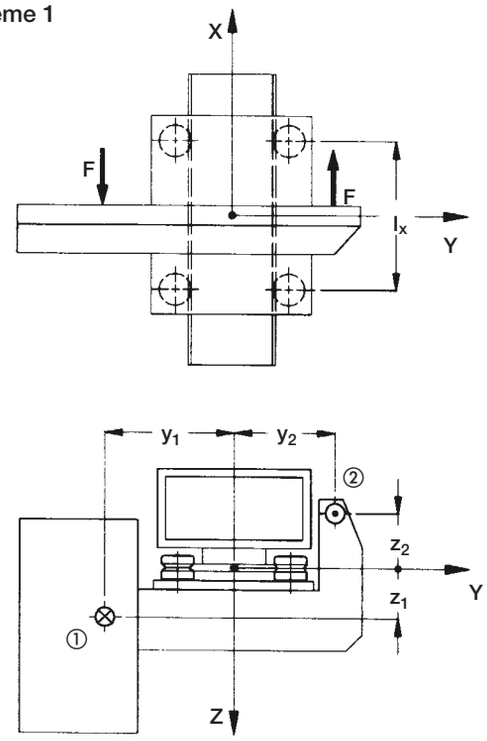
$$F_a/P_a > 1$$

Examples of calculation

1) A fork-light truck featuring vertical movement (scheme 1).
The resulting magnitude of the weight passes through point 1, while the vertical force that balances this, for instance the traction of a timing belt, passes through point 2.
Guide rollers type RKY 52 are used with guide rail type FS 62 MT

overload factor	f_w	=	1,0		
center distance	l_x	=	300 mm	l_y	= 144,3 mm
F = 1800 N	z_1	=	100 mm	y_1	= - 150 mm
	z_2	=	- 250 mm	y_2	= 350 mm
	Δ_z	=	350 mm	Δ_y	= 500 mm

scheme 1



Load on rollers

$$P_a = \frac{1800 \bullet 350}{2 \bullet 300} = 1050 \text{ N}$$

$$P_r = \frac{1800}{300} \bullet \left(\frac{350 \tan 40}{2} + 500 \right) = 3881 \text{ N}$$

Nominal life

X = 1 Y = 3,38

Equivalent dynamic load

$$P_{eq} = 1 \bullet 3881 + 3.38 \bullet 1050 = 7430 \text{ N}$$

$$L_{10} = 100 \left(\frac{40750}{7430 \bullet 1} \right)^{10/3} = 29093 \text{ km}$$

Limit load check
Equivalent limit load Fk
K=Pa/Pr=0,27

$$F_k = \frac{11900 \bullet 4250}{0.27 \bullet 11900 + (1 - 0.27 \tan 40) \bullet 4250} = 7780 \text{ N}$$

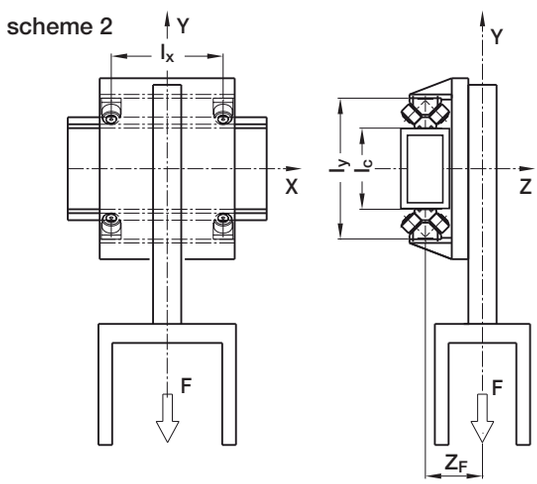
Technical features

Guide roller safety coefficient

$F_k/P_r = 7780 / 3881 = 2$

2) The horizontal axis of a manipulator in steel industry

The centre of gravity of the vertical axis and load is placed in the middle of the horizontal centre-axis lx and 160 mm distance from the guide axis.
The dirty environment and the possibility of shocks lead to the choice to ROLBLOC system.



Guide rollers BL252 are used with guide GU62M
Overload factor fw = 1,4
Centre distance l_x = 350 mm l_y = 400 mm
F = 6000 N x = 0 y = -1000 z_F = 160 mm

Load on rollers
The effective center axis l_c is 400 – 85 –85 = 230 mm

$$P_a = \frac{6000 \bullet 160}{2 \bullet 230} = 2087\ N$$

$$P_r = \frac{6000 \bullet (350+0)}{2 \bullet 350} + \frac{6000 \bullet 160 \tan 45}{2 \bullet 230} = 5087\ N$$

Nominal life

From the ROLBLOC table X=1, Y=1

$P_{eq} = 1 \bullet 2087 + 1 \bullet 5087 = 7174\ N$

$$L_{10} = 100 \left(\frac{59000}{7174 \bullet 1.4} \right)^{10/3} = 36577\ km$$

Limit load check

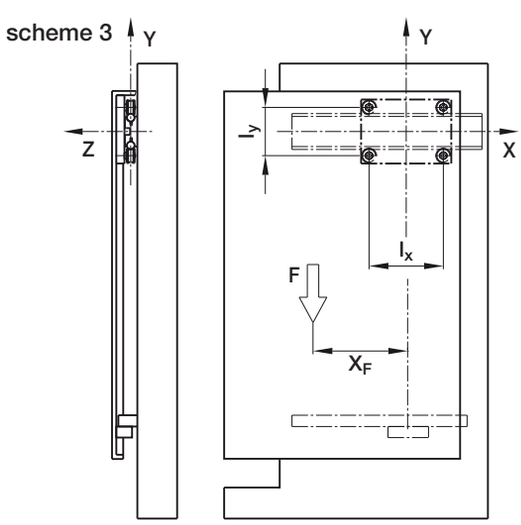
$K=P_a/P_r = 2087/5087 = 0,41$

$$F_k = \frac{16800 \bullet 8400}{0.41 \bullet 16800 + (1 - 0.41 \tan 45) \bullet 8400} = 11915\ N$$

$F_k/P_r = 11915 / 5087 = 2.3$

3) The sliding door of a machine tool (rail on top)

The door is supported by the rail DC type on the upper edge and driven on bottom side by an auto-aligning carriage C3RAL on LM guide rail type. Because of the effect of the bottom rail there isn't any torque applied at the DC rail. The door weight acts in a plane coincident with the roller/rail vertical axis and as such there is no over turning moment. In this case, limit load calculation can be easily carried out from basic data F_r without F_k calculation.
Of course the calculation is always the same.



Guide rail DC18.65 is used with carriage
T4 PFV 3518 250
Overload factor fw = 1,1
Centre distance l_x = 213 mm l_y = 113 mm
F=450 N x=-300 y=-500 z = 0
(because of LM rail) mm

Technical features

Load on rollers
The effective centeraxis l_c is 113 – 35 = 78 mm

$$P_a = \frac{450 \bullet 0}{2 \bullet 78} = 0\,N$$

$$P_r = \frac{450 \bullet (213 + 2 \bullet 300)}{2 \bullet 213} + \frac{450 \bullet 0 \tan 40}{2 \bullet 213} = 859\,N$$

Nominal life

$$L_{10} = 100 \left(\frac{4570}{859 \bullet 1,1}\right)^3 = 11300\ km$$

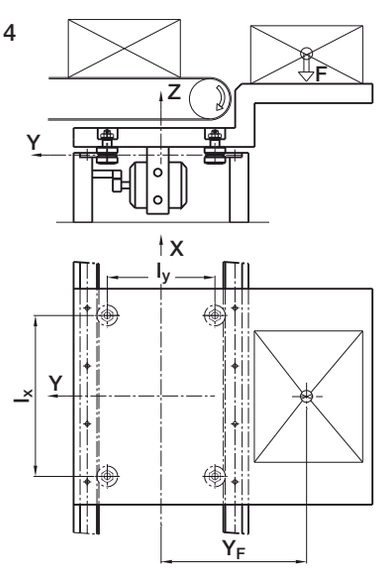
Limit load check

$F_r/P_r = 2120 / 859 = 2,4$

4) Transfer unit

The box weight loads the carriage with max axial load. In this load configuration the limit load check calculation can be easily done directly by the F_a value without F_k calculation.

scheme 4



Guide rollers FRN(R)32EI with rails FSH32M
Overload factor fw = 1,2
Centre distance l_x = 670 mm l_y = 450 mm
F=400 N x=0 y=650 z = 50 mm

Load on rollers
The effective center axis l_c is 450 + 32 = 482 mm

$$P_a = \frac{400}{4} + \frac{400 \bullet 650}{2 \bullet 482} = 370\,N$$

$P_r = 370 \tan 40 = 310\ N$

Nominal Life

$$L_{10r} = 100 \left(\frac{5600}{310 \bullet 1,2}\right)^{10/3} = 840000\ km$$

$$L_{10a} = 100 \left(\frac{2100}{370 \bullet 1,2}\right)^{10/3} = 17760\ km$$

$L_{10} = 17760$ km

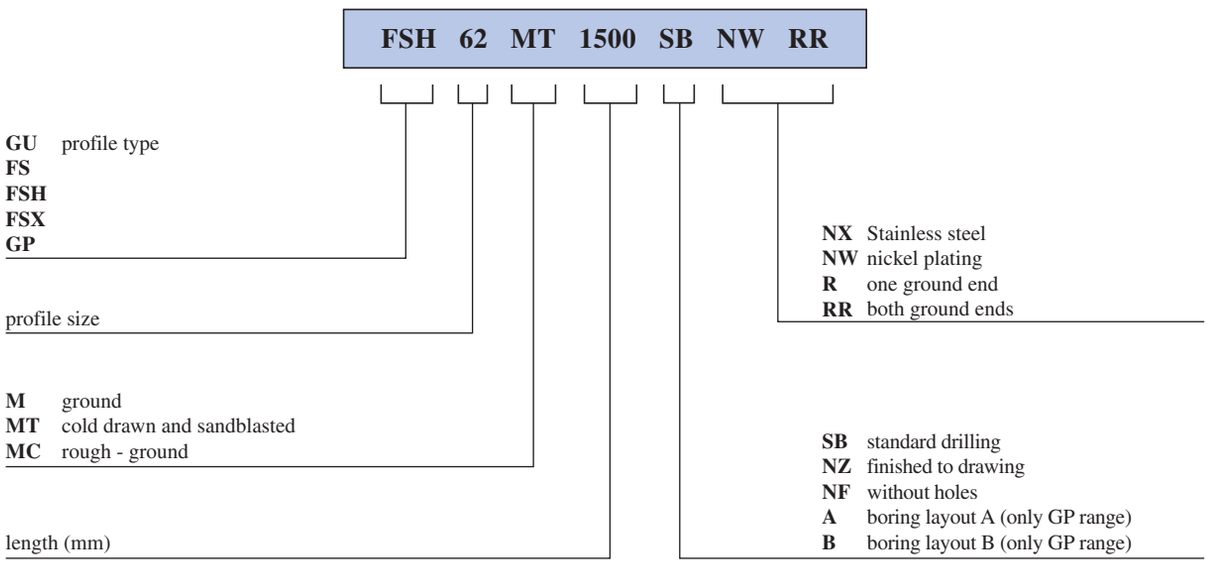
Limit load check

$F_a/P_a = 950 / 370 = 2.5$

For further details, contact the NADELLA Technical Service.

Guide rail order code

Steel rail



Alluminium rail