400 Series Profile Rail Linear Guides

Transport grade ball profile rail system

Technical Manual

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FEATURES and BENEFITS

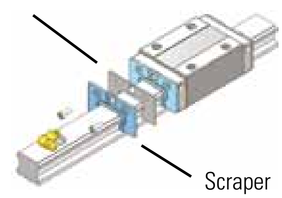
The 400 Series Profile Rail Linear Guide is the newest addition to the Thomson Linear Guide product line. The 400 Series is a cost effective, transport grade Profile Rail solution for cost-sensitive applications, and is a drop-in replacement with industry-standard envelope and hole patterns. Double-faced ball track bearing arrangements provide compliance during installation as well as equal load carrying capacity in all directions. Caged and non-caged carriages utilize the same rail design. This enables efficient use of inventory, as only one rail type needs to be stocked for either carriage type.

400 Series Ball/Caged Ball Assortment

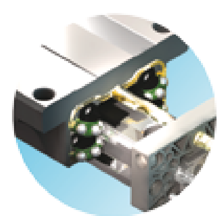
Width		Standard		Narrow				
Length			Long		Long		Long	Short
Height						High	High	
Designator		A	B	C	D	E	F	G
SIZE MM	15	•	•	•	•	•		•
	20	•	•	•		•	•	•
	25	•	•	•	•	•	•	•
	30	•	•	•	•	•	•	•
	35	•	•	•	•	•	•	•
	45	•	•	•	•	•	•	

Low Noise and Vibration
Polymer ball-return tube reduces noise while retaining lubrication.

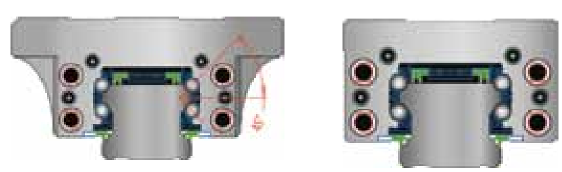
Modular Accessory Options
Standard double lip end and longitudinal seals retain lubrication while protecting the bearing from contamination. Additional seals and scrapers available.



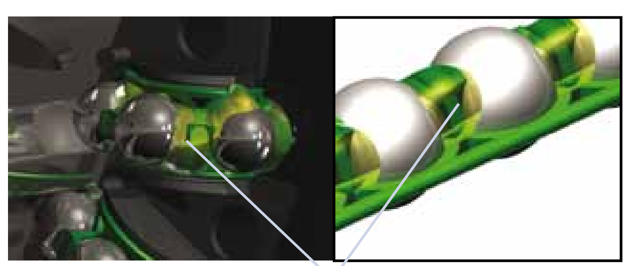
Lubrication Channels
Channels direct lubricant to individual ball tracks to maximize lubrication effectiveness



Double-Faced Ball Tracks
The 400 Series Linear Guide utilizes a 45°, face-to-face bearing arrangement, resulting in equal load-carrying capacity in all directions. The primary advantage of face-to-face configuration is that the rails are much more tolerant of mounting surface inaccuracies. This enables automation machine builders to reduce cost further by not having to prepare super-accurate mounting surfaces



400 Series Ball Cage
The 413 ball cage option provides:
- Increased running smoothness
- Low noise at high speeds
- Individual ball lubricant reservoirs



I. TERMS OF LINEAR GUIDE

1-1 Major factors:

a. Load and Life (L)

When choosing a linear guides, one has to consider the following variables to calculate a reliable static safety factor:

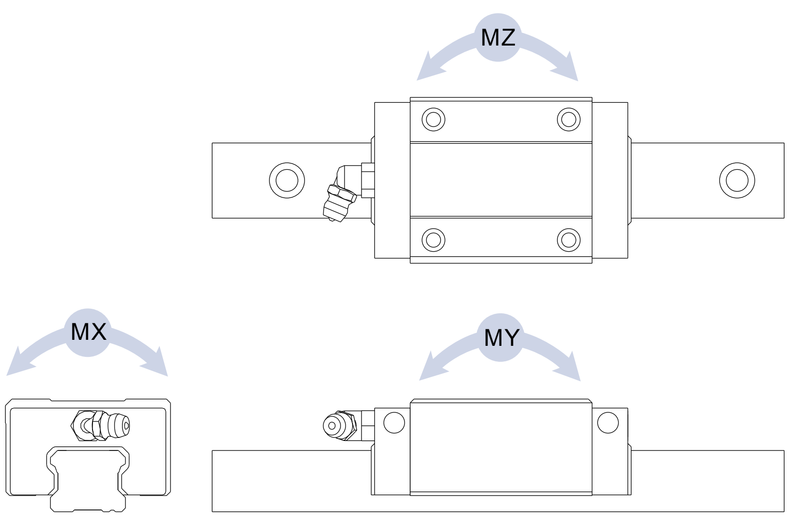
- average applied load from each direction
- basic static nominal load (C0)
- basic permissible static moment (Mx, My, Mz).

b. Basic static load rating (C0)

When a linear motion system is subjected to extreme or impact loading, permanent deformation will occur between the bearing races and rolling elements. If the deformation is excessive, the linear motion system cannot travel smoothly. The basic static nominal load (C0) is defined as the static load of a constant magnitude acting in one direction which results in a total permanent deformation of the rolling elements and races equal to 0.0001 times the diameter of the rolling elements.

c. Basic permissible static moment (Mx, My, Mz)

The basic permissible static moment directions are shown below. Mx designates loading in the roll direction, My for pitch, and Mz for yaw.



d. Static safety factor(fs)

The static safety factor indicates the ratio of Basic static nominal load(C0) to the load acting on the linear motion sytem.

$$f_s = \frac{fc \cdot C0}{P} \qquad f_s = \frac{fc \cdot M0}{M}$$

fs : Static safety factor
CO : Basic static load rating
P : Design load
fc : Contact factor
MO : Permissible static moment
M : Design moment

Recommended Static safety factor (fs) values are 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

e. Nominal life (L)

The nominal life L is the minimum distance of travel achieved by the bearing with 90% reliability under conventional operating conditions.

f. Basic dynamic load rating (C)

The basic dynamic load rating, C, is the applied load that will yield the rated travel life.

1-2 Subsidiary factors:

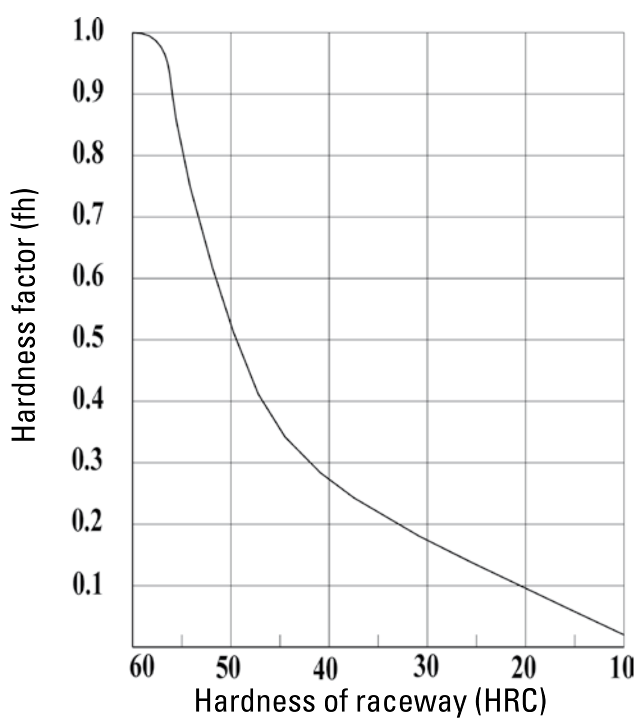
a. Contact factor(fc)

It is difficult to obtain uniform load distribution between adjacent carriages due to moment loads, errors in the mounting surfaces, and other factors. When two or more carriages on a rail are used in close contact, multiply the basic load ratings C and C0 by the contact factors shown below.

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

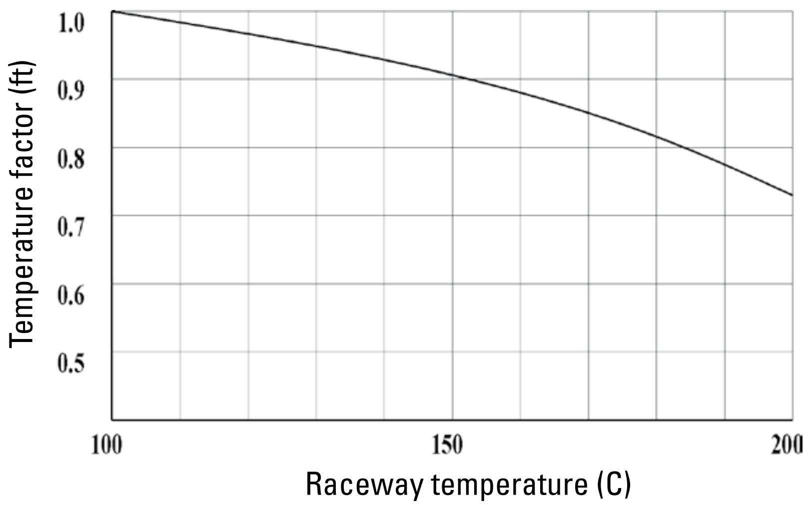
b. Hardness factor (fh)

Bearing races that are not hardened to a minimum of 60 HRC must apply the hardness factor fh.



c. Temperature factor (ft)

When working environment temperature exceeds 100°C, ft becomes a key factor.



Note: 400 Series carriages are limited to a maximum operating temperature of 80°C

d. Load factor (fw)

Reciprocating motion often incurs vibrations, impacts and variable loads. Typically, vibrations occur in high speed operation, while impacts are due to repeated starting and stopping of motion. These loads can be difficult to calculate. When these factors affect the loading conditions significantly, the basic load ratings C and C0 are divided 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/mn	$1.0 < G <= 2.0$	2.0 - 3.5

1-3 Life calculation:

Given the Basic Dynamic Load Rating C, and design load P, the bearing life is calculated with the following formula:

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

L: Nominal life(km)

The nominal life L is the minimum distance of travel achieved by the bearing with 90% reliability under conventional operating conditions.

C:	Basic nominal dynamic load	P:	Design load
fh:	Hardness factor	ft:	Temperature factor
fc:	Contact factor	fw:	Load factor

Life Ln in hours is calculated using the nominal life, stroke, and duty cycle

$$Ln = \frac{L \cdot 10^6}{2 \cdot Ls \cdot N1 \cdot 60}$$

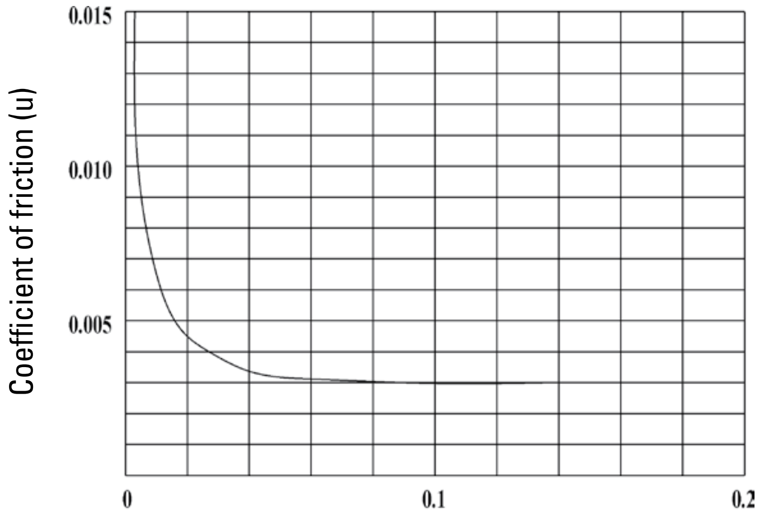
Ln = Life (hr)
$N1$ = Duty cycle (strokes per minute)
Ls = Stroke (mm)

1-4 Friction resistence

A profile rail linear guide is composed of a carriage, rail, and rolling elements (either balls or rollers). During motion, sliding occurs between these components, resulting in friction resistance, as shown below:

Friction can be calculated by:
F = u * W + f

F : Friction resistance
W : Load
u : Coefficient of friction
f : Block seals resistance

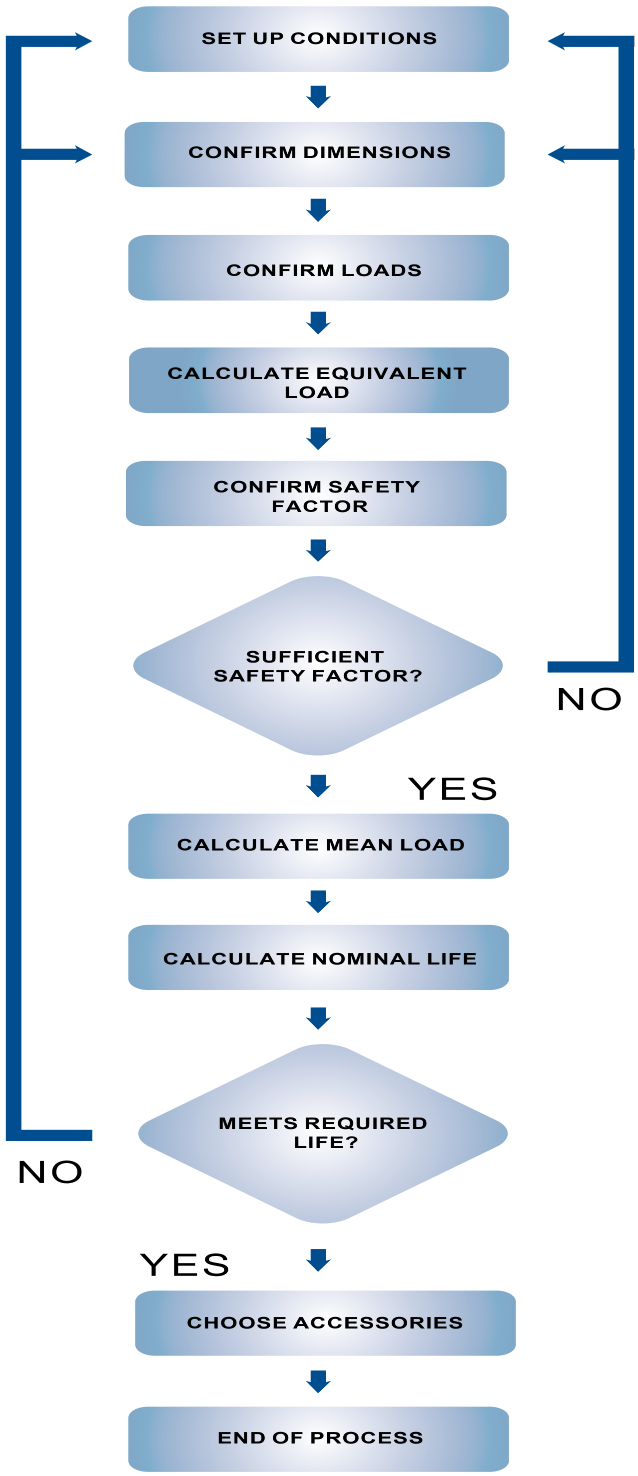


Load ratio (P/C)
P: Load
C: Basic dynamic load rating

Model No.	resistance	Model No.	resistance
411-15	0.3	413-15	0.45
411-20	0.4	413-20	0.6
411-25	0.45	413-25	0.7
411-30	0.7	413-30	0.9
411-35	1.0	413-35	1.2

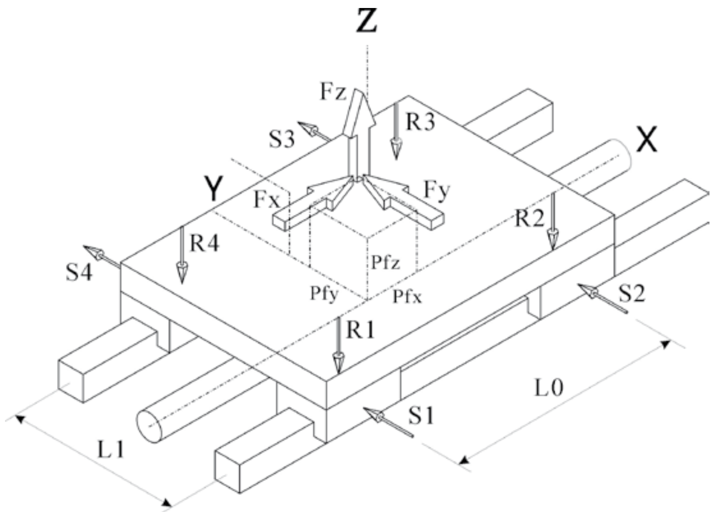
II. APPLICATION OF 400 SERIES LINEAR GUIDE

2-1 Application Flow Chart



2-2 Confirming conditions

The following parameters must be determined when selecting the proper profile rail linear guide:
A. Assembly: distance between rails and carriages, number of rail and carriages
B. Orientation: horizontal, vertical, slanted, wall mount, upside down
C. Applied load
D. Frequency of use



a. Assembly:

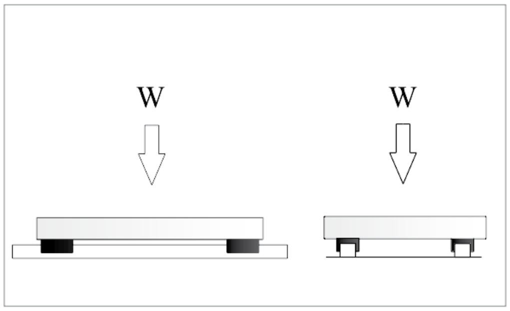
1. Distance between carriages and rail (L0 & L1 as shown)
   L0: Distance between two carriages on the same rail (mm)
   L1: Distance between rails (mm)
   As the aspect ratio L1/L0 increases, system stiffness is reduced

2. Number of carriages: typically, the more carriages used on a rail, the better the rigidity and the higher the load capacity. However, careful installation is required to ensure equal loading, and the effect on overall stroke must be considered.

3. Number of rails: increasing the number of rails can also improve rigidity and load, however constant parallelism must be maintained

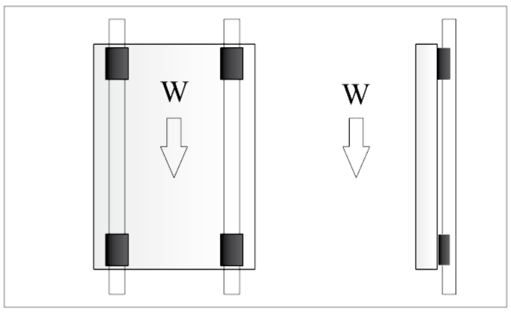
b. Installation

1.Horizontal Orientation



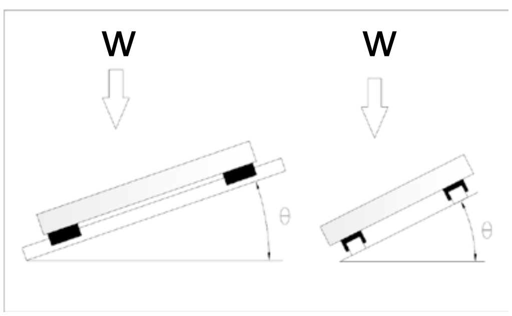
Horizontal Orientation
(W: load in direction of compression)
- The most common linear guide orientation
- Application: positioning or feeding
- W is vertical to the table mounting on the blocks
- W is vertical to direction of system movement

2.Vertical Orientation



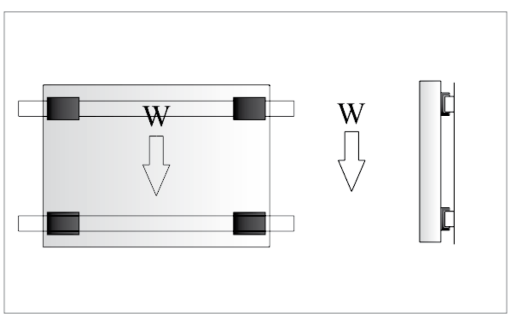
Vertical Orientation
(W: load in direction of compression)
- Application: elevating device
- W is parallel to working table
- W is parallel to direction of system moving

3.Slanting Orientation



Slanting Orientation
(W: load in direction of compression)
- Side slanting: W is vertical to direction of system moving
- Front slanting: Angle θ between W and direction of movement。

4.Wall Orientation



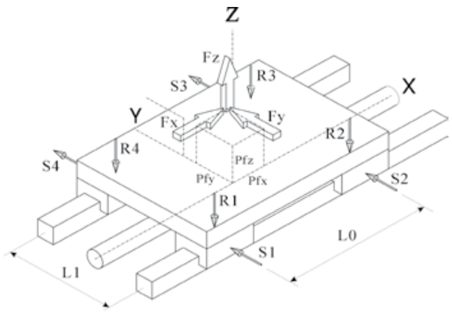
Wall Orientation
(W: load in direction of compression)
- Distance between 2 rails has to be considered
- W is parallel to working table.
- W is vertical to direction of system moving

c. Applied load

Loading contains 3 elements: force, direction of load, and the object subjected to load.

1. Force:
   Weight: system inertia must be considered when in motion
   Outer force: additional forces can be applied to the system, and have no inertia

2. Direction of load:
   The load direction can be divided into 3 segments:
   Fx, Fy, Fz (see figure)

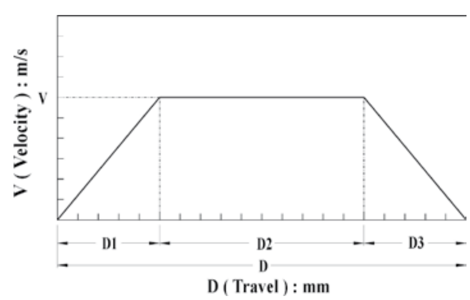


3. Position of load:
   Pfx, Pfy and Pfz are defined as the distance from the applied load to the system center

4. Distance between 2 carriages / rails:
   L0 & L1, as shown

5. V/D figure:
   Velocity (V): maximum speed
   Distance (D): linear guide stroke
   (D1): distance from static maximum speed
   (D2): distance at equivalent speed
   (D3): distance from maximum speed to static

6. Forces on carriages:
   R1, R2, R3, R4 - forces in vertical directions
   S1, S2, S3, S4 - forces in horizontal directions



d. Frequency of use:

Frequency of use should be considered when calculating the required system life.

Example 1: A system with a calculated life of 1000 km, operating at 1km/day, can operate for 1000 days

Example 2: A system with a calculated life of 5000 km, operating at 500km/day, can operate for 100 days

2-3 Selecting an optimal model

a. 411 or 413

411 ball carriages should be specified for most general use, while 413 ball chain carriages provide lower noise and higher running smoothness

b. 15, 20, 25, 30, 35, 45

Carriage size should be chosen based on loading and life requirements

2-4 Calculating applied load:

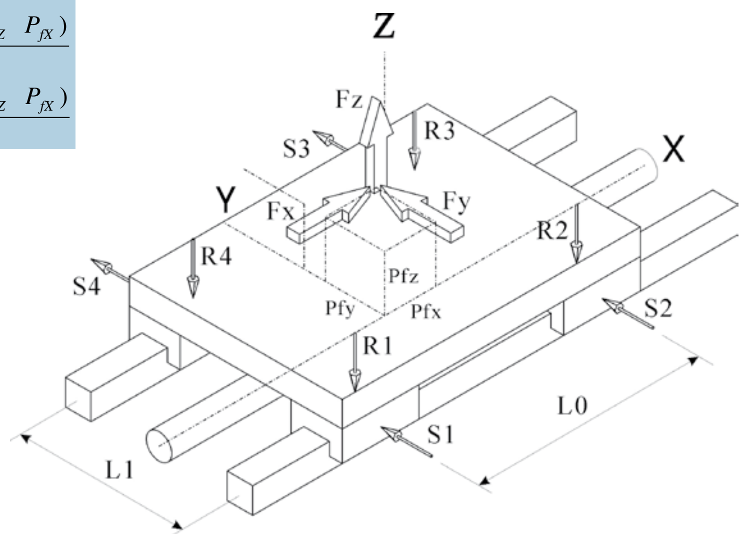
Carriage vertical load equations:

$$R_1 = \frac{-F_Z}{4} + \frac{(F_Z \; P_{fy} - F_Y \; P_{fz})}{2 \; L1} - \frac{(F_X \; P_{fZ} - F_Z \; P_{fX})}{2 \; L0}$$

$$R_2 = \frac{-F_Z}{4} + \frac{(F_Z \; P_{fy} - F_Y \; P_{fz})}{2 \; L1} + \frac{(F_X \; P_{fZ} - F_Z \; P_{fX})}{2 \; L0}$$

$$R_3 = \frac{-F_Z}{4} - \frac{(F_Z \; P_{fy} - F_Y \; P_{fz})}{2 \; L1} + \frac{(F_X \; P_{fZ} - F_Z \; P_{fX})}{2 \; L0}$$

$$R_4 = \frac{-F_Z}{4} - \frac{(F_Z \; P_{fy} - F_Y \; P_{fz})}{2 \; L1} - \frac{(F_X \; P_{fZ} - F_Z \; P_{fX})}{2 \; L0}$$



Carriage horizontal load equations:

$$S_1 = \frac{F_Y}{4} + \frac{(F_Y \; P_{fX} - F_X \; P_{fY})}{2 \; L0}$$

$$S_2 = \frac{F_Y}{4} - \frac{(F_Y \; P_{fX} - F_X \; P_{fY})}{2 \; L0}$$

$$S_3 = \frac{F_Y}{4} - \frac{(F_Y \; P_{fX} - F_X \; P_{fY})}{2 \; L0}$$

$$S_4 = \frac{F_Y}{4} + \frac{(F_Y \; P_{fX} - F_X \; P_{fY})}{2 \; L0}$$

2-5 Calculation of equivalent load

An equivalent load is used to consolidate applied load components into one value which can be used to calculate the minimum required load rating and the expected life of the carriage selected.

$F_{EQ} = R_n + S_n$

F_{EQ} = Equivalent load
R_n = Vertical component of applied load
S_n = Horizontal components of applied load

2-6 Confirming static safety factor

Calculating fs with static load rating:

$$fs = \frac{fc \cdot CO}{F_{EQ}}$$

Calculating fs with permissible static moment:

$$fs = \frac{fc \cdot MO}{M}$$

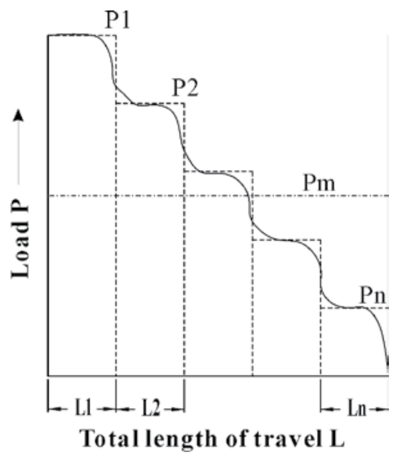
2-7 Calculating mean load

Calculation of changing mean load can be diversified into the following models:

STEP LOAD:

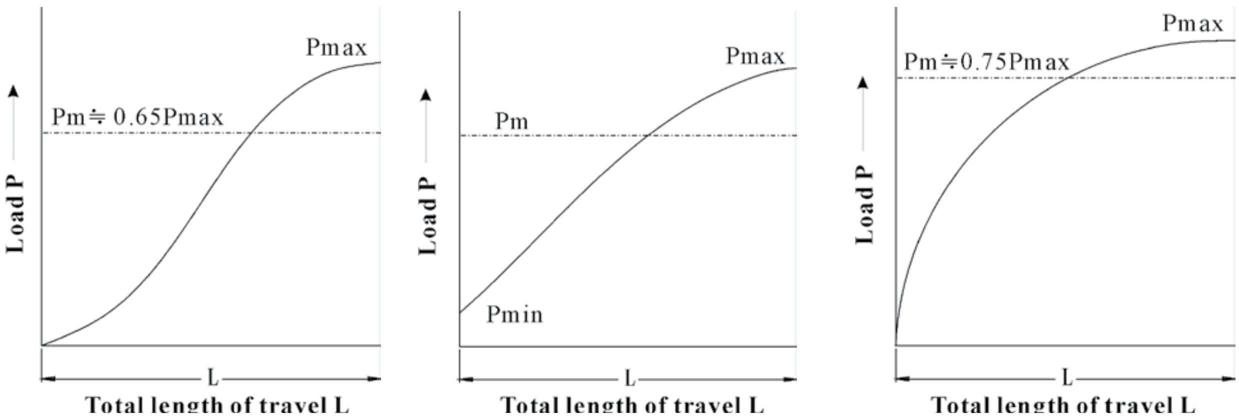
$$P_m = [\frac{(P1^n \cdot L1 + P2^n \cdot L2 .....Pn^n \cdot Ln)}{L}]^{\frac{1}{n}}$$

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.



Linear pattern of load:

Pm≒(Pmin+2xPmax)/3
Pmim:Minimum load(kgf)
Pmax:Maximum load(kgf)



2-8 Calculating nominal life:

Equation: $$L = \left(\frac{fh \cdot fT \cdot fc}{fw} \cdot \frac{C}{P} \right)^3 \cdot 50km$$

L: Nominal Life(km)
C: Basic dynamic rating load (kgf)
P: Calculated average load (kgf)
fc: Contact factor
fh: Hardness factor
ft: Temperature factor
fw: Load factor

2-9 Calculating life time:

Formula A: calculating in hours

Ln:Lifetime(h)
L:Nominal life(km)
Ls:Distance of travel(mm)
N1:Duty cycle (strokes per minute)

Formula A:

$$Ln = \frac{L \cdot 10^6}{2 \cdot Ls \cdot N1 \cdot 60}$$

Formula B: calculating in years

Ly:Lifetime(year)
L:Nominal life(km)
Ls:Distance of travel(mm)
N1:Duty cycle (strokes per minute)
M:Minutes of operation per hour(min/hr)
H:Hours of operation per day(hr/day)
D:Days of operation per year(day/year)

Formula B:

$$Ly = \frac{L \cdot 10^6}{2 \cdot Ls \cdot N1 \cdot M \cdot H \cdot D}$$

Example 1: A system using 400 Series linear guides has a nominal life of 45000 km. What is its life in hours?
Known:
Ls:Distance of travel= 3000mm
N1:4 strokes per minute

$$Ln = \frac{L \cdot 10^6}{2 \cdot Ls \cdot N1 \cdot 60} = \frac{45000 \cdot 10^6}{2 \cdot 3000 \cdot 4 \cdot 60} = 31250\,\text{hr}$$

2-10 Comparing with desired life

If the calculated life does not meet the desired life, return to the beginning of the flow chart:

1. Confirm conditions
2. Select the optimal model

1. Reconfirming the conditions of use:

   Evaluate the linear guide system assembly, including the number of rails and carriages, and spacing between components

2. Selecting another model:

   When the system assembly cannot be changed, a different linear guide size or type must be selected. If a larger size cannot be used, consider changing the carriage type, for example from standard to long. Contact Thomson when technical assistance is required.

Ball Carriage

STANDARD: 4 1 1 N 15 A 0 — **OPTIONS:** D WZ ES1 SM

- 4 — 400 Series Profile Carriage
- 1 — Product Type
  - 1 Carriage
- 1 — Type
  - 1 Ball
  - 3 Ball Cage
- N — Accuracy Class
  - N Normal Grade
  - H High Grade
- 15 — Size
  - 15, 20, 25, 30, 35, 45
- A — Carriage Style
  - A Standard
  - B Standard Long
  - C Narrow
  - D Narrow Long
  - E Narrow High
  - F Narrow Long High
  - G Narrow Short
  - K Narrow Compact
- 0 — Preload
  - 0 Clearance
  - 1 Approximately 0.03 C
- D — Corrosion-resistant Option
  - D Hard Chrome Plating
- WZ — Accessories
  - W Additional Rubber Wiper
  - Z Metal Scraper
- ES1 — Extended Standards - Options
  - ES1 6mm Dowel Hole - Slip Fit
  - ES2 10mm Dowel Hole - Slip Fit
  - ES3 1/4" Dowel Hole - Slip Fit
  - ES4 3/8" Dowel Hole - Slip Fit
  - ES12 (2) 6mm Dowel Holes - Press Fit
  - ES13 (2) 10mm Dowel Holes - Press Fit
  - ES14 (2) 1/4" Dowel Holes - Press Fit
  - ES15 (2) 3/8" Dowel Holes - Press Fit
  - G1 Greased with Mobilux® EP2
  - G2 Greased with Krytox® GPL227
  - GS Greased per customer specification
- SM — Specials
  - SM Special per customer print

1. Carriage does not retain ball bearings when end cap is removed. Removal of end caps can result in loss of ball bearings.
2. Carriage dynamic load ratings based on a travel life of 50 km.

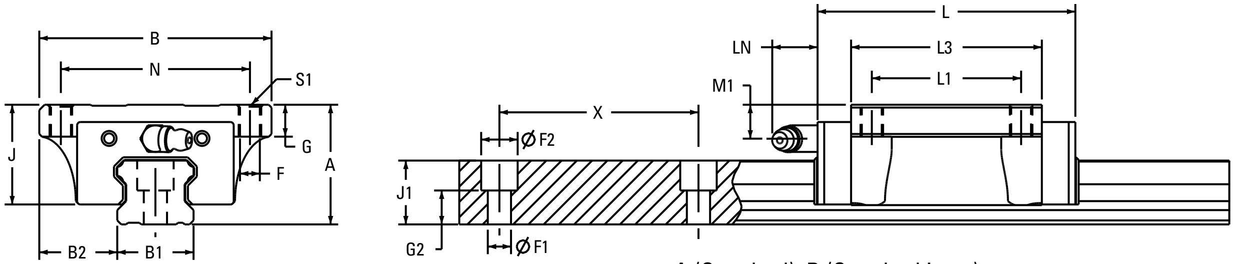
Ball Rail

STANDARD: 4 2 1 N 15 A D — **OPTIONS:** DH1 SM — **STANDARD:** +xxxx Y= (see note 1)

- 4 — 400 Series Profile Rail
- 2 — Product Type
  - 2 Rail
- 1 — Type
  - 1 Ball
- N — Accuracy Class
  - N Normal Grade
  - H High Grade
- 15 — Size
  - 15, 20, 25, 30, 35, 45
- A — Rail Style
  - A Standard
  - U Bolt up from Bottom
- D — Corrosion-resistant option
  - D Hard Chrome Plating
- DH1 — Machined Options
  - DH1 6mm Dowel Hole + Slot
  - DH2 10mm Dowel Hole + Slot
  - DH3 1/4" Dowel Hole + Slot
  - DH4 3/8" Dowel Hole + Slot
  - JT[3] Butt Joint
- SM — Specials
  - SM Special Per Customer Print
- +xxxx — Length (mm)
  - xxxx Customer Specified Length
  - RL4000 Stock Length[2]

1. Y = Distance from end of rail to center of first mounting hole, Y1 = Y2 unless specified.
2. Stock length of rails are considered random length, total length may exceed specified length, and Y1/Y2 are not equal. To be used only by customer who will cut to length.
3. Customer drawing required at time of quote and order.

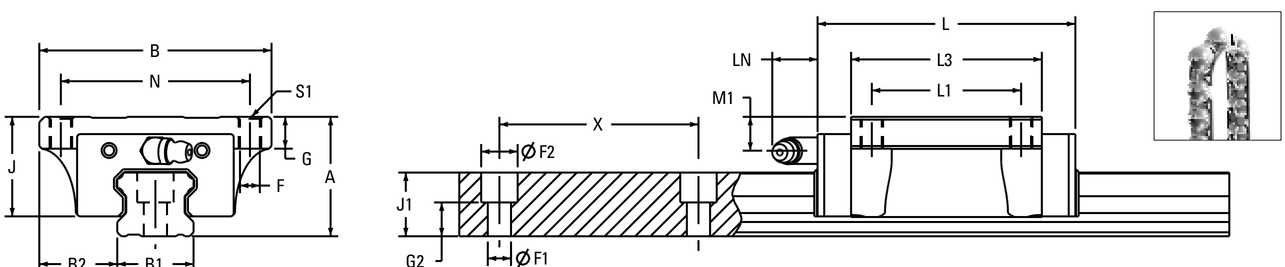
400 Series Specifications



A (Standard), B (Standard Long)

411 Standard

Item	Assembly [mm]				Carriage [mm]										Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	F	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1	F2	G2	C [N]	C0 [N]	[kg]	[kg/m]
411N15A0	24	47	16.0	21.0	58.6	38	30	M5	4.4	8.0	40.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.21	1.28
411N15B0	24	47	16.0	21.0	66.1	38	30	M5	4.4	8.0	47.7	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	11,300	23,700	0.23	1.28
411N20A0	30	63	21.5	25.5	69.3	53	40	M6	5.4	9.0	48.5	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.40	2.15
411N20B0	30	63	21.5	25.5	82.1	53	40	M6	5.4	9.0	61.3	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	18,600	39,500	0.46	2.15
411N25A0	36	70	23.5	30.2	79.7	57	45	M8	7.0	10.0	57.5	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,100	0.57	2.88
411N25B0	36	70	23.5	30.2	94.4	57	45	M8	7.0	10.0	72.2	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	10.2	25,900	52,800	0.72	2.88
411N30A0	42	90	31.0	35.0	94.8	72	52	M10	8.6	11.0	67.8	M6 X 1.0	8	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	1.10	4.45
411N30B0	42	90	31.0	35.0	105.0	72	52	M10	8.6	11.0	78.0	M6 X 1.0	8	(15.6)	28	22.8	80	9.0	14.0	10.8	38,500	70,700	1.34	4.45
411N35A0	48	100	33.0	40.5	111.5	82	62	M10	8.6	12.0	80.5	M6 X 1.0	8	(16.0)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.50	6.25
411N35B0	48	100	33.0	40.5	123.5	82	62	M10	8.6	12.0	92.5	M6 X 1.0	8	(16.0)	34	26.0	80	9.0	14.0	14.0	52,900	101,400	1.90	6.25
411N45A0	60	120	37.5	51.1	129.0	100	80	M12	10.6	15.5	94.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	2.27	9.60
411N45B0	60	120	37.5	51.1	145.0	100	80	M12	10.6	15.5	110.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	69,000	129,500	2.68	9.60

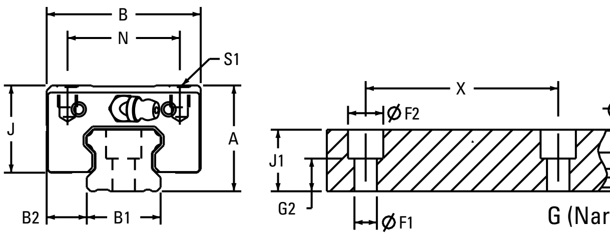


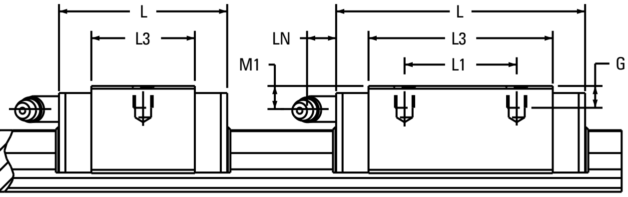
A (Standard), B (Standard Long)

413 Standard (Caged)

Item	Assembly [mm]				Carriage [mm]										Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	F	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1	F2	G2	C [N]	C0 [N]	[kg]	[kg/m]
413N15A0	24	47	16.0	21.0	58.6	38	30	M5	4.4	8.0	40.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.21	1.28
413N15B0	24	47	16.0	21.0	66.1	38	30	M5	4.4	8.0	47.7	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	11,300	23,700	0.23	1.28
413N20A0	30	63	21.5	25.5	69.3	53	40	M6	5.4	9.0	48.5	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.40	2.15
413N20B0	30	63	21.5	25.5	82.1	53	40	M6	5.4	9.0	61.3	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	18,600	39,500	0.46	2.15
413N25A0	36	70	23.5	30.2	79.7	57	45	M8	7.0	10.0	57.5	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,100	0.57	2.88
413N25B0	36	70	23.5	30.2	94.4	57	45	M8	7.0	10.0	72.2	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	10.2	25,900	52,800	0.72	2.88
413N30A0	42	90	31.0	35.0	94.8	72	52	M10	8.6	11.0	67.8	M6 X 1.0	8	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	1.10	4.45
413N30B0	42	90	31.0	35.0	105.0	72	52	M10	8.6	11.0	78.0	M6 X 1.0	8	(15.6)	28	22.8	80	9.0	14.0	10.8	38,500	70,700	1.34	4.45
413N35A0	48	100	33.0	40.5	111.5	82	62	M10	8.6	12.0	80.5	M6 X 1.0	8	(16.0)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.50	6.25
413N35B0	48	100	33.0	40.5	123.5	82	62	M10	8.6	12.0	92.5	M6 X 1.0	8	(16.0)	34	26.0	80	9.0	14.0	14.0	52,900	101,400	1.90	6.25
413N45A0	60	120	37.5	51.1	129.0	100	80	M12	10.6	15.5	94.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	2.27	9.60
413N45B0	60	120	37.5	51.1	145.0	100	80	M12	10.6	15.5	110.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	69,000	129,500	2.68	9.60

400 Series Specifications

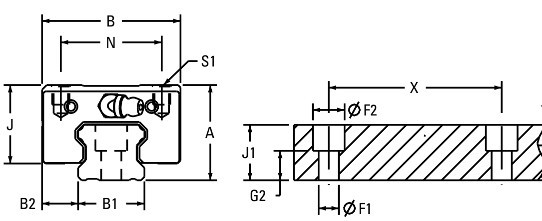


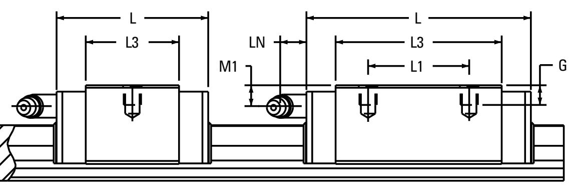


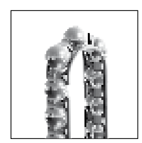
G (Narrow Short), C (Narrow), D (Narrow Long), K (Narrow Compact)

411 Narrow

Item	Assembly [mm]				Carriage [mm]									Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1	F2	G2	C [N]	C0 [N]	[kg]	[kg/m]
411N15G0	24	34	9.5	21.0	40.6	26	--	M4	4.8	22.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	4,600	9,800	0.10	1.28
411N15C0	24	34	9.5	21.0	58.6	26	26	M4	4.8	40.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.17	1.28
411N15D0	24	34	9.5	21.0	66.1	26	26	M4	4.8	47.7	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	11,300	23,700	0.18	1.28
411N20G0	28	42	11.0	23.5	48.3	32	--	M5	5.5	27.5	M6 X 1.0	5.1	(15.6)	20	16.3	60	6.0	9.5	7.8	7,400	15,700	0.17	2.15
411N20C0	30	44	12.0	25.5	69.3	32	36	M5	6.5	48.5	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.31	2.15
411N20K0	28	42	11.0	23.5	69.3	32	32	M5	5.5	48.5	M6 X 1.0	5.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.26	2.15
411N25G0	33	48	12.5	27.2	54.5	35	--	M6	6.8	32.3	M6 X 1.0	7.2	(15.6)	23	19.2	60	7.0	11.0	10.2	10,300	21,000	0.21	2.88
411N25C0	36	48	12.5	30.2	79.7	35	35	M6	9.0	57.5	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	9.0	20,100	41,100	0.40	2.88
411N25D0	36	48	12.5	30.2	109.1	35	50	M6	9.0	86.9	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	9.0	29,200	63,300	0.67	2.88
411N25K0	33	48	12.5	27.2	79.7	35	35	M6	6.8	57.5	M6 X 1.0	7.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,000	0.38	2.88
411N30G0	42	60	16.0	35.0	64.2	40	--	M8	10.0	37.2	M6 X 1.0	8.0	(15.6)	28	22.8	80	9.0	14.0	10.8	14,700	27,000	0.50	4.45
411N30C0	42	60	16.0	35.0	94.8	40	40	M8	10.0	67.8	M6 X 1.0	8.0	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	0.80	4.45
411N30D0	42	60	16.0	35.0	130.5	40	60	M8	10.0	103.5	M6 X 1.0	8.0	(15.6)	28	22.8	80	9.0	14.0	12.0	42,900	86,700	1.16	4.45
411N35G0	48	70	18.0	40.5	75.5	50	--	M8	10.0	44.5	M6 X 1.0	8.0	(15.6)	34	26.0	80	9.0	14.0	14.0	21,200	40,700	0.80	6.25
411N35C0	48	70	18.0	40.5	111.5	50	50	M8	10.0	80.5	M6 X 1.0	8.0	(15.6)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.20	6.25
411N35D0	48	70	18.0	40.5	153.5	50	72	M8	10.0	122.5	M6 X 1.0	8.0	(15.6)	34	26.0	80	9.0	14.0	12.0	58,300	125,300	1.84	6.25
411N45C0	60	86	20.5	51.1	129.0	60	60	M10	15.5	94.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	1.64	9.60
411N45D0	60	86	20.5	51.1	174.0	60	80	M10	15.5	139.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	17.0	79,700	163,300	2.42	9.60





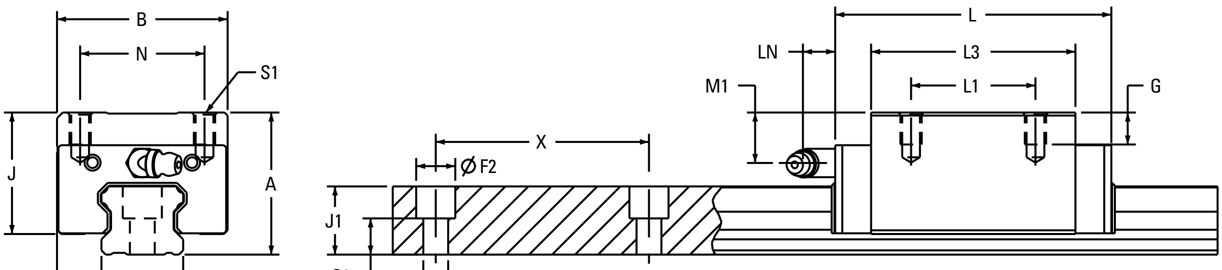


G (Narrow Short), C (Narrow), D (Narrow Long), K (Narrow Compact)

413 Narrow (Caged)

Item	Assembly [mm]				Carriage [mm]									Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1	F2	G2	C [N]	C0 [N]	[kg]	[kg/m]
413N15G0	24	34	9.5	21.0	40.6	26	--	M4	4.8	22.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	4,600	9,800	0.10	1.28
413N15C0	24	34	9.5	21.0	58.6	26	26	M4	4.8	40.2	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.17	1.28
413N15D0	24	34	9.5	21.0	66.1	26	26	M4	4.8	47.7	M4 X 0.7	5.5	(5.0)	15	13.0	60	4.5	7.5	7.0	11,300	23,700	0.18	1.28
413N20G0	28	42	11.0	23.5	48.3	32	--	M5	5.5	27.5	M6 X 1.0	5.1	(15.6)	20	16.3	60	6.0	9.5	7.8	7,400	15,700	0.17	2.15
413N20C0	30	44	12.0	25.5	69.3	32	36	M5	6.5	48.5	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.31	2.15
413N20K0	28	42	11.0	23.5	69.3	32	32	M5	5.5	48.5	M6 X 1.0	5.1	(15.6)	20	16.3	60	6.0	9.5	7.8	14,300	30,500	0.26	2.15
413N25G0	33	48	12.5	27.2	54.5	35	--	M6	6.8	32.3	M6 X 1.0	7.2	(15.6)	23	19.2	60	7.0	11.0	10.2	10,300	21,000	0.21	2.88
413N25C0	36	48	12.5	30.2	79.7	35	35	M6	9.0	57.5	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	9.0	20,100	41,100	0.40	2.88
413N25D0	36	48	12.5	30.2	109.1	35	50	M6	9.0	86.9	M6 X 1.0	10.2	(15.6)	23	19.2	60	7.0	11.0	9.0	29,200	63,300	0.67	2.88
413N25K0	33	48	12.5	27.2	79.7	35	35	M6	6.8	57.5	M6 X 1.0	7.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,000	0.38	2.88
413N30G0	42	60	16.0	35.0	64.2	40	--	M8	10.0	37.2	M6 X 1.0	8.0	(15.6)	28	19.2	80	9.0	14.0	10.8	14,700	27,000	0.50	4.45
413N30C0	42	60	16.0	35.0	94.8	40	40	M8	10.0	67.8	M6 X 1.0	8.0	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	0.80	4.45
413N30D0	42	60	16.0	35.0	130.5	40	60	M8	10.0	103.5	M6 X 1.0	8.0	(15.6)	28	22.8	80	9.0	14.0	12.0	42,900	86,700	1.16	4.45
413N35G0	48	70	18.0	40.5	75.5	50	--	M8	10.0	44.5	M6 X 1.0	8.0	(15.6)	34	22.8	80	9.0	14.0	14.0	21,200	40,700	0.80	6.25
413N35C0	48	70	18.0	40.5	111.5	50	50	M8	10.0	80.5	M6 X 1.0	8.0	(15.6)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.20	6.25
413N35D0	48	70	18.0	40.5	153.5	50	72	M8	10.0	122.5	M6 X 1.0	8.0	(15.6)	34	26.0	80	9.0	14.0	12.0	58,300	125,300	1.84	6.25
413N45C0	60	86	20.5	51.1	129.0	60	60	M10	15.5	94.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	1.64	9.60
413N45D0	60	86	20.5	51.1	174.0	60	80	M10	15.5	139.0	M8 X 1.25	14.4	(16.0)	45	31.1	105	14.0	20.0	17.0	79,700	163,300	2.42	9.60

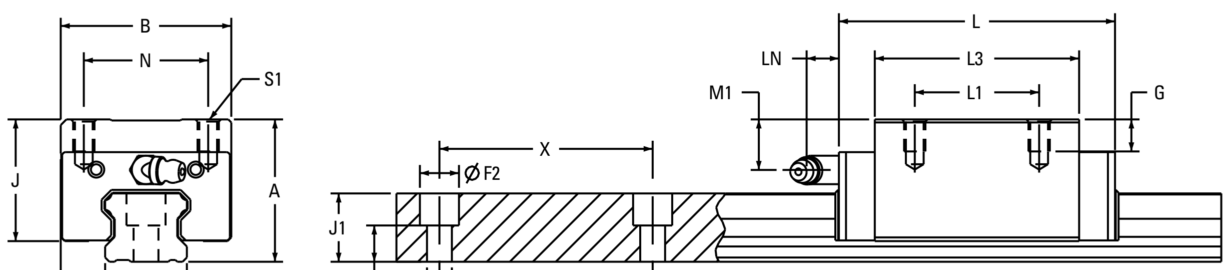
400 Series Specifications



E (Narrow High), F (Narrow High Long)

411 Narrow High

Item	Assembly [mm]				Carriage [mm]									Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1*	F2*	G2	C [N]	C0 [N]	[kg]	[kg/m]
411N15E0	28	34	9.5	21.0	58.6	26	26	M4	6.0	40.2	M4 X 0.7	9.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.19	1.28
411N20F0	30	44	12.0	25.5	82.1	32	50	M5	6.5	61.3	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	18,600	39,500	0.36	2.15
411N25E0	40	48	12.5	34.2	79.7	35	35	M6	9.0	57.5	M6 X 1.0	14.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,100	0.45	2.88
411N25F0	40	48	12.5	34.2	94.4	35	50	M6	9.0	72.2	M6 X 1.0	14.2	(15.6)	23	19.2	60	7.0	11.0	10.2	25,900	52,800	0.66	2.88
411N30E0	45	60	16.0	38.0	94.8	40	40	M8	12.0	67.8	M6 X 1.0	11.0	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	0.91	4.45
411N30F0	45	60	16.0	38.0	105.0	40	60	M8	12.0	78.0	M6 X 1.0	11.0	(15.6)	28	22.8	80	9.0	14.0	10.8	38,500	70,700	1.04	4.45
411N35E0	55	70	18.0	47.5	111.5	50	50	M8	12.0	80.5	M6 X 1.0	15.0	(15.6)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.50	6.25
411N35F0	55	70	18.0	47.5	123.5	50	72	M8	12.0	92.5	M6 X 1.0	15.0	(15.6)	34	26.0	80	9.0	14.0	14.0	52,900	101,400	1.80	6.25
411N45E0	70	86	20.5	61.1	129.0	60	60	M10	18.0	94.0	M8 X 1.25	24.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	2.28	9.60
411N45F0	70	86	20.5	61.1	145.0	60	80	M10	18.0	110.0	M8 X 1.25	24.4	(16.0)	45	31.1	105	14.0	20.0	14.1	69,000	129,500	2.67	9.60



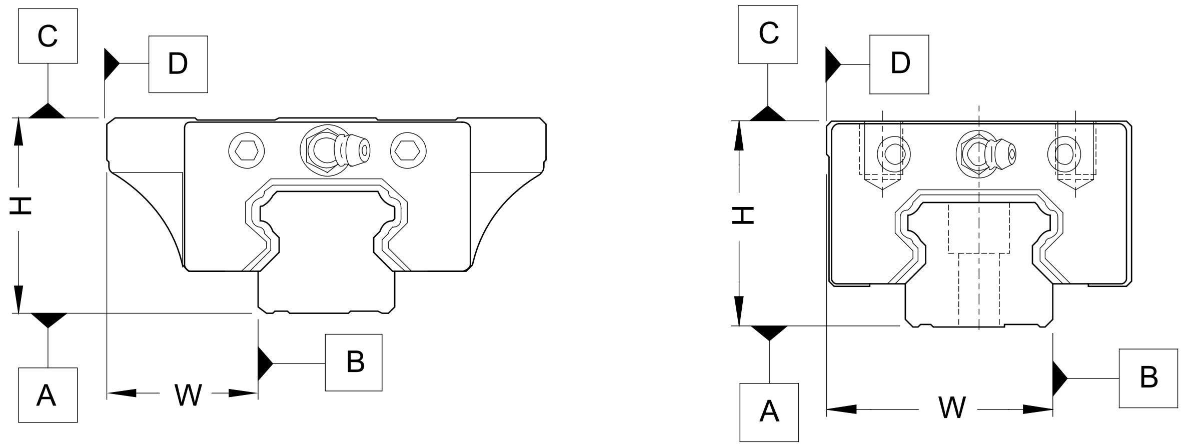
E (Narrow High), F (Narrow High Long)

413 Narrow High (Caged)

Item	Assembly [mm]				Carriage [mm]									Rail [mm]						Load Rating		Carriage Weight	Rail Weight
	A	B	B2	J	L	N	L1	S1	G	L3	Oil H	M1	LN	B1 +.02 -.05	J1	X	F1*	F2*	G2	C [N]	C0 [N]	[kg]	[kg/m]
413N15E0	28	34	9.5	21.0	58.6	26	26	M4	6.0	40.2	M4 X 0.7	9.5	(5.0)	15	13.0	60	4.5	7.5	7.0	9,300	19,600	0.19	1.28
413N20F0	30	44	12.0	25.5	82.1	32	36	M5	6.5	61.3	M6 X 1.0	7.1	(15.6)	20	16.3	60	6.0	9.5	7.8	18,600	39,500	0.36	2.15
413N25E0	40	48	12.5	34.2	79.7	35	35	M6	9.0	57.5	M6 X 1.0	14.2	(15.6)	23	19.2	60	7.0	11.0	10.2	20,100	41,000	0.45	2.88
413N25F0	40	48	12.5	34.2	94.4	35	35	M6	9.0	72.2	M6 X 1.0	14.2	(15.6)	23	19.2	60	7.0	11.0	10.2	25,900	52,800	0.66	2.88
413N30E0	45	60	16.0	38.0	94.8	40	40	M8	12.0	67.8	M6 X 1.0	11.0	(15.6)	28	22.8	80	9.0	14.0	10.8	29,700	54,600	0.91	4.45
413N30F0	45	60	16.0	38.0	105.0	40	40	M8	12.0	78.0	M6 X 1.0	11.0	(15.6)	28	22.8	80	9.0	14.0	10.8	38,500	70,700	1.04	4.45
413N35E0	55	70	18.0	47.5	111.5	50	50	M8	12.0	80.5	M6 X 1.0	15.0	(15.6)	34	26.0	80	9.0	14.0	14.0	42,400	81,100	1.50	6.25
413N35F0	55	70	18.0	47.5	123.5	50	50	M8	12.0	92.5	M6 X 1.0	15.0	(15.6)	34	26.0	80	9.0	14.0	14.0	52,900	101,400	1.80	6.25
413N45E0	70	86	20.5	61.1	129.0	60	60	M10	18.0	94.0	M8 X 1.25	24.4	(16.0)	45	31.1	105	14.0	20.0	14.1	58,000	108,900	2.28	9.60
413N45F0	70	86	20.5	61.1	145.0	60	60	M10	18.0	110.0	M8 X 1.25	24.4	(16.0)	45	31.1	105	14.0	20.0	14.1	69,000	129,500	2.67	9.60

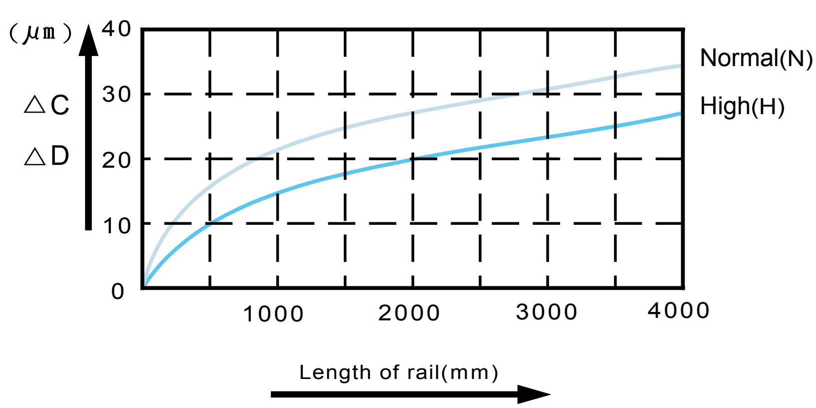
*Note: Mounting hole dimensions of 411 and 413 F Style carriages are different.

a. Accuracy standard:



Unit : mm

ITEM \ GRADE	Normal (N)	High (H)
Tolerance of height (H)	±0.1	±0.04
Tolerance of width (W)	±0.1	±0.04
Difference of heights (△H)	0.03	0.02
Difference of widths (△W)	0.03	0.02
Running parallelism of BR Block surface C with respect to surface A	△ C Refer to the below Fig.	
Running parallelism of BR Block surface D with respect to surface B	△ D Refer to the below Fig.	



Rail length and running parallelism

b. Choosing preload

Replacing larger rolling elements helps strengthening the entire rigidity of the carriage while there exists clearance within ball circulation.

Preload	No preload (0)	Light preload (1)
Conditions of use	1. Light corrosion 2. 2 parallel axes 3. Low accuracy 4. Low friction 5. Light load	1.Catilever 2. Mono axis. 3. Light load 4. High accuracy
Application	1. Welding machine 2. Cutting machine 3. Feeder 4. X & Y axis 5. Packaging machine	1. NC Lathe 2. EDN 3. Precision XY table 4. Robotic manipulator 5. Z axis 6. PCB drilling machine

Increasing preload reduces vibration as well as fretting corrosion. However, it will also add artificial loading to the rolling elements.

Preload grade:

C: Basic dynamic load rating

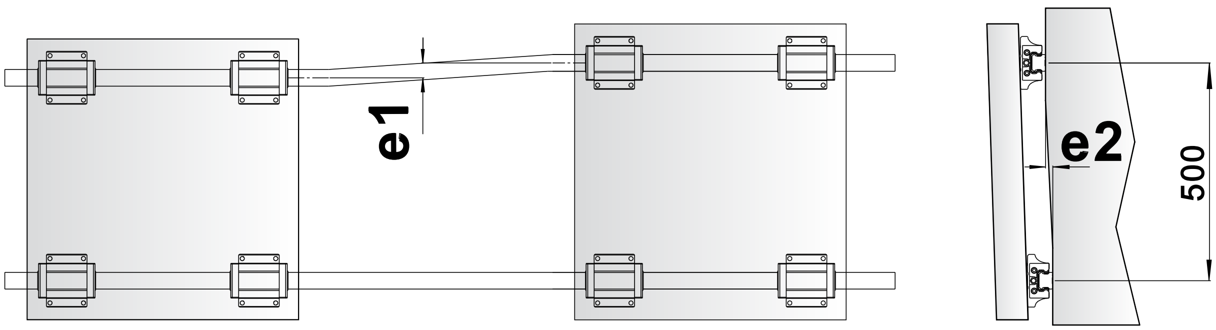
ITEM / PRELOAD	Symbol	Preload force
No Peload	0	0
Light Preload	1	0.02 C

Radial clearances:

Unit: μm

SYMBOL / SIZE	0	1
15mm	-4 – 4	-12 - -5
20mm	-5 – 5	-14 - -6
25mm	-6 – 6	-16 - -7
30mm	-7 – 7	-18 - -8
35mm	-8 – 8	-20 - -9
45mm	-9 – 9	-22 - -10

Suggested permissible difference on mounting surface:

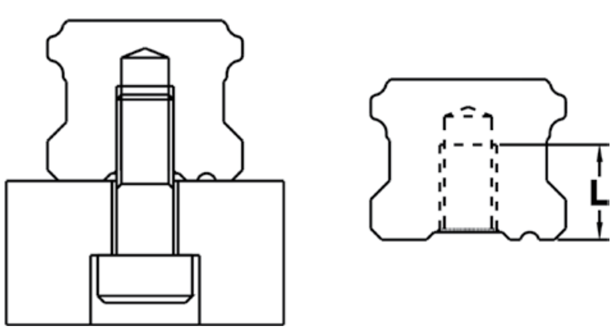


Unit: µm

SIZE	e1		e2	
	0	1	0	1
15mm		25	85	130
20mm	20	25	85	130
25mm	22	30	85	130
30mm	30	40	110	170
35mm	35	50	150	210
45mm	40	60	170	250

Rail with tapped holes:

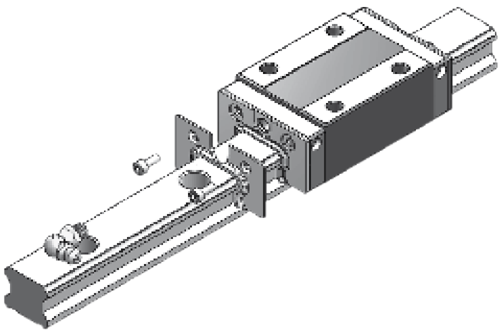
Bolting the rail from the underside allows for a clean top surface with no openings for debris and other particles to collect (see below figure).



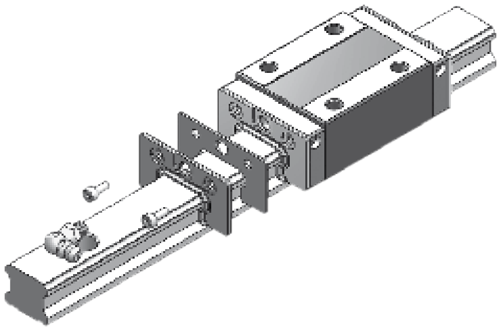
Size	Screw	Length of thread
15mm	M5	8mm
20mm	M6	10mm
25mm	M6	12mm
30mm	M8	15mm
35mm	M8	17mm
45mm	M12	24mm

c. Carriage Accessories:

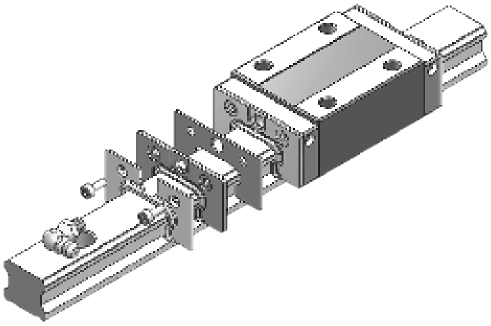
SCRAPERS:
Mainly used in metal machining application to protect the linear guide from debris, protecting the end seal from hot metal chips



ADDITIONAL WIPER:
The outer wiper protects the carriage from most debris, while the standard end seal protects from finer particulate.



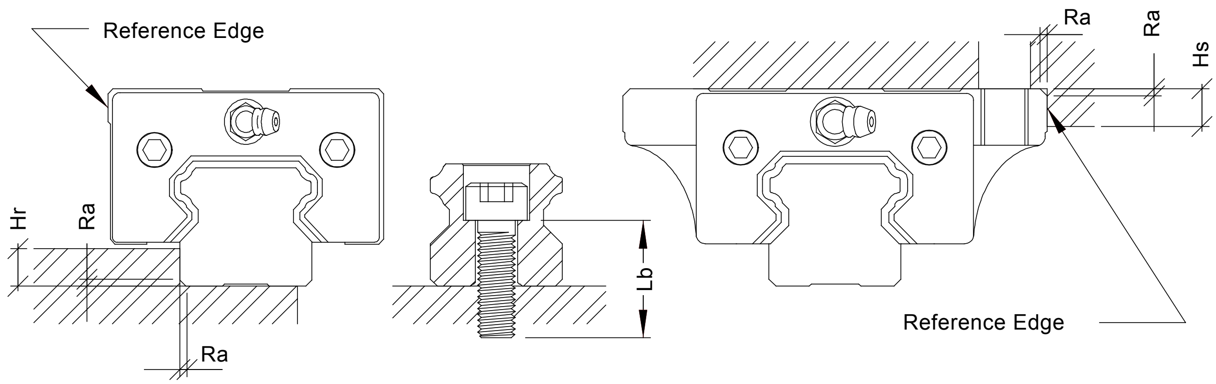
SCAPER and ADDITIONAL WIPERS:
Combination of the two accessories



See Ball Carriage table on page 19 for coding of wiper and scaper options.

III. MOUNTING A 400 SERIES LINEAR GUIDE

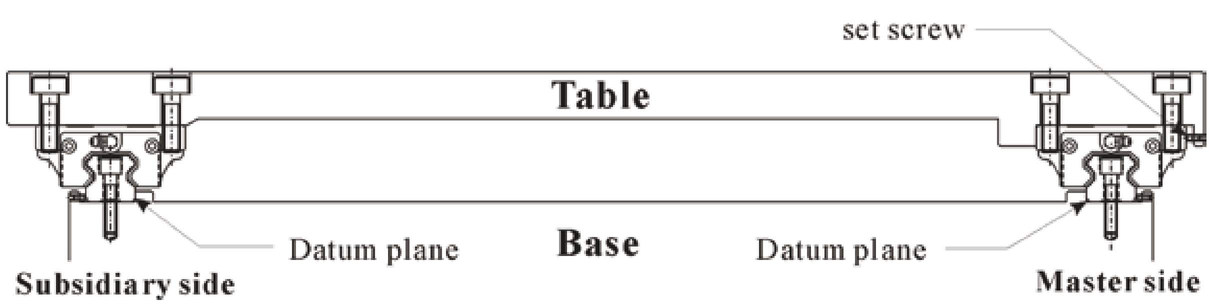
3-1 Critical Dimensions:



Unit: mm

ITEM	Maximum Fillet (Ra)	MaximumHeight (Hr) rail shoulder	Maximum Height (Hs) block shoulder	Suggested Rail Bolt Length (Lb)
15mm	0.6	2.8	5	M4x16
20mm	0.9	4.3	6	M5x20
25mm	1.1	5.6	7	M6x25
30mm	1.4	6.8	8	M8x30
35mm	1.4	7.3	9	M8x30
45mm	1.6	8.7	12	M12x35

Mounting procedure

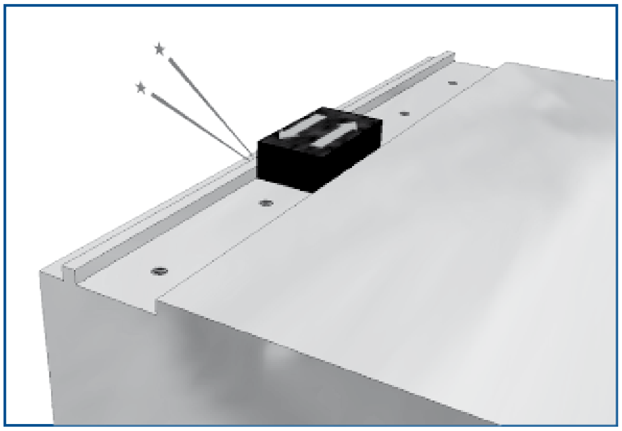


Features of the shown example:

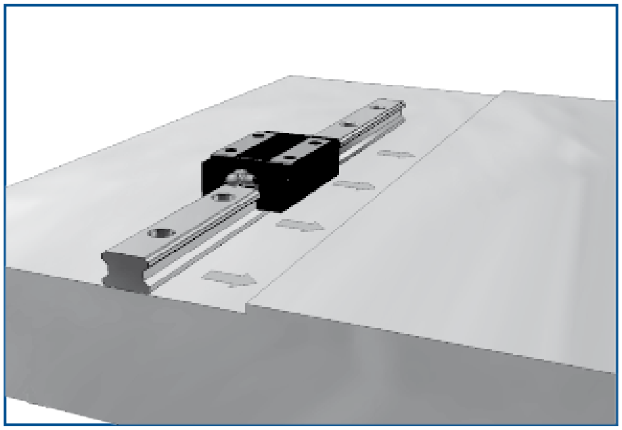
1. Two datum planes on a fixed base.
2. The table has a lateral datum surface and set screws.
3. Set screws are installed on the master profile rail to mount the carriage against datum surface.

3-2 Mounting Procedure

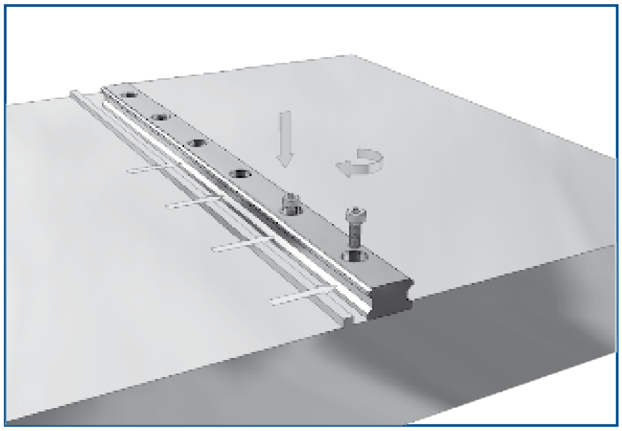
Step 1 Remove dents, burrs and dirt on mounting surfaces.
Note: Removing any oils on the mounting surface before installation is recommended.



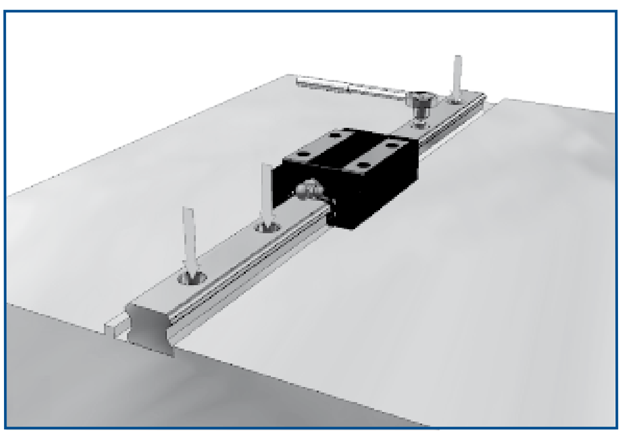
Step 2 Place rail against the shoulder of mounting surface.



Step 3 Tighten the mounting bolts lightly. Make sure holes on rail are aligned with holes on mounting surface.



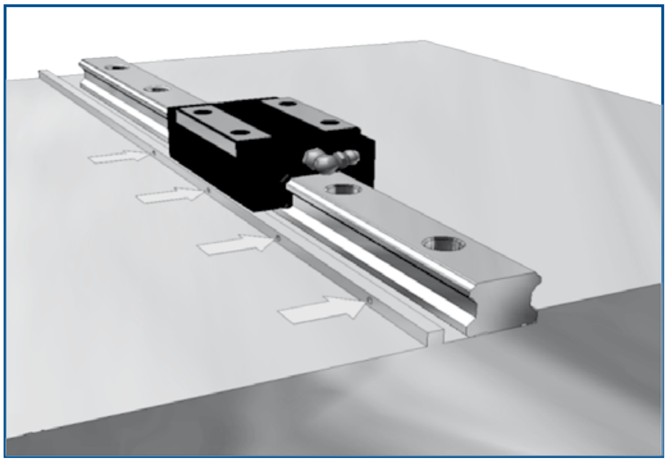
Step 4 Tighten the rail mounting bolts. When tightening, start with the bolt in the rail center, and work outward towards rail ends.



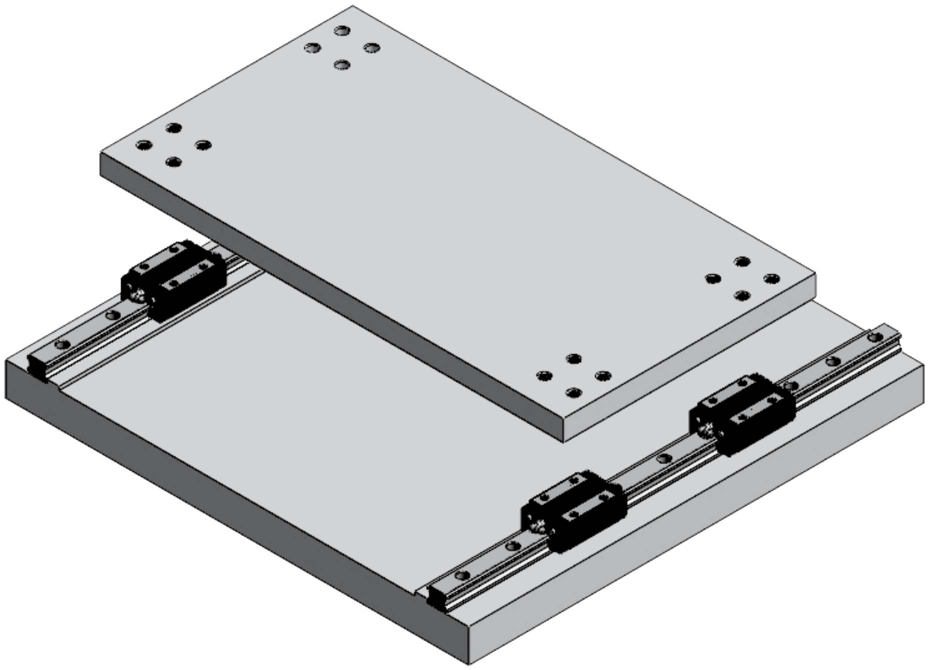
Tightening torque of screw

Screw size	Tightening totque (kfg*cm) – hexagonal socket screw		
	Steel	Cast Iron	Aluminum
M2	6.3	4.2	3.1
M2.3	8.4	5.7	4.2
M2.6	12.6	8.4	6.3
M3	21	13.6	10.5
M4	44.1	29.3	22
M5	94.5	63	47.2
M6	146.7	98.6	73.5
M8	325.7	215.3	157.5
M10	724.2	483.2	356.7
M12	1264.2	840	630
M14	1682.1	1125	840
M16	2100	1403.5	1050

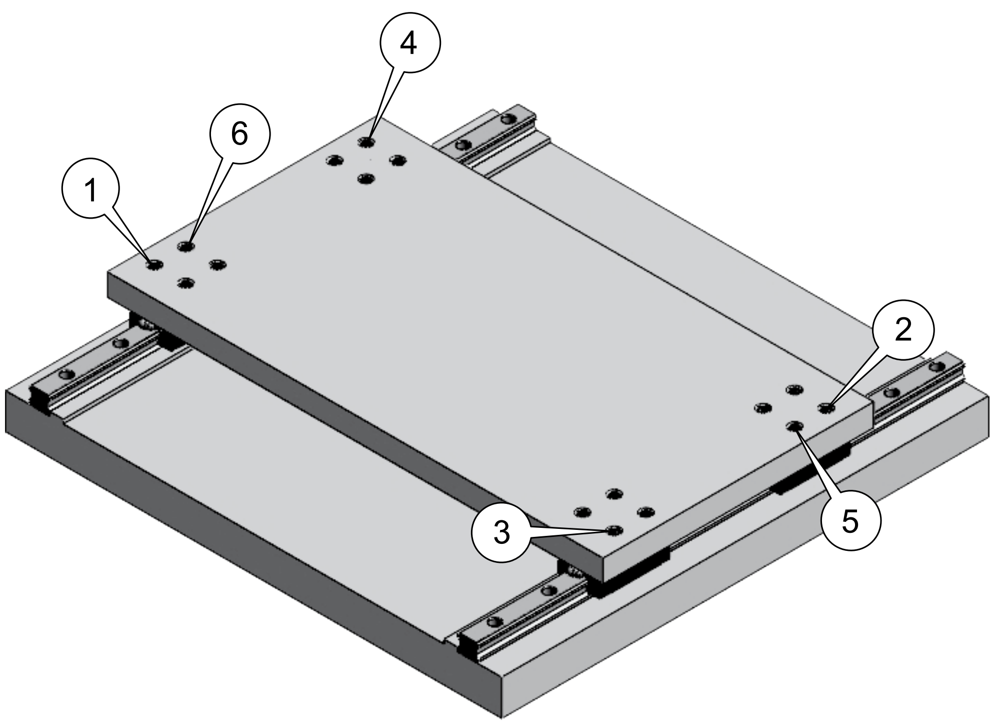
Step 5 Mount the second rail with the same procedure.



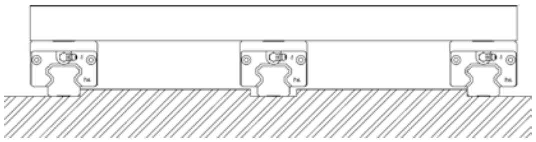
Step 6 Position the working table onto the master and subsidiary profile rails.

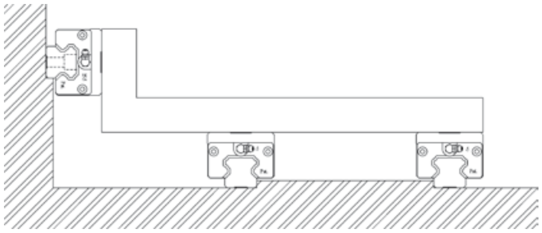


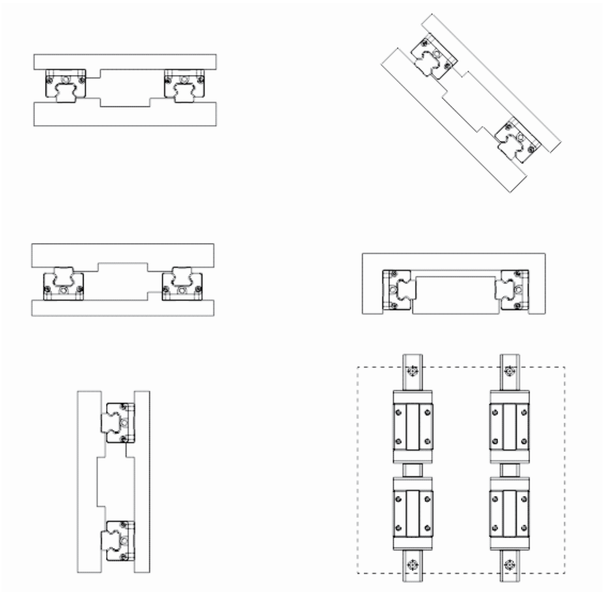
Step 7 Tighten the carriage mounting bolts in the sequence shown below.

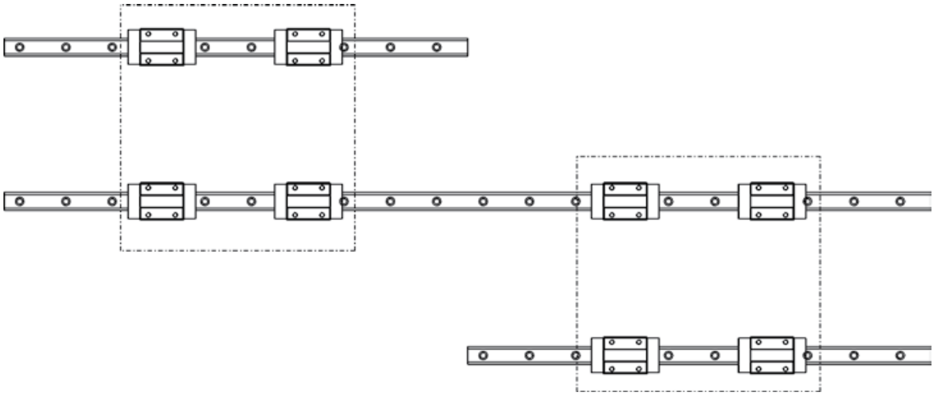


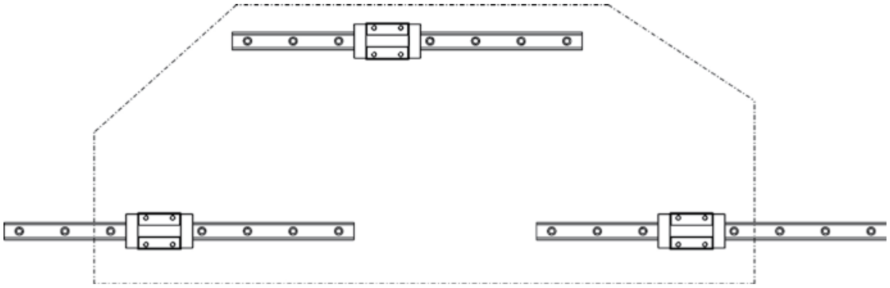
3-3 Common installations:



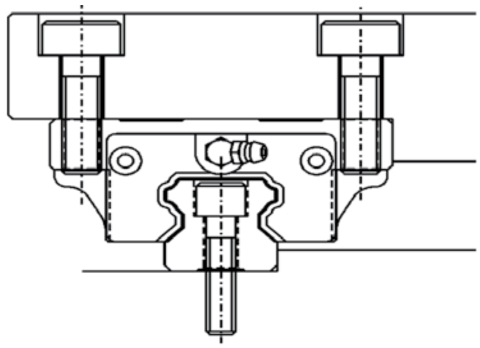


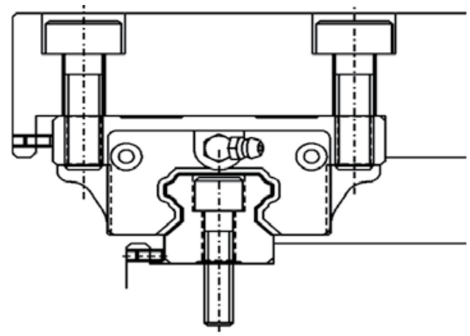


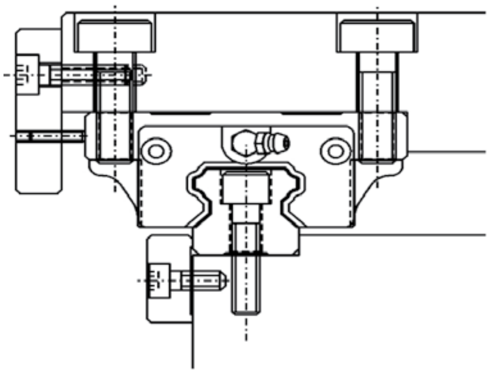


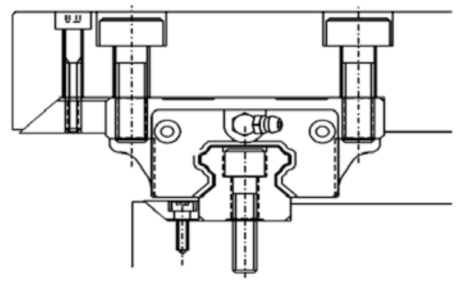


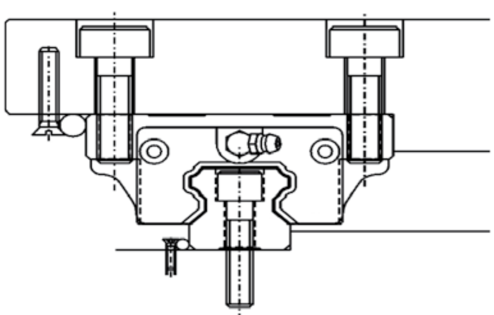
3-4 Common applications to fix carriages:

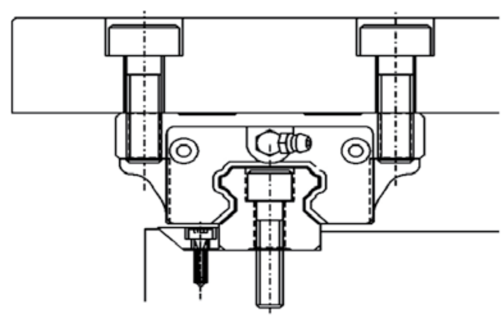


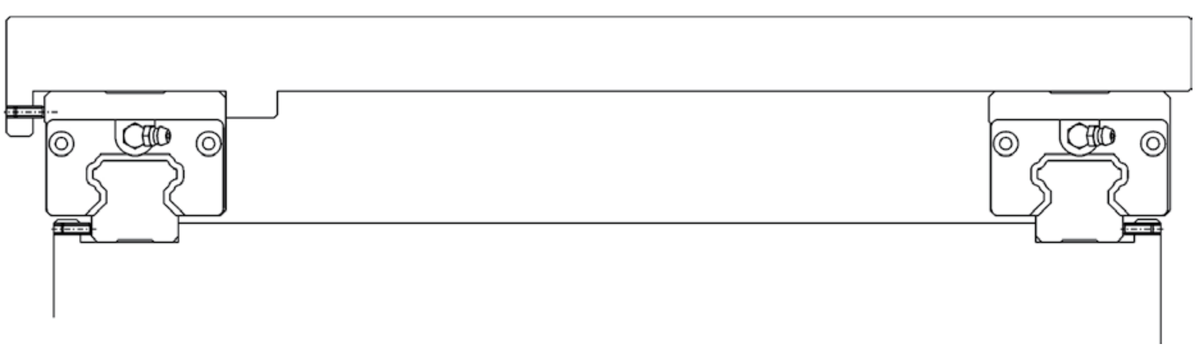












IV. 400 SERIES LINEAR GUIDE

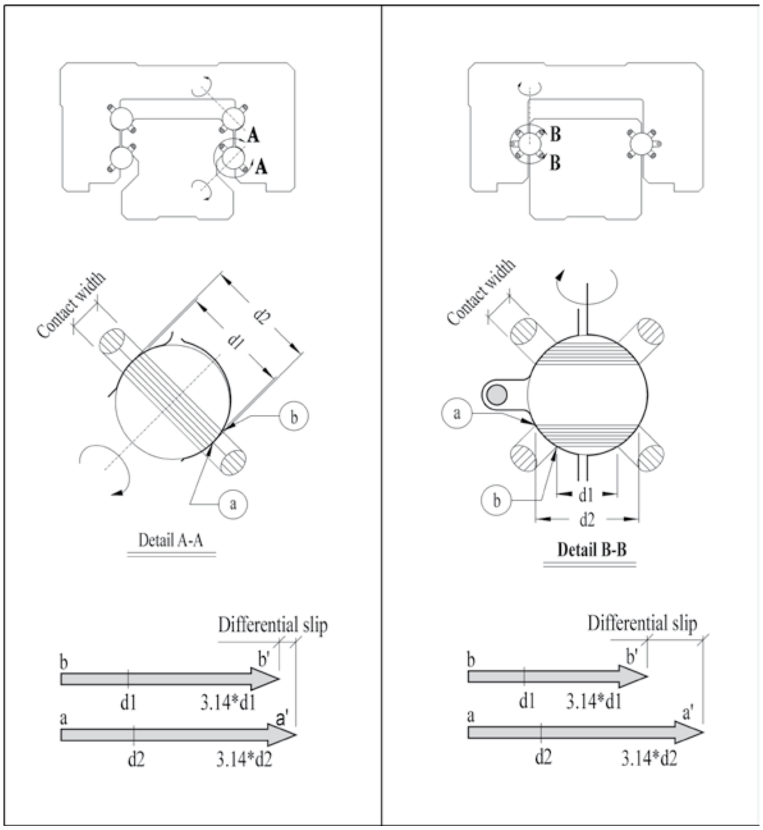
4-1. Standard type (Non-caged type)

a. Four-row angular contact

Four rows of balls make 45º contact between the carriage and rail at 4 points, which balances the applied force from all directions. Equivalent loading is achieved regardless of the rail setup. Compared to the Gothic 2-row design, the 4-row design has better stiffness, higher precision and longer life.

4 Row Angular Conatct vs. 2 Row Gothic Arch Design

4 Row Angular Conatct 2 Row Gothic Arch Design



Strengths:

1. Smooth running
2. Low friction
3. Heavy nominal load
4. Good stability

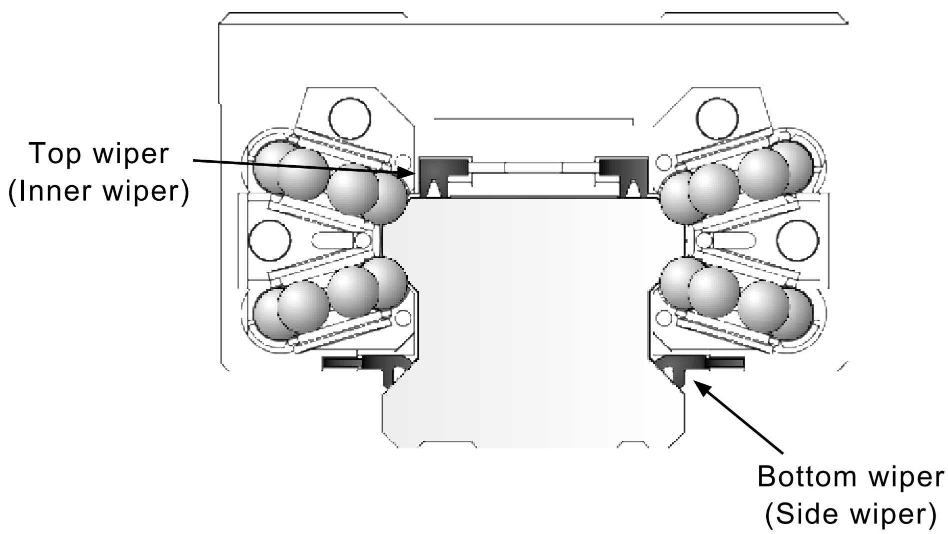
b. Sealing

Contamination is the most common cause of premature failure in a profile rail linear guide. Contamination restricts ball recirculation, leading to permanent damage to the rolling elements and bearing races. The carriage sealing system includes upper and bottom seal to prevent entry of particles.

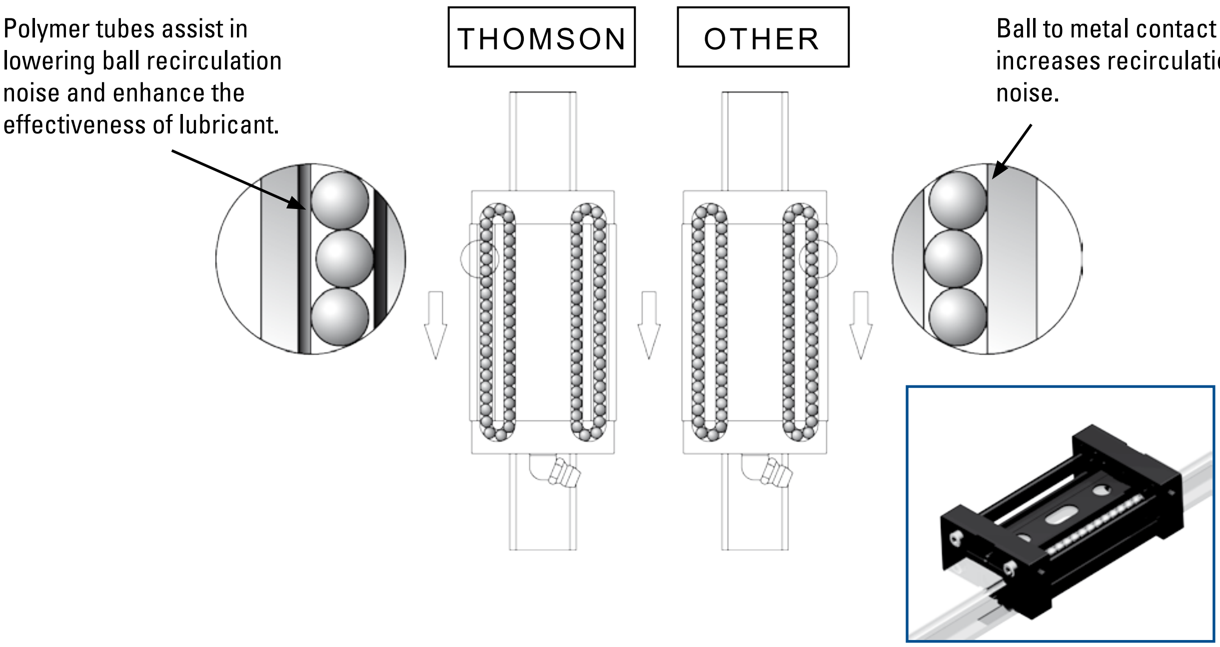
Common entry points for debris:

1. Screw hole:
   Dust gets in due to vibration or machine movement.
2. Space between carriage and rail:
   Larger particles can easily enter the ball circulation path in this area.

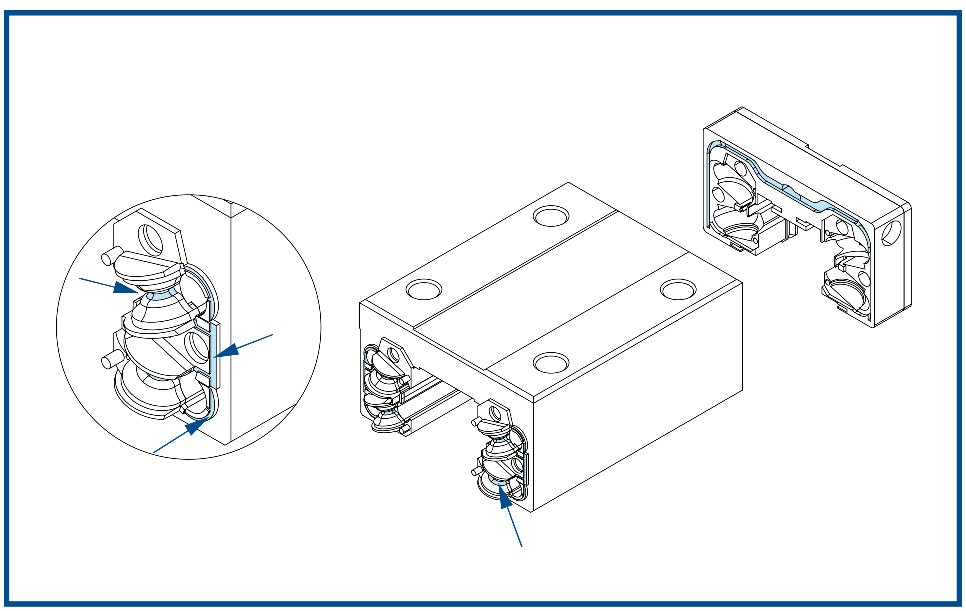
   To protect the bearing from contamination in these areas, wipers are installed inside the carriage (inner wiper) and outboard (side wiper)



c. Circulation tube



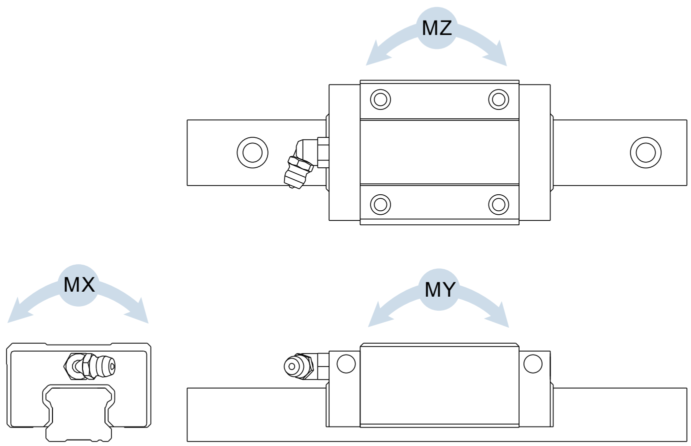
d. Oil Circulation System



Channels direct lubricant to individual ball tracks to maximize lubrication effectiveness. Ball circulation continues to distribute lubricant throughout the carriage.

e. Static nominal moment

As far as load is concened, single rail is different from a pair. It takes 3-axis moment to calculate the load applied to one single rail.



411 carriage static nominal moment:

Unit: N-m

Model	Basic permissible static moment		
	MX	MY	MZ
411N15E0	135	118	118
411N20C0	285	221	221
411N20F0	370	361	361
411N20K0	285	221	221
411N25K0	440	352	352
411N25E0	440	352	352
411N25F0	567	568	568
411N30E0	707	551	551
411N30F0	915	822	822
411N35E0	1283	973	973
411N35F0	1604	1398	1398
411N45E0	2302	1525	1525
411N45F0	2739	2124	2124
411N15A0	135	118	118
411N15B0	164	169	169
411N20A0	285	221	221
411N20B0	370	361	361
411N25A0	440	352	352
411N25B0	567	568	568
411N30A0	707	551	551
411N30B0	915	822	822
411N35A0	1283	973	973
411N35B0	1604	1398	1398
411N45A0	2302	1525	1525
411N45B0	2739	2124	2124

Model	Basic permissible static moment		
	MX	MY	MZ
411N15G0	68	32	32
411N15C0	135	118	118
411N20G0	146	65	65
411N25G0	226	101	101
411N25C0	440	352	352
411N25D0	680	820	820
411N30G0	350	150	150
411N30C0	707	551	551
411N30D0	1123	1338	1338
411N35G0	644	270	270
411N35C0	1283	973	973
411N35D0	1983	2288	2288
411N45C0	2302	1525	1525
411N45D0	3452	3382	3382

411 carriage dynamic nominal moment:

Unit: N-m

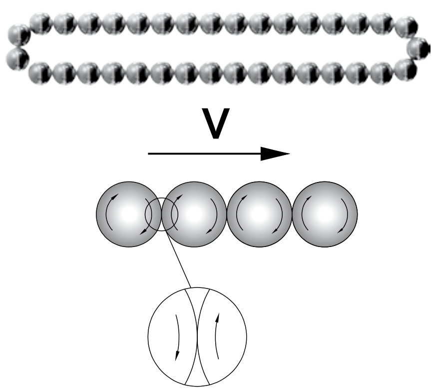
Model	Basic permissible dynamic moment		
	MX	MY	MZ
411N15A0	65	56	56
411N15B0	78	80	80
411N15C0	65	56	56
411N15D0	78	80	80
411N15E0	65	65	56
411N15G0	32	16	16
411N20A0	134	104	104
411N20B0	174	170	170
411N20C0	134	104	104
411N20K0	166	129	129
411N20F0	174	170	170
411N20G0	69	30	30
411N25A0	216	173	173
411N25B0	278	279	279
411N25C0	216	173	173
411N25D0	313	378	378
411N25E0	267	213	213
411N25K0	267	213	213
411N25F0	278	279	279
411N25G0	111	49	49
411N30A0	386	300	300
411N30B0	499	447	447
411N30C0	386	300	300
411N30D0	555	661	661
411N30E0	386	300	300
411N30F0	499	447	447
411N30G0	191	81	81
411N35A0	671	508	508
411N35B0	838	730	730
411N35C0	671	508	508
411N35D0	922	1063	1063
411N35E0	671	508	508
411N35F0	838	730	730
411N35G0	336	141	141
411N45A0	1225	812	812
411N45B0	1458	1130	1130
411N45C0	1225	812	812
411N45D0	1684	1651	1651
411N45E0	1225	812	812
411N45F0	1458	1130	1133

4-2. 413 Caged Carriage

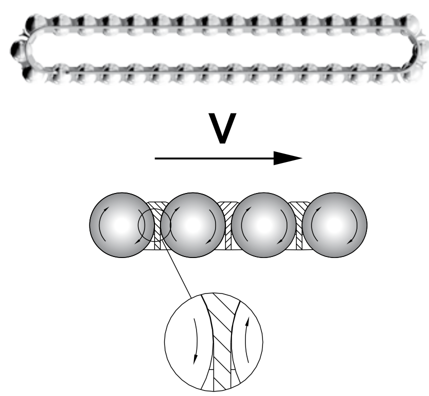
a. High speed feature

In standard profile rail linear guides, the ball bearings rotate between the rail and carriage. At the ball's point of contact, the tangential velocity is twice that of the ball itself. In addition, the contact area between two adjacent balls is essentially a point contact. The contact area A is so small that the contact pressure P approaches infinity (P = Force between balls / contact area A). This causes ball wear over time.

413 ball cage profile rail bearings have a cage spacer between ball bearings. The cage separates the balls and retains oil, reducing ball friction. This reduces ball wear and reduces heat generation, especially in high speed applications.

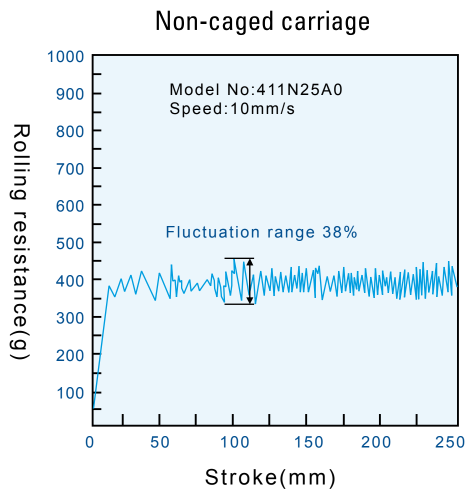


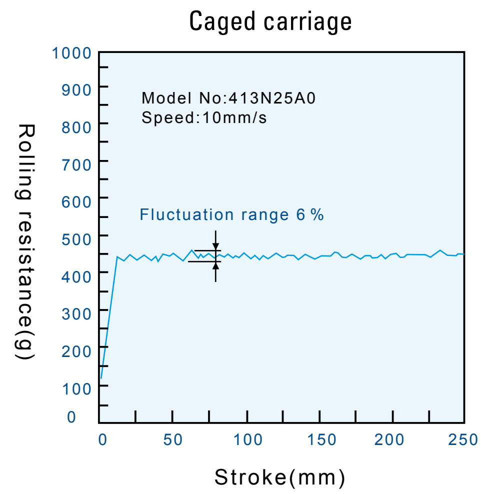
Typical ball contact

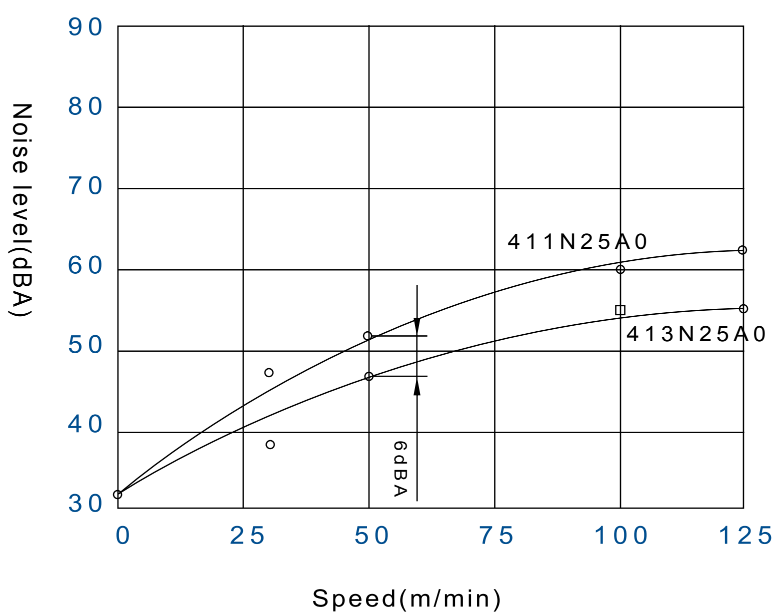


413 ball spacer contact

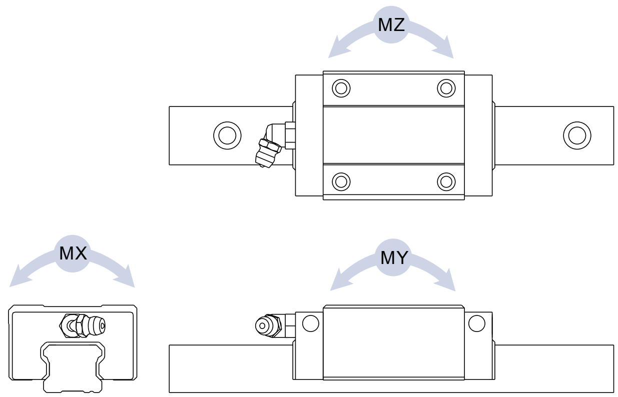
b. 413 Caged carriage increased running smoothness







c. 413 caged carriage static nominal moment



413 carriage static nominal moment:

Unit: N-m

Model	Basic permissible static moment		
	MX	MY	MZ
413N15E0	135	118	118
413N20C0	285	221	221
413N20F0	370	361	361
413N25E0	440	352	352
413N25F0	567	568	568
413N20K0	285	221	221
413N25K0	440	352	352
413N30E0	707	551	551
413N30F0	915	822	822
413N35E0	1283	973	973
413N35F0	1604	1398	1398
413N45E0	2302	1525	1525
413N45F0	2739	2124	2124
413N15A0	135	118	118
413N15B0	164	169	169
413N20A0	285	221	221
413N20B0	370	361	361
413N25A0	440	352	352
413N25B0	567	568	568
413N30A0	707	551	551
413N30B0	915	822	822
413N35A0	1283	973	973
413N35B0	1604	1398	1398
413N45A0	2302	1525	1525
413N45B0	2739	2124	2124

Model	Basic permissible static moment		
	MX	MY	MZ
413N15G0	68	32	32
413N15C0	135	118	118
413N20G0	146	65	65
413N25G0	226	101	101
413N25C0	440	352	352
413N25D0	680	820	820
413N30G0	350	150	150
413N30C0	707	551	551
413N30D0	1123	1338	1338
413N35G0	644	270	270
413N35C0	1283	973	973
413N35D0	1983	2288	2288
413N45C0	2302	1525	1525
413N45D0	3452	3382	3382

413 carriage dynamic nominal moment:

Unit: N-m

Model	Basic permissible dynamic moment		
	MX	MY	MZ
413N15A0	79	69	69
413N15B0	96	99	99
413N15C0	79	69	69
413N15D0	96	99	99
413N15E0	79	69	69
413N15G0	39	19	19
413N20A0	166	129	129
413N20B0	215	210	210
413N20C0	166	129	129
413N20K0	166	129	129
413N20F0	215	210	210
413N20G0	85	37	37
413N25A0	267	213	213
413N25B0	342	343	343
413N25C0	267	213	213
413N25D0	387	368	368
413N25E0	267	213	213
413N25K0	267	213	213
413N25F0	342	343	343
413N25G0	136	61	61
413N30A0	476	371	371
413N30B0	616	552	552
413N30C0	476	371	371
413N30D0	686	816	816
413N30E0	476	371	371
413N30F0	616	552	552
413N30G0	235	101	101
413N35A0	828	628	628
413N35B0	1034	902	902
413N35C0	828	628	628
413N35D0	1138	1314	1314
413N35E0	828	628	628
413N35F0	1034	902	902
413N35G0	415	174	174
413N45A0	1514	1003	1003
413N45B0	1800	1396	1396
413N45C0	1514	1003	1003
413N45D0	2080	2038	2038
413N45E0	1514	1003	1003
413N45F0	1800	1396	1396

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