Why V Guides are Often the Best Choice.

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The trend in linear motion product selection is very often to use profile guides or ball rails as they are known. These work on the principle of a block with internal recirculating balls that enable motion along a rail to be achieved. They are also available in international standard sizes.

In reality, though, designers would be better served in many applications by considering the merits of alternative technologies with V guides being top of the list. The simplicity, number of design options and ease of installation along with exceptional service life are making V guide products an increasingly popular choice for many designers

This white paper contains information on:

- Selection considerations
- How V guides compare.
- V product design options to reduce assembly time

For the sake of terminology V guides are also commonly known as V slides.

Selection considerations

Just about all of the products within the Hepco range are based on the very simple, but highly successful, V principle. Thousands of metres are travelled every day on Hepco V guides in all industry sectors.

Choices for simple applications are heavily influenced by price and whilst fitting a cheaper option can look attractive in the short term, the real consideration should be how the system is likely to perform over the entire life of the machine.

Down time caused by system replacement can have a serious affect on production rates and manufacturing costs, not withstanding the extra spares inventory required.

The trend to ensuring lower maintenance costs for production machinery has brought V guide technology to the forefront of designers thinking as they prove to be more reliable than many other solutions.

How do V guides compare with ball rails?

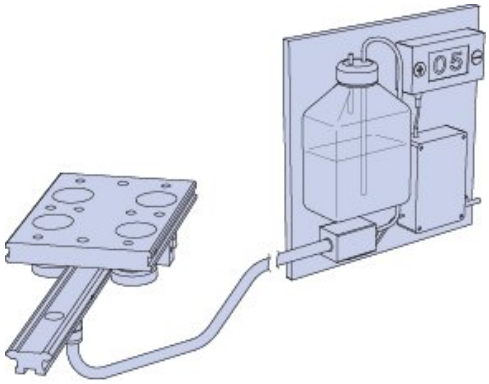
1. Life

Ball rails, size for size, have a higher load carrying capacity but V guides are always sized to provide the Customer with the life that is required based on the duty cycle of the machine.

This might mean a size penalty but unless the designer is looking for the last mm in space then physically larger systems are rarely seen as a major problem.

It is also rare for a customer to have to replace a V system in its entirety because it has come to the end of its natural life. The flagship HepcoMotion GV3 V system is generally supplied as double edge slides with carriages fitted ready to use. Standard carriages incorporate 4 bearings, 2 of the 4 have an eccentric feature allowing adjustment. All bearings are covered with cap seals (covers) that provide enough lubrication, in many cases, for the life of the machine.

Where higher duty cycles are involved or travel over longer strokes is evident a standard bleed lubrication system is fitted that will provide the lubrication on an automatic basis.



In a properly lubricated system the bearings running on the V guide are the limiting factor and periodic replacement of the bearings may be required, but generally only after thousands of kilometers travel. With the slide inevitably in good condition the user can achieve further thousands of trouble free kilometers following bearing replacement.

In cases where slide wear has occurred through lack of lubrication play can be taken out by readjusting the eccentric bearings on to the guide.

2. Load Capacity.

Load capacity has to be linked to life but the point at which bearing replacement is needed is the result of the life calculation as indicated typically in the GV3 catalogue. The advent of play in the system caused by bearing wear does not, in many applications, prevent the operation of the machine but is a clear indication that bearing replacement should be carried out. Hepco define the life of a lubricated system as the first signs of fatigue pitting of the bearings.

The mistake that can be made by using load capacities of ball rail blocks against GV3 carriages as the only selection criteria is that the life achieved of the two systems is very much dependant on the application conditions.
Take a standard size Hepco LBG25F ball rail with an L2 capacity of 21,400N and an Ms capacity of 193Nm.

This sounds far superior to a GV3 assembled unit AU4434 with an L2 of 6000N and an Ms of 73Nm.

Used in the same configuration with a 500N direct L2 load and an additional 20Nm offset Ms load, the ball rail life calculation will clearly be in excess of the GV3 unit until you factor in the application conditions of 1m/s speed during the cycle.

The factors used in the ball rail calculation, speed, impact vibration, mounting, temperature etc can reduce the life considerably, but where speed is involved the difference between the two technologies becomes significant. There is clearly less of a need for lubrication with a V guide as, to put it simply, there is less metal in contact.

The calculation for a size 25 ball rail provides a life of 3,058 Km whereas the GV3 AU4434 unit has a calculated life of 4,956 Km.

Size 25 ball rail

$$Lf = \frac{L2}{L2(\max)} + \frac{Ms}{Ms(\max)}$$

$$Lf = \frac{500}{21{,}400} + \frac{20}{193} = 0.1269$$

$$50 \times \left(\frac{1xfrxftxfb}{Lfxfv}\right)^3$$

Where fr = raceway hardness factor
ft = guideway temperature factor
fb = mounting factor
fv = load factor based on speed / vibration for 1m/s = 2

$$50 \times \left(\frac{1x1x1x1}{0.1269x2}\right)^3 = 3058\text{km}$$

GV3 NM44/ AU4434 carriage with DR bearings/ cap seals.

$$Lf = \frac{L2}{L2(\max)} + \frac{Ms}{Ms(\max)}$$

$$Lf = \frac{500}{6000} + \frac{20}{73} = 0.357$$

$$\text{Life (km)} = \frac{BasicLife}{(0.03 + 0.97Lf)^3}$$

$$\text{Life (km)} = \frac{250}{(0.03 + 0.97x0.357)^3}$$

= 4956 km

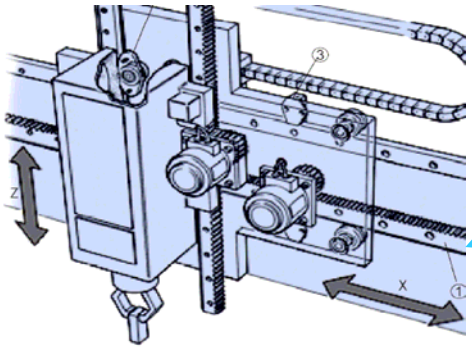
Both systems capacity, of course, can be increased by the addition of extra blocks or carriages but the GV3 life calculation is based on the need only to replace the bearings, not the entire system.

3. Incorporating a drive

Longer travel distances often lend themselves to the use of a rack and pinion drive. If this is not integral with the guidance system then precision parallel setting of a separate rack to the guide is required. In turn this can mean another precision machined surface is needed just to mount the rack.

GV3 double and single edge rails can be supplied with the rack already in position. With the double edge rail this is a separate component fixed to top of the slide at manufacture whereas with single edge rails the rack is machined into the free back edge of the rail parallel with the V faces.

With the inclusion of a standard rack driven carriage for the double edge system and a pinion supplied to suit the single edge option, the whole aspect of driving the system becomes a simple and easy process that is compact and does not require additional components and setting.



Rack is integral with V guide

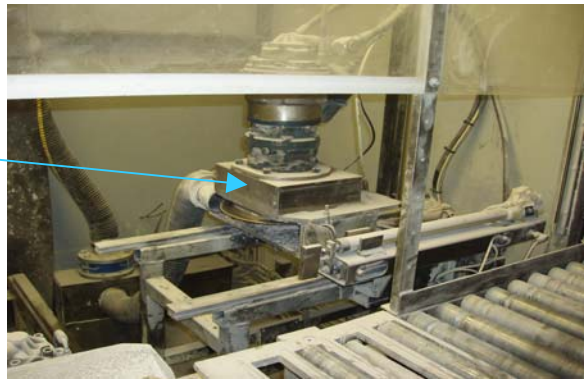
4. Operating conditions.

The Hepco V principle functions, very successfully, on the basis of tight geometrical control over matching slide and bearing V's. In turn this provides a wiping action in operation with the speed of the bearing at its circumference being faster than the speed at the root diameter of the V. The resulting action causes dirt to be pushed to the extremities of the bearing.

The wiping action has actually two benefits, not only will dirt be wiped away, oil from the bearing cap seals (covers) is wiped across the V providing lubrication to the system. The effectiveness of this process is explained later in the next point. Most Hepco systems are fitted with cap seals (covers) over the individual bearings for lubrication and life benefits, but also they are highly effective at preventing dirt ingress in the first place.

Many modern recirculating ball rail systems offer sophisticated block sealing methods incorporating metal scrapers, end seals and lubricators however, the vast majority of users rely on the end seals not to become damaged in service to prevent dirt ingress or significant grease loss.
This can be difficult to ensure in hostile conditions, and it still remains the case in many applications that dirt ingress in sufficient amounts can cause premature failure of the block. Invariably this results in the complete system having to be replaced.

V slide

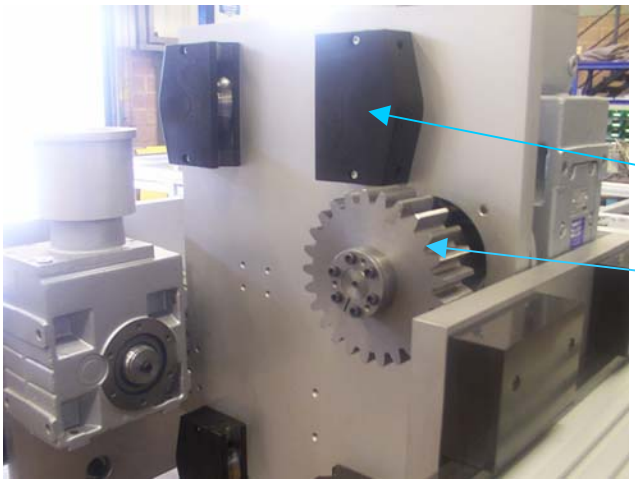


5. Maintenance – lubrication.

One key point with V technology is that only a small amount of lubrication is required to prevent wear of the slide. Whether the load is radial or axial the slide V surface contact area is accurately matched to the bearing V ensuring an even distribution of the load. Within reduced load parameters V slides can also run dry; very beneficial in certain scientific or food applications.

GV3 re lubrication intervals are in most cases very generous when compared to ball guides and it's not unusual after 1000km travel to not have to apply additional lubrication to the bearing cap seal.

Recirculating ball rails rely on consistent effective lubrication in order to reduce wear of the recirculating balls and associated raceways. Re lubrication intervals will vary depending upon conditions but manufacturers state clear distances for re greasing often as low as 50km.



Carriage fitted with low maintenance cap seals with pinion drive in position.

6. Speed and travel distances

High speed and short travel strokes can cause significant wear in linear systems if certain precautions are not taken.

Ball rails provide excellent load capacity by the size and number of balls within the block that are in contact with the rail at any one time. However, with short travel distances where constant forward and reverse movements are present, ensuring sufficient amounts of lubrication are retained within the block can be challenging.

Over longer travel distances lubrication loss can also be a problem and many manufacturers limit speeds generally to 2m/s.

Because of the mechanically efficient principle a V guide can perform at strokes barely 20mm and where longer travel distances are concerned speeds up to 8m/s with no reduction in service life.

Lubrication, in these instances becomes more important but given that only a light film of oil is required between slide and bearing it is less critical than a ball guide system.

7. Mounting / installation

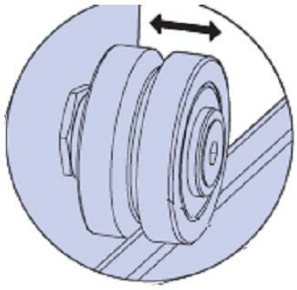
Optimum performance of any guidance system will always be achieved when the surface that it is mounted to is flat and parallel.

The inherent high rigidity of a ball rail system is affected by the amount of preload and unless the product is being used in a machine tool many automation applications use either a light preload or even clearance.

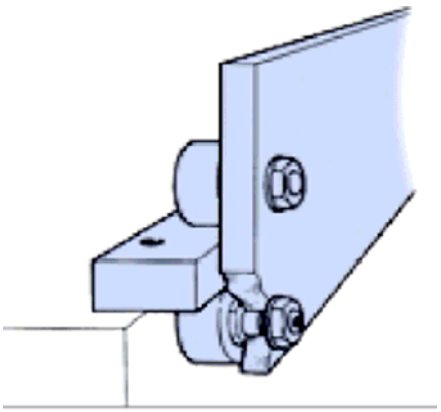
In this respect the mounting tolerances will need to be tightly controlled. Typical figures taken

from manufacturers technical data would state that a rail parallelism tolerance of 0.030mm over the entire travel length for a size 25 block will be required with normal block clearance. Any further inaccuracies in the mounting surface will be taken up by inducing additional block preload that would increase the system friction and could have an adverse affect on life.

V guides on the other hand don't operate under such high rigidity requirements most applications within automation do not require machine tool type rigidity and a certain amount of compliance is often preferable when setting two rails in parallel.



Axial float from floating needle bearing offers compliance



Flat track and rollers for axial compliance

8. Compliance – setting two systems in parallel.

In this respect the GV3 product has a number of features to simplify the process of setting two rails in parallel.

The easiest solution is to position flat track parallel to the V system at a distance apart to suit the application and run cambered rollers along the track.

Where it is desirable to locate two V slides in parallel with the V's orientated in the vertical plane Hepco floating bearings will allow a V parallel misalignment up to 1.5/ 2.0mm of the opposing V system.

9. Accuracy

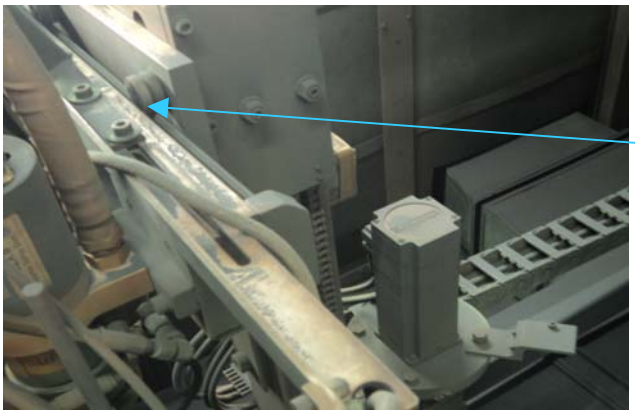
With ball rails being used more in general automation applications the default N (normal grade) satisfies the vast majority of applications.

Given the attention that has to be applied to the mounting surface in order to ensure a smooth running ball rail system, alternative GV3 un ground P3 guides have found favour with many designers who want to be able to just fit a

system to a surface with minimal preparatory work.

GV3 guide rails are available in 3 precision grades to suit the application, P1 fully ground, P2 semi ground (V's only) and P3 unground. By using the unground version customers are not paying for product accuracies that are not required in the application.

GV3 ground slides best option for precision movement



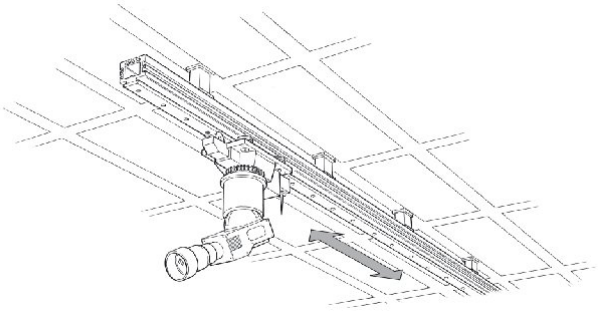
Un- ground slides for non precision applications

10 Design options to reduce assembly time

GV3 as a product line does incorporate a number of design features that are unique and will ease the assembly process. These will also reduce the amount of engineering required to achieve the efficient running of a system. The following is a summary of the key design features.

a) Achieving a straight slide – spacer type slides have a keyway to accommodate dowel pins which will enable a straight slide to be achieved. This eradicates the need to machine a side datum face for the slide to push up to.

b) Slide mounting beams – alternatively slides can be mounted to bespoke beams and bought as a complete assembly.



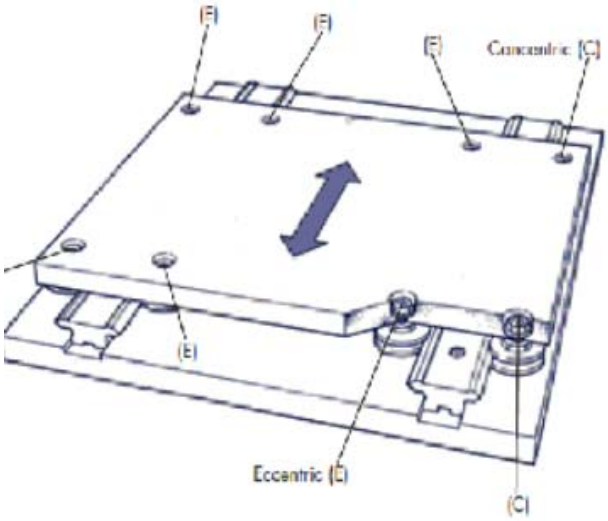
c) Incorporating the rack directly to the slide saves on setting a separate component (as described in point 3)

d) The use of flat track and rollers or floating bearings to allow system compliance and make the assembly process easier (as described in point 8)

e) The use of blind hole fixing bearings allowing fixing to a firm base where access is limited

f) Complete rack driven carriages with gearbox and pinion saving the customer having to design a bespoke solution.

g) Carriage plates with wide platforms to mount components to or fit to machine structures will make the assembly process simpler without the need for additional sub plates to link systems. This is particularly beneficial in installations where two rails are situated in parallel with four ball rail carriages. In many cases the four carriages can be replaced by bearings fitted to a common plate using the eccentric feature within the bearing fixing stud to achieve smooth running. This negates the need to set two rails in parallel to a high degree of accuracy.



Picture shows the two slides located into two machined slots. Alternatively to achieve sufficient parallelism the slides can be fitted to a clear surface using the dowel pins located into the slide base keyway as stated point 10a

h) The ability to mix and match slides and bearings of different sizes to suit the application space and load requirements.

SUMMARY

V guide technology as used in the GV3 product line has many design and application benefits over traditional ball rail products. Ball rails have become the default choice in many installations and are proven to be a reliable product in the vast majority of cases.

However, a greater examination of the GV3 product does reveal some interesting key user benefits that are not always being considered in the users choice of a linear system.

This can be seen particularly in longer length applications where setting of profile rails can be time consuming compared to V guides that offer more cost effective solutions.
Another key factor is the requirement for systems to work in hostile conditions; V guides have been proven to be a highly effective solution under such conditions.

Whilst cost is always a key factor it often pays to look into the system assembly / mounting options together with the longer term maintenance issues applicable to any one application. To this end GV3 is often found to be an easy to assemble reliable performer that does offer a reduced engineering package not often seen with other linear solutions.

Many of the benefits seen with GV3 are apparent in other V guide ranges specifically the Heavy Duty (HDS2) system and SL2 (stainless steel guides and bearings) giving customers a wider choice of V solutions.