HepcoMotion®
ADVANCED LINEAR SOLUTIONS

DualVee®
Guide Wheels and Track Technical Guide

DUALVEE® GUIDE WHEELS (OVERVIEW)

WHEEL TYPE	PART NUMBER SCHEME	APPLICATION CONDITIONS	APPLICATION EXAMPLES	AVAILABLE SIZES	PROTECTION	WHEEL MATERIAL & HARDNESS	BALL RETAINER MATERIAL	GREASE	TEMPERATURE RANGE (°F)
Original Guide Wheels Carbon	W_	• General purpose • Factory floor conditions	• Automation • Automotive • Woodworking • Printing • Packaging • Paper/textiles	0, 1	Shield	52100 Steel	Nylon 6,6	Shell Alvania EP2	-35° to +120°
	W_X			0,1,2, 3, 4, 4XL	Seal/shield	52100 Steel	Nylon 6,6	Shell Alvania EP2	-30° to +100°
Original Guide Wheels Stainless	W_SSX	• Corrosive conditions	• Medical • Laboratory • Food & beverage	1	Seal	440C Stainless	Nylon 6,6	Shell Alvania EP2	-30° to +100°
				2, 3, 4, 4XL	Seal/shield				
Studded Polymer Wheels	SWI__P	• Corrosive conditions • Low noise require-ments	• Electronics • Medical • Laboratory	0,1, 2	Shield	Polymer (overmold) 440C Stainless	300 Stainless	Kluberplex BEM034-132	-20° to +120°
Vacuum Wheels	W_SSVAC	• Vacuum environments	• Material science	1, 2	Shield	440C Stainless	304 Stainless	Lubcon Ultratherm 2000	-35° to +250°
Washdown Wheels	WDW_SSX	• Washdown conditions • Hygienic environments	• Food processing • Food packaging	2, 3	Double seal	440C Stainless	Nylon 6,6	Klubersynth UH1 14-151	-30° to +100°
Food/ Pharma Wheels	W_SSXH1	• Washdown conditions • Food equipment • Pharma equipment	• Food processing • Food packaging • Pharmaceutical	2, 3	Seal/shield	440C Stainless	Nylon 6,6	Klubersynth UH1 14-151	-22° to +176°
NEW Solid Lubricant	W_SSXH1SL	• Washdown conditions • Wet / humid conditions • Food equipment • Pharma equipment	• Food processing • Food packaging • Medical device manufacturing	1, 2, 3, 4	Seal/shield	440C Stainless	304 Stainless Steel	H1 Food Grade Oil-Filled Polymer Matrix	-40° to +80°
Extreme Temperature Wheels	W_SS227	• High temp. conditions • Corrosive conditions	• Baking • Welding • Plasma cutters	0,1, 2, 3, 4	Shield	440C Stainless	304 Stainless	Krytox® GPL227	-30° to +260°
	W_SS300	• Low temp. conditions • Subzero conditions • Corrosive conditions	• Aerospace • Refrigeration • Flash freezing	0,1, 2, 3, 4	Shield	440C Stainless	304 Stainless	Kluber Isoflex PDL 300A	-70° to +110°

Wheel hardness between 56 - 64 HRC
Shield material is 300 series stainless steel
Seal material is NBR
Seal/shield materials are 300 series stainless steel and NBR combination

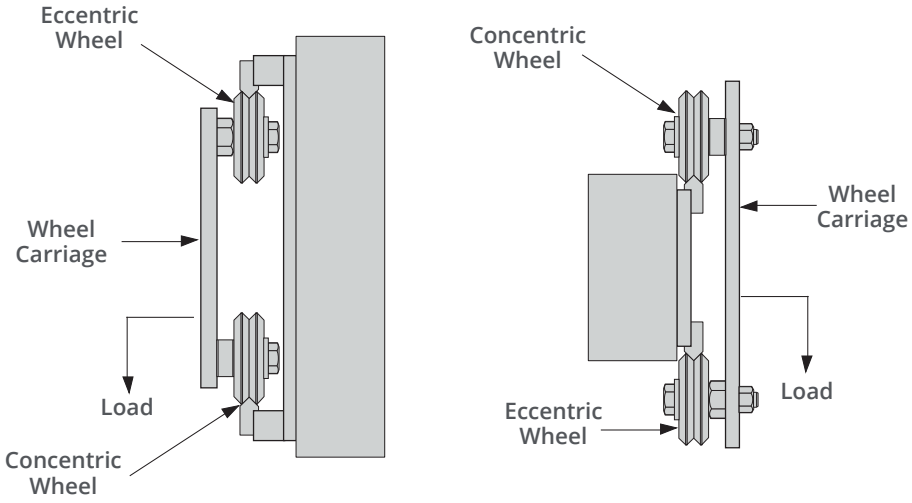
Wheels can be assembled with user specified grease lubricants; call for more information
Shell Alvania is owned by Royal Dutch Shell
Ultratherm is owned by Lubcon
Kluberplex, Klubersynth, and Isoflex are owned by Kluber Lubrication
Krytox® is owned by DuPont

SYSTEM CONFIGURATION AND GUIDE WHEEL MOUNTING

Load Orientation and Eccentric Wheels

In designing a wheel carriage, it is important to use the right combination and orientation of eccentric and concentric guide wheels. Linear guide systems should always have two concentric wheels and all the other guide wheels should be eccentric. The eccentric wheels are adjusted to remove the play between the wheels and track, equally loading all the wheels so that they roll instead of slide or skid on the track. When the wheel carriage is loaded in the radial direction, the pair of concentric wheels should carry the primary load.

It is important to note that the location of the eccentric wheel is dependent upon whether the track guideway is on the outside or inside of the wheel carriage.



The images to the left show two configurations where the wheels are radially loaded. When wheels are mounted on the inside of the track pair, the concentric wheel should be located in the direction of loading relative to the eccentric wheels (in this case, below). When wheels are mounted outside the track pair, the concentric wheels should be located opposite the direction of loading relative to the eccentric wheels (in this case, above).

Common Carriage Configurations

Below are several wheel carriage configurations. Typical carriage configurations will have 3 or 4 wheels per carriage. Additional guide wheels will increase the load capacity and should be added as additional eccentric versions as shown in the 6 wheel carriage configuration.

3 WHEEL CARRIAGE

4 WHEEL CARRIAGE

6 WHEEL CARRIAGE

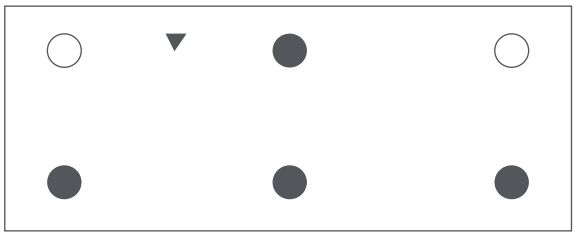


Diagram Symbols:

○ = Concentric guide wheel

● = Eccentric guide wheel

▼ = Radial loading direction

LIFE AND WEAR RESISTANCE

Harsh/Debris-Laden Environments and Wear Resistance

Since the circumference of the wheel is greater at the major diameter than at the minor diameter, each rotation creates a variation of velocity on the surface of the wheel. This wheel surface velocity variation results in a constant sweeping action. As such, DualVee® guide wheels are successfully employed in a wide variety of harsh environments, including in the presence of metal chips, powders, fibres, slurries, and other environments. The presence of harsh contaminants will reduce the service life of all types of linear guides. However, the DualVee® guide wheel will drastically exceed the service life of competing technologies in harsh, debris-laden environments.

As the hardness of the contaminants approaches the hardness of the track and wheels, the wear rate will increase. For these cases, an adjustment factor should be applied to maximum axial and radial working load capacities to provide a longer operating life.

Lubrication

The other main factor affecting wear resistance is lubrication. Lubrication is the key to maximizing the life of DualVee® linear guide products. Internally, DualVee® guide wheels are lubricated for life with an extreme pressure, corrosion resistant grease. The lubrication of the wheel/track interface is the responsibility of the user.

Lubrication of the guide ways will maximize the load capacity of the system and will significantly increase the service life over a non-lubricated configuration under the same loads. A light machine oil, extreme pressure grease, vegetable oil, or dry lubricant will minimize wear, reduce the friction coefficient and associated stick slip, and inhibit corrosion on the guide ways of a DualVee®-based design. Bishop-Wisecarver uses a lightweight synthetic oil 5W-30 weight for lubrication of guide wheels on vee guide tracks.

Wheel covers or lubricators should be designed in whenever possible. Both will distribute a thin coating of oil lubricant along the contact surface of the DualVee® track. The wheel cover offers added protection by preventing debris from entering the wheel/track contact surface. Lubricated and relatively clean wheel/track contact surfaces will ensure maximum service life in the DualVee® linear guide.

Lubrication will also increase the maximum linear velocity that a DualVee® bearing arrangement can endure. In applications where high speed or high acceleration rates are present, lubrication of the wheel/track interface is highly recommended. Lastly, lubrication will reduce the overall coefficient of friction of the guide, which, depending on the level of preload, can fall anywhere from 0.008 to 0.015. The availability of lubricators and wheel covers gives design engineers an opportunity to design lubrication right into the DualVee® mechanism with little effort. See specifications on wheel covers and lubricators for more details.

Factors Influencing Load/Life

Several factors influence the service life of a linear guide wheel. Through research and development, Bishop-Wisecarver has devised a simple method to estimate the load/life relationship for a specific **DualVee®, MadeWell®, and MinVee®** guide mechanism under defined loading conditions. The methodology accounts for the size of the bearing elements and the load orientation and magnitude. The equation is based upon clean and well lubricated track conditions; for applications where lubrication is prohibitive, a derating factor must be applied. It is important to note that secondary considerations such as maximum velocity, acceleration rates, duty cycle, stroke length, environmental conditions, the presence of shock and vibration, and extreme temperature ranges can all impact service life to varying degrees. As such, the sizing method is considered only as a guideline for the sizing of **DualVee®, MadeWell®, and MinVee®** components.

For maximum loading and heavy continuous use, the “T” series hard edge track should be used. For prototype or light duty intermittent use, the “TS” series unhardened track can be used at a lower cost. Hardened track is surface hardened and polished on the vee surfaces and can be easily drilled or machined in the soft shoulder area.

LOAD CAPACITIES, LIFE ESTIMATE, AND SIZING/SELECTION

Guide Wheel Load Capacity & Mass

WHEEL VARIETY	WHEEL SIZE	RADIAL L_R	AXIAL L_A	MAX LINEAR SPEED	MASS (g)		
		N	N	(m/s)	ORIGINAL (W...)	BLIND HOLE STUD (SWS.../ SWI...)	THROUGH HOLE STUD (SWA...)
Polymer Overmold	0	28	12	1	-	6	-
	1	55	28	1	-	11	-
	2	70	42	1	-	27	-
Carbon Steel, Stainless Steel, & Food/Pharma	0	650	123	5.4	5.1	9	9
	1	1220	252	5.4	11.1	17	20
	2	2650	625	5.5	39	56	75
	3	5900	1701	5.3	130.2	166	193
	4	9700	4001	5.3	276	338	403
	4XL	14300	6552	5.1	575	-	-
Solid Lubricant	1	1220	252	2	11.1	-	-
	2	2650	625	2	39	-	-
	3	5900	1701	2	130.2	-	-
	4	9700	4001	2	276	-	-
High Temp. & Low Temp.	0	540	102	5.4	5.1	9	9
	1	1013	209	5.4	11.1	17	20
	2	2200	519	5.5	39	56	75
	3	4897	1412	5.3	130.2	166	193
	4	8051	3321	5.3	276	338	403
Washdown	2	2420	400	5.5	37.8	56	75
	3	5200	578	5.3	128.3	166	193
Vacuum	1	854	178	5.4	12	17	20
	2	1855	440	5.5	39	56	75

Notes:

1. Eccentrically studded or bushed wheels provide adjustability of the wheel to the track. Because of their ability to move and adjust, eccentric wheels are not intended to be the primary carrier of external radial loads. See Wheel Carriage Configurations on page 5.

LOAD CAPACITIES, LIFE ESTIMATE, AND SIZING/SELECTION

Sizing and Selection Steps

The load/life estimation requires a basic understanding of the principles of statics, the ability to work with free body diagrams, and the capacity to resolve externally applied forces on a **DualVee®, MadeWell®, and MinVee®** based carriage assembly into the radial and axial reaction forces at each guide wheel in the design. The life of a **DualVee®, MadeWell®, and MinVee®** based carriage assembly will be limited to the life of the most heavily loaded wheel in the design.

Step 1: Calculate the resultant radial and axial loads reflected to each guide wheel element in the linear guide design

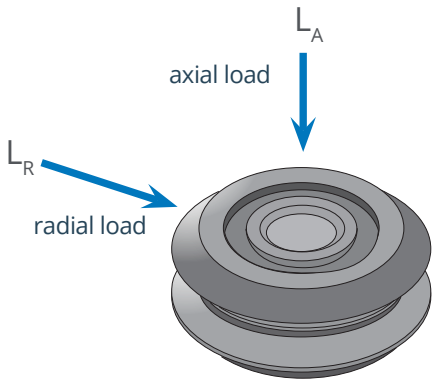
All standard considerations involved in statics calculations must be accounted for, including inertial forces, gravitational forces, external forces such as tool pressure, bearing element spacing, and magnitude and direction of the payload. Any external forces that generate a reaction through the wheel/track interface need to be considered. If assistance is required in resolving specific loads into the resultant reaction forces at the guide wheel interface, contact our Applications Engineering staff for support.

Step 2: Calculate the load factor for the most heavily loaded bearings

Bearings should be sized such that $L_F \leq 1$.

The most heavily loaded bearing will have the highest load factor.

Load capacities are available on the previous page.



$$L_F = \frac{F_A}{L_A} + \frac{F_R}{L_R}$$

WHERE

- L_F = Load factor
- F_A = Resultant axial load on the guide wheel
- L_A = Axial working load capacity of guide wheel
- F_R = Resultant radial load on the guide wheel
- L_R = Radial working load capacity of guide wheel

Step 3: Calculate life by applying the load factor to the load/life equation below

Due to varying application load and speed parameters and environmental conditions, the appropriate adjustment factor (A_F) must be applied to the life equation.

The Life Estimate below shares units with the Life Constant.

$$\text{Life Estimate} = \left(\frac{L_C}{(L_F)^3} \right) A_F$$

WHERE

- L_F = Load factor
- L_C = Life constant
- A_F = Adjustment factor

Life Constant L_C

SYSTEM SIZE	KILOMETERS OF TRAVEL LIFE
0	41
1	55
2	88
3	131
4	173
4XL	218

Adjustment Factor A_F

CONDITIONS	A_F
Clean, adequate lubrication, low duty, low shock, low vibration	1.0 – 0.7
Moderate contamination, medium duty, medium shock, low to medium vibration	0.7 – 0.4
Heavy contamination, limited lubrication, high duty, high acceleration, medium to high shock, high vibration	0.4 - 0.1

LOAD CAPACITIES, LIFE ESTIMATE, AND SIZING/SELECTION

Example Loading Scenarios

Scenario 1

F_A = Resultant axial force

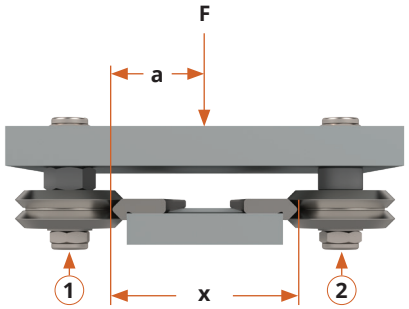
$F_{A1} = \frac{F(x-a)}{x}$

$F_{A2} = \frac{Fa}{x}$

F = Applied force

a = Distance from force to wheel

x = Track vee apex spacing distance



Scenario 2

F_A = Resultant axial force

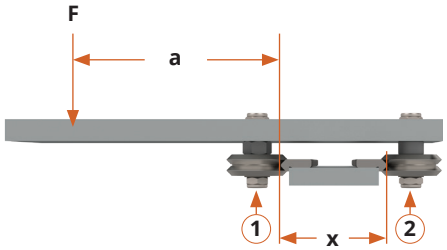
$F_{A1} = \frac{F(x+a)}{x}$

$F_{A2} = \frac{-Fa}{x}$

F = Applied force

a = Distance from track vee apex to force

x = Track vee apex spacing distance



Scenario 3

F_A = Resultant axial force

$F_{A1} = \frac{-Fa}{x}$

$F_{A2} = \frac{Fa}{x}$

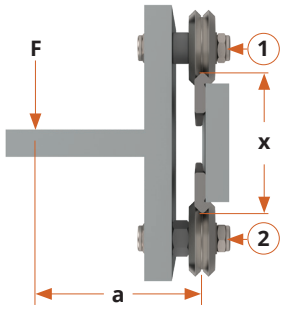
F_R = Resultant radial force

$F_{R1} = F$

F = Applied force

a = Distance from force to wheel

x = Track vee apex spacing distance



Example: Scenario 3

Using Scenario 3's loading configuration with two concentric wheels on the top track (1) and two eccentric wheels on the bottom track (2):

F = 900N

a = 0.38M

x = 0.127M

$F_{A1} = \frac{-900\ (0.38)}{0.127}$ = -2693N, or -1346.5N per concentric wheel

$F_{A2} = \frac{900\ (0.38)}{0.127}$ = 2693N, or 1346.5N per eccentric wheel

F_{R1} = 900N, or 450N per wheel

MOUNTING

Mounting Dimensions and Formulas

When fabricating a DualVee® linear guide from components the following formulas are applicable for mating wheel plate and track plate designs.

For sizes 1 through 4XL DualVee® single-edge track with equivalent sized guide wheels:

Inboard mounting (see Fig. 1): **A = B + X**

Outboard mounting (see Fig. 2): **A = C - X**

Exterior mounting (see Fig. 3): **A = D - Y**

WHERE ***A*** = Distance between wheel plate hole centers

B & C = Distance between track reference edges

D = Distance between the theoretical sharp of 90° exterior angles

X & Y = Size-specific dimension given in the table to the right

Dimensions		
DUALVEE® WHEEL SIZE	X (MM)	Y (MM)
1	22.20	23.72
2	34.90	36.47
3	50.80	53.95
4	66.60	69.85
4XL	79.35	88.90

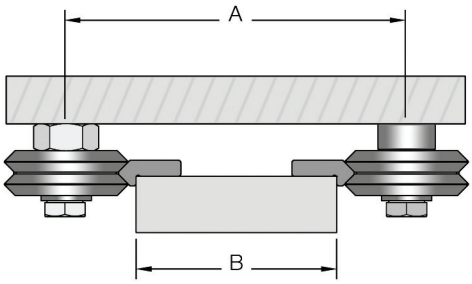


FIG. 1
INBOARD MOUNTING

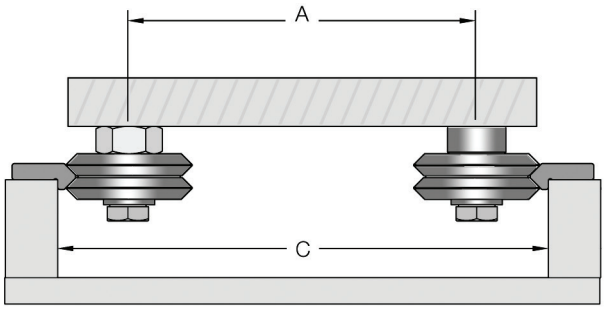


FIG. 2
OUTBOARD MOUNTING

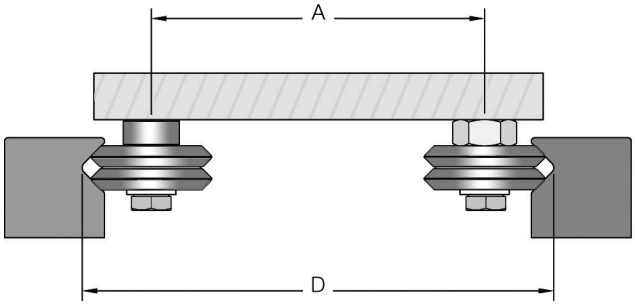
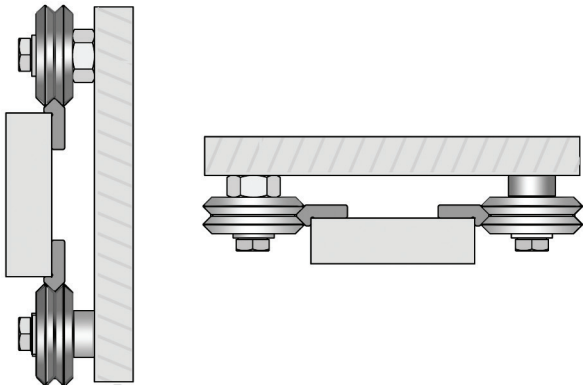


FIG. 3
EXTERIOR MOUNTING



MOUNTING ORIENTATIONS

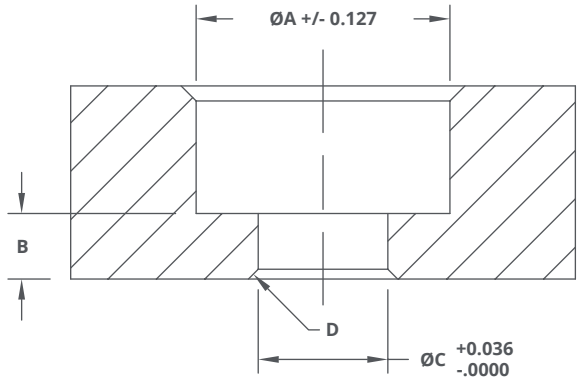
Notes:

1. Information above uses the same size DualVee® track and wheel except for size 4XL which uses W4XL guide wheel with size T4 track.
2. Side views shown only; length of wheel plates can be any length required.
3. It is recommended that wheel plates be constructed with concentric bushings on one side of the plate and eccentric bushings on the opposing side. Place concentric wheels on highest loaded side if applicable.

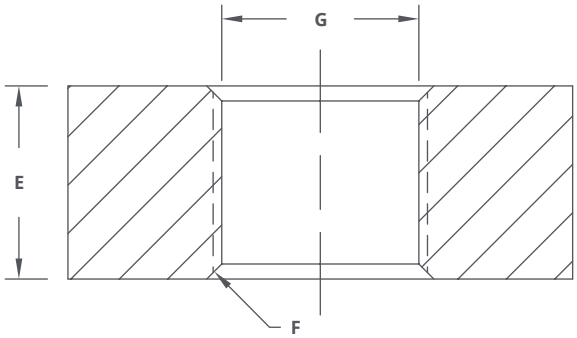
MOUNTING

Machining for Mounting Studded Guide Wheels

Suggested machining for mounting studded wheels (SWS series and SWI polymer) is shown below:



ECCENTRIC STUD HOLE GEOMETRY



CONCENTRIC STUD HOLE GEOMETRY

Dimensions

WHEEL SIZE	C'BORE DIAMETER	REMAINING MATERIAL	REAMED HOLE DIAMETER	REAMED HOLE CHAMFER	MINIMUM THICKNESS	CHAMFER	THREAD
	A	B MIN	C	D	E	F	G
0	Ø12.7	2.46	Ø5.63	90° T0 Ø6.70	7.75	90° T0 Ø6.30	M6 x 1.0
1	Ø15.49	2.41	Ø6.36	90° T0 Ø7.44	8.69	90° T0 Ø8.36	M8 x 1.25
2	Ø19.56	3.28	Ø9.59	90° T0 Ø10.67	11.66	90° T0 Ø10.41	M10 x 1.5
3	Ø23.01	5.21	Ø10.78	90° T0 Ø11.86	15.62	90° T0 Ø12.45	M12 x 1.75
4	Ø27.94	6.88	Ø12.76	90° T0 Ø13.84	21.49	90° T0 Ø14.48	M14 x 2.0

*All dimensions are in mm

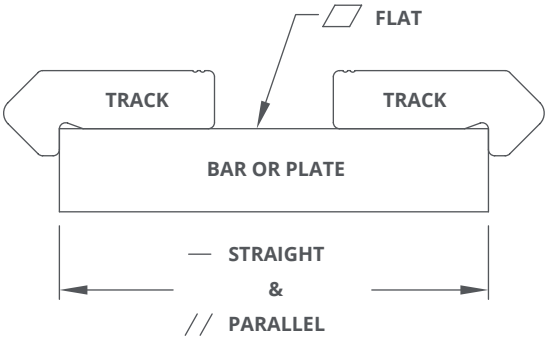
MOUNTING

Track Mounting

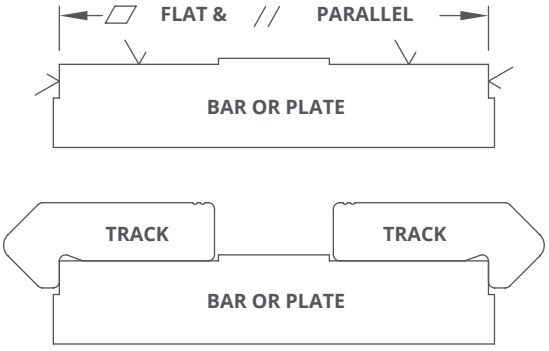
As a matter of good engineering practice the DualVee® components should not be used where their wear or failure could cause personal injury.

Track Flatness, Straightness, and Parallelism

In most DualVee® applications, accuracy plays a small role in the successful implementation of a guide wheel system. The flatness, straightness, and parallelism of the plate or bar to which the DualVee® track is attached (bolted) determine the accuracy of the system. Cold finished or extruded bar or plate is adequate for many applications. The DualVee® track incorporates a mounting shoulder to locate the track on the bar or plate.

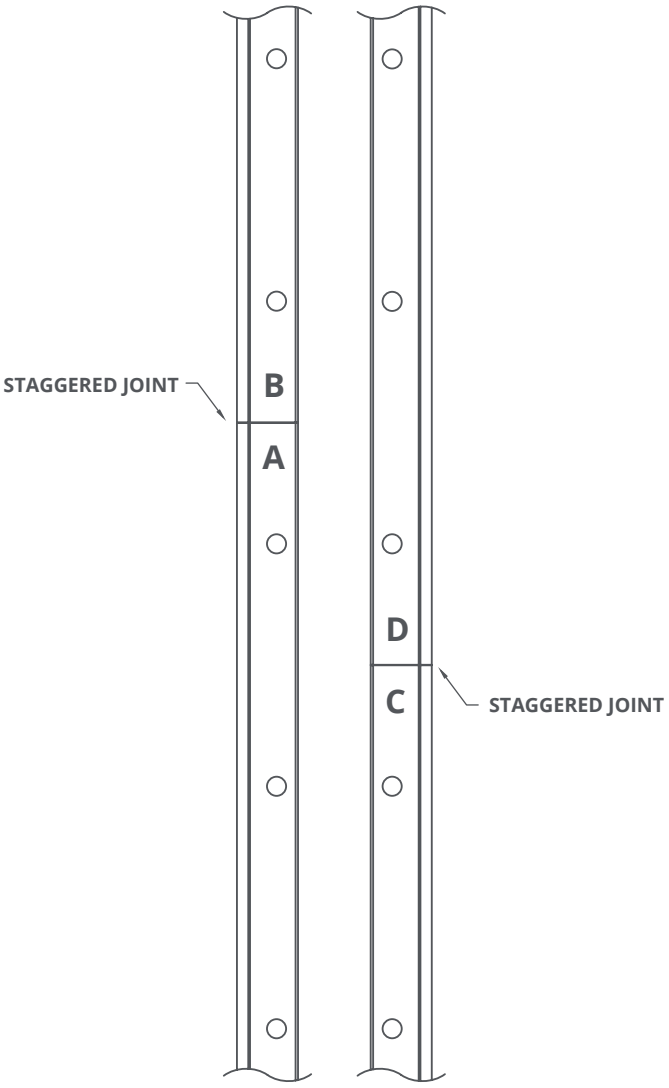


Greater accuracy can be obtained by using a plate or bar that has been ground flat and parallel on the mounting surfaces. To achieve straightness and flatness characteristics to within N grade accuracy levels is fairly routine (± .10 mm). In fact, accuracies as high as (±0.03mm) can be achieved using carefully prepared mounting surfaces in relatively short stroke applications (0.3-1 m). For designs requiring accuracy levels of ±.005 inch and better, mounting surfaces must be prepared straight and flat, and appropriate doweling or reference edge assembly techniques should be employed.



Track Staggering for Long Travel Lengths (DualVee®)

Precut lengths of track are not suitable for butting end to end. Please contact an Applications Engineer when track lengths longer than the maximum available single piece lengths are required. Track that is suitable for butting is available upon request. When constructing track systems longer than 6.096m, the joints on parallel tracks should be staggered for greater accuracy and smoothness.



PRELOADING AND ADJUSTMENT

Benefits of Preloading

Typically, in a guide wheel and carriage application, there should be two concentric mounted wheels and the rest of the wheels should be on eccentric mounts. The eccentric type guide wheels are used to create a cam action to preload the guide wheels against one side of the guide track.

Normal adjustment is obtained by rotating the eccentric bushing, journal, or stud feature until all free play is removed from the carriage assembly. When the eccentrics are adjusted and the carriage plate is held firmly in place, one should be able to rotate by hand any one of the four guide wheels against the mating track. If rotation is not possible the preload should be reduced accordingly.

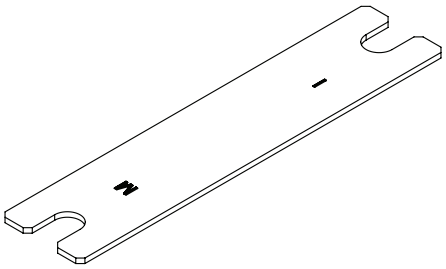
Preloading enhances system rigidity, linear accuracy, and repeatability while reducing vibration and noise. Proper preloading reduces loading variation on the guide wheels, resulting in longer system life.

Tools for Preloading DualVee® Guide Wheels

For DualVee® guide wheels with separate bushings and fasteners, two open end wrenches are required.

For DualVee® guide wheels with swaged studs, a special open end flat wrench and a socket wrench are required.

Although there are slightly different tools required for each type of DualVee® guide wheel, the process is the same for all of them.



DualVee Adjustment Wrench (Inch and Metric)

Standard	*Low Head (PWB) Bushings, SWA wheels, and LoPro® Wiper Wheel Plate*
Size 0: BAW0	
Size 1: BAW1	Size 1: 1PWRX
Size 2: BAW2	Size 2: 2PWRX
Size 3: BAW3	Size 3: 3PWRX
Size 4: BAW4	Size 4: 4PWRX

Adjust all size 4XL bushings with standard open end wrenches. Note the hex head thicknesses for 4XL low profile bushings:

4XLPWBX: 0.188" [4.78 mm]
M4XLPWBX: 0.201" [5.11 mm]

Wheel Preload

Generally, wheel preload is used to eliminate play between the wheel and track. Preload equals the radial load when the system is not loaded by another outside force. Preload can be determined by:

$$\text{Preload} = \left(\frac{BF}{CoF} \right) - F_R$$

BF = Breakaway force

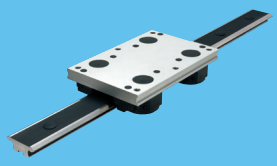
CoF = Coefficient of friction

F_R = Resultant radial force

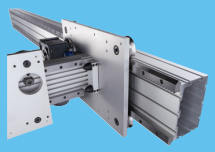
Caution must be used when applying preload because too much preload on the wheels can cause undue stress and can lead to premature failure. The rated radial value should never be exceeded by the preload and subsequent radial loads applied to the wheel when in service. Note that in a four guide wheel assembly sustaining a load that runs along a linear beam, preload on the wheels cannot compensate for deflection on the beam.

HepcoMotion®

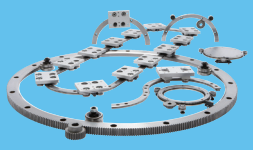
ADVANCED LINEAR SOLUTIONS



GV3
Linear Guidance and Transmission System



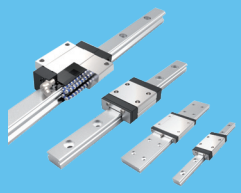
HDS2
Heavy Duty Slide System



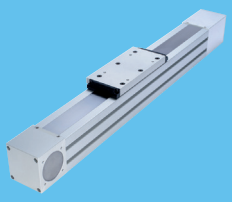
PRT2
Ring Slides and Track System

HDRT
Heavy Duty Ring Slides and Track System

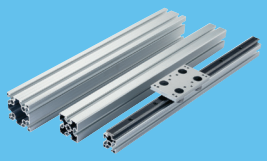
SL2
Stainless Steel Based Slide System



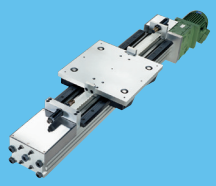
HLG
Hepco Ball Guides



SBD
Sealed Belt Drive

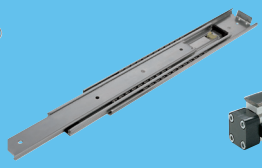


MCS
Aluminium Frame and Machine Construction System

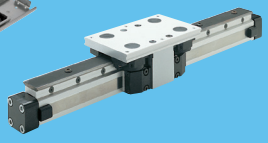


HDLS
Heavy Duty Driven Linear System

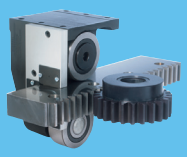
DLS
Linear Transmission and Positioning System



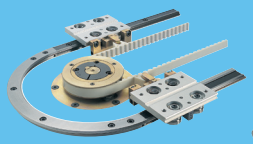
HTS
Telescopic Ball Bearing Slides



HPS
Powerslide-2 Guided Rodless Cylinder

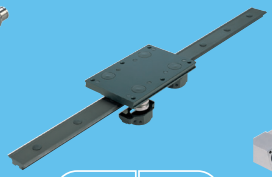


MHD
Heavy Duty Track Roller Guidance System

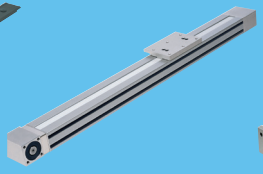


DTS
Driven Track System

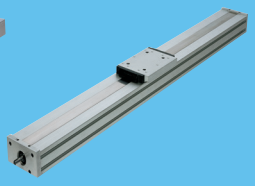
Hepco Ball Screws



Simple Select®
Vee Slide Linear Guidance Systems

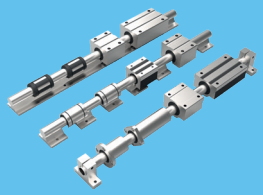


PDU2
Profile Driven Unit

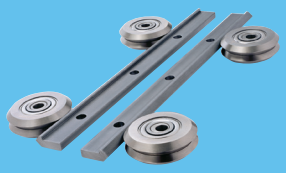


PSD120
Profile Screw Driven Unit

Shaft
Precision Steel and Aluminium Shaft

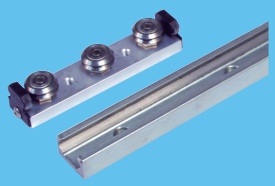


Ball Bushings
Linear Bearing System



DUALVEE®
Single Edge Slide System

LoPro®
Aluminium Based Slide System



UtiliTrak®
Lightweight U Channel Guideway