This data sheet interacts with

PRT2 Catalogue

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HepcoMotion®

No. 1 Design Criteria for Track System Drives

HepcoMotion® Track Systems provide an extremely useful means of moving a component or process along a path composed of straight and curved portions. The tracks may be open lengths or form a closed circuit.

Often a system will have a number of carriages which are to be driven round together (this is common in transfer systems and many other applications). The drive may be provided by several methods including projections or drag links on a chain or toothed belt, or by positively driving one (or more) of the carriages, which are themselves linked together to form a chain.

In each of the possible driving methods, care must be taken to allow for the geometry of the carriage movement as it travels across the transition from the straight to the curved section where two important things happen; Fixed centre type carriages momentarily develop a clearance (see figure 1 and table 1) and become slightly loose on the track; and all carriages 'move' towards the centre of the ring (see figure 2 and table 2).

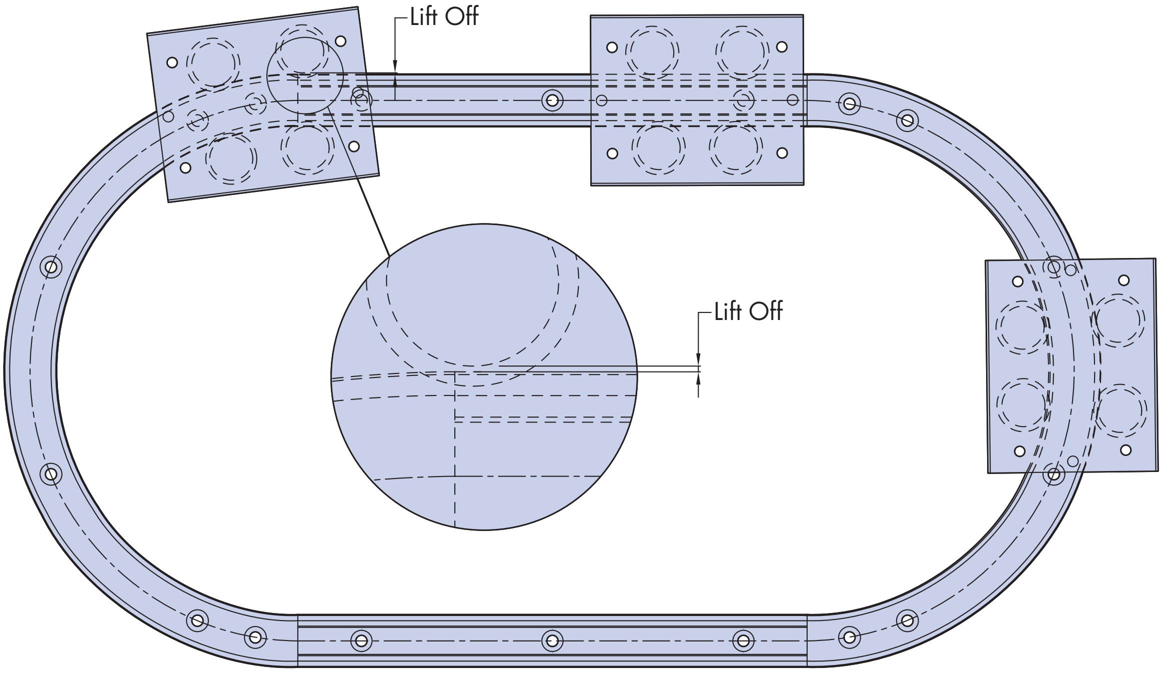

Figure 1 Track system showing lift off of carriages

Carriage Type	**FCC 12 93**	**FCC 12 127**	**FCC 20 143**	**FCC 20 210**	**FCC 25 159**	**FCC 25 255**	**FCC 25 351**	**FCC 44 468**	**FCC 44 612**	**FCC 76 799**	**FCC 76 1033**	**FCC 76 1267**	**FCC 76 1501**
Maximum Clearance/mm	0.17	0.08	0.18	0.10	0.47*	0.15	0.09	0.21	0.14	0.22	0.19	0.17	0.16

Table 1 Fixed Centre Carriage Play at Track System Joints

These figures are theoretical clearances. In most applications, the bearings are slightly preloaded against the slides, and some of this clearance will appear as a 'relaxation' of the system. In these instances the carriage will have a slightly freer movement as it traverses between the straight and curved section than when the carriage is fully on the straight slide or curved segment. In most duties the clearance or momentary reduction in preload will not present an issue, however, in some applications it may be undesirable.

* The FCC 25 159 has greater than normal clearance. This will be noticeable, but not detrimental in many applications.

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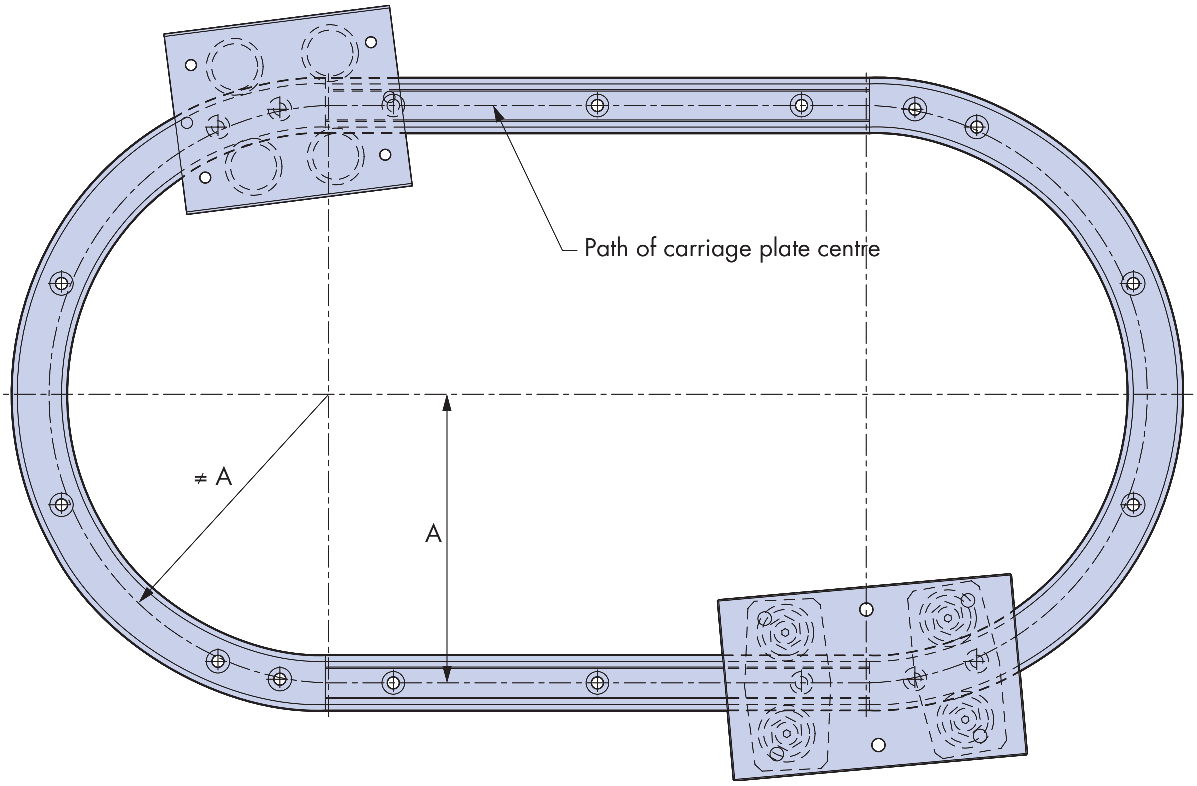
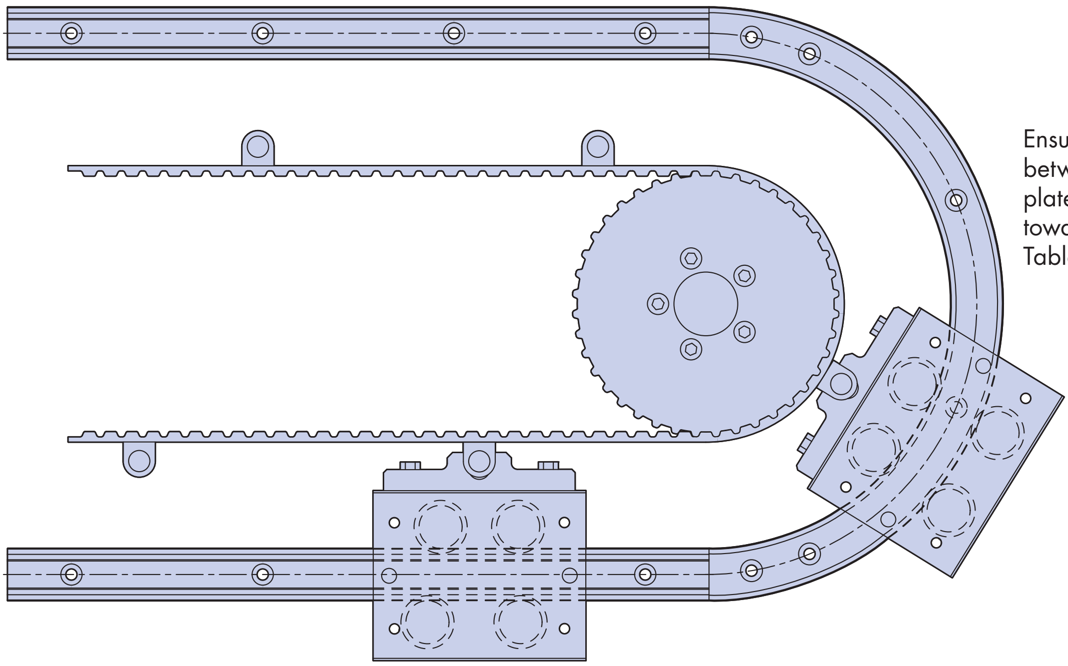


Figure 2 Path of centre of carriage traversing an oval track

Carriage Type	FCC 12 93	FCC 12 127	FCC 20 143	FCC 20 210	FCC 25 159	FCC 25 255	FCC 25 351	FCC 44 468	FCC 44 612	FCC 76 799	FCC 76 1033	FCC 76 1267	FCC 76 1501
Movement into centre	1.44	0.96	1.46	1.12	3.11	1.61	1.32	2.69	2.28	2.99	3.32	3.69	4.08
Carriage Type	BCP25 On R25159	BCP25 On R25255	BCP25 On R25351	BCP44 On R44468	BCP44 On R44612	BCP76 On R76799	BCP76 On R761033	BCP76 On R761267	BCP76 On R761501				
Movement into centre	9.4	5.7	4.1	5.4	4.1	5.4	4.1	3.3	2.8				

Table 2 Movement of carriage towards centre of ring segment as the carriage turns the corner

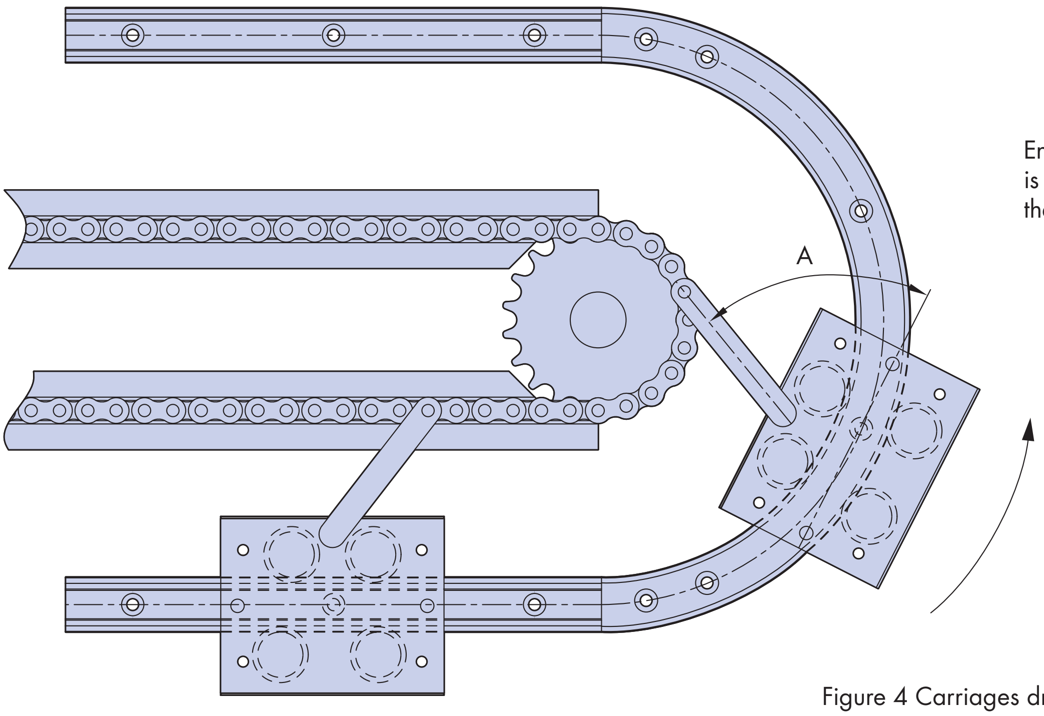
In most applications for closed circuit track systems, the important area for the process is the straight section, where the 'action' of the application occurs. The curved section usually only functions as a return path. In such instances, precise motion control is only needed on the straight sections and hence the slight clearance which develops as the fixed centre carriages traverse the joint from straight to curve (or vice versa) is unlikely to cause a problem. In those circumstances where this clearance is unacceptable then Hepco bogie carriages, which do not develop play in this way, may be specified.
When driving a track system using a chain or toothed belt, bends will usually be negotiated by wrapping the chain or belt around sprockets or pulleys. Because of the movement of the carriage plate towards the centre of the curve as the carriage traverses the joint, some flexibility must be engineered into the system to accommodate this. Driving via a spigot engaging in a slot as shown in figure 3 is a practical means of achieving this.



Ensure that the connection between the belt and carriage plate allows for movement towards the centre identified in Table 2.

Figure 3 Carriages driven via a spigot on a toothed belt or chain

When using this type of arrangement, it is usual to have the driving force on the carriage off centre, and consequently there will be some contribution to the moment loading of the system. Such loading must be accounted for when calculating the load and life of the system (see datasheet No. 3 Load life information). Alternatively the carriage may be connected to the chain or belt via a drag link as illustrated in figure 4 below.



Ensure that the effect of angle 'A' is accounted for when calculating the load on the system.

Figure 4 Carriages driven by a drag link on a chain

When using a drag link it should be remembered that there will be a component of force pulling the carriage towards the centre of the track system, and this force should be accounted for when calculating the load and life of the system. The force on the carriage plate should be calculated when the carriage is on the curve, since this is where the worst case occurs.

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In systems which use carriages linked by tie bars to form a carriage train, there is a tendency for the apparent length of the train to change as the carriages traverse the joint between straight and curved sections. The link between any pair of carriages cut a chord across the ring segment centre line, which lengthens the carriage train. At the same time the ends of the links move to a larger effective radius, due to being mounted outboard of the bearing assemblies, which has the effect of shortening the carriage train. The combination of these 2 effects is that the length of the carriage train varies as it traverses the track system. If mounted to a simple oval, figure 5, as the train goes round the track, the gap between the first and last carriages 'D' will expand and contract slightly, going through 1 cycle of contraction and expansion for a movement of 1 carriage pitch.

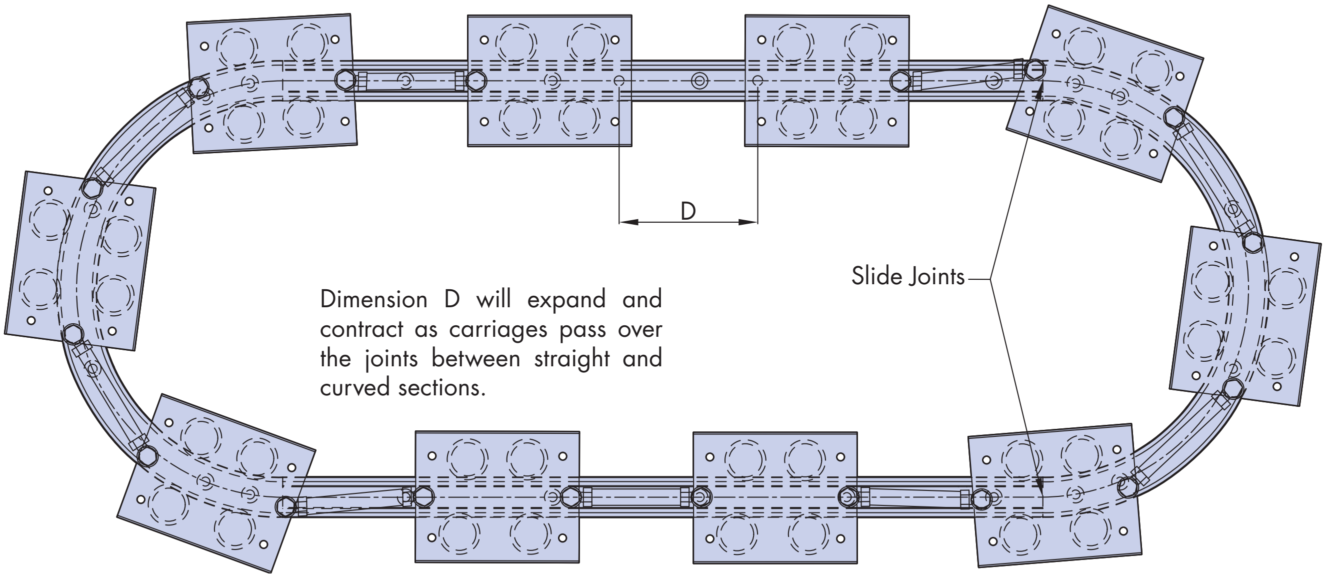

Figure 5 Simple oval track system with linked carriage plates

This change in length of the carriage train will be important in those applications which require a continuous train of carriages forming a closed loop, since the expansion of the train could be restricted. This restrained expansion can cause some increase in the resistance to motion, or in extreme circumstances the carriages can seize in position.
These potential problems can be avoided by careful design. In a good design, the amount of the expansion and contraction should be minimised, and sufficient clearance or compliance allowed in the links to absorb the length change in the train. This need not be a very taxing requirement since in a typical system the amount of contraction and expansion might be 2mm and this could be absorbed in a system with 10 carriages by having only 0.1mm of clearance in each of the 20 link joints.

The following general rules can be applied to minimise the effect of the change in length of the carriage train.

1. The length of the links between carriages should be kept to a minimum and short carriage plates (i.e. FCC's as opposed to BCP's) will be preferred.
2. Systems running large diameter ring segments have lower length change.
3. Systems running thinner section ring segments have lower length change.
4. It is best to avoid four carriages passing over the joints at the same time since if this happens the effect of expansion and contraction will coincide and reinforce each other. This can best be achieved by having the track joints separated by a distance of a whole number plus half a carriage pitch. On a simple oval track system with a continuous train of carriages, an odd number of evenly spaced carriages will achieve this requirement.

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If expansion and contraction of the carriage train may be a problem in an application, then it will be advisable to estimate the amount of length change in the system. Table 3 below gives typical figures for the length change associated with a single joint from straight to curve.

Track system curve diameter	Link Length	Link centre on carriage	Approximate expansion/Contraction per track joint
93	40	45	1.3mm
127	40	45	0.7mm
143	55	65	1.2mm
210	60	70	1.3mm
159	**Do Not**	**Use In A Linked**	**Carriage System**
255	65	85	1.1mm
255	80	85	1.5mm
351	90	90	0.3mm
351	100	90	0.7mm
468	115	125	0.3mm
612	120	130	0.6mm
799	145	165	0.3mm
799	165	165	0.8mm
1033	175	185	0.7mm
1267	200	225	0.9mm
1501	225	245	0.4mm

Table 3 Approximate expansion and contraction of carriage trains.

The information contained in Table 3 can be used to calculate the approximate expansion and contraction in a carriage train as follows:

Example: A track system uses two TNS25 straight slides with two TR 25 255 R180 ring segments. On the track system there are 10 FCC 25 255 fixed centre carriages. They are linked by solid tie bars which are 80mm long and located at 85mm centres on the centre line of the carriage plates (broadly as illustrated in figure 5).Referring to table 3, we see that for this type of system there is an approximate expansion/contraction of 1.5mm per joint. Since there are a total of four joints between straight and curved sections, then the total amount of expansion and contraction in the system will be about 6mm.

It should be borne in mind that in most well designed systems, the amount of contraction of a system will be considerably less than the figure for a single joint multiplied by the number of joints, since the expansions and contractions will often cancel each other out to a large extent if the guidelines detailed above relating to system design are adhered to.

In the example above, there is a large amount of expansion and contraction. If the design rules on page 4 are applied, by reducing the tie bar length from 80mm to 65mm, and by putting in an extra carriage to make an odd number, the amount of expansion and contraction reduces from 6mm to about 0.3mm. This amount of change in length can be easily accommodated by the compliance of the link train.

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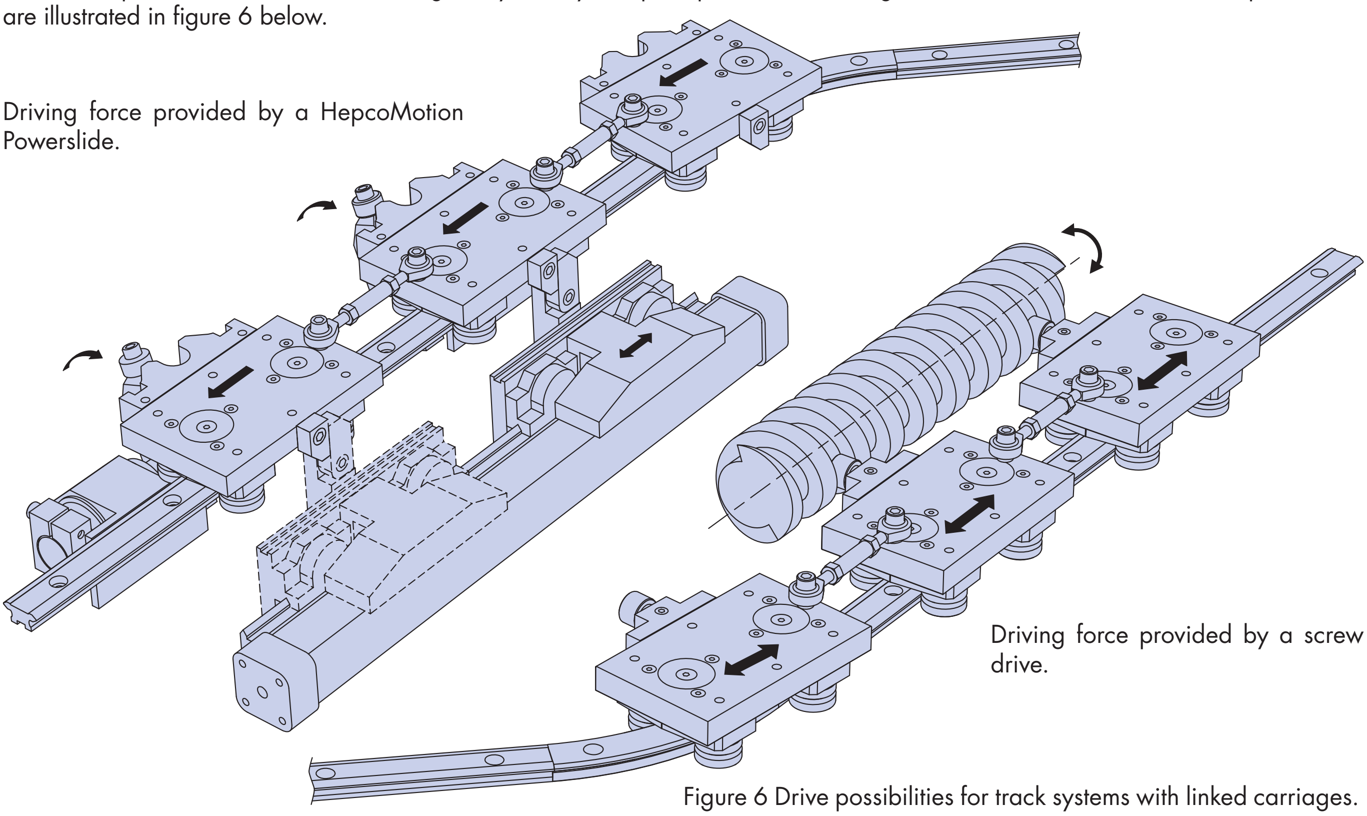
When using linked carriages as described above, several methods may be used to provide the driving force. These methods include the use of a HepcoMotion Powerslide indexing the system by one pitch per stroke, or using a screw drive. Both of these drive possibilities are illustrated in figure 6 below.

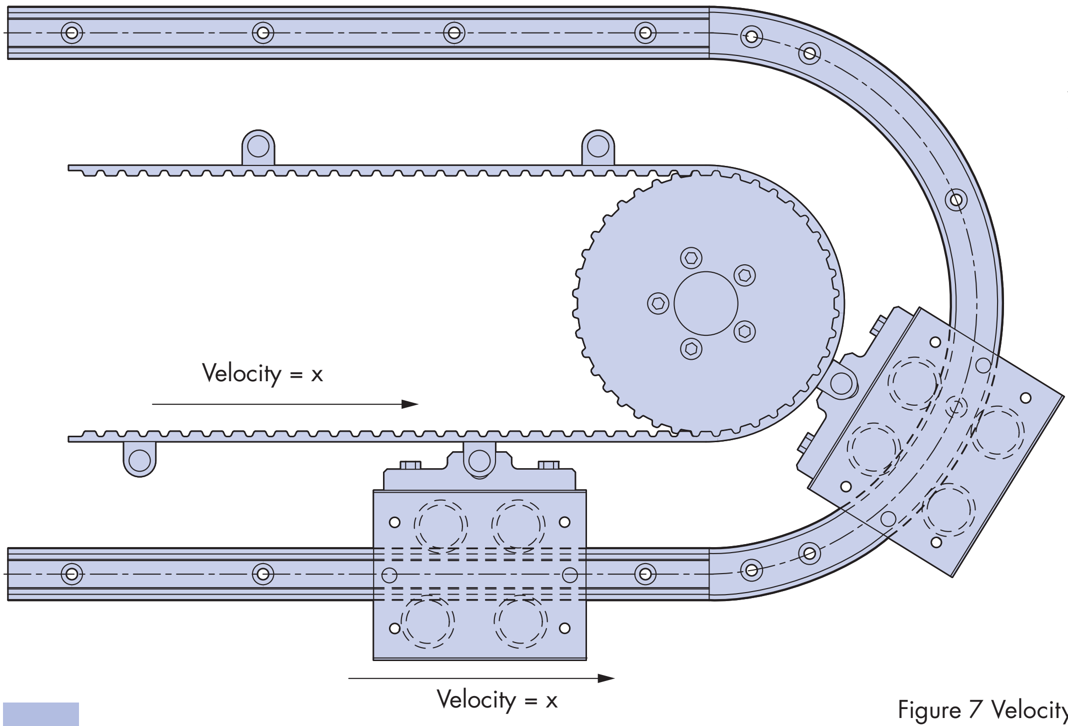
Driving force provided by a HepcoMotion Powerslide.



Driving force provided by a screw drive.

Figure 6 Drive possibilities for track systems with linked carriages.

Linked carriage drives can encounter difficulties if the tie bar length or carriage plate link mounting centres are larger than about 40% of the ring diameter. This criterion prevents the use of this driving method with 159 diameter rings.
A scale drawing should be made to visualise the track system in those applications where long links are required on small diameter rings. Since this will identify any adverse driving conditions where the links are at a large angle to the ring tangent and hence will have a tendency to generate significant edge loading or even cause uneven running or jam-ups.
If a screw drive is being specified, care should be taken when designing a linked carriage system to ensure that the distance between adjacent carriages is a whole number of screw pitches. In most closed circuit applications, the distance between carriages would be determined by the overall length of the track along with the number of carriages, so this must be accounted for when selecting the screw.
When designing a drive for a belt or chain driven system, care should be taken to take into account the increase in speed of the carriage as it travels from straight to curve. When the carriage is travelling along the straight track it has the same velocity as the belt. (See figure 7).



Velocity of the carriage on the straight is the same as the velocity of the belt.

Figure 7 Velocity change in the track system.

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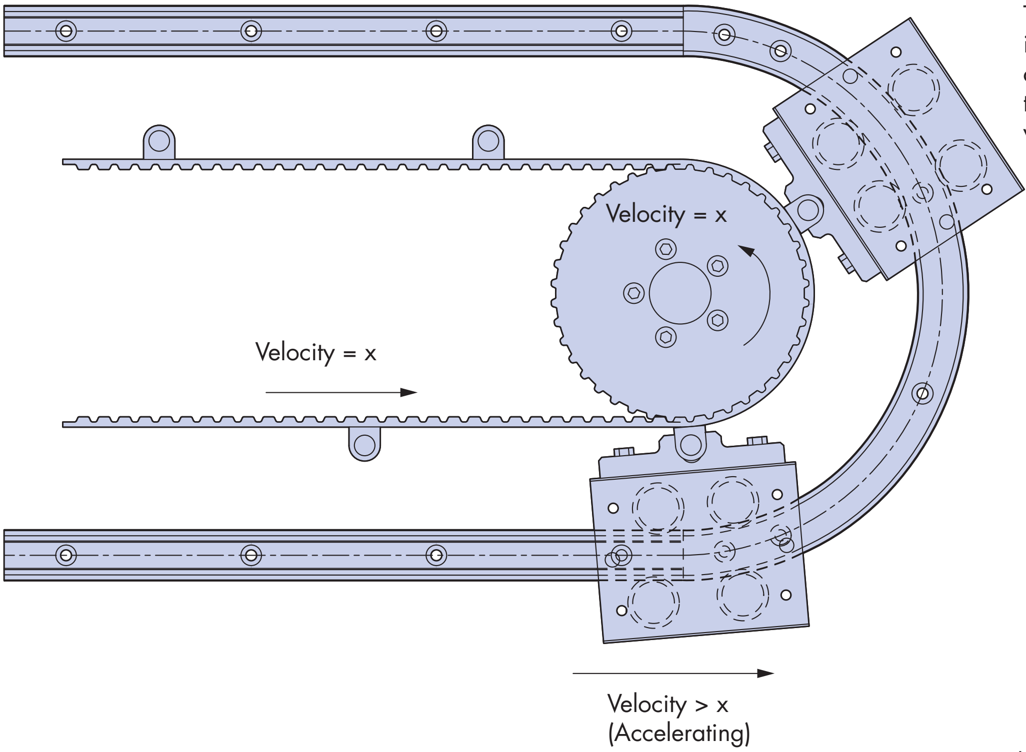
As the carriage travels from the straight to the curve, there is a rapid change in velocity due to the increased distance the carriage needs to travel compared with the belt. This increase in velocity takes place over a very small distance, and therefore extremely high accelerations can take place at the slide/segment joint. Care should be taken in the design of the drive system and the belt lugs to take into account the large forces generated due to the high accelerations (see figure 8). Hepco have developed a successful belt connection method used in the DTS system, please refer to datasheet No. 8 DTS Components for more details.



The belt maintains its velocity as it travels around the pulley, as the carriage travels from the straight to the curve it accelerates over a very small distance.

Figure 8 Velocity change in the track system.

Once the carriage is fully on the segment, it will be travelling at a constant velocity, however this velocity will be much higher than the velocity of the belt. The relationship between the velocities of the carriage and belt is directly proportional to the difference in the diameters of the pulley and ring segment. (See figure 9).

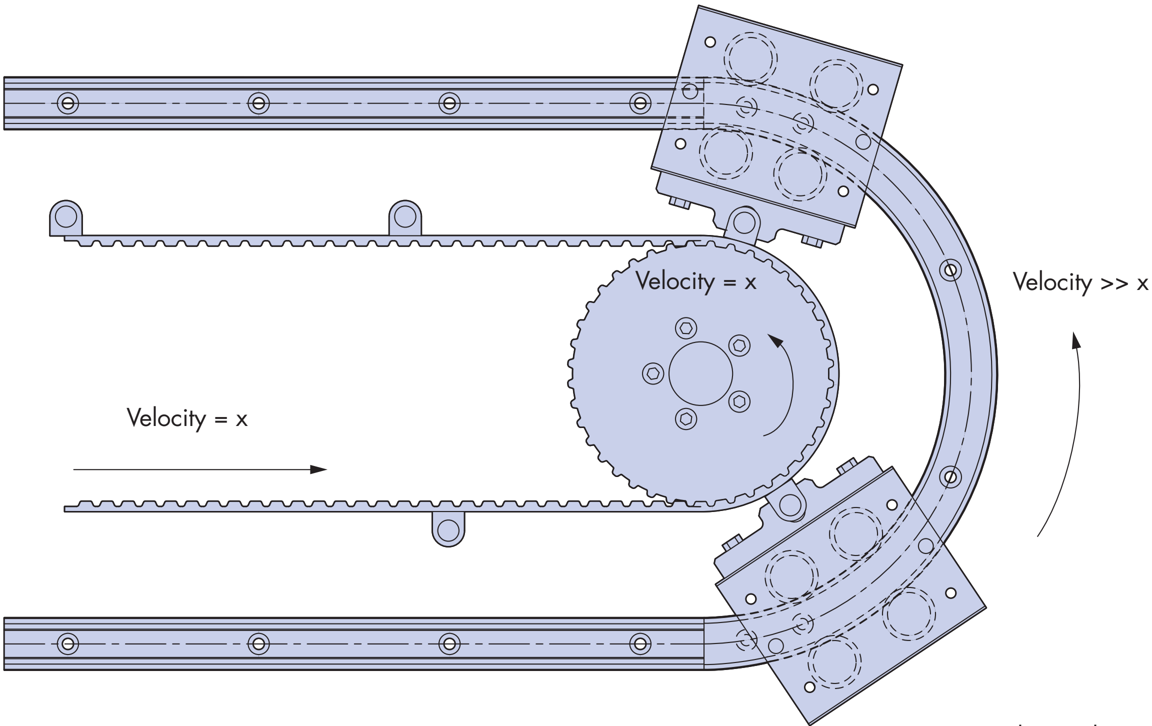
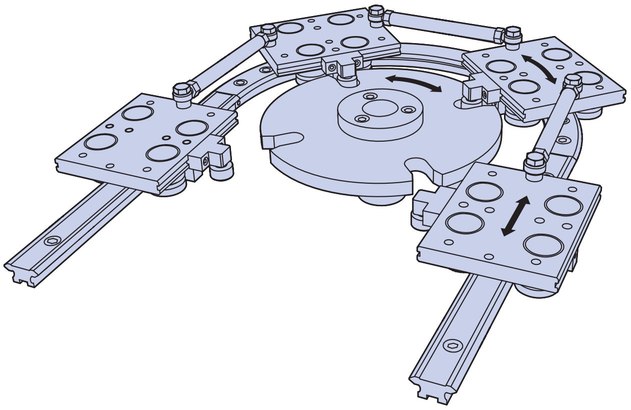


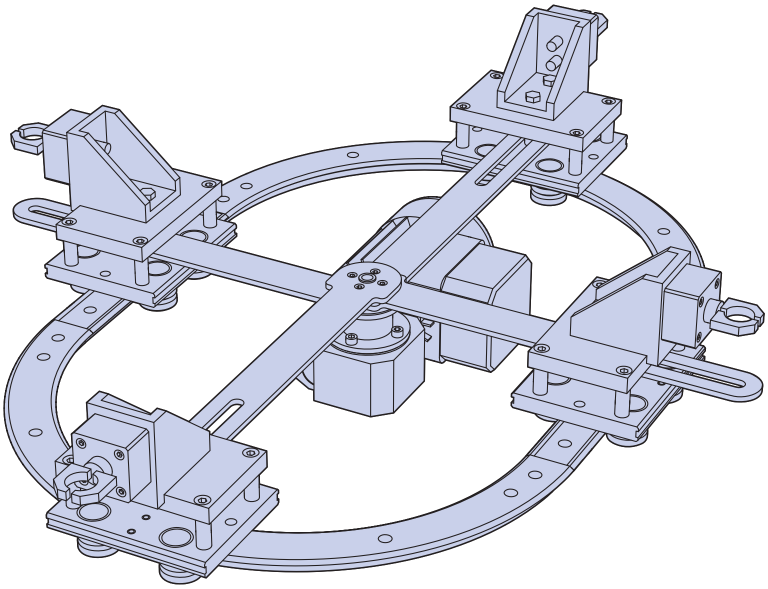
Figure 9 Velocity change in the track system.

No. 1 Design Criteria for Track System Drives

The illustrations below give details of alternative methods of driving track systems with linked carriages. For more information or for help with a particular application, please contact Hepco's technical department.

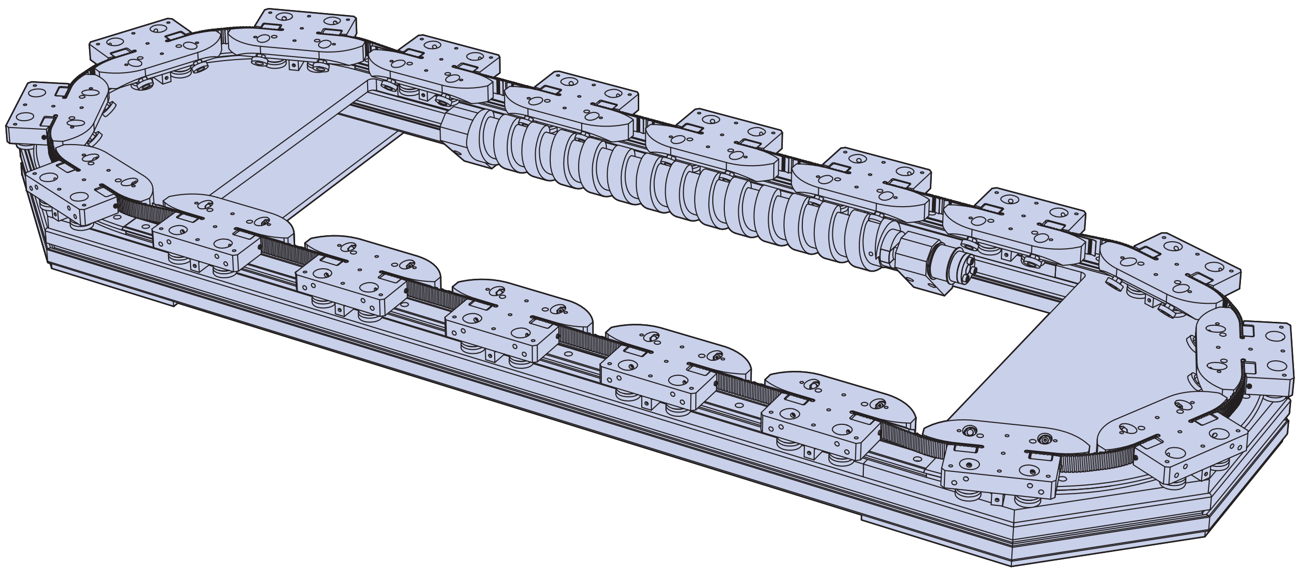


Pocket Wheel Drive
Carriages are linked together by connecting rods. A cam follower located on each carriage engages with cutouts in a pocket drive wheel which moves the carriages around the track system. This method of driving requires some compliance in the connecting rods and sufficient clearance in the wheel for cam follower engagement.



Spider Drive
For use with short track systems, carriages can be driven from a central motor and spider. The arms of the spider incorporate slots to accommodate the changing distance of the carriages from the motor drive shaft.

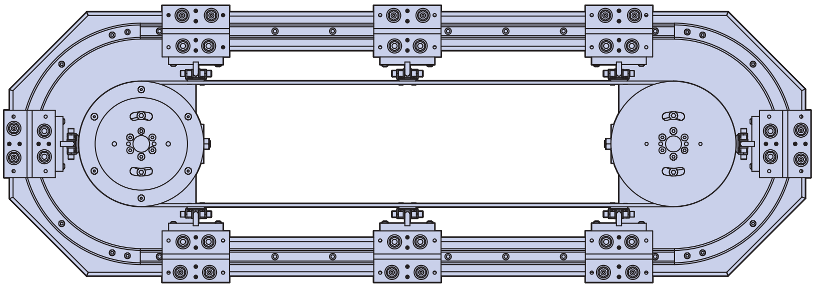
DTS2 Dynamic Track System
Derived from PRT2, the DTS2 was developed for tracks requiring high speed, rapid indexing and high driving forces. Standard or corrosion resistant versions are available. For more information please see **www.HepcoMotion.com/dts2datauk**.



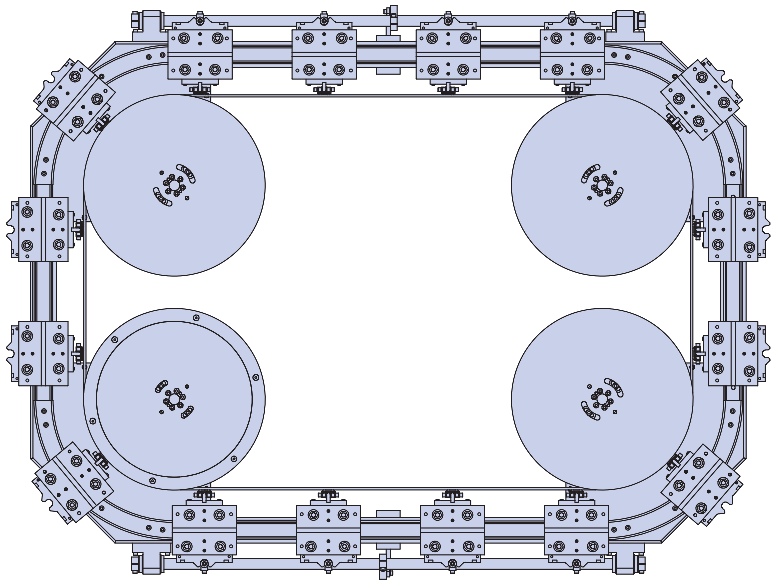
No. 1 Design Criteria for Track System Drives

Standard oval and rectangular driven track systems are available as shown below. For more information on driven track system components, please visit **www.HepcoMotion.com/PRT2datauk** and select datasheet No. 8 DTS Components.

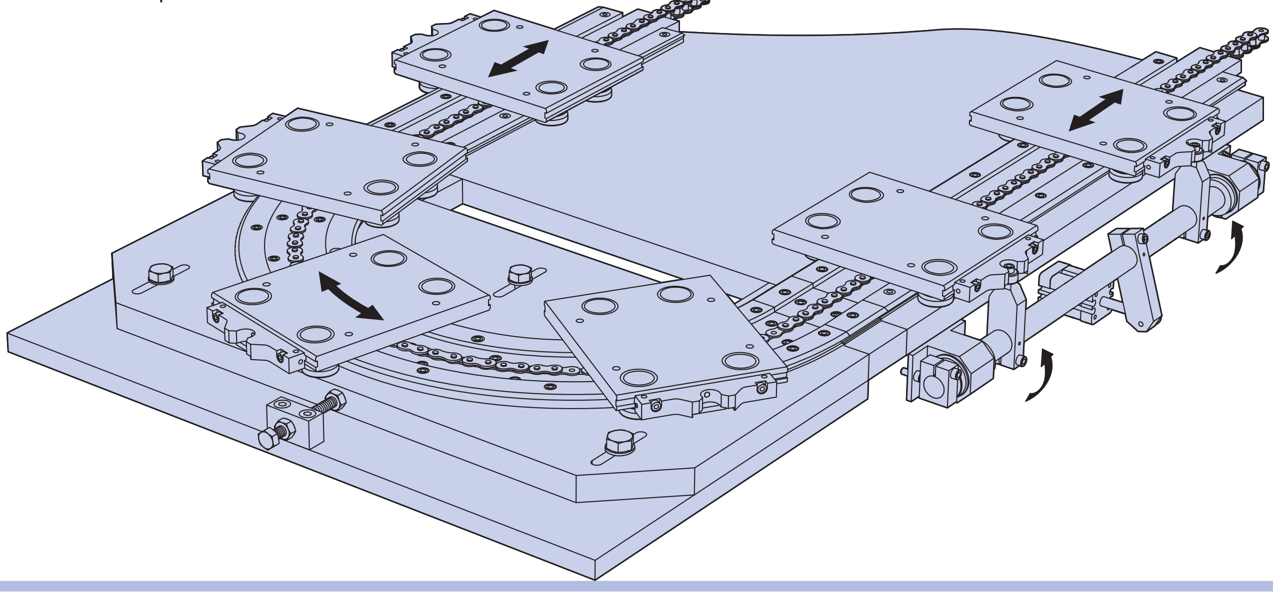
Oval Path Driven Track System



Rectangular Path Driven Track System



Duplex Track System with Centre Chain Drive
The track system comprises of duplex single edge slides and a central drive to ensure constant velocity around the system. This system is available complete with special chain and scroll drive system. If required it can also be supplied complete with a motor and mounted onto a Hepco MCS frame.



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