INTRODUCTION

Traditional slewing ring bearings are the default choice for wind turbines and many heavy industries including military, construction and defense. The impressive load capacities available in a small size envelope enable designers to provide compact solutions where space is often at a premium.

Their use, though, in many automation applications less load dependent, can mean a considerable amount of preparatory work in order to achieve a running solution. In addition, users looking for low maintenance costs over the life of the machine have the option of other technologies that can often provide better value for money. Properly sized vee ring systems have grown in popularity for designers looking for a solution that will perform thousands of hours of maintenance free service and will have low preparation and installation costs.

This white paper contains information on:

- Ring system concept and construction
- Size a ring system to provide a long and trouble free life
- Mounting and installation of rings
- Operating conditions
- Maintenance of Vee Ring Systems
- Maintenance of Slewing Bearings
- Maintenance of Gears

RING CONCEPT AND CONSTRUCTION CONCEPT

The vee ring systems, as manufactured by HepcoMotion, are produced in single piece diameters up to 1.8 meters in a variety of designs. They are produced with a double edge having a Vee profile on the inside and outside diameters. They are also produced with a single Vee profile on the inside or outside diameter. A gear profile for power transmission is available on the inside diameter or on the outside diameter. A belt tooth profile is an option for the outside diameter and enables the use of toothed drive belts. Diameters above 1.8 meters are offered in easy to fit segments complete with gear drive. This concept is covered in a separate white paper.

Concept of Vee Rings

Vee ring systems offer a different concept to slewing rings relying on Vee bearings running on a ring Vee to provide load carrying capacity and guidance. The style of bearing used is either a twin bearing construction or a double row (DR). Twin bearings are two separate bearings located on a fixing stud and offer more compliance. They have the ability to handle certain inaccuracies in the machine construction whilst still providing a smooth motion. However, they do have a lower load capacity than DR bearings making them more suitable for lighter applications where ultimate smooth motion takes preference over load capacity.
Twin or double row ball bearings are used within the Hepco PRT2 product line up to 54mm outside diameter to satisfy the general automation application. DR ball bearings of much larger diameters, up to 120mm, are available in the HDRT line, making this system ideal for heavier duty installations where load capacity is the key requirement. A larger, 150mm diameter twin taper roller bearing design with 50,000 N radial load capacity is also available from the HDS2 line.

**Construction of Vee Rings**

All rings are precision machined from a specialized steel that has been selected following years of application experience and testing. Vee running faces are hardened with the ring Vee angles accurately controlled to match the bearings. Lubrication between the bearing and the ring vees is provided by either slide, or bearing lubricators. Further details are provided under the maintenance section of this paper.

Rings have fixing holes for mounting to a firm base with bearings located either in carriage plates or more commonly directly to the machine base. Rings benefit from an integral gear making it easy to incorporate a drive without installing separate components. Rings are also available with an external timing belt drive offering low backlash with a drive that doesn’t require lubrication.

Providing turntable movements are a common application for rings given their low inertia and easy method of applying a drive. Within the PRT2 product line rings can be constructed as ring discs which enable users to fit fixtures, handling equipment directly to the disc dispensing with the need for a separate top plate.

**SIZE A RING SYSTEM FOR LONG AND TROUBLE FREE LIFE**

Double edge rings enable bearings to be positioned both on the inside and outside vees, which can be a useful way of increasing capacity in an axial direction. However, their main use is to form the 180 degree return segments for a complete ring and track system or to provide movement of a carriage through an arc as seen on tool changer movements.

For basic rotary motion, the single edge rings with gear drive are the common choice as they provide a more compact solution with the ability to position the drive internally or externally depending on space requirements. Users also find the increased space available in the center of the ring very useful to mount services and other handling devices.

**Number of Vee Bearings and Spacing**

The number of vee bearings located around the vee running surface will determine the load capacity of the system, regardless of whether it is an internal or external vee ring. Whilst it is usual to space the bearings equally around the circumference any number of bearings, space allowing, an be positioned at points where the load is the highest leaving other lighter loaded bearings to perform mainly a guidance function.
Rings can be mounted either horizontally as in a turntable application for assembly operations or vertically typically for rotating large rolls or fixtures. Most turntables see the bearings loaded axially whereas vertical applications invariably effect a combination of radial and axial loading.

Regardless of the ring orientation the same principles apply in sizing a suitable system. The minimum number of bearings that can be applied is 3. However, the vast majority of applications use 4 bearings evenly spaced at 90 degrees as this arrangement offers better overall rigidity.

Load capacities of ring systems will never match those of comparable size slewing ring bearings as the two concepts are totally different. The key to successfully specifying a ring system is to select the correct ring bearing combination that will provide the life that the application requires.

**Sample Life Estimates**

Consider the following life examples for a typical turntable arrangement having a direct axial load of 500kg with 4 bearings positioned equally spaced around and external vee ring design.

1. An HDRT ring size HDRE1280 with 4x THJR120 bearings will provide a life of 63,540km or 15,961,876 revolutions.

2. Using the same ring but specifying smaller 4x THJR95 bearings under the same conditions the life is 25,000km or 6,270,378 revolutions.

3. Using the same ring with 6x THJR95 bearings the life is 54,744km or 13,730,624 revolutions.

Relating these figures to a typical automation turntable subject to indexing and stopping for an assembly operation, it is unlikely that in a full working 16 hour day that the ring would be subject to more than 2,000 full revolutions. This would make example #1 with 4x THJR 120 bearings last over 20 years before the bearings are likely to require changing. It can be seen that example #3 with the 6x smaller THJR95 bearing combination will not be significantly less whereas example #2 with the 4x THJR95 set would provide a creditable 8 years of life.

**A Very Practical Alternative to Slewing Rings**

In terms of load carrying capacity and life achieved, HD rings offer a very practical alternative to slewing rings when the right selection is made. The important aspect is to specify a ring and bearing combination that meets the life requirements of the installation. As it can be seen if space is a problem a greater number of smaller diameter bearings can be specified with very similar results.

Replacing bearings after 8 years of use would be seen as low maintenance while specifying a combination capable of 20 years is probably adding cost unnecessarily.
In theory, to increase the load capacity further, any number of bearings could be positioned around the vee diameter as space permits. However, it is not generally recommended to exceed 8 bearings as it is difficult to ensure that under load that the number of bearings are sharing the load equally.

**Lubrication to Ensure Life**

A key element to achieving a long and trouble free life is lubrication. This is where the vee system has significant benefits over slewing rings. Vee bearings are internally grease packed and sealed for life. The only area where lubrication maintenance is required is on the mating vee faces of the bearing and ring. Small amounts of oil are required to be effective for the life of the equipment. Lubrication can be provided by either bearing or slide lubricators and both incorporate oil soaked felts that deposit oil on the mating vee surfaces.

**MOUNTING AND INSTALLATION OF RINGS**

Mounting and installation is an area where vee rings can save a considerable amount of time, both in the preparation of mounting surfaces and in the total time required to install. In order to understand this in more detail it is useful to compare a typical installed slewing ring arrangement against a vee ring system.

**Slewing Ring Mounting Requirements**

The cross-section arrangement shown of a slewing ring requires that the mounting surfaces for both the inner and outer raceway rings be machined flat and parallel to a high degree of precision. For a slewing bearing of 1.5m diameter, opposing ring faces will need to be parallel to within 0.15mm with mounting surface flatness within 0.190mm.

There is very little allowance for inaccuracies, as any distortion of the rings could have a detrimental effect on the internal running of the balls. In turn, this can cause an increase in the friction and in the worst cases a reduction in life. The high number of fixing holes will need to be tightened to a specific torque to prevent possible ring distortion on the assembly. During the tightening procedure it is normal to rotate the ring to check for any high spots or increased friction. If any abnormalities are detected it may be necessary to remove the ring and check the mounting surface.

**Vee Ring Mounting Requirements**

Vee rings systems are less likely to be affected by mounting inaccuracies due to their somewhat thicker cross sections and principle of operation. Consequently they require far less attention before they are operational. In most cases, rings can just be bolted to a top place, preferably using standard controlled height spacers. This method of installation saves considerable setting time and uses the inherent roundness and flatness of the ring to best effect. Vee bearings can be simply mounted to a base plate with two bearings on concentric through hole fixing journals and the balance of bearings on eccentric fixing journals. The eccentrics can be adjusted to the vee ring to achieve optimum running prior to locating the drive pinion.
Unsupported Mounting of Vee Ring
Installing rings unsupported is an increasing trend as designers try to cut installation costs further. Within the HDRT product line, and with most of the PRT2 rings, this is possible providing that the applied load is well supported and high accuracy is not required. This is most likely to occur on rotational fixtures where products need to be located for an operator. In these cases, the installation relies on the flatness and roundness of the ring to maintain consistent low friction movement.

OPERATING CONDITIONS
Most automation conditions where product assembly is taking place are generally clean, but there are an increasing number of processes where cutting and machining are involved that are being automated. Hostile conditions can ruin linear and rotary systems very quickly leading to costly maintenance. The correct choice of system is vital if high manufacturing efficiency is to be maintained.

Protection for Harsh Conditions
The slewing ring arrangement shown has a built in NBR seal protecting the inside ball track and ball system. In particularly hostile conditions a secondary seal is often required, this could be an additional NBR seal or a mechanical labyrinth type fitted to the outside mounting structure.

By contrast, vee ring systems are open by design allowing the vee wiping principle to wipe away contaminates and maintain efficient running. Only the vee bearings are sealed and the action of the bearing wiping on the ring vee is well proven and extremely efficient. The arrangement allows the end-user to assess the operating conditions of the installation both from lubrication and life perspectives.

MAINTENANCE OF VEE RING SYSTEMS
In general, linear vee systems are known for their low maintenance and vee based rings are no exception. Linear systems use cap wipers that completely cover the bearing and act as additional protection for the bearing while providing lubrication for the guide. However, cap wipers will only work on straight slides or very large diameter curves. Therefore, lubricators for ring systems can be located on the bearing vee or the ring vee, as shown, to provide enough lubricant to prevent wear of the ring.

Lubricators With Wiping Action
In hostile conditions, the lubricator performs the dual function of lubricating through oil soaked felt wipers and acting as a scraper to remove larger grit particles. The wiping action will spread lubrication across the ring vee face providing efficient lubrication. A key advantage with the vee principle is that only a small amount of lubricant is required to prevent wear. The number of lubricators is normally 4 with each lubricator fitted close to a bearing.

Relubrication
Relubrication intervals are application dependent. A simple checking function built into the equipment maintenance manual is all that is required to ensure that the felts are not running dry. Typical relubrication intervals are rarely under 3 months and in many cases can be as long as 9 months.
Bearing Replacement
In a properly lubricated ring system it will be the bearings that are the limiting factor and all calculations for life are based on these wearing first. When replacement becomes necessary, bearings can be simply released from the central fixing stud and replaced without disassembling the system. This procedure can be completed in a matter of minutes.

Optimizing System Life
Providing that care has been taken to ensure the ring vee has been kept well lubricated throughout the life of the bearings, then it should be possible to achieve a similar life with a second set of bearings. The original life calculation of 8 years could, in fact, be extended to 16 years for the vee ring.

MAINTENANCE OF SLEWING BEARINGS
On slewing bearings the internal ball tracks will require periodic relubrication in order to prevent dry running and the possibility of a catastrophic failure. If this happens, the complete bearing will need to be replaced. Similar to the vee ring lubricators, a checking procedure can be adopted or lubrication can be applied from an automatic system linked to the machine. Time based deposition canisters are also a popular solution.

Relubrication
The relubrication interval with slewing rings is dependant on the number of service hours but attention is required more often than with vee rings. Typically, for continuous operation of 40 hours per week, then the bearing will require relubrication every 6 weeks.

Seals for Harsh Environments
Under hostile conditions particular attention will need to be paid to the seals as grit or abrasive dirt particles can damage them affecting their efficiency. It is not uncommon to have to replace the bearing seals in certain operating conditions.

GEAR LUBRICATION AND MAINTENANCE
With both slewing bearings and vee ring systems with gears, grease is required to be applied during assembly and should be monitored in line with the other moving elements. Gear relubrication intervals for slewing rings are typically longer than for the bearing ball tracks and can be almost double. Vee ring intervals would follow suit. Automatic systems are also available for gears in line with the bearing elements.
CONCLUSION
Both vee and slewing ring systems have many attributes in their respective applications. While it is fair to say that vee rings require less preparation and installation time, slewing ring have a far greater load capacity enabling the solution to be used in high load, space limited applications. The particular market vee rings are intended for, though, is basic automation systems where both products are often vying for the same business. In this area, low installation costs and minimal maintenance are often more important than load capacity.

Vee rings can demonstrate by correct specifying that they provide a capacity in keeping with the life demands of the application. The prospect of minimal maintenance and only having to replace vee bearings is seen as a way forward to keeping maintenance costs down. Vee rings offer considerable design flexibility enabling the designer to reduce engineering costs, and at the same time offer a reliable, convenient and easy to integrate solution.

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ABOUT
Bishop-Wisecarver Group is a woman-owned family of WBENC certified companies in its second generation, and has remained one of the most respected names in custom automation solutions and guided motion technology since 1950. The San Francisco Bay Area company manufacturers, stocks, and distributes guided motion components and systems for linear, rotary and curved track applications. Bishop-Wisecarver products are used worldwide in industries such as packaging, medical device manufacturing, wood processing, food processing and semiconductor fabrication.