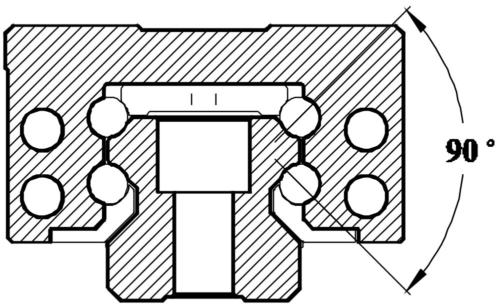
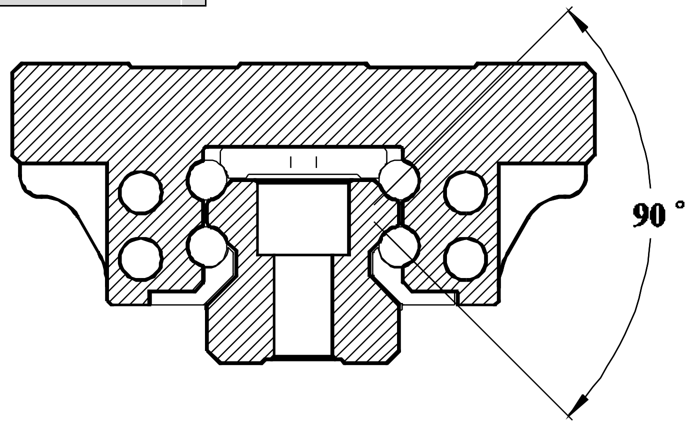
ABBA Linear Ball Rail ---- *BR series*

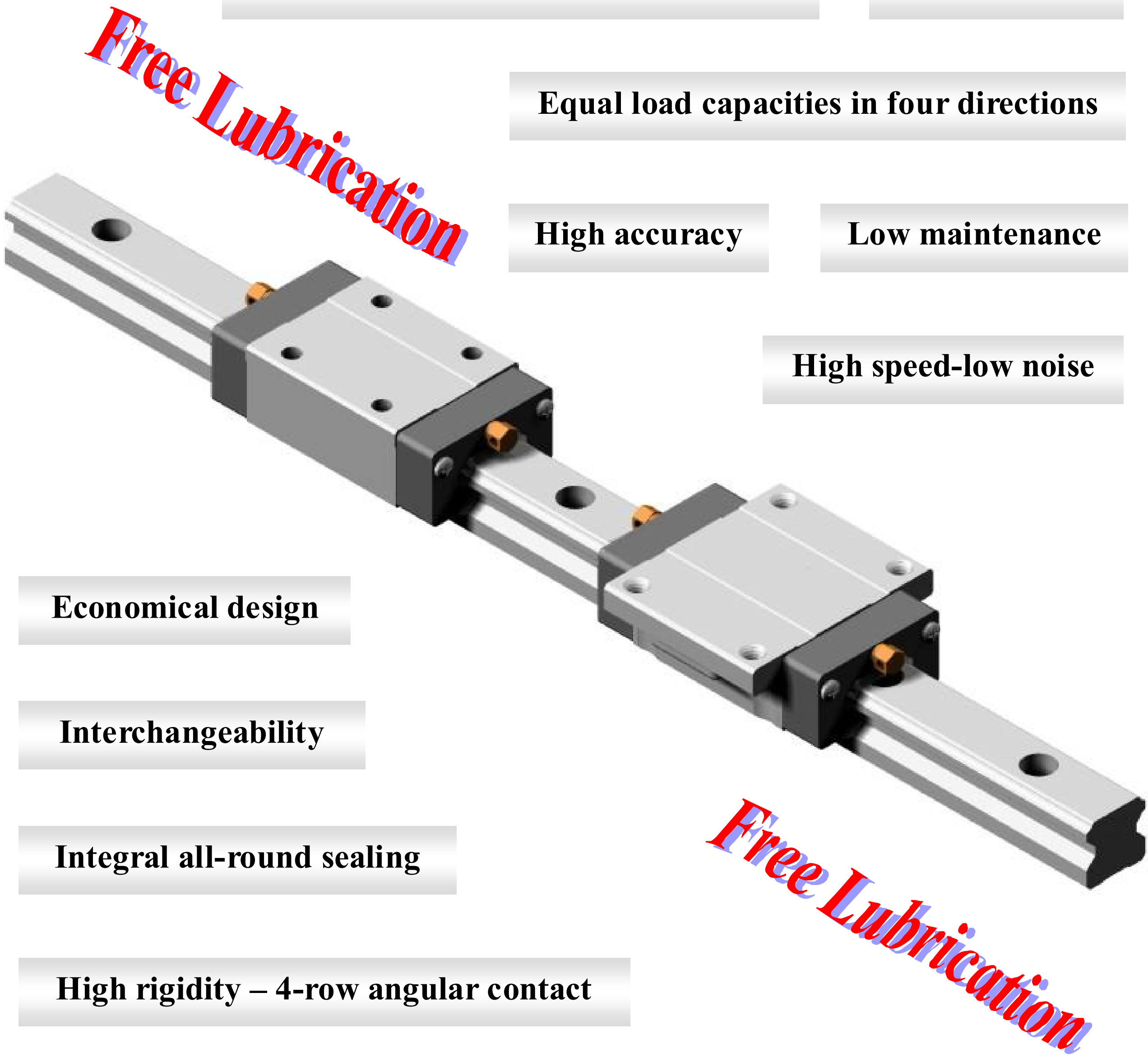
International Standard Dimension Design

Characteristics of ABBA Linear Ball Rail





- **Built-in long life lubrication (patent)**
- **Low friction**
- **Equal load capacities in four directions**
- **High accuracy**
- **Low maintenance**
- **High speed-low noise**



- **Economical design**
- **Interchangeability**
- **Integral all-round sealing**
- **High rigidity – 4-row angular contact**
- **Smooth running due to new ball re-circulation (patent)**

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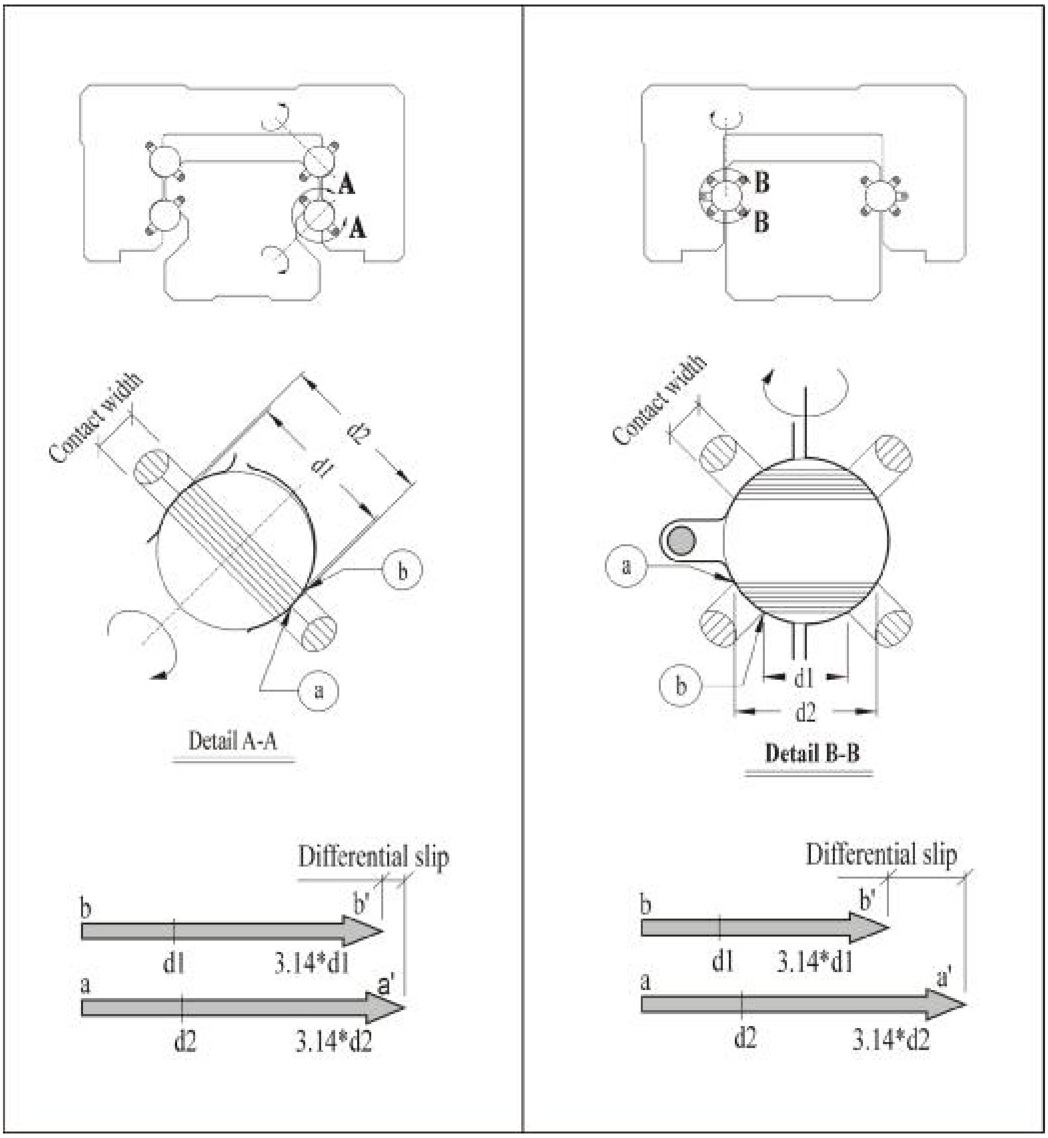
Comparison of ***ABBA*** *4-row circular arc and 2-row Gothic arch*

4-row circular arc contact | **2-row Gothic arch contact**



Comparison :

1. **Light motion** : The circular arc design has **the smaller differential slip** than Gothic arch.
2. **Low installation accuracy** : The circular arc design can achieve **the ideal two-point contact structure**. When balls occur elastic deformation at the contact points, the circular arc design has the better ability of absorbing errors on the installation surfaces without compromising smooth, light motion.
3. **Low frictional resistance** : **Due to the two-point contact structure** for the circular arc design, even when we preload to the intended rigidity, the friction will not significantly increase.
4. **High load rating** : The radius of curvature of the ball rolling track for **the circular arc design is 52 to 53% of the ball diameter and the Gothic arch is 55 to 60%**.

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Unit : mm

GRADE / ITEM	Normal (N)	High (H)	Precision (P)	Super-Precision (SP)	Ultra-Precision (UP)
Tolerance of height (H)	±0.1	±0.04	0 -0.04	0 -0.02	0 -0.01
Tolerance of width (W)	±0.1	±0.04	0 -0.04	0 -0.02	0 -0.01
Difference of heights (△ H)	0.03	0.02	0.01	0.005	0.003
Difference of widths (△ W)	0.03	0.02	0.01	0.005	0.003
Running parallelism of BR Block surface C with respect to surface A	△ C Refer to Fig.4-1				
Running parallelism of BR Block surface D with respect to surface B	△ D Refer to Fig.4-1				

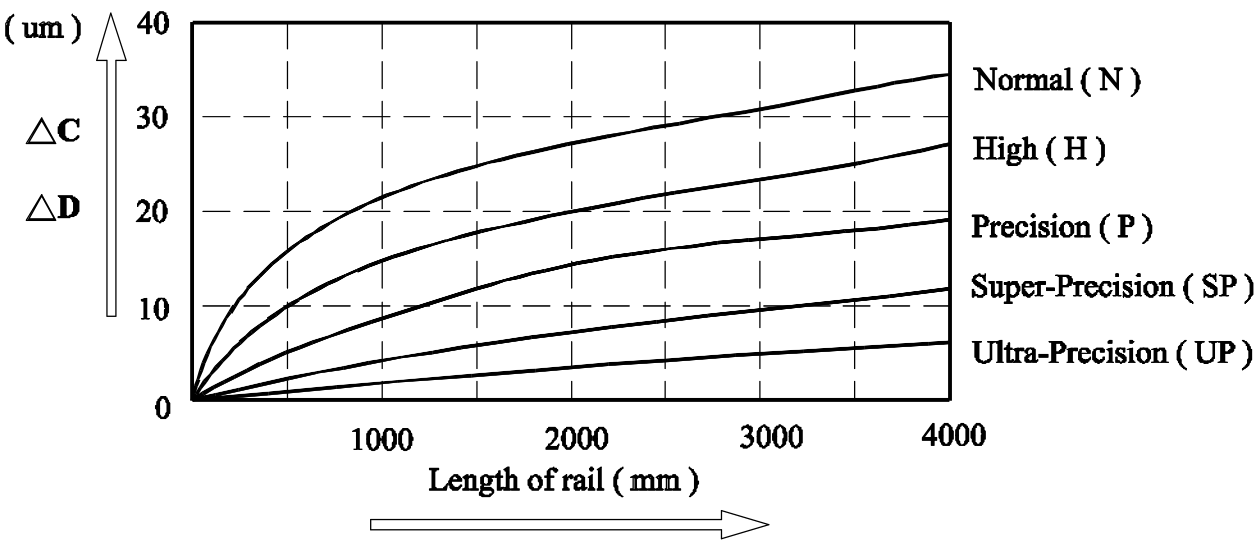

Fig. 4-1 BR rail length and running parallelism

Preload grade

C : Basic dynamic load rating

GRADE \ ITEM	Symbol	Preload force
Clearance	ZF	0
No Preload	Z0	0
Light Preload	Z1	0.02 C
Middle Preload	Z2	0.05 C
Heavy Preload	Z3	0.07 C

Radial clearances

Unit : um

Type \ Symbol	ZF	Z0	Z1	Z2	Z3
BR 15	4 ~ 14	-4 ~ 4	-12 ~ -4	-20 ~ -12	-28 ~ -20
BR 20	5 ~ 15	-5 ~ 5	-14 ~ -5	-23 ~ -14	-32 ~ -23
BR 25	6 ~ 16	-6 ~ 6	-16 ~ -6	-26 ~ -16	-36 ~ -26
BR 30	7 ~ 17	-7 ~ 7	-19 ~ -7	-31 ~ -19	-43 ~ -31
BR 35	8 ~ 18	-8 ~ 8	-22 ~ -8	-35 ~ -22	-48 ~ -35
BR 45	10 ~ 20	-10 ~ 10	-25 ~ -10	-40 ~ -25	-55 ~ -40
BR 55	12 ~ 22	-12 ~ 12	-29 ~ -12	-46 ~ -29	-63 ~ -46

Rigidity of ABBA Linear Ball Rail with Z2 preload

Unit : kgf/um

Type	Rigidity	Type	Rigidity
BR 20	50	**BR 35**	80
BR 25	58	**BR 45**	125
BR 30	66	**BR 55**	190

ABBA Linear Ball Rail ---- *BR series*

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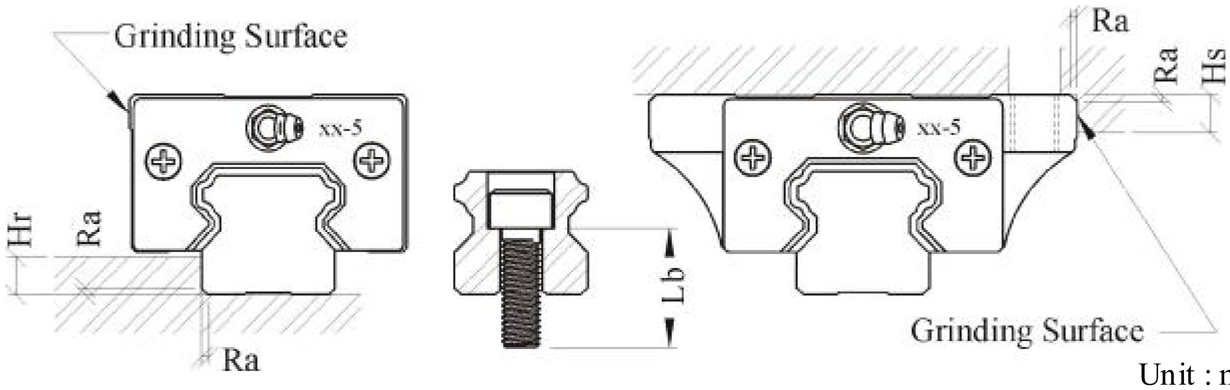
Interchangeable and Non-interchangeable

	Non-interchangeable					Interchangeable	
Accuracy	UP	SP	P	H	N	H	N
Preload	Z1 Z2 Z3	Z1 Z2 Z3	Z0 Z1 Z2 Z3	Z0 Z1 Z2 Z3	Z0 Z1 Z2 Z3	Z0 Z1	ZF Z0 Z1

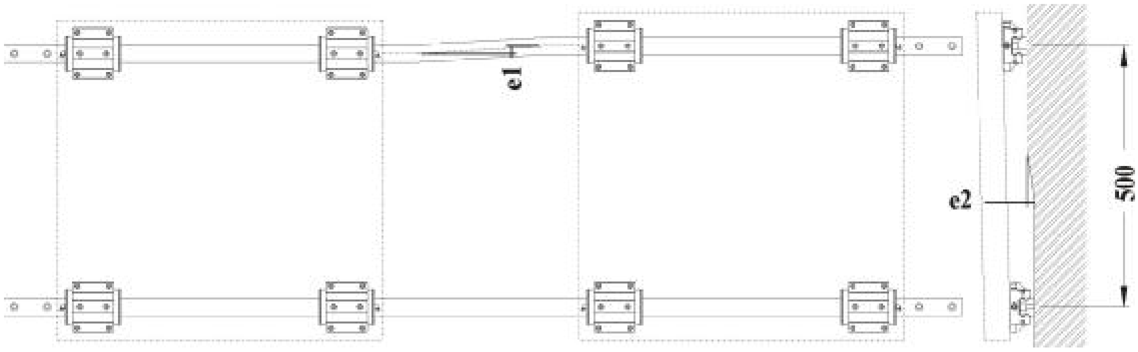
Suggestion in Assembly for ABBA Linear Ball Rail



Unit : mm

ITEM	Maximum Fillet (Ra)	Maximum Height (Hr) rail shoulder	Maximum Height (Hs) block shoulder	Rail Bolt Length (Lb) suggestion
BR 15	0.8	4	5	M4*16
BR 20	0.8	4.5	6	M5*20
BR 25	1.2	6	7	M6*25
BR 30	1.2	8	8	M8*30
BR 35	1.2	8.5	9	M8*30
BR 45	1.6	12	11	M12*40
BR 55	1.6	13	12	M14*45

Permissible tolerances of mounting surfaces



Unit : um

ITEM	Permissible tolerances for parallelism (e1)					Permissible tolerances of two level offset (e2)				
	Z3	Z2	Z1	Z0	ZF	Z3	Z2	Z1	Z0	ZF
BR 15			18	25	35			85	130	190
BR 20		18	20	25	35		50	85	130	190
BR 25	15	20	22	30	42	60	70	85	130	195
BR 30	20	27	30	40	55	80	90	110	170	250
BR 35	22	30	35	50	68	100	120	150	210	290
BR 45	25	35	40	60	85	110	140	170	250	350
BR 55	30	45	50	70	95	125	170	210	300	420

Tightening torque of screw

Unit : kgf*cm

Screw size	Tightening torque	Screw size	Tightening torque
M4	25	**M10**	440
M5	52	**M12**	770
M6	88	**M14**	1240
M8	220	**M16**	2000

Definition of Load and Life

Basic static load rating: **C0**

When a linear motion system in the static state or in motion is subject to an extreme load or impact, a permanent deformation will occur between raceway and rolling elements. If the deformation is excessive, the linear motion system can not travel smoothly.

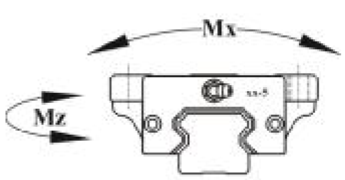
Now, we define the basic static load rating C0 is a static load of constant magnitude acting in one direction under which the sum of the permanent deformations of rolling elements and raceway equals 0.0001 times the diameter of the rolling elements.

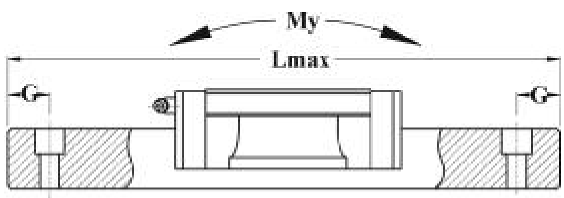
Static permissible moment: M0

When a linear motion system is subject to a moment load, the maximum stress occurs in the rolling elements at both ends. The static permissible moment M0 is a moment of constant magnitude acting in one direction under which the sum of the permanent deformations of rolling elements and raceway equals 0.0001 times the diameter of the rolling elements.

Basic static permissible moment: Mx , My , Mz

In the linear motion system, we define basic static permissible moments Mx, My and Mz are the moments of the static permissible moment M0 in X, Y and Z direction.





Static safety factor: fs

Static safety factor fs is the ratio of the basic static load rating C0 to the load acting on the linear motion system.

$$fs = (fc * C0) / P \quad \text{or} \quad fs = (fc * M0) / M$$

fs : static safety factor — fc : Contact factor

C0 : basic static load rating — M0 : static permissible moment

P : design load — M : design moment

Reference value of static safety factor fs shown below :

Operating condition	Load condition	Minimum fs
Normally stationary	Small impact and deflection	1.0 ~ 1.3
	Impact or twisting load are applied	2.0 ~ 3.0
Normally moving	Small impact or twisting load are applied	1.0 ~ 1.5
	Impact or twisting load are applied	2.5 ~ 5.0

Nominal life: L

The nominal life L is the total distance of travel reached without flaking by 90% of a group of identical linear motion system that are operated independently under the same condition.

Basic dynamic load rating: C

When each of a group of identical linear motion system is applied independently under the same condition, basic dynamic load rating C is the load of constant magnitude acting in one direction that results in a nominal life of 50 km for a system using balls.

Contact factor: fc

In linear motion system, it is hard to obtain uniform load distribution in close contact installation due to moments, errors on the mounting surfaces and other factors. When two or more blocks in a rail are used in close contact, multiply basic load ratings C and C0 by the contact factors shown below.

Number of blocks in close contact	Contact factor
2	0.81
3	0.72
4	0.66
5	0.61
Normal operation	1

Formula of nominal life L

Given the basic dynamic load rating C and applied load P, the following formulas express the nominal life L of a linear motion system using balls.

$$L = \left(\frac{fh*fT*fc}{fw} \times \frac{C}{P} \right)^3 \times 50$$

L : nominal life
C : basic dynamic load rating
P : applied load

fh : Hardness factor
fT : Temperature factor
fc : Contact factor
fw : Load factor

Hardness factor: fh

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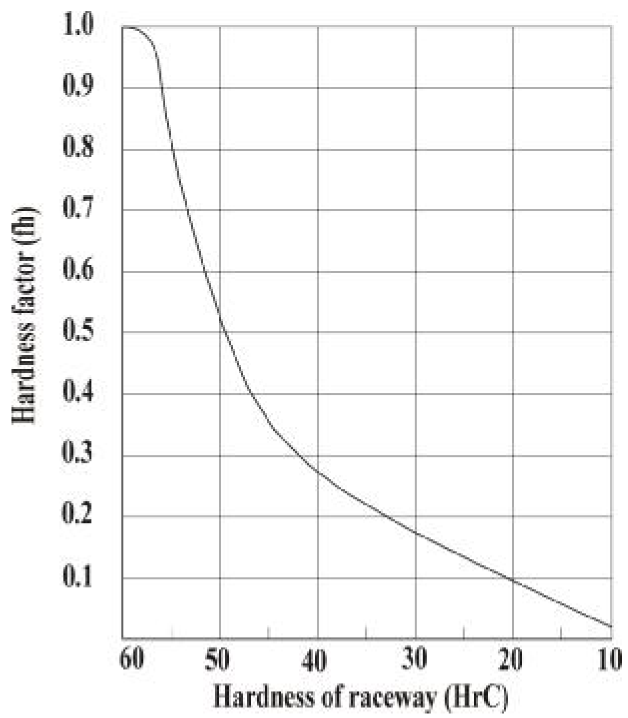
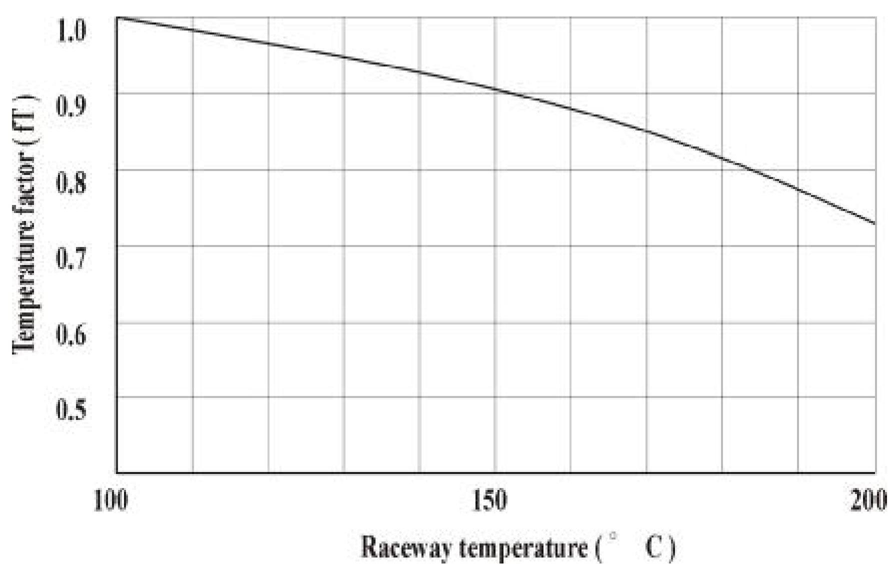
For linear motion system, its optimum load carrying capability is HrC 58 to 64 hardness on the raceways.

If the hardness is lower than HrC 58, both the basic dynamic load rating and basic static load rating should be multiplied by hardness factor fh.



Temperature factor: fT

When a linear motion system is subject to temperature above 100°C, the temperature factor should be taken into consideration.



Note 1: When used in above 80°C, the seals and end plates should be designed for high temperature operation.

Note 2: When used in above 120°C, special treatment should be designed for stabilizing the dimension.

Load factor: fw

Reciprocating motion usually occur vibrations, impacts and variable loads. In general, vibrations occur in high-speed operation, impacts due to repeated starting and stopping and variable loads it is difficult to calculate. When above factor affect the loading conditions significantly, divided basic load ratings C and C0 by the experimentally obtained load factors shown below.

Impacts and vibrations	Speed (V)	Measured vibration (G)	fw
Without external Impacts or Vibrations	At low speed V <= 15 m/min	G <= 0.5	1 ~ 1.5
Without significant Impacts or Vibrations	At medium speed 15 < V <= 60 m/min	0.5 < G <= 1.0	1.5 ~ 2.0
With external Impacts or Vibrations	At high speed V > 60 m/min	1.0 < G <= 2.0	2.0 ~ 3.5

Frictional resistance

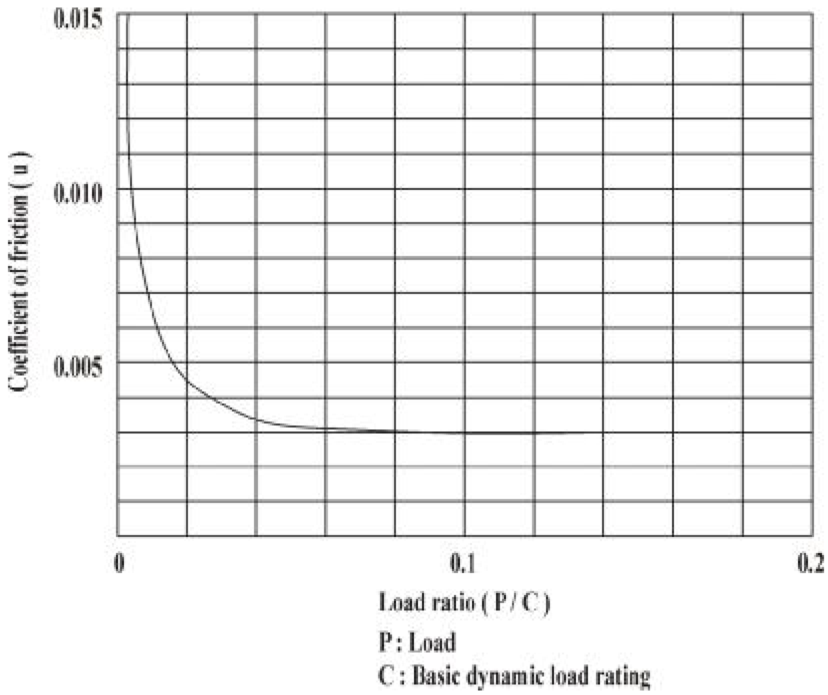
The frictional resistance can be calculated from following formula.

$$F = u * W + f$$

F : frictional resistance W : load

u : coefficient of friction f : seal resistance

Coefficient of friction : u

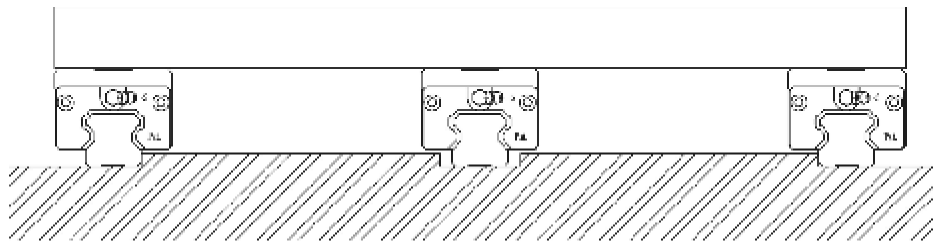


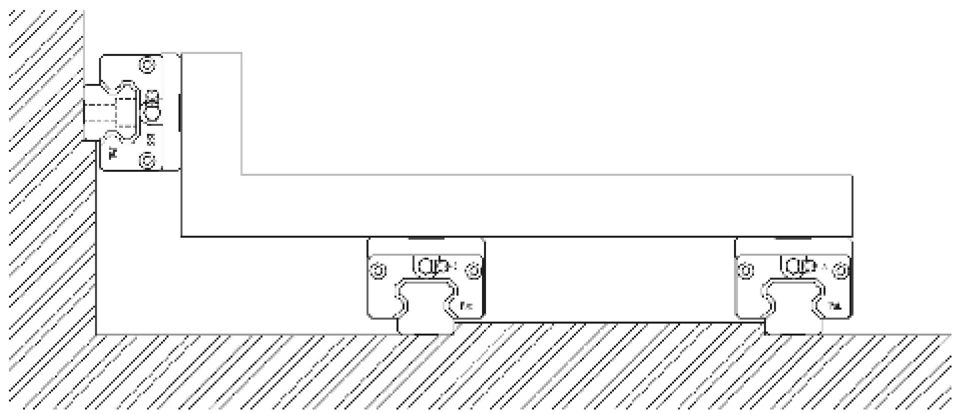
Seal resistance : f

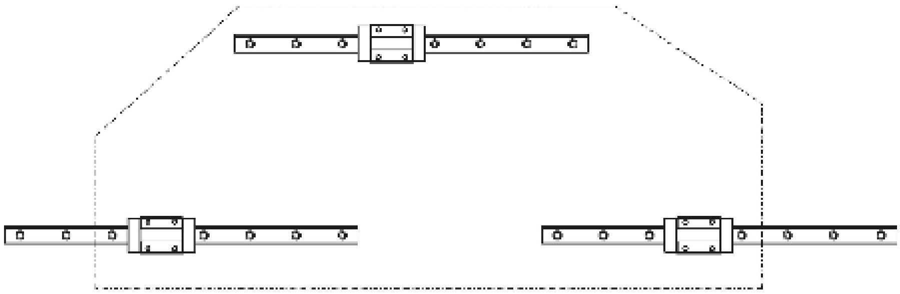
Unit : kgf

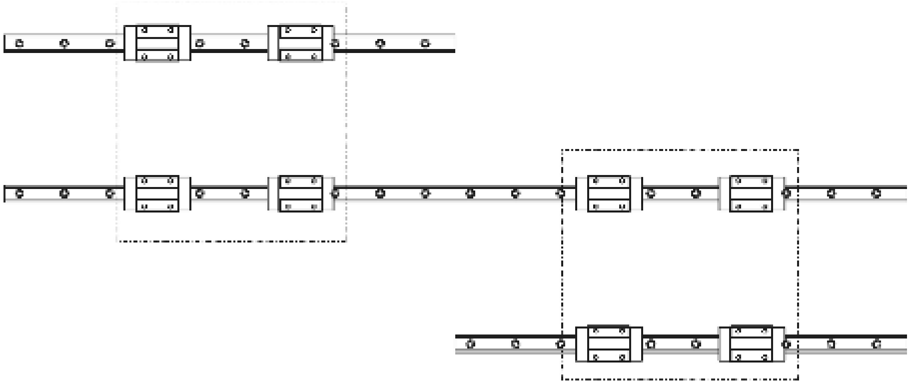
Model No.	resistance	Model No.	resistance
BR 15	0.3	**BR 35**	0.7
BR 20	0.4	**BR 45**	0.9
BR 25	0.4	**BR 55**	1.0
BR 30	0.5		

Mounting orientations

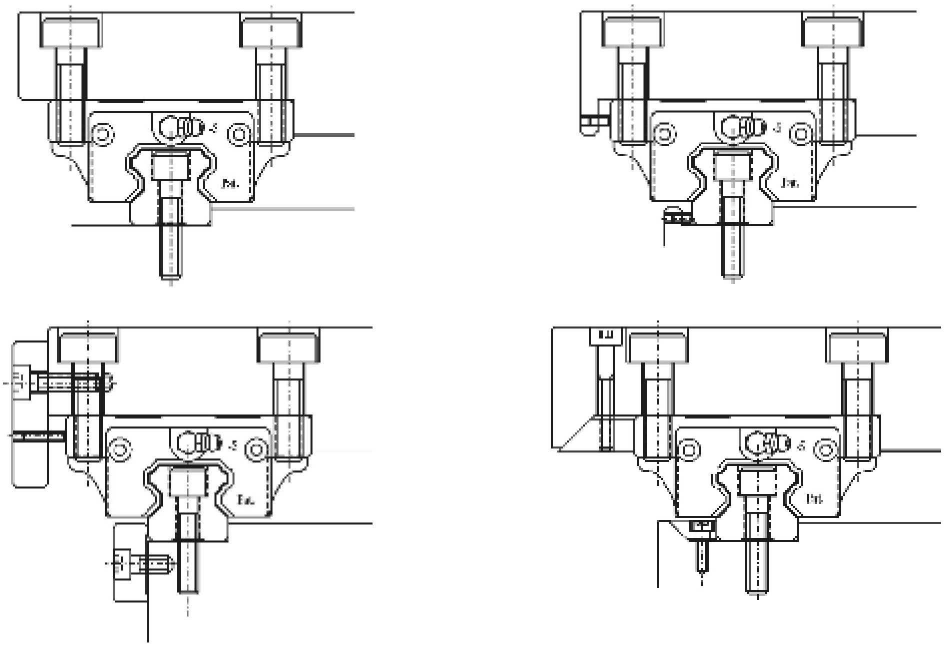








Fixing methods



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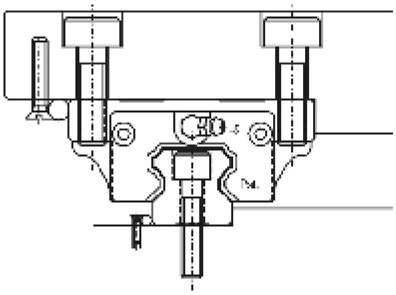
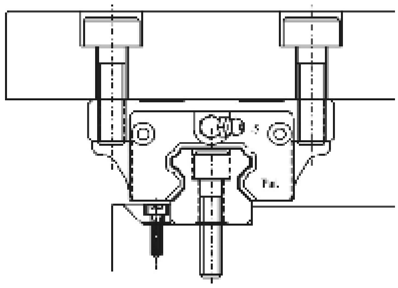
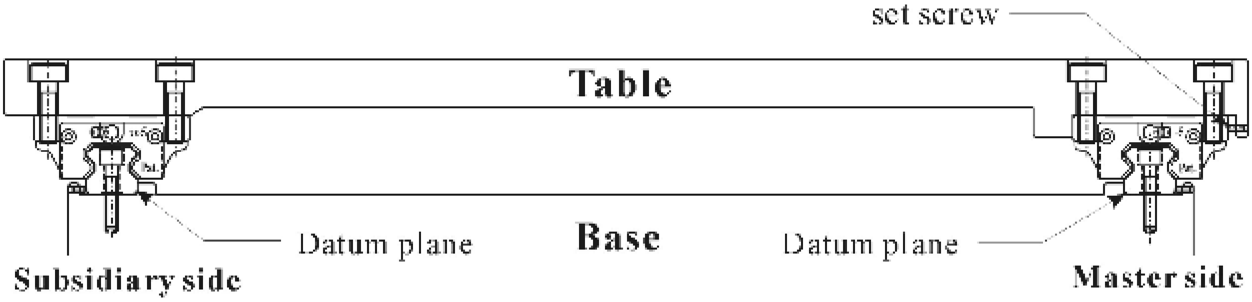




Mounting procedure



Step 1 : Remove dents, burrs and dirt on mounting surfaces.

Step 2 : Place rail against the shoulder of mounting surfaces.

Step 3 : Tighten the mounting bolts lightly.

Note : i . check that holes on rail are aligned with the screw holes on mounting surfaces.

ii . do not tighten a bolt if the holes are not aligned.

Step 4 : Tighten the rail set screws.

Note : i . when tightening the mounting bolts, start with the bolt at the longitudinal center of the rail and move towards both rail ends.

Step 5 : Mount the other rail in the same way.

Step 6 : Install caps in mounting holes.

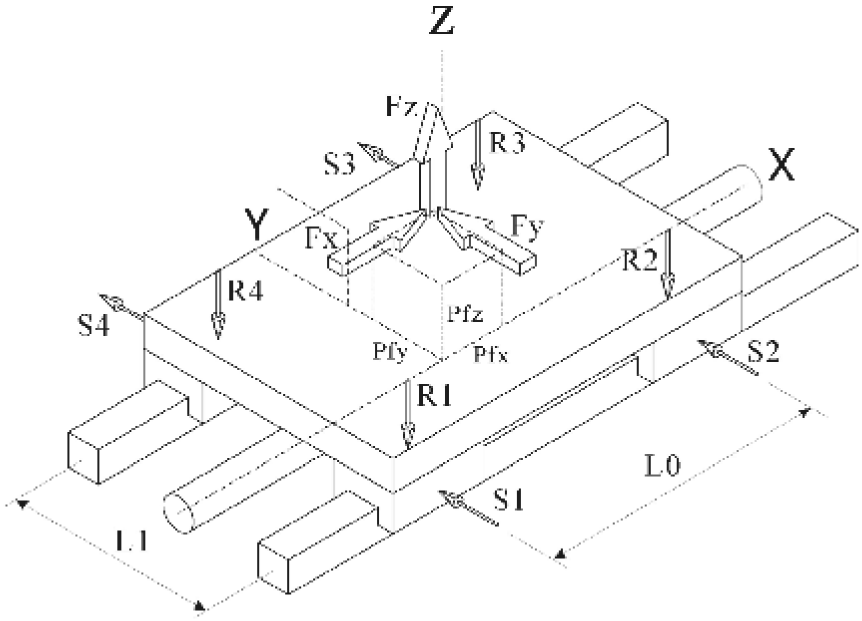
Step 7 : Place the table on the blocks carefully.

Step 8 : Tightening the block set screw to position the table.

Step 9 : Tighten the mounting bolts on the master and subsidiary blocks.

Note : i . Tighten the mounting bolts in the diagonal sequence.

Calculate the applied loads



R1= -Fz/4+(Fz*Pfy-Fy*Pfz)/(2*L1)-(Fx*Pfz-Fz*Pfx)/(2*L0)

R2= -Fz/4+(Fz*Pfy-Fy*Pfz)/(2*L1)+(Fx*Pfz-Fz*Pfx)/(2*L0)

R3= -Fz/4-(Fz*Pfy-Fy*Pfz)/(2*L1)+(Fx*Pfz-Fz*Pfx)/(2*L0)

R4= -Fz/4-(Fz*Pfy-Fy*Pfz)/(2*L1)-(Fx*Pfz-Fz*Pfx)/(2*L0)

S1= Fy/4+(Fy*Pfx-Fx*Pfy)/(2*L0) **S2= Fy/4-(Fy*Pfx-Fx*Pfy)/(2*L0)**

S3= Fy/4-(Fy*Pfx-Fx*Pfy)/(2*L0) **S4= Fy/4+(Fy*Pfx-Fx*Pfy)/(2*L0)**

▿ **X= (R2-R1)*(Pfz)/(L0*Kr)+(S2-S1)*(Pfy)/(L0*Ks)**

▿ **Y= (R2-R3)*(Pfz)/(L1*Kr)+(S2-S1)*(Pfx)/(L0*Ks)-(S2+S1)/(2*Ks)**

▿ **Z= (R2+R4)/(2*Kr)+(R1-R2)*(Pfx)/(L0*Pfy)/(L1*Kr)**

User input data :

Fx : Load in X direction (- or +) kgf **Fy : Load in Y direction (- or +) kgf**

Fz : Load in Z direction (- or +) kgf **Pfx : Positon in X direction (- or +) mm**

Pfy : Positon in Y direction (- or +) mm **Pfz : Positon in Z direction (- or +) mm**

L0 : Distance in blocks (mm) **L1 : Distance in rails (mm)**

The applied loads for BR Linear Motion System (kgf) :

R1 : Radial load for Block No1. (- or +) **R2 : Radial load for Block No2. (- or +)**

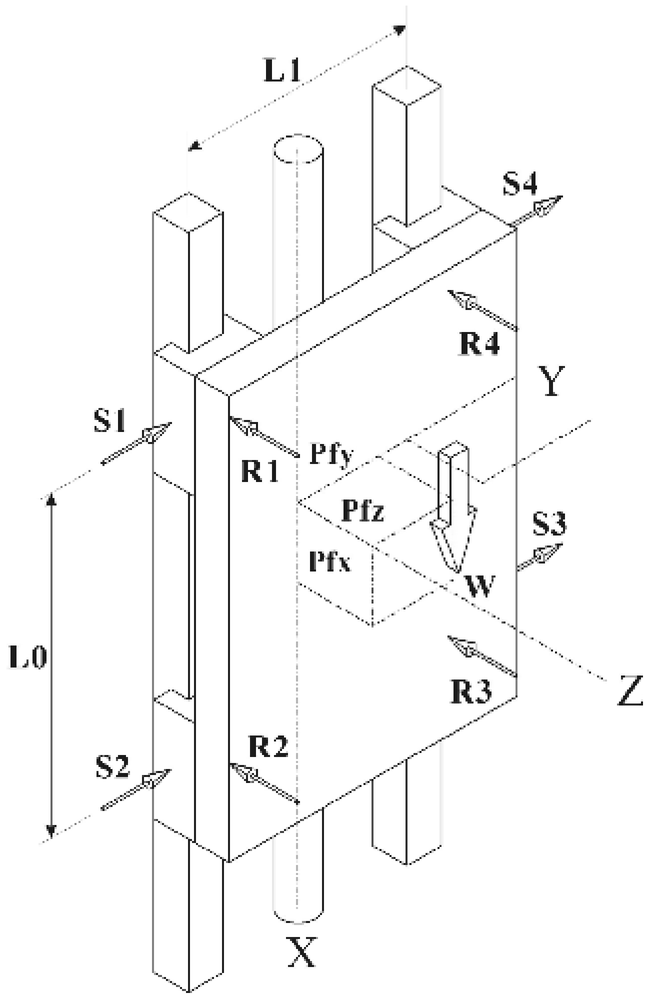
R3 : Radial load for Block No3. (- or +)
R4 : Radial load for Block No4. (- or +)
S1 : Lateral load for Block No1. (- or +)
S2 : Lateral load for Block No2. (- or +)
S3 : Lateral load for Block No3. (- or +)
S4 : Lateral load for Block No4. (- or +)

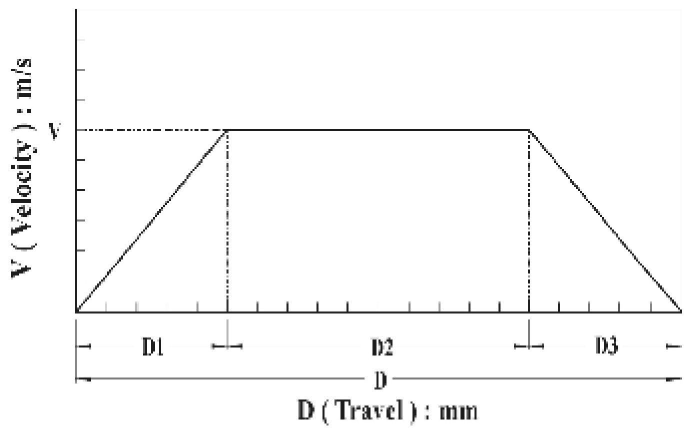
Deformation (mm) for applied loads :

Kr : Stiffness in Radial direction (kgf/um)
Ks : Stiffness in Lateral direction (kgf/um)

- **▿ X: Deflection in X direction (- or +) mm**
- **▿ Y: Deflection in Y direction (- or +) mm**
- **▿ Z: Deflection in Z direction (- or +) mm**

Example 1 :





This case is divided into three sections.

Section 1 : it is subject to

⇨ W(weight) and ---------------- Fx(W)
(W/g)*A(acceleration) -------- Fx(A)

Section 2 : we are subject to

⇨ W(weight) --------------------- Fx(W)

Section 3 : we are subject to

⇨ W(weight) and ---------------- Fx(W)

(W/g)*(-A)(deceleration) ----- Fx(-A)

User input data :

V*V = V0*V0 + 2*A*D1 => A = (V*V – V0*V0)/(2*D1)

D1 = 1000 mm   D2 = 2000 mm   D3 = 1000 mm

V = 1 m/s   V0 = 0 m/s   => (A) = 0.5 m/s^2 for acceleration

V = 0 m/s   V0 = 1 m/s   => (-A) = -0.5 m/s^2 for deceleration

Fx(W) = 98 kgf   Fy(W) = 0   Fz(W) = 0

Fx(A) = (98/9.8)*0.5 = 5kgf   Fy(A) = 0   Fz(A) = 0

Fx(-A) = (98/9.8)*(-0.5) = -5kgf   Fy(-A) = 0   Fz(-A) = 0

Pfx = 80 mm   Pfy = 250 mm   Pfz = 280 mm

L0 = 300 mm   L1 = 500 mm   fw = 1.5

Calculation applied loads :

R1(W) = -Fx(W)*Pfz/(2*L0) = -45.73 kgf   S1(W) = -Fx(W)*Pfy/(2*L0) = -40.83 kgf

R2(W) = Fx(W)*Pfz/(2*L0) = 45.73 kgf   S2(W) = Fx(W)*Pfy/(2*L0) = 40.83 kgf

R3(W) = Fx(W)*Pfz/(2*L0) = 45.73 kgf   S3(W) = Fx(W)*Pfy/(2*L0) = 40.83 kgf

R4(W) = -Fx(W)*Pfz/(2*L0) = -45.73 kgf   S4(W) = -Fx(W)*Pfy/(2*L0) = -40.83 kgf

R1(A) = -Fx(A)*Pfz/(2*L0)= -2.33 kgf   S1(A) = -Fx(A)*Pfy/(2*L0) = -2.08 kgf

R2(A) = Fx(A)*Pfz/(2*L0) = 2.33 kgf   S2(A) = Fx(A)*Pfy/(2*L0) = 2.08 kgf

R3(A) = Fx(A)*Pfz/(2*L0) = 2.33 kgf   S3(A) = Fx(A)*Pfy/(2*L0) = 2.08 kgf

R4(A) = -Fx(A)*Pfz/(2*L0) = -2.33 kgf   S4(A) = -Fx(A)*Pfy/(2*L0) = -2.08 kgf

R1(-A) = -Fx(-A)*Pfz/(2*L0) = 2.33 kgf   S1(-A) = -Fx(-A)*Pfy/(2*L0) = 2.08 kgf

R2(-A) = Fx(-A)*Pfz/(2*L0) = -2.33 kgf   S2(-A) = Fx(-A)*Pfy/(2*L0) = -2.08 kgf

R3(-A) = Fx(-A)*Pfz/(2*L0) = -2.33 kgf   S3(-A) = Fx(-A)*Pfy/(2*L0) = -2.08 kgf

R4(-A) = -Fx(-A)*Pfz/(2*L0) = 2.33 kgf   S4(-A) = -Fx(-A)*Pfy/(2*L0) = 2.08 kgf

The applied load – section 1 :

R1(1) = R1(W)+R1(A) = -48.06 kgf **S1(1) = S1(W)+S1(A) = -42.91 kgf**
R2(1) = R2(W)+R2(A) = 48.06 kgf **S2(1) = S2(W)+S2(A) = 42.91 kgf**
R3(1) = R3(W)+R3(A) = 48.06 kgf **S3(1) = S3(W)+S3(A) = 42.91 kgf**
R4(1) = R4(W)+R1(A) = -48.06 kgf **S4(1) = S4(W)+S4(A) = -42.91 kgf**

The applied load – section 2 :

R1(2) = R1(W) = -45.73 kgf **S1(2) = S1(W) = -40.83 kgf**
R2(2) = R2(W) = 45.73 kgf **S2(2) = S2(W) = 40.83 kgf**
R3(2) = R3(W) = 45.73 kgf **S3(2) = S3(W) = 40.83 kgf**
R4(2) = R4(W) = -45.73 kgf **S4(2) = S4(W) = -40.83 kgf**

The applied load – section 3 :

R1(3) = R1(W)+R1(-A) = -43.4 kgf **S1(3) = S1(W)+S1(-A) = -38.75 kgf**
R2(3) = R2(W)+R2(-A) = 43.4 kgf **S2(3) = S2(W)+S2(-A) = 38.75 kgf**
R3(3) = R3(W)+R3(-A) = 43.4 kgf **S3(3) = S3(W)+S3(-A) = 38.75 kgf**
R4(3) = R4(W)+R1(-A) = -43.4 kgf **S4(3) = S4(W)+S4(-A) = -38.75 kgf**

Calculate the single equivalent load

When a radial load (Rn) and lateral load (Sn) are exerted simultaneously,the single equivalent load is expressed by the following equation for BR linear motion system.

Re = Rn + Sn

The single equivalent load – section 1 : **R11,R21,R31 & R41**

R11 = | R1(1) | + | S1(1) | = 90.97 kgf **R21 = | R2(1) | + | S2(1) | = 90.97 kgf**
R31 = | R3(1) | + | S3(1) | = 90.97 kgf **R41 = | R4(1) | + | S4(1) | = 90.97 kgf**

The single equivalent load – section 2 : **R12,R22,R32 & R42**

R12 = | R1(2) | + | S1(2) | = 86.56 kgf **R22 = | R2(2) | + | S2(2) | = 86.56 kgf**
R32 = | R3(2) | + | S3(2) | = 86.56 kgf **R42 = | R4(2) | + | S4(2) | = 86.56 kgf**

The single equivalent load – section 3 : **R13,R23,R33 & R43**

R13 = | R1(3) | + | S1(3) | = 82.15 kgf **R23 = | R2(3) | + | S2(3) | = 82.15 kgf**
R33 = | R3(3) | + | S3(3) | = 82.15 kgf **R43 = | R4(3) | + | S4(3) | = 82.15 kgf**

Calculate the mean load

We must calculate the mean value of the varying load to evaluate the life of BR linear motion system.

Step loads

$$Pm = [(P1^n xL1+P2^n xL2\ldots.. +Pn^n xLn)/L]^{1/n}$$

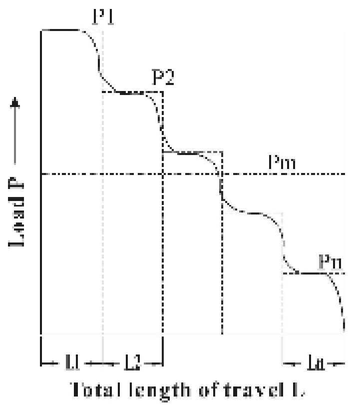
Pm : Mean load (kgf)

Pn : Varying load (kgf)

L : Total length of travel (mm)

Ln : Length of travel carrying Pn (mm)

n = 3 when the rolling elements are balls.

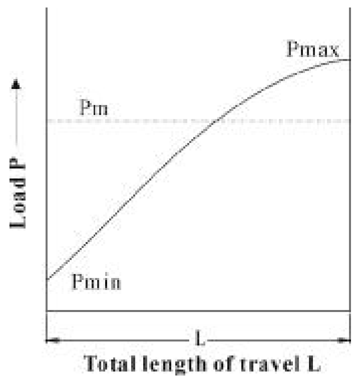


Loads that vary linearly

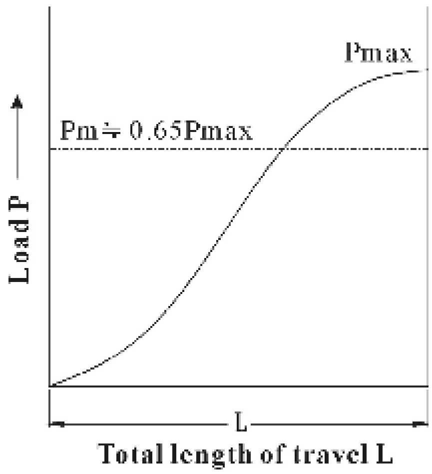
$$Pm \fallingdotseq (Pmin+2xPmax)/3$$

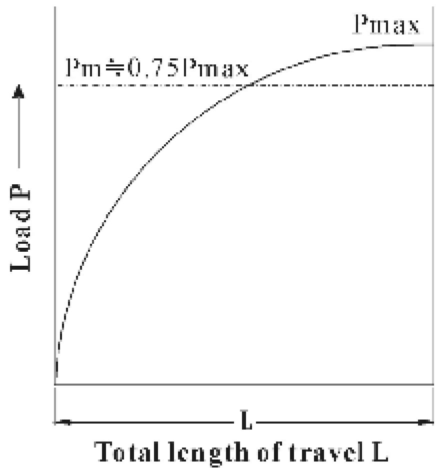
Pmim : Minimum load (kgf)

Pmax : Maximum load (kgf)



Loads varying sinusoidally





Now we calculate the mean loads of example 1. (step load type) : **R1,R2,R3 & R4**

$R1 = [(R11^3 x1000+R12^3 x2000+R13^3 x1000)/4000]^{1/3} = 86.7$ kgf

$R2 = [(R21^3 x1000+R22^3 x2000+R23^3 x1000)/4000]^{1/3} = 86.7$ kgf

$R3 = [(R31^3 x1000+R32^3 x2000+R33^3 x1000)/4000]^{1/3} = 86.7$ kgf

$R4 = [(R41^3 x1000+R42^3 x2000+R43^3 x1000)/4000]^{1/3} = 86.7$ kgf

Calculate nominal life L

$$L = \left(\frac{fh*fT*fc}{fw} \text{ X } \frac{C}{P} \right)^3 \text{x } 50 \quad \text{km}$$

BR linear motion system of use : **BRH20A 2 L4000 NZ0 => C = 1450 kgf C0 = 2560 kgf**

Given : **(P : the mean load)**

fh = 1 fT = 1 fc = 1 & fw = 1.5

$L1 = [C/(R1xfw)]^3$ x 50 = 69351.5 km **$L2 = [C/(R2xfw)]^3$ x 50 = 69351.5 km**

$L3 = [C/(R3xfw)]^3$ x 50 = 69351.5 km **$L4 = [C/(R4xfw)]^3$ x 50 = 69351.5 km**

calculate static safety factor fs

fs = (fc * C0) / P = 2560/R11 = 28.14

(P : Maximum single equivalent load = R11 or R21 or R31 or R41)