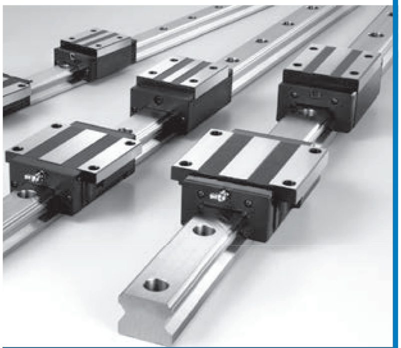
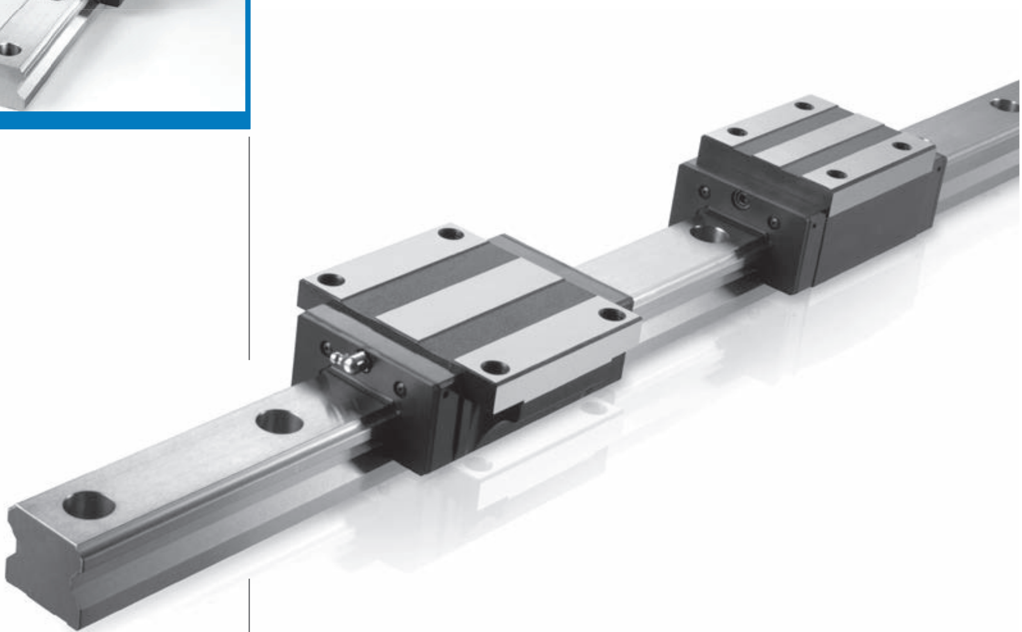


Linear Guideway



1 The Characteristics of *PMI* Linear Guideways

(1) High positioning accuracy, high repeatability

The *PMI* linear guideway is a design of rolling motion with a low friction coeffcient, and the difference between dynamic and static friction is very small. Therefore, the stick-slip will not occur when submicron feeding is making.

(2) Low frictional resistance, high precision maintained for long period

The frictional resistance of a linear guideway is only 1/20th to 1/40th of that in a slide guide. With a linear guideway, a well lubrication can be easily achieved by supplying grease through the grease nipple on carriage or utilizing a centralized oil pumping system, thus the frictional resistance is decreased and the accuracy could be maintained for longperiod.

(3) High rigidity with four-way load design

The optimum design of geometric mechanics makes the linear guideway to bear the load in all four directions, radial, reversed radial, and two lateral directions. Furthermore, the rigidity of linear guideway could be easily achieved by preloading carriage and by adding the number of carriages.

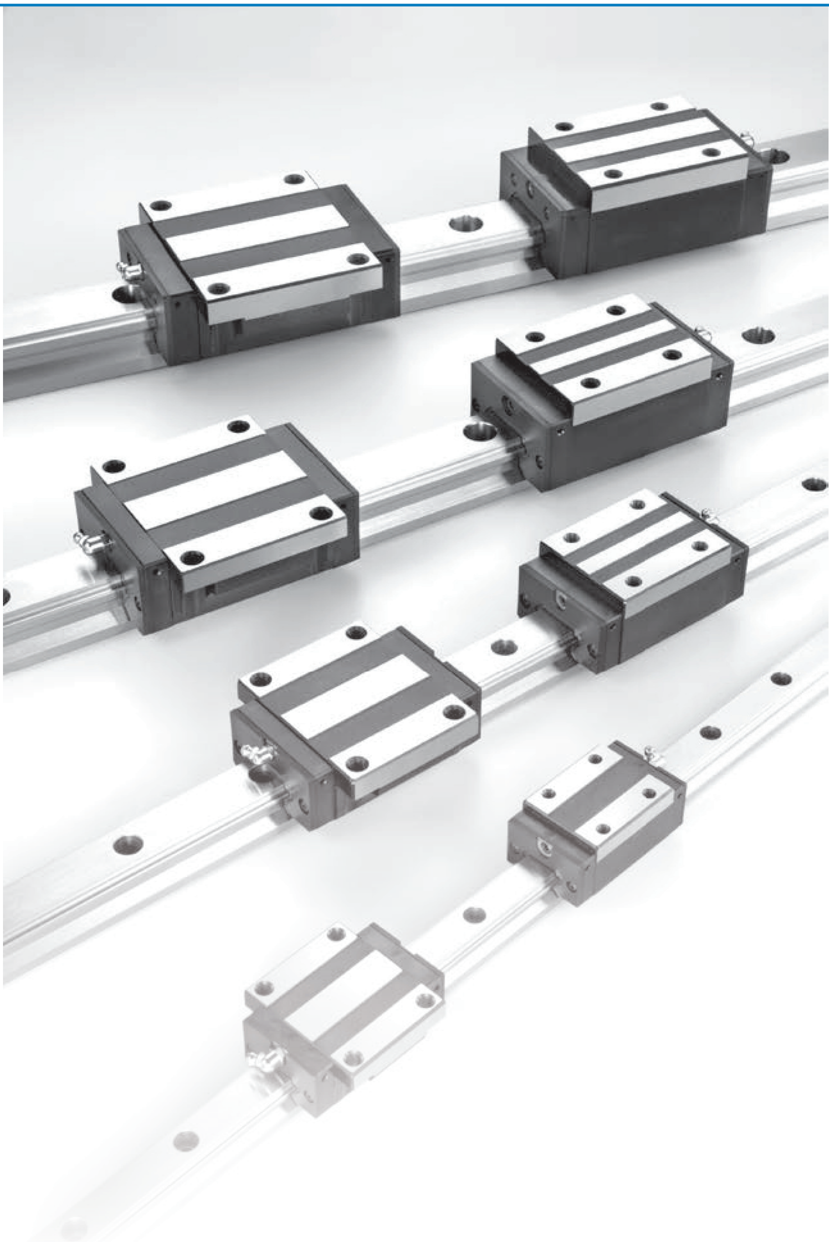
(4) Suitable for high speed operation

Due to the characteristic of low frictional resistance, the required driving force is much lower than in other systems, thus the power consumption is small. Moreover, the temperature rising effect is small even under high speed operation.

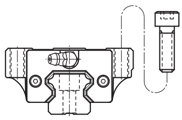
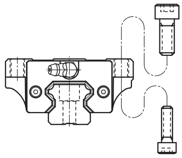
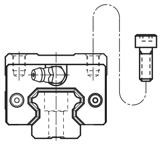
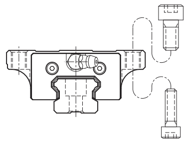
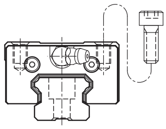
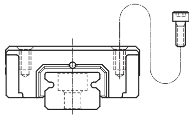
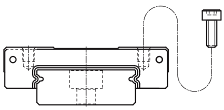
(5) Easy installation with interchangeability

Compared with the high-skill required scrapping process of conventional slide guide, the linear guideway can offer high precision even if the mounting surface is machined by milling or grinding. Moreover the interchangeability of linear guideway gives a convenience for installation and future maintenance.

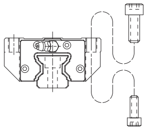
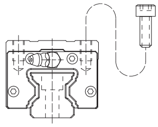
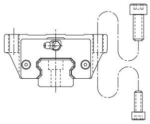
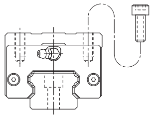
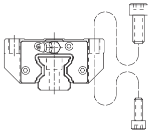
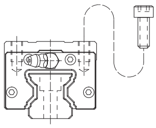
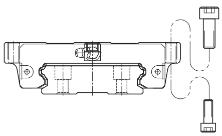
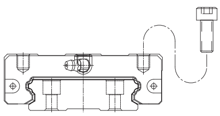
The Characteristics of *PMI* Linear Guideways



2 The Classification Chart of *PMI* Linear Guideways

Type	Model	
Full Ball, Heavy Load Type	MSA-A MSA-LA	
	MSA-E MSA-LE	
	MSA-S MSA-LS	
Full Ball, Compact Type	MSB-TE MSB-E	
	MSB-TS MSB-S	
Full Ball, Miniature Type	MSC	
	MSD	

	Characteristics	Major Application
	• Heavy Load, High Rigidity • Self Alignment Capability • Smooth Movement • Low Noise • Interchangeability	Machine Center, NC lathe, XYZ axes of heavy cutting machine tools, Grinding head feeding axis of grinding machines, Milling machine, Z axis of boring machine and machine tools, EDM, Z axis of industrial machine, Measuring equipment, Precision XY table, Welding machine, Binding machine, Auto packing machine
	• Compact, High Load • Self Alignment Capability • Smooth Movement • Low Noise • Interchangeability	
	• Ultra Compact • Smooth Movement • Low Noise • Ball Retainer • Interchangeability	IC/LSI manufacturing machine, Hard disc drive, Slide unit of OA equipment, Wafer transfer equipment, Printed circuit board assembly table, Medical equipment, Inspection equipment

Type	Model	
Full Roller, Heavy Load Type	MSR-E MSR-LE	
	MSR-S MSR-LS	
Ball Chain, Heavy Load Type	SME-E SME-LE	
	SME-S SME-LS	
Roller Chain, Heavy Load Type	SMR-E SMR-LE	
	SMR-S SMR-LS	
Full Ball Wide Rail type	MSG-E	
	MSG-S	

	Characteristics	Major Application
	• Ultra Heavy Load • Ultra High Rigidity • Smooth Movement • Low Noise • Good lubricant Effect	Machine Center, NC lathe, Grinding machine, Five axes milling machine, Jig borer, Drilling machine, Horizontal milling machine, Mold processing machine, EDM
	• Heavy Load, High Rigidity • Self Alignment Capability • Ball Chain Design • Smooth Movement • Low Noise, Good Lubricant Effect • Interchangeability	Machine Center, NC lathe, XYZ axes of heavy cutting machine tools, Grinding head feeding axis of grinding machines, milling machine, Z axis of boring machine and machine tools, EDM, Z axis of industrial machine, Measuring equipment, Precision XY table, Welding machine, Binding machine, Auto packing machine
	• Ultra Heavy Load • Ultra High Rigidity • Roller Chain Design • Smooth Movement • Low Noise • Good Lubricant Effect	Machine Center, NC lathe, Grinding machine, Five axes milling machine, Jig borer, Drilling machine, Horizontal milling machine, Mold processing machine, EDM
	• Heavy Load, High Rigidity • Self Alignment Capability • Smooth Movement • Low Noise • Interchangeability	Machine Center, Auto packing machine, Binding machine, laser cutting machine

3 The Procedure of Select Linear Guideway

Identify the operating conditions

Parameters for calculating load on the linear guideway

- Space available for installation
- Size (span, No. of carriages, No. of rails)
- Installation position (horizontal, vertical, tilted, or wall-hung, etc.)
- Magnitude, direction, and location of imposed load
- Frequency of use (duty cycle)
- Stroke length
- Moving speed , acceleration
- Required service life, and accuracy
- Operating environment

(span, No. of carriages, No. of rails change)

Select type

Select proper type and size
(If applied with ballscrew, the size of guideway should be similar to diameter of ballscrew.)

(Type or size changed)

Calculate the applied load

Calculate the load applied on each carriage

Calculate the equivalent load

Convert the load of block exerts in each direction into equivalent load

Calculate the static safety factor

The safety factor verified by basic static load rating and max equivalent load

Verification of safety factor — NO / YES

Calculate mean load

Averaging the applied loads that fluctuate during operation and convert them into mean load

Calculate nominal life

Using the service-life equation to calculate the running distance or hours

Does the calculated value satisfy the required service life — NO / YES

Identify stiffness

- Select preload
- Determine the fastening methods
- Determine the rigidity of fastened area

Identify accuracy

- Select accuracy grade
- Identify the precision of mounting surface

Lubrication and dust protection

- Types of lubrication (grease, oil, special lubrication)
- Method of lubrication (periodic or forced lubrication)
- Dust prevention design.

Completion

4 Load Rating and Service Life of Linear Guideway

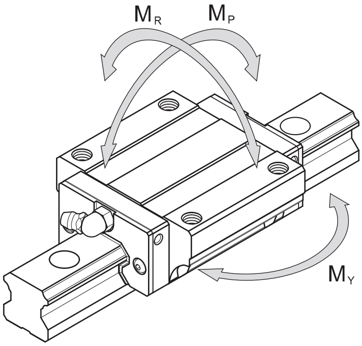
To obtain a model which is most suitable for your service conditions of the linear guideway system, the load capacity and service life of the model must be taken into consideration. To verify the static load capacity, the basic static load rating (C_0) is taken to obtain the static safety factor. The service life can be obtained by calculating the nominal life based on basic dynamic load rating. As the raceways or rolling elements are subjected repeated stresses, the service life of a linear guideway is defined as the total running distance that the linear guideway travel until flaking occurs.

4.1 Basic Static Load Rating(C_0)

A localized permanent deformation will develop between raceways and rolling elements when a linear guideway receives an excessive load or a large impact. If the magnitude of the deformation exceeds a certain limit, it could obstruct the smooth motion of the linear guideway. The basic static load rating (C_0) refers to a static load in a given direction with a specific magnitude applied at the contact area under the most stress where the sum of permanent deformation develops between the raceway and rolling elements is 0.0001 times of the diameter of rolling ball. Therefore, the basic static load rating sets a limit on the static permissible load.

4.2 Static Permissible Moment(M_0)

When a moment is applied to a linear guideway, the rolling balls on both ends will receive the most stress among the stress distribution over the rolling elements in the system. The static permissible moment (M_0) refers to a static moment in a given direction with specific magnitude applied at the contact area under the most stress where the sum of permanent deformation develops between the raceway and rolling elements is 0.0001 times the diameter of rolling elements. Therefore, the static permissible moment sets a limit on the static moment. In linear guideway system, the static permissible moment is defined as M_P, M_Y, M_R three directions. See the figure below.



4.3 Static Safety Factor(f_s)

Due to the impact and vibration while the guideway at rest or moving, or the inertia from start and stop, the linear guideway may encounter with an unexpected external force. Therefore, the safety factor should be taken into consideration for effects of such operating loads. The static safety factor (f_s) is a ratio of the basic static load rating (C_0) to the calculated working load. The static safety factor for different kinds of application is shown as Table.

$$f_s = \frac{C_0}{P} \quad \text{or} \quad f_s = \frac{M_0}{M}$$

f_s Static safety factor

C_0 Basic static load rating (N)

M_0 Static permissible moment ($N \cdot m$)

P Calculated working load (N)

M Calculated moment ($N \cdot m$)

Machine Type	Load Condition	f_S (Lower limit)
Regular industrial machine	Normal loading condition	1.0 ~ 1.3
	With impact and vibration	2.0 ~ 3.0
Machine tool	Normal loading condition	1.0 ~ 1.5
	With impact and vibration	2.5 ~ 7.0

Standard value of static safety factor

4.4 Basic Dynamic Load Rating (C)

Even when identical linear guideways in a group are manufactured in the same way or applied under the same condition, the service life may be varied. Thus, the service life is used as an indicator for determining the service life of a linear guideway system. The nominal life (L) is defined as the total running distance that 90% of identical linear guideways in a group, when they are applied under the same conditions, can work without developing flaking. The basic dynamic load rating (C) can be used to calculate the service life when linear guideway system response to a load. The basic dynamic load rating (C) is defined as a load in a given direction and with a given magnitude that when a group of linear guideways operate under the same conditions. As the rolling element is ball, the nominal life of the linear guideway is 50 km. Moreover, as the rolling element is roller, the nominal life is 100 km.

4.5 Calculation of Nominal Life (L)

The nominal life of a linear guideway can be affected by the actual working load. The nominal life can be calculated base on selected basic dynamic load rating and actual working load. The nominal life of linear guideway system could be influenced widely by environmental factors such like hardness of raceway, environmental temperature, motion conditions, thus these factors should be considered for calculation of nominal life.

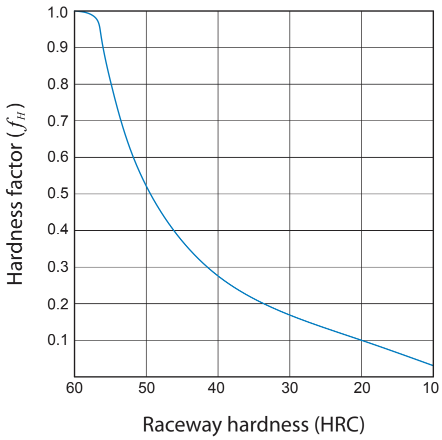
Ball $$L = \left(\frac{f_H \times f_T}{f_W} \times \frac{C}{P} \right)^3 \times 50$$

Roller $$L = \left(\frac{f_H \times f_T}{f_W} \times \frac{C}{P} \right)^{\frac{10}{3}} \times 100$$

L Nominal life (km)
C Basic dynamic load rating (N)
P Working load (N)
f_H Hardness factor
f_T Temperature factor
f_W Load factor

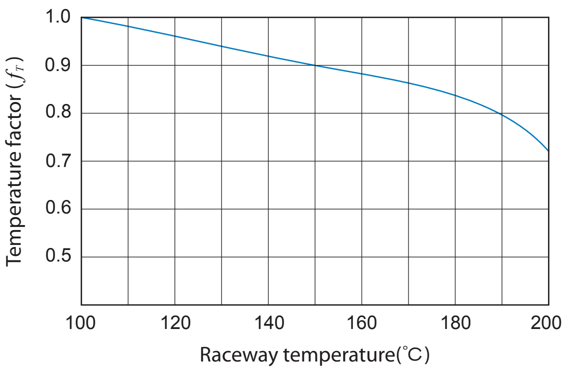
Hardness factor f_H

In order to ensure the optimum load capacity of linear guideway system, the hardness of raceway must be HRC58~64. If the hardness is lower than this range, the permissible load and nominal life will be decreased. For this reason, the basic dynamic load rating and the basic static load rating should be multiplied by hardness factor for rating calculation. See figure below. The hardness requirement of ***PMI*** linear guideway is above HRC58, thus the f_H=1.0.



Temperature factor f_T

When operating temperature higher than 100°C, the nominal life will be degraded. Therefore, the basic dynamic and static load rating should be multiplied by temperature factor for rating calculation. See figure below. The assemble parts of ***PMI*** guideway are made of plastic and rubber, therefore, the operating temperature below 100°C is strongly recommend. For special need, please contact us.



Load factor f_w

Although the working load of liner guideway system can be obtained by calculation, the actual load is mostly higher than calculated value. This is because the vibration and impact, caused by mechanical reciprocal motion, are difficult to be estimated. This is especially true when the vibration from high speed operation and the impact from repeated start and stop. Therefore, for consideration of speed and vibration, the basic dynamic load rating should be divided by the empirical load factor. See the table below.

Motion Condition	Operating Speed	f_W
No impact & vibration	V≦15 m/min	1.0~1.2
Slight impact & vibration	15＜V≦60 m/min	1.2~1.5
Moderate impact & vibration	60＜V≦120 m/min	1.5~2.0
Strong impact & vibration	V≧120 m/min	2.0~3.5

4.6 Calculation of Service Life in Time (L_h)

When the nominal life (L) is obtained, the service life in hours can be calculated by using the following equation when stroke length and reciprocating cycles are constant.

$$L_h = \frac{L \times 10^3}{2 \times l_S \times n_1 \times 60}$$

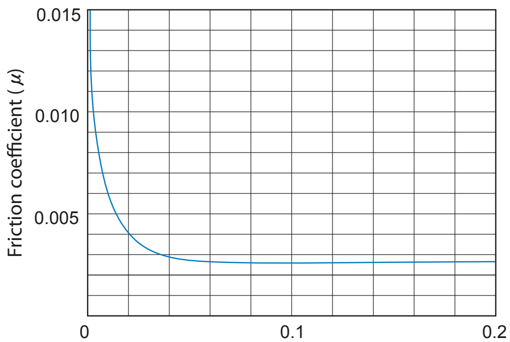
L_h Service life in hours (hr)
L Nominal life (km)
l_S Stroke length (m)
n_1 No. of reciprocating cycles per minute (min^{-1})

5 Friction Coefficient

A linear guideway manipulates linear motion by rolling elements between the rail and the carriage. In which type of motion, the frictional resistance of linear guideway can be reduced to 1/20th to 1/40th of that in a slide guide. This is especially true in static friction which is much smaller than that in other systems. Moreover, the difference between static and dynamic friction is very little, so that the stick-slip situation does not occur. As such low friction, the submicron feeding can be carried out. The frictional resistance of a linear guideway system can be varied with the magnitude of load and preload, the viscosity resistance of lubricant, and other factors. The frictional resistance can be calculated by the following equation base on working load and seals resistance. Generally, the friction coefficient will be different from series to series, the friction coefficient of ball type is 0.002~0.003 (without considering the seal resistance) and the roller type is 0.001~0.002(without considering the seal resistance)

$$F = \mu \times P + f$$

F Frictional resistance (kgf)
μ Dynamic friction coefficient
P Working load (kgf)
f Seal resistance (kgf)



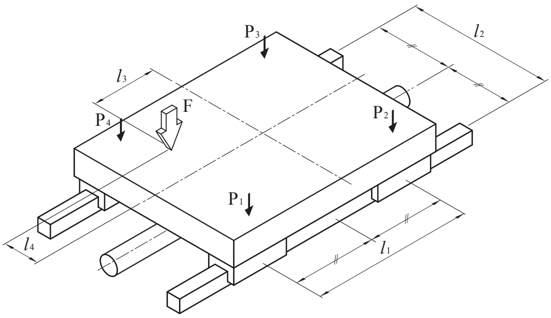
Load ratio (P/C)
P: Working load
C: Basic dynamic load rating

Relationship between working load and friction coefficient

6 Calculation of Working Load

The load applied to a linear guideway system could be varied with several factors such as the location of the center gravity of an object, the location of the thrust, and the inertial forces due to acceleration and deceleration during starting and stopping.
To select a correct linear guideway system, the above conditions must be considered for determining the magnitude of applied load.

Examples for calculating working load

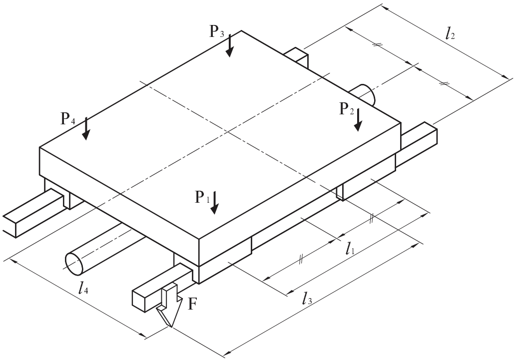
Type	**Horizontal application:** **Uniform motion or at rest**
Operation Conditions	
Equations	$P_1 = \frac{F}{4} + \frac{F \cdot l_3}{2 \cdot l_1} - \frac{F \cdot l_4}{2 \cdot l_2}$ $P_2 = \frac{F}{4} - \frac{F \cdot l_3}{2 \cdot l_1} - \frac{F \cdot l_4}{2 \cdot l_2}$ $P_3 = \frac{F}{4} - \frac{F \cdot l_3}{2 \cdot l_1} + \frac{F \cdot l_4}{2 \cdot l_2}$ $P_4 = \frac{F}{4} + \frac{F \cdot l_3}{2 \cdot l_1} + \frac{F \cdot l_4}{2 \cdot l_2}$

Type

Overhung horizontal application:

Uniform motion or at rest

Operation Conditions



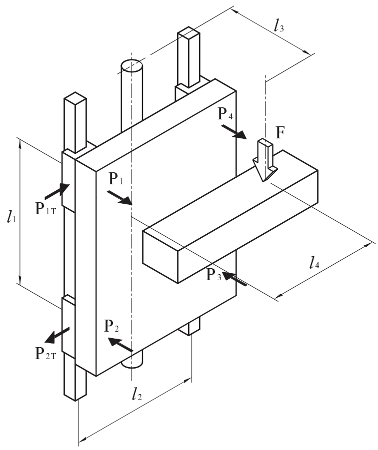
Equations

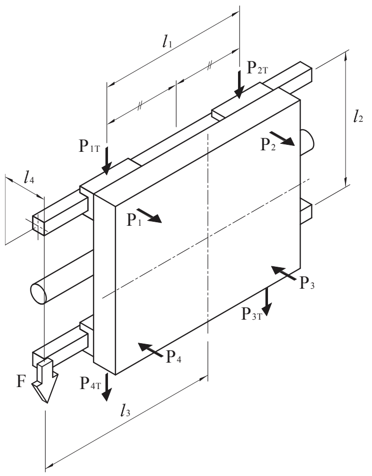
$$P_1 = \frac{F}{4} + \frac{F \cdot l_3}{2 \cdot l_1} + \frac{F \cdot l_4}{2 \cdot l_2}$$

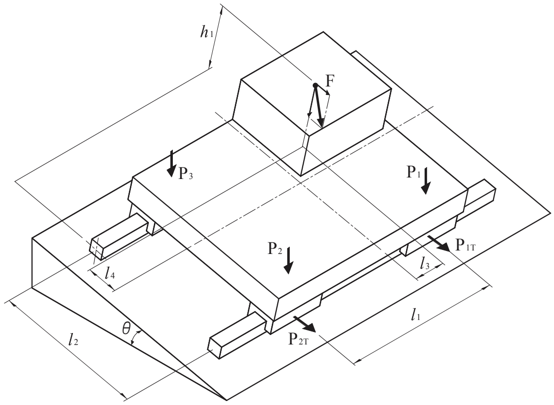
$$P_2 = \frac{F}{4} - \frac{F \cdot l_3}{2 \cdot l_1} + \frac{F \cdot l_4}{2 \cdot l_2}$$

$$P_3 = \frac{F}{4} - \frac{F \cdot l_3}{2 \cdot l_1} - \frac{F \cdot l_4}{2 \cdot l_2}$$

$$P_4 = \frac{F}{4} + \frac{F \cdot l_3}{2 \cdot l_1} - \frac{F \cdot l_4}{2 \cdot l_2}$$

Type	**Vertical application:** Uniform motion or at rest
Operation Conditions	
Equations	$P_1 = P_2 = P_3 = P_4 = \frac{F \cdot l_3}{2 \cdot l_1}$ $P_{1T} = P_{2T} = P_{3T} = P_{4T} = \frac{F \cdot l_4}{2 \cdot l_1}$

Type	**Wall installation application:** **Uniform motion or at rest**
Operation Conditions	
Equations	$$P_1 = P_2 = P_3 = P_4 = \frac{F \cdot l_4}{2 \cdot l_2}$$ $$P_{1T} = P_{4T} = \frac{F}{4} + \frac{F \cdot l_3}{2 \cdot l_1}$$ $$P_{2T} = P_{3T} = \frac{F}{4} - \frac{F \cdot l_3}{2 \cdot l_1}$$

Type	Laterally tilted application
Operation Conditions	
Equations	see below

$$P_1=\frac{F\cdot\cos\theta}{4}+\frac{F\cdot\cos\theta\cdot l_3}{2\cdot l_1}-\frac{F\cdot\cos\theta\cdot l_4}{2\cdot l_2}+\frac{F\cdot\sin\theta\cdot h_1}{2\cdot l_2}$$

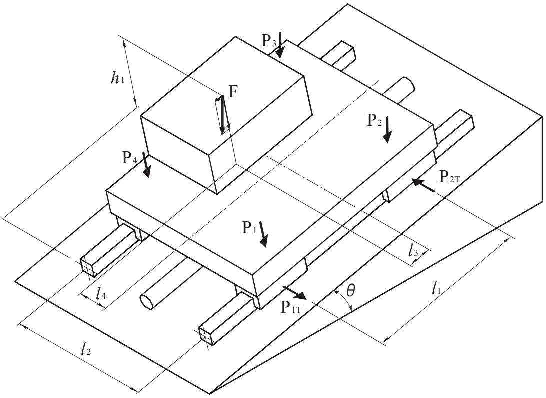
$$P_2=\frac{F\cdot\cos\theta}{4}-\frac{F\cdot\cos\theta\cdot l_3}{2\cdot l_1}-\frac{F\cdot\cos\theta\cdot l_4}{2\cdot l_2}+\frac{F\cdot\sin\theta\cdot h_1}{2\cdot l_2}$$

$$P_3=\frac{F\cdot\cos\theta}{4}-\frac{F\cdot\cos\theta\cdot l_3}{2\cdot l_1}+\frac{F\cdot\cos\theta\cdot l_4}{2\cdot l_2}-\frac{F\cdot\sin\theta\cdot h_1}{2\cdot l_2}$$

$$P_4=\frac{F\cdot\cos\theta}{4}+\frac{F\cdot\cos\theta\cdot l_3}{2\cdot l_1}+\frac{F\cdot\cos\theta\cdot l_4}{2\cdot l_2}-\frac{F\cdot\sin\theta\cdot h_1}{2\cdot l_2}$$

$$P_{1T}=P_{4T}=\frac{F\cdot\sin\theta}{4}+\frac{F\cdot\sin\theta\cdot l_3}{2\cdot l_1}$$

$$P_{2T}=P_{3T}=\frac{F\cdot\sin\theta}{4}-\frac{F\cdot\sin\theta\cdot l_3}{2\cdot l_1}$$

Type	Longitudinally tilted application
Operation Conditions	
Equations	see below

Equations

$$P_1 = \frac{F \cdot cos\theta}{4} + \frac{F \cdot cos\theta \cdot l_3}{2 \cdot l_1} - \frac{F \cdot cos\theta \cdot l_4}{2 \cdot l_2} + \frac{F \cdot sin\theta \cdot h_1}{2 \cdot l_1}$$

$$P_2 = \frac{F \cdot cos\theta}{4} - \frac{F \cdot cos\theta \cdot l_3}{2 \cdot l_1} - \frac{F \cdot cos\theta \cdot l_4}{2 \cdot l_2} - \frac{F \cdot sin\theta \cdot h_1}{2 \cdot l_1}$$

$$P_3 = \frac{F \cdot cos\theta}{4} - \frac{F \cdot cos\theta \cdot l_3}{2 \cdot l_1} + \frac{F \cdot cos\theta \cdot l_4}{2 \cdot l_2} - \frac{F \cdot sin\theta \cdot h_1}{2 \cdot l_1}$$

$$P_4 = \frac{F \cdot cos\theta}{4} + \frac{F \cdot cos\theta \cdot l_3}{2 \cdot l_1} + \frac{F \cdot cos\theta \cdot l_4}{2 \cdot l_2} + \frac{F \cdot sin\theta \cdot h_1}{2 \cdot l_1}$$

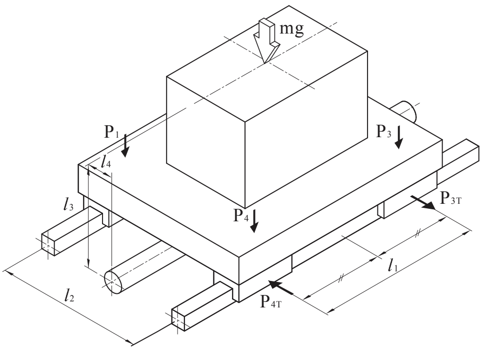
$$P_{1T} = P_{4T} = + \frac{F \cdot sin\theta \cdot l_4}{2 \cdot l_1}$$

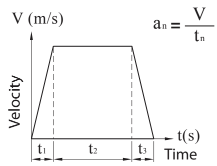
$$P_{2T} = P_{3T} = - \frac{F \cdot sin\theta \cdot l_4}{2 \cdot l_1}$$

Type

Horizontal application:
Subjected to inertia

Operation Conditions





Velocity diagram

Equations

During acceleration

$$P_1 = P_4 = \frac{mg}{4} - \frac{m \cdot a_1 \cdot l_3}{2 \cdot l_1}$$

$$P_2 = P_3 = \frac{mg}{4} + \frac{m \cdot a_1 \cdot l_3}{2 \cdot l_1}$$

$$P_{1T} = P_{2T} = P_{3T} = P_{4T} = \frac{m \cdot a_1 \cdot l_4}{2 \cdot l_1}$$

In uniform motion

$$P_1 = P_2 = P_3 = P_4 = \frac{mg}{4}$$

During deceleration

$$P_1 = P_4 = \frac{mg}{4} + \frac{m \cdot a_3 \cdot l_3}{2 \cdot l_1}$$

$$P_2 = P_3 = \frac{mg}{4} - \frac{m \cdot a_3 \cdot l_3}{2 \cdot l_1}$$

$$P_{1T} = P_{2T} = P_{3T} = P_{4T} = \frac{m \cdot a_3 \cdot l_4}{2 \cdot l_1}$$

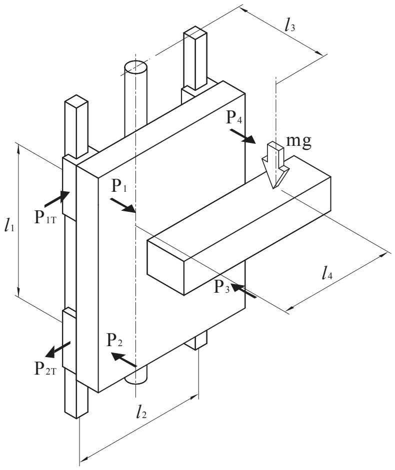
Type	Vertical application: Subjected to inertia

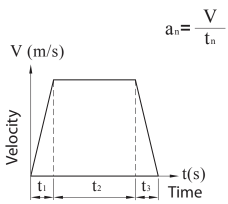
Type

Vertical application:

Subjected to inertia

Operation Conditions





Velocity diagram

Equations

During acceleration

$$P_1=P_2=P_3=P_4=\frac{m\cdot(g+a_1)\cdot l_3}{2\cdot l_1}$$

$$P_{1T}=P_{2T}=P_{3T}=P_{4T}=\frac{m\cdot(g+a_1)\cdot l_4}{2\cdot l_1}$$

During deceleration

$$P_1=P_2=P_3=P_4=\frac{m\cdot(g-a_3)\cdot l_3}{2\cdot l_1}$$

$$P_{1T}=P_{2T}=P_{3T}=P_{4T}=\frac{m\cdot(g-a_3)\cdot l_4}{2\cdot l_1}$$

In uniform motion

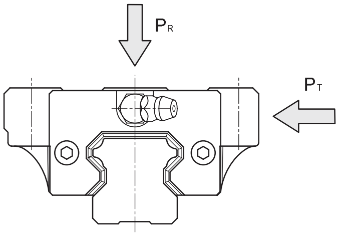
$$P_1=P_2=P_3=P_4=\frac{m\cdot g\cdot l_3}{2\cdot l_1}$$

$$P_{1T}=P_{2T}=P_{3T}=P_{4T}=\frac{m\cdot g\cdot l_4}{2\cdot l_1}$$

7 Calculation of the Equivalent Load

The linear guideway system can take up loads and moments in all four directions those are radial load, reverse-radial load, and lateral load simultaneously. When more than one load is exerted on linear guideway system simultaneously, all loads could be converted into radial or lateral equivalent load for calculating service life and static safety factor. *PMI* linear guideway has four-way equal load design. The calculation of equivalent load for the use of two or more linear guideways is shown as below.

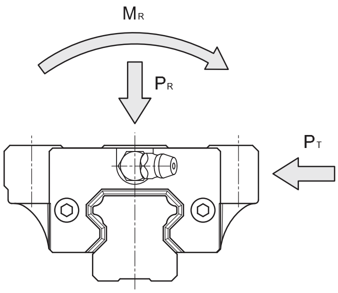
$$P_E = |P_R| + |P_T|$$



P_E Equivalent load (N)
P_R Radial or reverse-radial load (N)
P_T Lateral load (N)

For the case of mono rail, the moment effect should be considered. The equation is:

$$P_E = |P_R| + |P_T| + C_0 \cdot \frac{|M|}{M_R}$$



P_E Equivalent load (N)
P_R Radial or reverse-radial load (N)
P_T Lateral load (N)
C_0 Basic static load rating (N)
M Calculated moment ($N \cdot m$)
M_R Permissible static moment ($N \cdot m$)

8 The Calculation of the Mean Load

When a linear guideway system receives varying loads, the service life could be calculated in consideration of varying loads of the host-system operation conditions. The mean load (Pm) is the load that the service life is equivalent to the system which under the varying load conditions. The equation of mean load is:

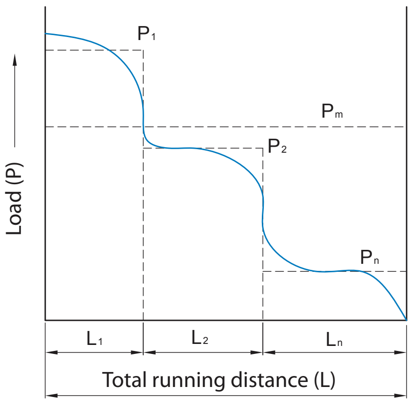
$$P_m = \sqrt[e]{\frac{1}{L} \cdot \sum_{n=1}^{n} (P_n^e \cdot L_n)}$$

P_m Mean load (N)
P_n Varying load (N)
L Total running distance (mm)
L_n Running distance under load P_n (mm)
e Exponent (Ball type:3, Roller type:10/3)

Examples for calculating mean load

Types of Varying Load	Calculation of Mean Load

Loads that change stepwise

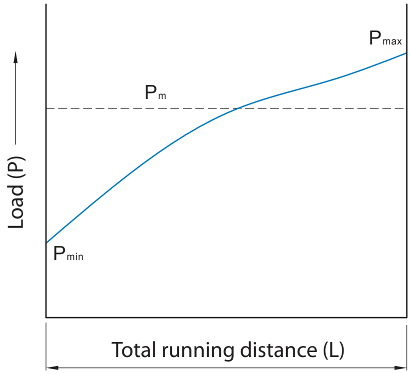


$$P_m = \sqrt[e]{\frac{1}{L}(P_1^e \cdot L_1 + P_2^e \cdot L_2 \cdots\cdots + P_n^e \cdot L_n)}$$

P_m Mean load (N)
P_n Varying load (N)
L Total running distance (mm)
L_n Running distance under load P_n (mm)

Types of Varying Load | Calculation of Mean Load

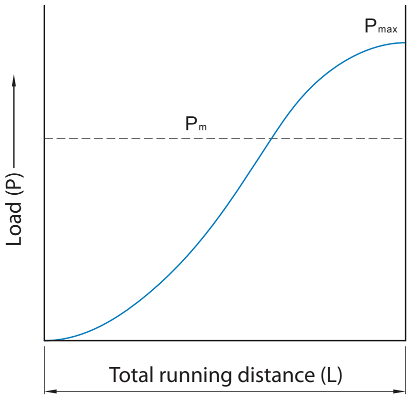
Loads that change monotonously

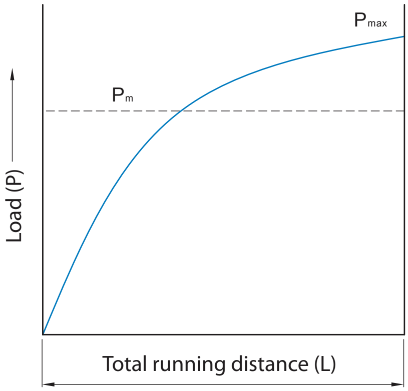


$$P_m \cong \frac{1}{3}(P_{min} + 2 \cdot P_{max})$$

P_m Mean load (N)
P_{min} Minimum load (N)
P_{max} Maximum load (N)

Loads that change sinusoidally





$$P_m \cong 0.65 \cdot P_{max}$$

P_m Mean load (N)
P_{max} Maximum load (N)

$$P_m \cong 0.75 \cdot P_{max}$$

P_m Mean load (N)
P_{max} Maximum load (N)

9 Calculation Example

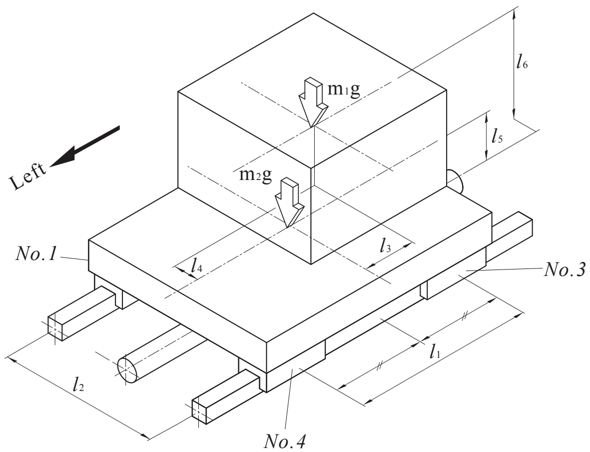
Operation conditions

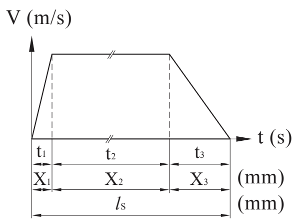
Modle MSA35LA2SSFC + R2520-20/20 P II

Basic dynamic load rating ： C = 63.6 kN

Basic static load rating ： C_0 = 100.6 kN

Mass	$m_1 = 700$ kg $m_2 = 450$ kg	Stroke	$l_s = 1500$ mm
Velocity	V = 0.75 m/s	Distance	$l_1 = 650$ mm $l_2 = 450$ mm $l_3 = 135$ mm $l_4 = 60$ mm $l_5 = 175$ mm $l_6 = 400$ mm
Time	$t_1 = 0.05$ s $t_2 = 1.9$ s $t_3 = 0.15$ s		
Acceleration	$a_1 = 15$ m/s² $a_3 = 5$ m/s²		





Velocity diagram

9.1 Calculate the load that each carriage exerts

9.1.1 Uniform motion, Radial load P_n

$$P_1 = \frac{m_1 g}{4} - \frac{m_1 g \cdot l_3}{2l_1} + \frac{m_1 g \cdot l_4}{2l_2} + \frac{m_2 g}{4}$$

$= 2562.4$ N

$$P_2 = \frac{m_1 g}{4} + \frac{m_1 g \cdot l_3}{2l_1} + \frac{m_1 g \cdot l_4}{2l_2} + \frac{m_2 g}{4}$$

$= 3987.2$ N

$$P_3 = \frac{m_1 g}{4} + \frac{m_1 g \cdot l_3}{2l_1} - \frac{m_1 g \cdot l_4}{2l_2} + \frac{m_2 g}{4}$$

$= 3072.6$ N

$$P_4 = \frac{m_1 g}{4} - \frac{m_1 g \cdot l_3}{2l_1} - \frac{m_1 g \cdot l_4}{2l_2} + \frac{m_2 g}{4}$$

$= 1647.8$ N

9.1.2 During acceleration to the left, Radial load $P_n la_1$

$$P_1 la_1 = P_1 - \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_1 \cdot l_5}{2l_1}$$

$= -1577$ N

$$P_2 la_1 = P_2 + \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_1 \cdot l_5}{2l_1}$$

$= 8126.6$ N

$$P_3 la_1 = P_3 + \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_1 \cdot l_5}{2l_1}$$

$= 7212$ N

$$P_4 la_1 = P_4 - \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_1 \cdot l_5}{2l_1}$$

$= -2491.6$ N

Lateral load $Pt_n la_1$

$$Pt_1 la_1 = -\frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = -484.6 \text{ N}$$

$$Pt_2 la_1 = \frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = 484.6 \text{ N}$$

$$Pt_3 la_1 = \frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = 484.6 \text{ N}$$

$$Pt_4 la_1 = -\frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = -484.6 \text{ N}$$

9.1.3 During deceleration to the left, Radial load $P_n la_3$

$$P_1 la_3 = P_1 + \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 3942.2 \text{ N}$$

$$P_3 la_3 = P_3 - \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 1692.8 \text{ N}$$

$$P_2 la_3 = P_2 - \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 2607.4 \text{ N}$$

$$P_4 la_3 = P_4 + \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 3027.6 \text{ N}$$

Lateral load $Pt_n la_3$

$$Pt_1 la_3 = \frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = 161.5 \text{ N}$$

$$Pt_3 la_3 = -\frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = 161.5 \text{ N}$$

$$Pt_2 la_3 = -\frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = -161.5 \text{ N}$$

$$Pt_4 la_3 = \frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = -161.5 \text{ N}$$

9.1.4 During acceleration to the right, Radial load $P_n ra_1$

$$P_1 ra_1 = P_1 + \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_1 \cdot l_5}{2l_1} = 6701.8 \text{ N}$$

$$P_3 ra_1 = P_3 - \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_1 \cdot l_5}{2l_1} = -1066.8 \text{ N}$$

$$P_2 ra_1 = P_2 - \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_1 \cdot l_5}{2l_1} = -152.2 \text{ N}$$

$$P_4 ra_1 = P_4 + \frac{m_1 \cdot a_1 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_1 \cdot l_5}{2l_1} = 5787.2 \text{ N}$$

Lateral load $Pt_n la_3$

$$Pt_1 ra_1 = \frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = 484.6 \text{ N}$$

$$Pt_3 ra_1 = -\frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = -484.6 \text{ N}$$

$$Pt_2 ra_1 = -\frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = -484.6 \text{ N}$$

$$Pt_4 ra_1 = \frac{m_1 \cdot a_1 \cdot l_4}{2l_1} = 484.6 \text{ N}$$

9.1.5 During deceleration to the right, Radial load $P_n ra_3$

$$P_1 ra_3 = P_1 - \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 1182.6\ \text{N}$$

$$P_3 ra_3 = P_3 + \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 4452.4\ \text{N}$$

$$P_2 ra_3 = P_2 + \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} + \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 5367\ \text{N}$$

$$P_4 ra_3 = P_4 - \frac{m_1 \cdot a_3 \cdot l_6}{2l_1} - \frac{m_2 \cdot a_3 \cdot l_5}{2l_1} = 268\ \text{N}$$

Lateral load $Pt_n ra_1$

$$Pt_1 ra_3 = -\frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = -161.5\ \text{N}$$

$$Pt_3 ra_3 = \frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = 161.5\ \text{N}$$

$$Pt_2 ra_3 = \frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = 161.5\ \text{N}$$

$$Pt_4 ra_3 = -\frac{m_1 \cdot a_3 \cdot l_4}{2l_1} = -161.5\ \text{N}$$

9.2 Calculate equivalent load

9.2.1 In uniform motion

$P_{E1} = P_1 = 2562.4 \text{ N}$

$P_{E2} = P_2 = 3987.2 \text{ N}$

$P_{E3} = P_3 = 3072.6 \text{ N}$

$P_{E4} = P_4 = 1647.8 \text{ N}$

9.2.2 During acceleration to the left

$P_{E1}la_1 = |P_1la_1| + |Pt_1la_1| = 2061.6 \text{ N}$

$P_{E2}la_1 = |P_2la_1| + |Pt_2la_1| = 8611.2 \text{ N}$

$P_{E3}la_1 = |P_3la_1| + |Pt_3la_1| = 7696.6 \text{ N}$

$P_{E4}la_1 = |P_4la_1| + |Pt_4la_1| = 2976.2 \text{ N}$

9.2.3 During deceleration to the left

$P_{E1}la_3 = |P_1la_3| + |Pt_1la_3| = 4103.7 \text{ N}$

$P_{E2}la_3 = |P_2la_3| + |Pt_2la_3| = 2768.9 \text{ N}$

$P_{E3}la_3 = |P_3la_3| + |Pt_3la_3| = 1854.3 \text{ N}$

$P_{E4}la_3 = |P_4la_3| + |Pt_4la_3| = 3189.1 \text{ N}$

9.2.4 During acceleration to the right

$P_{E1}ra_1 = |P_1la_1| + |Pt_1la_1| = 7186.4 \text{ N}$

$P_{E2}ra_1 = |P_2la_1| + |Pt_2la_1| = 636.8 \text{ N}$

$P_{E3}ra_1 = |P_3la_1| + |Pt_3la_1| = 1551.4 \text{ N}$

$P_{E4}ra_1 = |P_4la_1| + |Pt_4la_1| = 6271.8 \text{ N}$

9.2.5 During deceleration to the right

$P_{E1}ra_3 = |P_1la_3| + |Pt_1la_3| = 1344.1 \text{ N}$

$P_{E2}ra_3 = |P_2la_3| + |Pt_2la_3| = 5528.5 \text{ N}$

$P_{E3}ra_3 = |P_3la_3| + |Pt_3la_3| = 4613.9 \text{ N}$

$P_{E4}ra_3 = |P_4la_3| + |Pt_4la_3| = 429.5 \text{ N}$

9.3 Calculation of static factor

From above, the maximum load is exerted on carriage No.2 when during acceleration of the 2nd linear guideway to the left.

$$fs = \frac{C_O}{P_{E2}la_1} = \frac{100.6\times10^3}{8611.2} = 11.7$$

9.4 Calculate the mean load on each carriage Pm_n

$$P_{m1} = \sqrt[3]{\frac{(P_{E1}la_1^3\cdot X_1 + P_{E1}^3\cdot X_2 + P_{E1}la_3^3\cdot X_3 + P_{E1}ra_1^3\cdot X_1 + P_{E1}^3\cdot X_2 + P_{E1}ra_3^3\cdot X_3)}{2l_S}} = 2700.7\ \text{N}$$

$$P_{m2} = \sqrt[3]{\frac{(P_{E2}la_1^3\cdot X_1 + P_{E2}^3\cdot X_2 + P_{E2}la_3^3\cdot X_3 + P_{E2}ra_1^3\cdot X_1 + P_{E2}^3\cdot X_2 + P_{E2}ra_3^3\cdot X_3)}{2l_S}} = 4077.2\ \text{N}$$

$$P_{m3} = \sqrt[3]{\frac{(P_{E3}la_1^3\cdot X_1 + P_{E3}^3\cdot X_2 + P_{E3}la_3^3\cdot X_3 + P_{E3}ra_1^3\cdot X_1 + P_{E3}^3\cdot X_2 + P_{E3}ra_3^3\cdot X_3)}{2l_S}} = 3187.7\ \text{N}$$

$$P_{m4} = \sqrt[3]{\frac{(P_{E4}la_1^3\cdot X_1 + P_{E4}^3\cdot X_2 + P_{E4}la_3^3\cdot X_3 + P_{E4}ra_1^3\cdot X_1 + P_{E4}^3\cdot X_2 + P_{E4}ra_3^3\cdot X_3)}{2l_S}} = 1872.6\ \text{N}$$

9.5 Calculation of nominal life (L_n)

Base on the equation of the nominal life, we assume the f_W=1.5 and the result is as below:

$$L_1 = \left(\frac{C}{f_W\cdot P_{m1}}\right)^3\times 50 = 193500\ \text{km}$$

$$L_3 = \left(\frac{C}{f_W\cdot P_{m3}}\right)^3\times 50 = 117700\ \text{km}$$

$$L_2 = \left(\frac{C}{f_W\cdot P_{m2}}\right)^3\times 50 = 56231\ \text{km}$$

$$L_4 = \left(\frac{C}{f_W\cdot P_{m4}}\right)^3\times 50 = 580400\ \text{km}$$

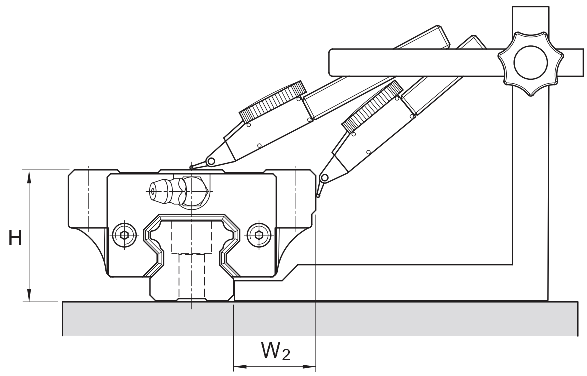
From these calculations and under the operating conditions specified as above, the 56231 km running distance as service life of carriage No.2 is obtained.

10 Accuracy Standard

The accuracy of linear guideway includes the dimensional tolerance of height, width, and the running accuracy of the carriage on the rail. The standard of the dimension difference is built for two or more carriages on a rail or a number of rails are used on the same plane. The accuracy of linear guideway is divided into 5 classes, normal grade (N), high precision (H), precision (P), super precision (SP), and ultra precision (UP).

Running parallelism

The running accuracy is the deviation of parallelism between the reference surface of carriage and reference surface of rail when carriage moving over the entire length of rail.



Height difference (ΔH)

The height difference (ΔH) means the height difference among carriages installed on the same plane.

Width difference (ΔW_2)

The width difference (ΔW_2) means the width difference among carriages installed on a rail.

Additional remarks：

1. When two or more linear guideways are used on the same plane, the tolerance of W_2 and difference of ΔW_2 is applicable to master rail only.

2. The accuracy is measured at the center or central area of carriage.

10.1 The Selection of Accuracy Grade

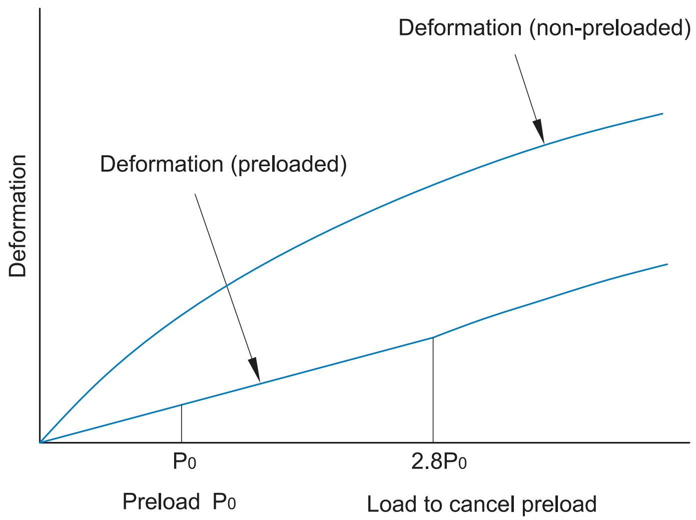
The accuracy grade for different applications shown as table below.

Sort	Application	Accuracy Grade				
		N	H	P	SP	UP
Machine Tool	Machining center			●	●	
	Lathe			●	●	
	Milling machine			●	●	
	Boring machine			●	●	
	Jig borer				●	●
	Grinding machine				●	●
	Electric discharge machine			●	●	●
	Punching press		●	●		
	Laser-beam machine		●	●	●	
	Woodworking machine	●	●	●		
	NC drilling machine		●	●		
	Tapping center		●	●		
	Pallet changer	●				
	ATC	●				
	Wire cutter			●	●	
	Dresser				●	●

Sort	Application	Accuracy Grade				
		N	H	P	SP	UP
Industrial Robot	Cartesian coordinate robot	●	●	●		
	Cylindrical coordinate robot	●	●			
Semiconductor Manufacturing	Wire bonder			●	●	
	Prober				●	●
	Electronic-component inserter		●	●		
	Printed-circuit-board drilling machine		●	●	●	
Others	Injection-molding machine	●	●			
	3D measuring instrument				●	●
	Office equipment	●	●			
	Transfer equipment	●	●			
	XY table		●	●	●	
	Painting machine	●	●			
	Welding machine	●	●			
	Medical equipment	●	●			
	Digitizer		●	●	●	
	Inspection equipment			●	●	●

11 Calculation of the Equivalent Load

The rigidity of a linear guideway could be enhanced by increasing the preload. As shown as below figure, the load could be raised up to 2.8 times the preload applied. The preload is represented by negative clearance resulting from the increase of rolling element diameter. Therefore, the preload should be considered in calculation service life.



11.1 The Selection of Preload

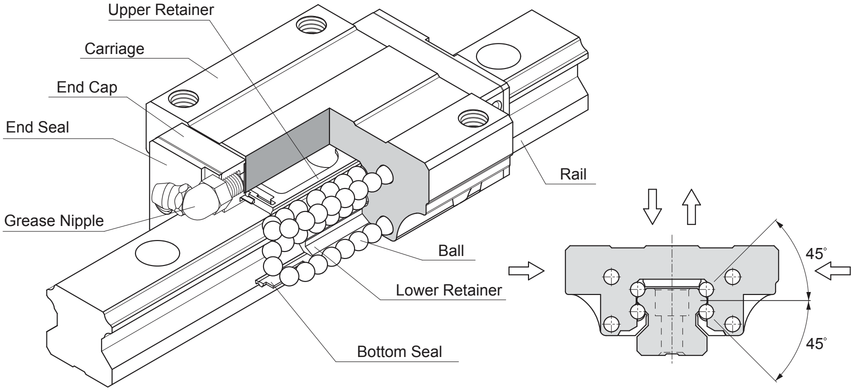
Selecting proper preload from table below to adapt the specific application and condition.

Preload grade	Fitted condition	Application examples
Clearance (FZ)	• The loading direction is fixed, vibration and impact are light, and two axes are applied in parallel. • High precision is not required, and the low frictional resistance is need.	Semiconductor facilities, medical equipment, stage systems, press machine, welding machine, industrial robot, and other small sliding systems.
Light preload (FC)	• The loading direction is fixed, vibration and impact are light, and two axes are applied in parallel. • High precision is not required, and the low frictional resistance is needed.	Welding machine, binding machine, auto packing machine, XY axis of ordinary industrial machine, material handling equipments.
Medium preload (F0)	• Overhang application with a moment load. • Applied in one-axis configuration • The need of light preload and high precision.	Z axis of industrial machines, EDM, precision XY table, PC board drilling machine, industrial robot, NC lathe, measuring equipment, grinding machine, auto painting machine.
Heavy preload (F1)	• Machine is subjected to vibration and impact, and high rigidity required. • Application of heavy load or heavy cutting.	Machine center, NC lathe, grinding machine, milling machine, Z axis of boring machine and machine tools.
Ultra heavy preload (F2)	• Machine is subjected to vibration and impact, and high rigidity required. • Application of heavy load or heavy cutting.	Machine center, NC lathe, grinding machine, milling machine, Z axis of boring machine and machine tools.

12 Introduction of Each Series

12.1 Heavy Load Type, MSA Series

A. Construction



B. Characteristics

The trains of balls are designed to a contact angle of 45° which enables it to bear an equal load in radial, reversed radial and lateral directions. Therefore, it can be applied in any installation direction. Furthermore, MSA series can achieve a well balanced preload for increasing rigidity in four directions while keeping a low frictional resistance. This is especially suit to high precision and high rigidity required motion.

The patent design of lubrication route makes the lubricant evenly distribute in each circulation loop. Therefore, the optimum lubrication can be achieved in any installation direction, and this promotes the performance in running accuracy, service life, and reliability.

High Rigidity, Four-way Equal Load

The four trains of balls are allocated to a circular contact angle at 45°, thus each train of balls can take up an equal rated load in all four directions. Moreover, a sufficient preload can be achieved to increase rigidity, and this makes it suitable for any kind of installation.

Smooth Movement with Low Noise

The simplified design of circulating system with strengthened synthetic resin accessories makes the movement smooth and quiet.

Self Alignment Capability

The self adjustment is performed spontaneously as the design of face-to-face (DF) circular arc groove. Therefore, the installation error could be compensated even under a preload, and which results in precise and smooth linear motion.

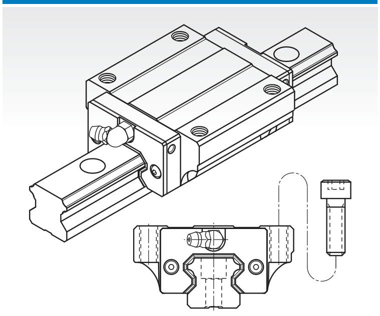
Interchangeability

For interchangeable type of linear guideway, the dimensional tolerances are strictly maintained within a reasonable range, and this has made the random matching of the same size of rails and carriages possible. Therefore, the similar preload and accuracy can be obtained even under the random matching condition. As a result of this advantage, the linear guideway can be stocked as standard parts, the installation and maintenance become more convenient. Moreover, this is also beneficial for shortening the delivery time.

C. Carriage Type

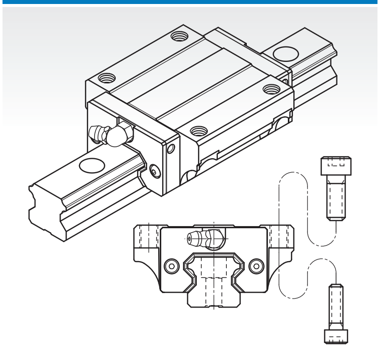
Heavy Load

MSA-A Type



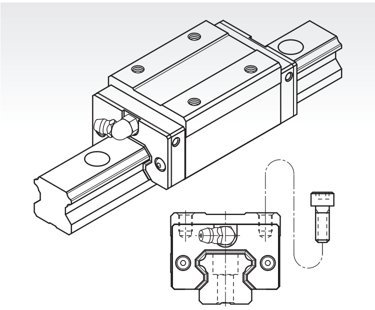
Installed from top side of carriage with the thread length longer than MSA-E type.

MSA-E Type



This type offers the installation either from top or bottom side of carriage.

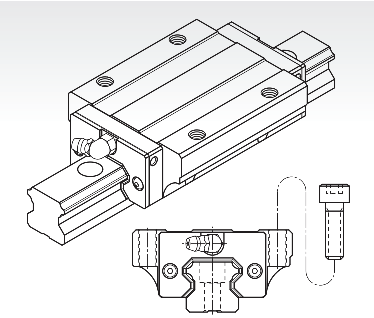
MSA-S Type



Square type with smaller width and can be installed from top side of carriage.

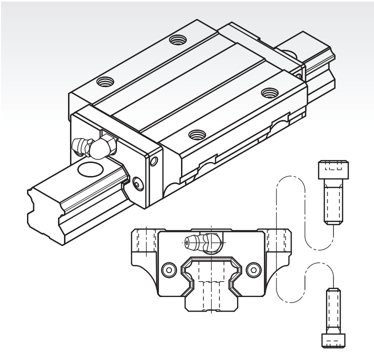
Ultra Heavy Load

MSA-LA Type



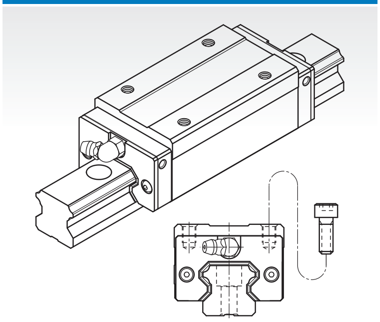
All dimensions are same as MSA-A except the length is longer, which makes it more rigid.

MSA-LE Type



All dimensions are same as MSA-E except the length is longer, which makes it more rigid.

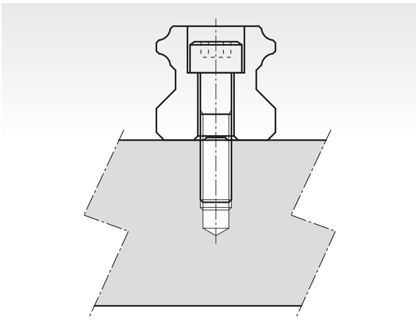
MSA-LS Type



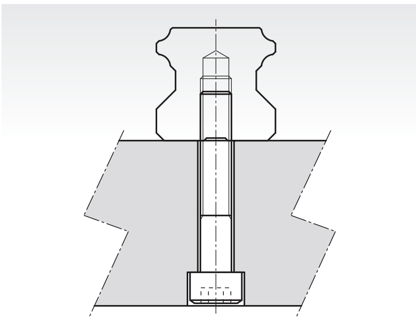
All dimensions are same as MSA-S except the length is longer, which makes it more rigid.

D. Rail Type

Counter bore (R type)



Tapped Hole (T type)



E. Description of Specification

(1) Non-Interchangeable Type

MSA 25 A 2 SS F0 _

Series : **MSA**

Size : **15, 20, 25, 30, 35, 45, 55, 65**

Carriage type : (1) Heavy load
- **A** : Flange type, mounting from top
- **E** : Flange type, mounting either from top or bottom
- **S** : Square type

(2) Ultra heavy load
- **LA** : Flange type, mounting from top
- **LE** : Flange type, mounting either from top or bottom
- **LS** : Square type

Number of carriages per rail : **1, 2, 3 ...**

Dust protection option of carriage :
No symbol, **UU, SS, ZZ, DD, KK, LL, RR, HD** (refer to chapter 15.1 Dust Proof)

Preload : **FC** (Light preload) , **F0** (Medium preload) , **F1** (Heavy preload)

Code of special carriage : **No symbol, A, B, ...**

Rail type : **R** (Counter-bore type), **T** (Tapped hole type)

Rail length (mm)

Rail hole pitch from start side (**E1**, see Fig.12.1)

Rail hole pitch to the end side (**E2**, see Fig.12.1)

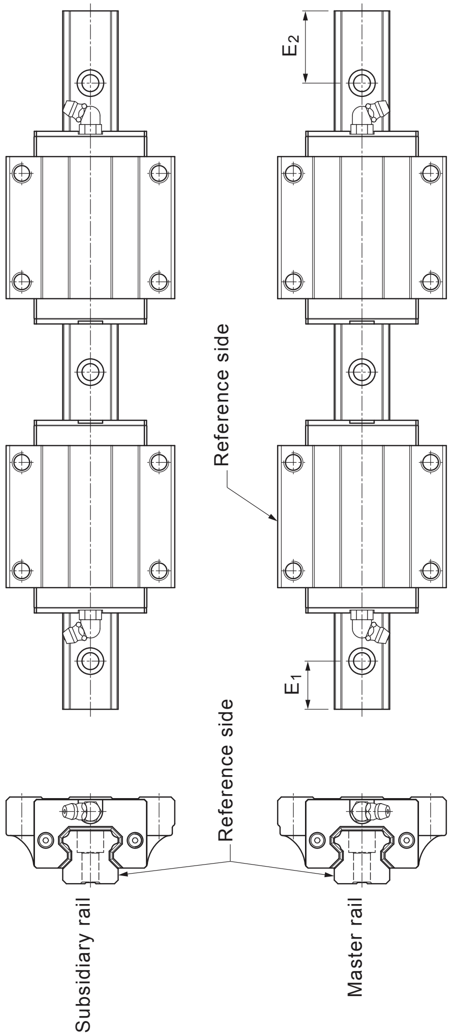
Accuracy grade : **N, H, P, SP, UP**

Code of special rail : **No symbol, A, B ...**

Dust protection option of rail : **No symbol, /CC, /MC, /MD**
(refer to chapter 15.1 Code of contamination fro Rail)

Number of rails per axis : **No symbol, II, III, IV ...**

+R 1200 - 20 / 40 P II



E2
Reference side
E1
Reference side
Subsidiary rail
Master rail

Fig12.1

(2) Interchangeable Type

Code of Carriage

MSA 25 A SS FC N

Series : **MSA**

Size : **15, 20, 25, 30, 35, 45, 55, 65**

Carriage type : (1) Heavy load
- **A** : Flange type, mounting from top
- **E** : Flange type, mounting either from top or bottom
- **S** : Square type

(2) Ultra heavy load
- **LA** : Flange type, mounting from top
- **LE** : Flange type, mounting either from top or bottom
- **LS** : Square type

Dust protection option of carriage : **No symbol, UU, SS, ZZ, DD, KK, LL, RR, HD**
(refer to chapter 15.1 Dust Proof)

Preload : **FC** (Light preload), **F0** (Medium preload) , **F1**(Heavy preload)
We don't provide **F1**(Heavy preload) to MSA15

Accuracy grade : **N, H, P**

Code of special carriage : **No symbol, A, B, ...**

Code of Rail

MSA 25 R 1200 - 20 / 40 N

Series : **MSA**

Size : **15, 20, 25, 30, 35, 45, 55, 65**

Rail type : **R** (Counter-bore type), **T** (Tapped hole type)

Rail length (mm)

Rail hole pitch from start side (**E1**, see Fig.12.1)

Rail hole pitch to the end side (**E2**, see Fig.12.1)

Accuracy grade : **N, H, P**

Code of special rail : **No symbol, A, B ...**

Dust protection option of rail : **No symbol, /CC, /MC , /MD**
(refer to chapter 15.1 Code of contamination fro Rail)

F. Accuracy Grade

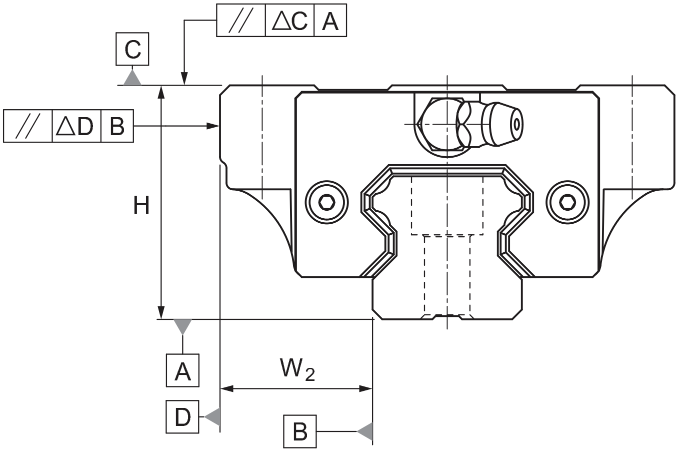


Table 1 Running Parallelism

Rail length (mm)		Running Parallelism Values(μm)				
Above	Or less	N	H	P	SP	UP
0	315	9	6	3	2	1.5
315	400	11	8	4	2	1.5
400	500	13	9	5	2	1.5
500	630	16	11	6	2.5	1.5
630	800	18	12	7	3	2
800	1000	20	14	8	4	2
1000	1250	22	16	10	5	2.5
1250	1600	25	18	11	6	3
1600	2000	28	20	13	7	3.5
2000	2500	30	22	15	8	4
2500	3000	32	24	16	9	4.5
3000	3500	33	25	17	11	5
3500	4000	34	26	18	12	6

A Non-Interchangeable Type

Model No.	Item	Accuracy Grade				
		Normal N	High H	Precision P	Super Precision SP	Ulitra Precision UP
15 20	Tolerance for height H	±0.1	±0.03	0 -0.03	0 -0.015	0 -0.008
	Height difference ΔH	0.02	0.01	0.006	0.004	0.003
	Tolerance for distance W_2	±0.1	±0.03	0 -0.03	0 -0.015	0 -0.008
	Difference in distance $W_2(\Delta W_2)$	0.02	0.01	0.006	0.004	0.003
	Running parallelism of surface C with surface A	ΔC (see the table 1)				
	Running parallelism of surface D with surface B	ΔD (see the table 1)				
25 30 35	Tolerance for height H	±0.1	±0.04	0 -0.04	0 -0.02	0 -0.01
	Height difference ΔH	0.02	0.015	0.007	0.005	0.003
	Tolerance for distance W_2	±0.1	±0.04	0 -0.04	0 -0.02	0 -0.01
	Difference in distance $W_2(\Delta W_2)$	0.03	0.015	0.007	0.005	0.003
	Running parallelism of surface C with surface A	ΔC (see the table 1)				
	Running parallelism of surface D with surface B	ΔD (see the table 1)				
45 55	Tolerance for height H	±0.1	±0.05	0 -0.05	0 -0.03	0 -0.02
	Height difference ΔH	0.03	0.015	0.007	0.005	0.003
	Tolerance for distance W_2	±0.1	±0.05	0 -0.05	0 -0.03	0 -0.02
	Difference in distance $W_2(\Delta W_2)$	0.03	0.02	0.01	0.007	0.005
	Running parallelism of surface C with surface A	ΔC (see the table 1)				
	Running parallelism of surface D with surface B	ΔD (see the table 1)				
65	Tolerance for height H	±0.1	±0.07	0 -0.07	0 -0.05	0 -0.03
	Height difference ΔH	0.03	0.02	0.01	0.007	0.005
	Tolerance for distance W_2	±0.1	±0.07	0 -0.07	0 -0.05	0 -0.03
	Difference in distance $W_2(\Delta W_2)$	0.03	0.025	0.015	0.01	0.007
	Running parallelism of surface C with surface A	ΔC (see the table 1)				
	Running parallelism of surface D with surface B	ΔD (see the table 1)				

B Interchangeable Type

Model No.	Item	Accuracy Grade		
		Normal **N**	High **H**	Precision **P**
15 20	Tolerance for height H	±0.1	±0.03	0 -0.03
	Height difference ΔH	0.02	0.01	0.006
	Tolerance for distance W_2	±0.1	±0.03	0 -0.03
	Difference in distance W_2(ΔW_2)	0.02	0.01	0.006
	Running parallelism of surface C with surface A	ΔC (see the table 1)		
	Running parallelism of surface D with surface B	ΔD (see the table 1)		
25 30 35	Tolerance for height H	±0.1	±0.04	0 -0.04
	Height difference ΔH	0.02	0.015	0.007
	Tolerance for distance W_2	±0.1	±0.04	0 -0.04
	Difference in distance W_2(ΔW_2)	0.03	0.015	0.007
	Running parallelism of surface C with surface A	ΔC (see the table 1)		
	Running parallelism of surface D with surface B	ΔD (see the table 1)		
45 55	Tolerance for height H	±0.1	±0.05	0 -0.05
	Height difference ΔH	0.03	0.015	0.007
	Tolerance for distance W_2	±0.1	±0.05	0 -0.05
	Difference in distance W_2(ΔW_2)	0.03	0.02	0.01
	Running parallelism of surface C with surface A	ΔC (see the table 1)		
	Running parallelism of surface D with surface B	ΔD (see the table 1)		
65	Tolerance for height H	±0.1	±0.07	0 -0.07
	Height difference ΔH	0.03	0.02	0.01
	Tolerance for distance W_2	±0.1	±0.07	0 -0.07
	Difference in distance W_2(ΔW_2)	0.03	0.025	0.015
	Running parallelism of surface C with surface A	ΔC (see the table 1)		
	Running parallelism of surface D with surface B	ΔD (see the table 1)		

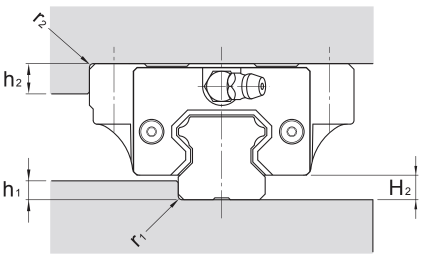
G. Preload Grade

Series	Preload grade		
	Light preload (FC)	Medium preload (F0)	Heavy preload (F1)
MSA15	0~0.02C	0.03~0.05C	-
MSA20			0.05~0.08C
MSA25			
MSA30			
MSA35			
MSA45			
MSA55			
MSA65			
MSA20L	0~0.02C	0.03~0.05C	0.05~0.08C
MSA25L			
MSA30L			
MSA35L			
MSA45L			
MSA55L			
MSA65L			

Note: C is basic dynamic load rating in above table. Refer to the specification of products, please.

H. The Shoulder Height and Corner Radius for Installation

MSA series



Unit: mm

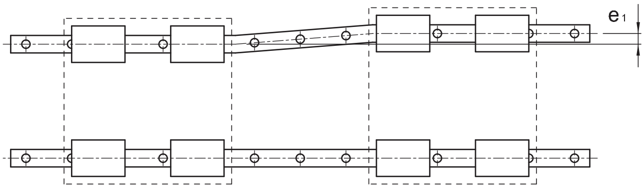
Model No.	r_1 (max.)	r_2 (max.)	h_1	h_2	H_2
15	0.5	0.5	3	4	4.2
20	0.5	0.5	3.5	5	5
25	1	1	5	5	6.5
30	1	1	5	5	8
35	1	1	6	6	9.5
45	1	1	8	8	10
55	1.5	1.5	10	10	13
65	1.5	1.5	10	10	15

I. Dimensional Tolerance of Mounting Surface

MSA Series

With the self alignment capability, the minor dimensional error in mounting surface could be compensated and achieves smooth linear motion. The tolerances of parallelism between two axes are shown as below.

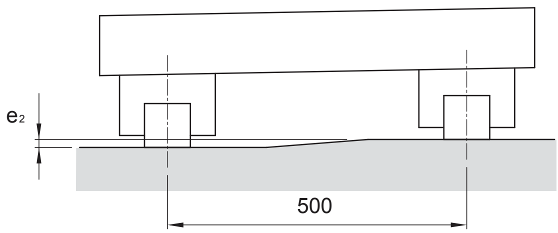
The parallel deviation between two axes (e_1)



Unit: μm

Model No.	Preload Grade		
	FC	F0	F1
15	25	18	-
20	25	20	18
25	30	22	20
30	40	30	27
35	50	35	30
45	60	40	35
55	70	50	45
65	80	60	55

Level difference between two axes (e_2)

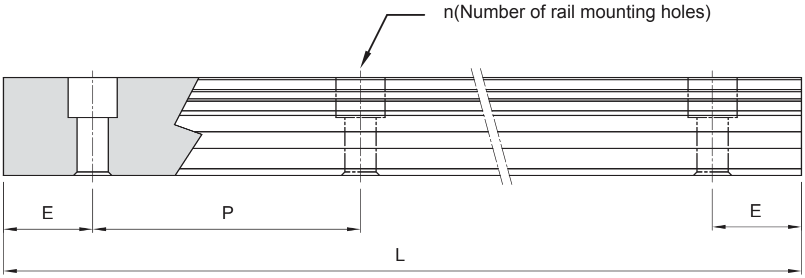


Unit: μm

Model No.	Preload Grade		
	FC	F0	F1
15	130	85	-
20	130	85	50
25	130	85	70
30	170	110	90
35	210	150	120
45	250	170	140
55	300	210	170
65	350	250	200

Note: The permissible values in table are applicable when the span is 500mm wide.

J. Rail Maximum Length and Standrad



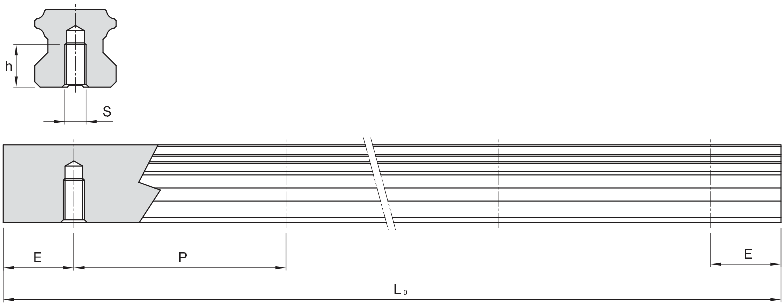
$$L=(n-1)\times P+2\times E$$

L: Total Length of rail *(mm)*
n: Nuber of mounting holes
P: Distance between any two holes *(mm)*
E: Distance from the center of the last hole to the edge *(mm)*

Unit: mm

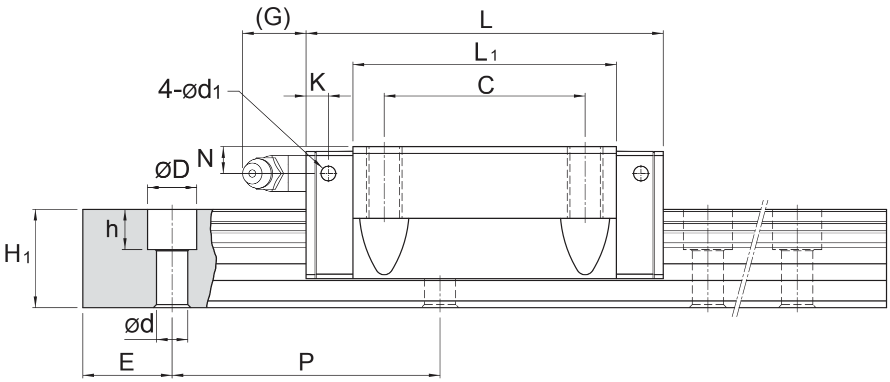
Model No.	Standard Pitch (P)	Standard ($E_{std.}$)	Minimum ($E_{min.}$)	Max (L_0 max.)
MSA 15	60	20	5	4000
MSA 20	60	20	6	4000
MSA 25	60	20	7	4000
MSA 30	80	20	8	4000
MSA 35	80	20	8	4000
MSA 45	105	22.5	11	4000
MSA 55	120	30	13	4000
MSA 65	150	35	14	4000

K. Tapped-hole Rail Dimensions



Rail Model	S	h(mm)
MSA 15 T	M5	8
MSA 20 T	M6	10
MSA 25 T	M6	12
MSA 30 T	M8	15
MSA 35 T	M8	17
MSA 45 T	M12	24
MSA 55 T	M14	24
MSA 65 T	M20	30

Dimensions of MSA-A / MSA-LA



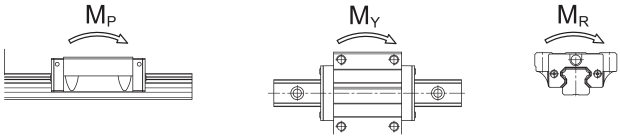
Unit: mm

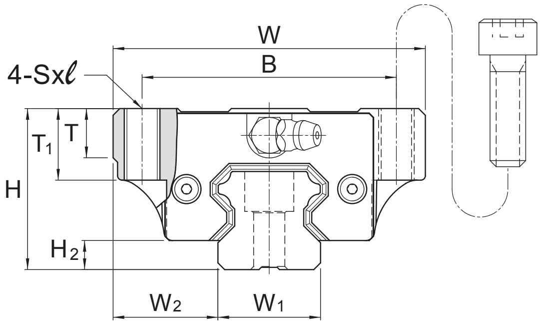
Model No.	External dimension					Carriage dimension											
	Height H	Width W	Length L	W_2	H_2	B	C	S×ℓ	L_1	T	T_1	N	G	K	d_1	Grease Nipple
MSA 15 A	24	47	56.3	16	4.2	38	30	M5×11	39.3	7	11	4.3	7	5.7	3.3	G-M4
MSA 20 A MSA 20 LA	30	63	72.9 88.8	21.5	5	53	40	M6×10	51.3 67.2	7	10	5	12	5.8	3.3	G-M6
MSA 25 A MSA 25 LA	36	70	81.6 100.6	23.5	6.5	57	45	M8×16	59 78	11	16	6	12	5.8	3.3	G-M6
MSA 30 A MSA 30 LA	42	90	97 119.2	31	8	72	52	M10×18	71.4 93.6	11	18	7	12	6.8	3.3	G-M6
MSA 35 A MSA 35 LA	48	100	111.2 136.6	33	9.5	82	62	M10×21	81 106.4	13	21	8	11.5	8.6	3.3	G-M6
MSA 45 A MSA 45 LA	60	120	137.7 169.5	37.5	10	100	80	M12×25	102.5 134.3	13	25	10	13.5	10.6	3.3	G-PT1/8

Note: Request for size 55 and 65 MSA-A / MSA-LA carriage, please refer to MSA-E / MSA-LE carriage type.

Note: The basic dynamic load rating C of ball type is based on the 50 km for nomonal life. The conversion between C for 50 km and C_{100} for 100 km is $C=1.26 \times C_{100}$.

Note*: Single: Single carriage/ Double: Double carriages closely contacting with each other.

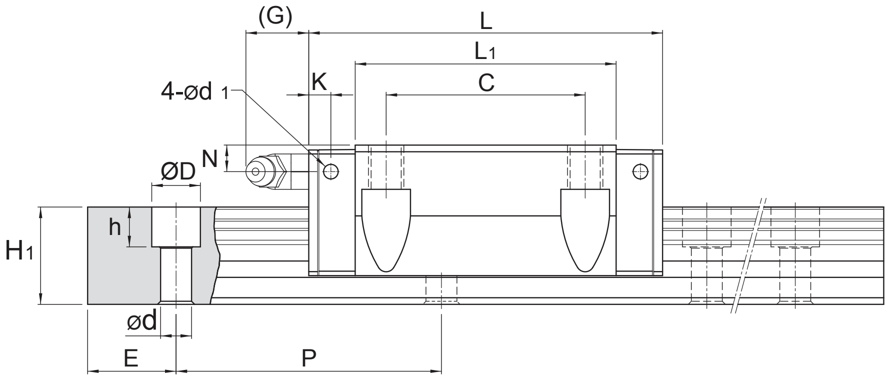




Unit: mm

Model No.	Rail dimension					Basic load rating		Static moment rating					Weight	
	Width W_1	Height H_1	Pitch P	E std.	D×h×d	Dynamic C kN	Static C_o kN	M_P kN-m Single*	M_P kN-m Double*	M_Y kN-m Single*	M_Y kN-m Double*	M_R kN-m	Carriage kg	Rail kg/m
MSA 15 A	15	15	60	20	7.5×5.3×4.5	11.8	18.9	0.12	0.68	0.12	0.68	0.14	0.18	1.5
MSA 20 A MSA 20 LA	20	18	60	20	9.5×8.5×6	19.2 23.3	29.5 39.3	0.23 0.39	1.42 2.23	0.23 0.39	1.42 2.23	0.29 0.38	0.4 0.52	2.4
MSA 25 A MSA 25 LA	23	22	60	20	11×9×7	28.1 34.4	42.4 56.6	0.39 0.67	2.20 3.52	0.39 0.67	2.20 3.52	0.48 0.63	0.62 0.82	3.4
MSA 30 A MSA 30 LA	28	26	80	20	14×12×9	39.2 47.9	57.8 77.0	0.62 1.07	3.67 5.81	0.62 1.07	3.67 5.81	0.79 1.05	1.09 1.43	4.8
MSA 35 A MSA 35 LA	34	29	80	20	14×12×9	52.0 63.6	75.5 100.6	0.93 1.60	5.47 8.67	0.93 1.60	5.47 8.67	1.25 1.67	1.61 2.11	6.6
MSA 45 A MSA 45 LA	45	38	105	22.5	20×17×14	83.8 102.4	117.9 157.3	1.81 3.13	10.67 16.95	1.81 3.13	10.67 16.95	2.57 3.43	2.98 3.9	11.5

Dimensions of MSA-E / MSA-LE

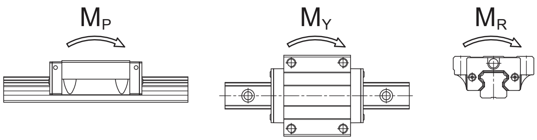


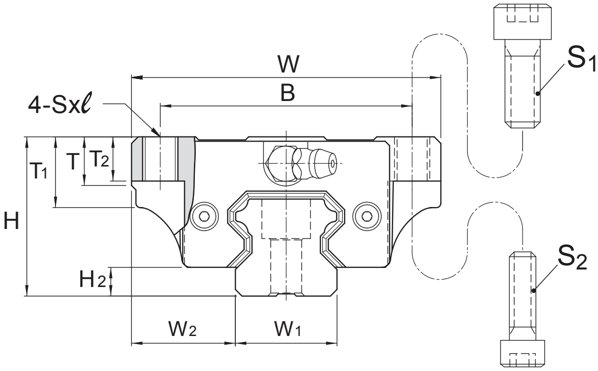
Unit: mm

Model No.	External dimension					Carriage dimension											
	Height H	Width W	Length L	W_2	H_2	B	C	S×ℓ	L_1	T	T_1	T_2	N	G	K	d_1	Grease Nipple
MSA 15 E	24	47	56.3	16	4.2	38	30	M5×7	39.3	7	11	7	4.3	7	5.7	3.3	G-M4
MSA 20 E MSA 20 LE	30	63	72.9 88.8	21.5	5	53	40	M6×10	51.3 67.2	7	10	10	5	12	5.8	3.3	G-M6
MSA 25 E MSA 25 LE	36	70	81.6 100.6	23.5	6.5	57	45	M8×10	59 78	11	16	10	6	12	5.8	3.3	G-M6
MSA 30 E MSA 30 LE	42	90	97 119.2	31	8	72	52	M10×10	71.4 93.6	11	18	10	7	12	6.8	3.3	G-M6
MSA 35 E MSA 35 LE	48	100	111.2 136.6	33	9.5	82	62	M10×13	81 106.4	13	21	13	8	11.5	8.6	3.3	G-M6
MSA 45 E MSA 45 LE	60	120	137.7 169.5	37.5	10	100	80	M12×15	102.5 134.3	13	25	15	10	13.5	10.6	3.3	G-PT 1/8
MSA 55 E MSA 55 LE	70	140	161.5 199.5	43.5	13	116	95	M14×17	119.5 157.5	19	32	17	11	13.5	8.9	3.3	G-PT 1/8
MSA 65 E MSA 65 LE	90	170	199 253	53.5	15	142	110	M16×23	149 203	21.5	37.5	23	19	13.5	8.9	3.3	G-PT 1/8

Note: The basic dynamic load rating C of ball type is based on the 50 km for nomonal life. The conversion between C for 50 km and C_{100} for 100 km is C=1.26 x C_{100}.

Note*: Single: Single carriage/ Double: Double carriages closely contacting with each other.



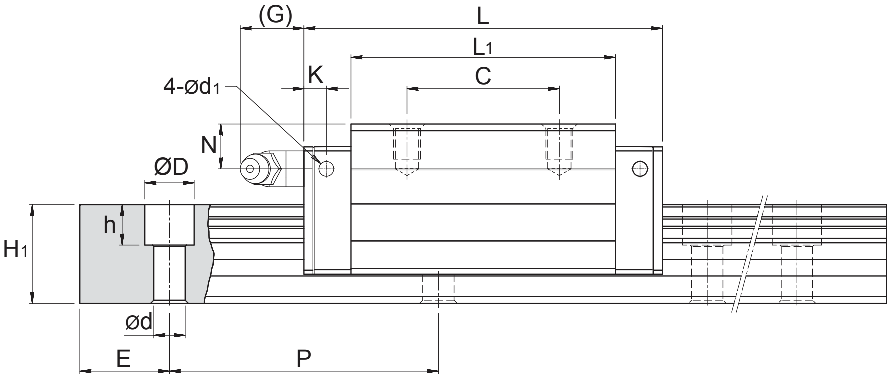


Model No.	Bolt Size	
	S_1	S_2
MSA 15	M5	M4
MSA 20	M6	M5
MSA 25	M8	M6
MSA 30	M10	M8
MSA 35	M10	M8
MSA 45	M12	M10
MSA 55	M14	M12
MSA 65	M16	M14

Unit: mm

Model No.	Rail dimension					Basic load rating		Static moment rating					Weight	
	Width W_1	Height H_1	Pitch P	E std.	D×h×d	Dynamic C kN	Static C_o kN	M_P kN-m Single*	M_P kN-m Double*	M_Y kN-m Single*	M_Y kN-m Double*	M_R kN-m	Carriage kg	Rail kg/m
MSA 15 E	15	15	60	20	7.5×5.3×4.5	11.8	18.9	0.12	0.68	0.12	0.68	0.14	0.18	1.5
MSA 20 E MSA 20 LE	20	18	60	20	9.5×8.5×6	19.2 23.3	29.5 39.3	0.23 0.39	1.42 2.23	0.23 0.39	1.42 2.23	0.29 0.38	0.4 0.52	2.4
MSA 25 E MSA 25 LE	23	22	60	20	11×9×7	28.1 34.4	42.4 56.6	0.39 0.67	2.20 3.52	0.39 0.67	2.20 3.52	0.48 0.63	0.62 0.82	3.4
MSA 30 E MSA 30 LE	28	26	80	20	14×12×9	39.2 47.9	57.8 77.0	0.62 1.07	3.67 5.81	0.62 1.07	3.67 5.81	0.79 1.05	1.09 1.43	4.8
MSA 35 E MSA 35 LE	34	29	80	20	14×12×9	52.0 63.6	75.5 100.6	0.93 1.60	5.47 8.67	0.93 1.60	5.47 8.67	1.25 1.67	1.61 2.11	6.6
MSA 45 E MSA 45 LE	45	38	105	22.5	20×17×14	83.8 102.4	117.9 157.3	1.81 3.13	10.67 16.95	1.81 3.13	10.67 16.95	2.57 3.43	2.98 3.9	11.5
MSA 55 E MSA 55 LE	53	44	120	30	23×20×16	123.6 151.1	169.8 226.4	3.13 5.40	17.57 28.11	3.13 5.40	17.57 28.11	4.50 6.00	4.17 5.49	15.5
MSA 65 E MSA 65 LE	63	53	150	35	26×22×18	198.8 253.5	265.3 375.9	6.11 11.84	33.71 57.32	6.11 11.84	33.71 57.32	8.36 11.84	8.73 11.89	21.9

Dimensions of MSA-S / MSA-LS

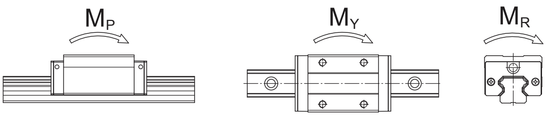


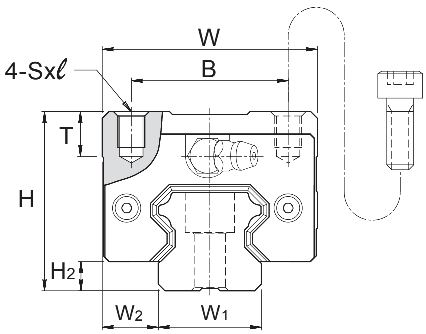
Unit: mm

Model No.	External dimension					Carriage dimension									
	Height H	Width W	Length L	W_2	H_2	B	C	S×ℓ	L_1	T	N	G	K	d_1	Grease Nipple
MSA 15 S	28	34	56.3	9.5	4.2	26	26	M4×5	39.3	7.2	8.3	7	5.7	3.3	G-M4
MSA 20 S MSA 20 LS	30	44	72.9 88.8	12	5	32	36 50	M5×6	51.3 67.2	8	5	12	5.8	3.3	G-M6
MSA 25 S MSA 25 LS	40	48	81.6 100.6	12.5	6.5	35	35 50	M6×8	59 78	10	10	12	5.8	3.3	G-M6
MSA 30 S MSA 30 LS	45	60	97 119.2	16	8	40	40 60	M8×10	71.4 93.6	11.7	10	12	6.8	3.3	G-M6
MSA 35 S MSA 35 LS	55	70	111.2 136.6	18	9.5	50	50 72	M8×12	81 106.4	12.7	15	11.5	8.6	3.3	G-M6
MSA 45 S MSA 45 LS	70	86	137.7 169.5	20.5	10	60	60 80	M10×17	102.5 134.3	16	20	13.5	10.6	3.3	G-PT 1/8
MSA 55 S MSA 55 LS	80	100	161.5 199.5	23.5	13	75	75 95	M12×18	119.5 157.5	18	21	13.5	8.9	3.3	G-PT 1/8
MSA 65 S MSA 65 LS	90	126	199 253	31.5	15	76	70 120	M16×20	149 203	23	19	13.5	8.9	3.3	G-PT 1/8

Note: The basic dynamic load rating C of ball type is based on the 50 km for nomonal life. The conversion between C for 50 km and C_{100} for 100 km is $C=1.26 \times C_{100}$.

Note*: Single: Single carriage/ Double: Double carriages closely contacting with each other.





Unit: mm

Model No.	Rail dimension: Width W_1	Height H_1	Pitch P	E std.	D × h × d	Basic load rating: Dynamic C kN	Static C_o kN	Static moment rating: M_P kN-m Single*	M_P kN-m Double*	M_Y kN-m Single*	M_Y kN-m Double*	M_R kN-m	Weight: Carriage kg	Rail kg/m
MSA 15 S	15	15	60	20	7.5×5.3×4.5	11.8	18.9	0.12	0.68	0.12	0.68	0.14	0.18	1.5
MSA 20 S	20	18	60	20	9.5×8.5×6	19.2	29.5	0.23	1.42	0.23	1.42	0.29	0.3	2.4
MSA 20 LS						23.3	39.3	0.39	2.23	0.39	2.23	0.38	0.39	
MSA 25 S	23	22	60	20	11×9×7	28.1	42.4	0.39	2.20	0.39	2.20	0.48	0.52	3.4
MSA 25 LS						34.4	56.6	0.67	3.52	0.67	3.52	0.63	0.68	
MSA 30 S	28	26	80	20	14×12×9	39.2	57.8	0.62	3.67	0.62	3.67	0.79	0.86	4.8
MSA 30 LS						47.9	77.0	1.07	5.81	1.07	5.81	1.05	1.12	
MSA 35 S	34	29	80	20	14×12×9	52.0	75.5	0.93	5.47	0.93	5.47	1.25	1.45	6.6
MSA 35 LS						63.6	100.6	1.60	8.67	1.60	8.67	1.67	1.9	
MSA 45 S	45	38	105	22.5	20×17×14	83.8	117.9	1.81	10.67	1.81	10.67	2.57	2.83	11.5
MSA 45 LS						102.4	157.3	3.13	16.95	3.13	16.95	3.43	3.7	
MSA 55 S	53	44	120	30	23×20×16	123.6	169.8	3.13	17.57	3.13	17.57	4.50	4.12	15.5
MSA 55 LS						151.1	226.4	5.40	28.11	5.40	28.11	6.00	4.91	
MSA 65 S	63	53	150	35	26×22×18	198.8	265.3	6.11	33.71	6.11	33.71	8.36	6.43	21.9
MSA 65 LS						253.5	375.9	11.84	57.32	11.84	57.32	11.84	8.76	