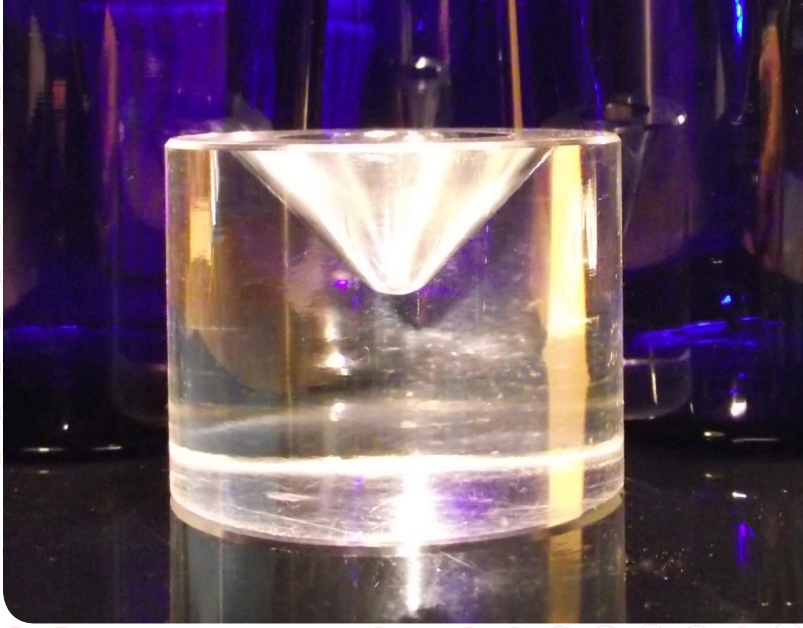
BIRD PRECISION 1913 to 2013

100 YEARS OF PRECISION

VEE JEWEL



SAPPHIRE AND GLASS VEE JEWELS

Vee bearings are available in sapphire, ruby, hard Pyrex glass and tungsten carbide materials.

Vee and cup type jewel bearings afford one of the lowest coefficient of friction in the miniature instrument bearing field. (Approximately .12 steel on sapphire) Several reasons account for this. Foremost, vee bearings provide point contact with the moving shaft element. Other miniature bearing types have line contact. Secondarily, the sapphire and glass materials offer low elastic deformation characteristics.

Glass vee bearings have slightly lower friction because they have fire polished surfaces. Fire polishing minimizes the interlocking asperities common to lapped surfaces. This factor is especially evident when the vee bearing is used in the horizontal position. In this position the mating conical shaft will try to roll up the surface of the vee bearing radius. But with the fire polished glass the interlocking of the pivot and glass surface is almost non-existent so friction and drag are optimized. Vee bearings in the vertical position have the lowest friction due to the point contact.

Another nice feature of vee systems is that the conical entry will afford a small amount of misalignment, without binding.

Vee jewels are commonly employed in moving coil and moving magnet meter movements, compasses, encoders, turbine flow devices, galvanometers, wind speed indicators, dip needles, balances and various timing mechanisms.

Because of the low elastic deformation, hardness and chemical resistant properties of the sapphires materials used, friction and torque do not increase appreciably over the life of the bearing, wear is usually found in the pivoting member or shaft rather than the bearing. This may be a function of load and speed and the choice of shaft materials. Choice of the size of the Vee bearing radius and the pivot radius have a lot to do with the load bearing capabilities and the friction induced.

Typically the conical vee angle is 85 degrees and the conical pivot angle is 55 degrees thereby allowing a little angular misalignment. Glass vee bearings with small radii will support up to 200 milligrams. Larger radius points will tolerate much higher loads.

Sapphire vee bearings will support much higher loads, it is usually the pivot point that is the weaker member. For instance a pivot point of less than .002” may be damaged with a load as little as 50 grams. When under shock or vibration whereas larger pivot radii may support 500 grams or more, vertically.

There are tremendous pressures exerted at the point contact area of the vee and shaft. According to the Hertz formula, used by V. Stott in his study, The Use of Pivots and Jewels in Instruments and Meters, page 37. We see the following. (Paraphrased)

For a 40 gram load on a 60 degree hardened steel pivot point, with a radius point of .002” the expectant force would be 1,237 KG per mm2. But if the pivot radius is increased to .0032” the force is reduced dramatically down to only 131 KG mm2. Friction also increases in a vee system as the pivot radius increases, so the designer must determine the optimum point were performance and durability meet.

Choice of pivot material is also extremely important to good design. Generally pivot points should be hardened to Rc 45 or better, and have a point and cone finish of 4 micro – inch. Corrosion resistance and non-magnetic properties are also nice features depending on the application.

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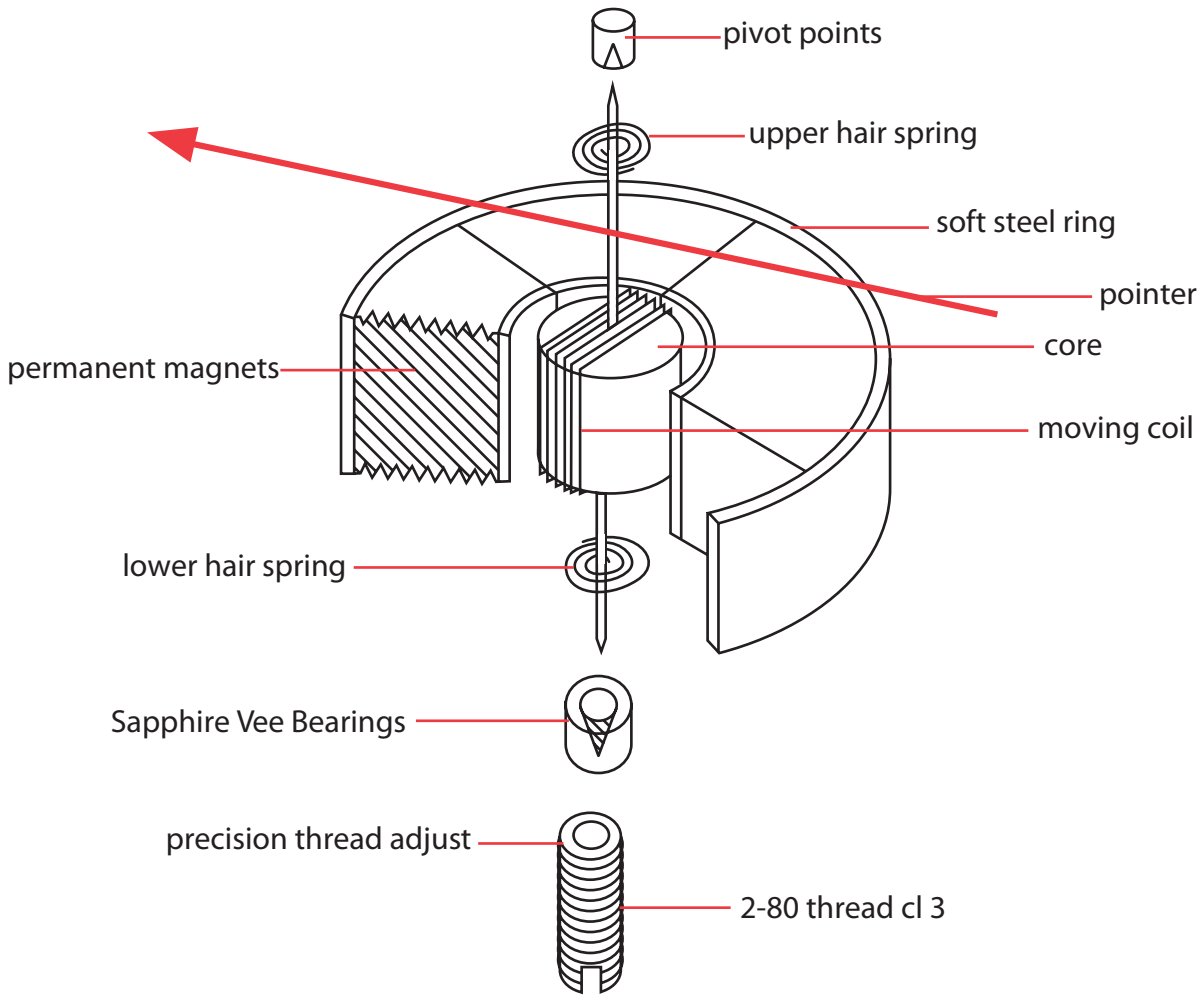
DESIGN CONSIDERATIONS FOR SAPPHIRE AND GLASS VEE JEWEL SYSTEMS

Sapphire and glass vee jewels are commonly mounted in fine pitch screws. See Figure 1, which shows a typical moving coil instrument with Sapphire vee bearings mounted in fine pitch screws.

Moving Coil Meter Movement

FIG. 1



1. In the vertical position moving coil instruments typically utilize a fixed vee jewel for the top position. The bottom position will have a spring loaded vee bearing in a fine pitch thread for end play adjustment.

2. The spring is tensioned to support the moving coil and is free to travel under shock or vibration.

3. The pivot points are shouldered to contact the top of the jewel screw rather than being allowed to bottom out the springs. (If the spring is bottomed out it will lose some of its resiliency) See figure 4 for typical shouldered pivots.

4. Glass vee bearings are used for movements under 200 milligrams. (But heavier movements can be tolerated by increasing the pivot radius. Sapphire vees are used for heavier or more ruggedized movements.)

The reason for the fine pitch of the thread is to facilitate the very precise end play adjustment between the shaft radius points and the vee jewel radius points. (see Fig. 3)

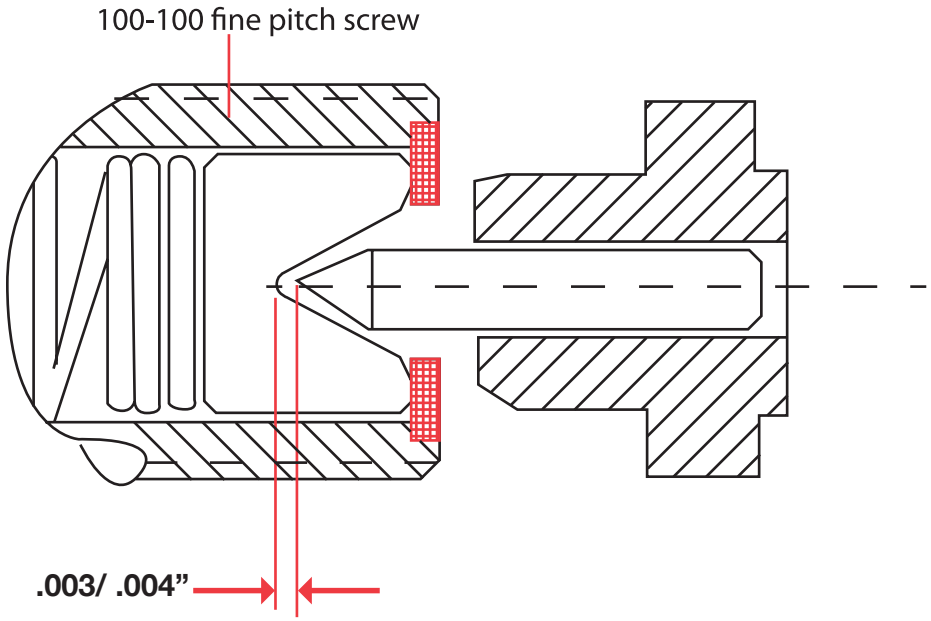
The generally accepted adjustment is .003/.004". The adjustment must be done cautiously, never locking up the points; the screw is turned down until only the slightest hesitation is sensed. Then the screw is backed off. Locking up the shaft and vee will damage the points, so a very light touch is needed.

Some instrument manufacturers set the moving element in motion, when they see a hesitation then they back off. So if you are using a 100-100 thread this is approximately ¼ turn of the screw.

Proper End Play

Adjustment of .003/ .004"

FIG. 2



This will be approximately ¼ turn on a 100-100 thread

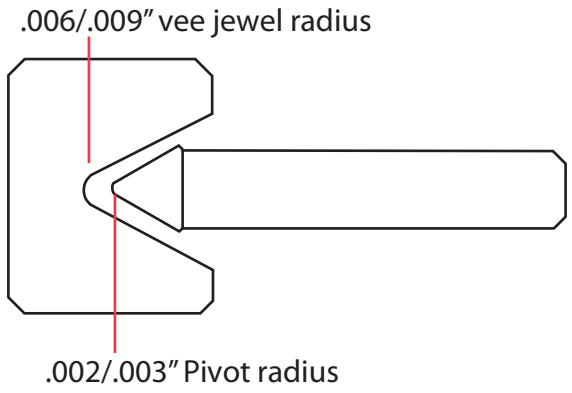
For small radius points (.0008/.002"), a weight of 50 grams or more can potentially put a flat on your pivot point, so if weights exceeding 50 grams are needed then the radius points of the pivot must be increased. (perhaps .005/.007" typical) depending on weight The best frictional result is when the ratio of vee radius and shaft radius is 3:1.
Example if the sapphire vee radius is .006/.009 the shaft radius should be approx. . . .002/.003. (see Fig. 3)

Sapphire and glass vee jewels can be either spring loaded or cushion loaded. That is the vee jewel can be made to support a certain weight before it begins to move.

Spring loading, or cushion loading one or more of the jewel screws can help protect the points in shock

Ratio 3:1

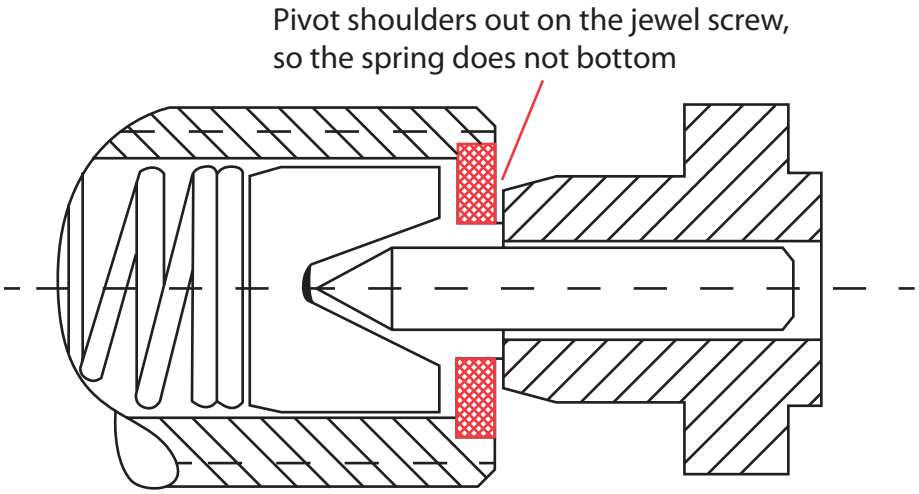
FIG. 3



Vee System under Shock with the Vee Depressed

FIG. 4

Under normal conditions the spring supports the movement



or vibration environments. The spring load is set to support the moving element weight so movement only results under some type of g force. The pivots are fashioned with shoulders; the shoulder distance is preset to avoid the spring bottoming during shock.

Some amp and volt meters are designed to survive being dropped in this manner. Most instruments where the movement is vertical will have a spring loaded vee on the bottom position and a fixed vee on the top. Horizontal movements can have one or both ends spring loaded.

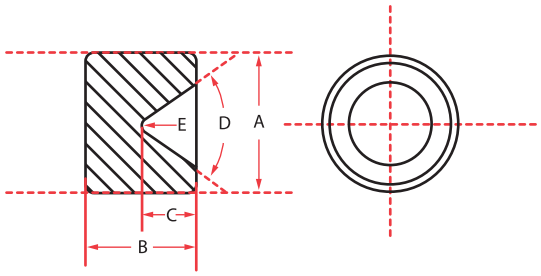
Bird Precision will be happy to recommend a set of bearings to fit your particular application needs. With over 100 years of design experience, Bird has a huge supply of precision screws, springs, vee jewels and matching pivot choices to facilitate custom design needs. So a turn key bearing system may be possible, or ask a Bird design associate for custom options as well.

For your design consideration we include the following listings.

1. Stock sapphire and glass vee jewels, see separate pdf.
2. Stock listing of possible conical pivots from our stock
3. Stock jewel screw sizes for fixed and spring loaded designs

Vee Jewel Nomenclature

FIG. 5



Nomenclature

A- Outside Diameter (OD)
B- Thickness (Th)
C- Depth
D- Angle (∠)
E- Radius (R)

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Choosing Pivots

Choosing the correct pivot points to match the sapphire vee jewel is critical. Below is a list of stock pivots . Please pay particular attention to the radius of the points. As noted the correct ration between the sapphire cone radius and the pivot point radius is 3:1.

Modern Instruments generally use Niva Alloy material. This is a chrome, cobalt and valadium alloy, comparable to Elgiloy N-100. This premium material is non-magnetic, corrosion resistant, RC 62 or greater hardness. This material exhibits low frictional qualities with both both glass and sapphire vee bearings.

To a lesser degree other materials in use are tungsten carbide, 440 C stainless, 420 f stainless and European alloys such as Sanvik 20 AP, or 20WIV. Hardness is very important, since the point can mushroom or wear down if they are soft. Generally hardness should be above RC45 for best performance.

SINGLE CONE PIVOTS STOCK LIST

PART NUMBER	MATERIAL	DIAMETER	LENGTH	ANGLE	RADIUS OF POINT
RB44354	NIVA ALLOY	.0197/.0199”	.140”	55˚	.002/.0026”
RB44471	NIVA ALLOY	.0198/.0202”	.105”	40˚	.0006/.0008”
RB44044	NIVA ALLOY	.0197/.0200”	.120”	55˚	.0007”/.0010”
RB44039	NIVA ALLOY	.0198/.0200”	.125”	40˚	.0013”/.0015”
RB44054	CARBIDE	.0197/.0200”	.200”	55˚	.001/.0012”
RB44046	NIVA ALLOY	.0402/.0404”	.200”	40˚	.0025/.0035”
RB44150	NIVA ALLOY	.0400/.0403”	.615	40˚	.002/.003”
RB44015	440C	.0402/.0404”	.200”	40˚	.0023/.0027”
RB44574	NIVA ALLOY	.0400/.0403”	1.25”	40˚	.0023/.0027”
RB44006	CARBIDE	.0862/.0864”	.394”	40˚	.007/.009”

DOUBLE ENDED CONES STOCK LIST

PART NUMBER	MATERIAL	DIAMETER	LENGTH	ANGLE	RADIUS OF POINT
RB44014	NIVA ALLOY	.0198/.0202”	.398”	50˚	.0009/.0011”
RB44520	NIVA ALLOY	.0198/.0202”	.239”	53˚	.0009/.0011”
RB44465	NIVA ALLOY	.0198/.0202”	.180”	53˚	.0009/.0011”
RB44051	NIVA ALLOY	.0397/.0403”	.160”	50˚	.0008/.0011”
RB44664	NIVA ALLOY	.0397/.0403”	.370”	50˚	.0008/.0011”
RB44984	NIVA ALLOY	.0397/.0403”	.656”	50˚	.0008/.0011”
RB44551	DRILL ROD	.0615/.0635”	.500”	60˚	.0025/.004”

List of available screws for fixed sapphire vee jewel assemblies

Choose a screw size to fit specific diameter of vee jewel sizes, as follows:

Screw thread sizes 0-200 or larger can accept .0394" (1mm) diameter sapphire and glass vee jewels.

Screw thread sizes 2-80, or larger can accept up to .049" (1.2mm) diameter sapphire and glass vee jewels.

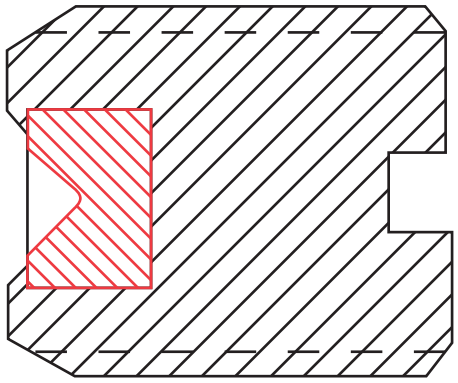
Screw thread sizes 3-56,m3, 100-100 and 4-40, or larger can accept up to .059"(1.5mm) diameter sapphire and glass vee jewels.

Screw thread sizes 6-32 or larger can accept up to .078" (2mm) sapphire and glass vee jewels.

Screw thread sizes 10-32 or larger can accept all sapphire and glass vee jewels up to .125"diameter.

FIXED VEE JEWEL ASSEMBLY

FIG. 6



choose thread size and vee size from listing

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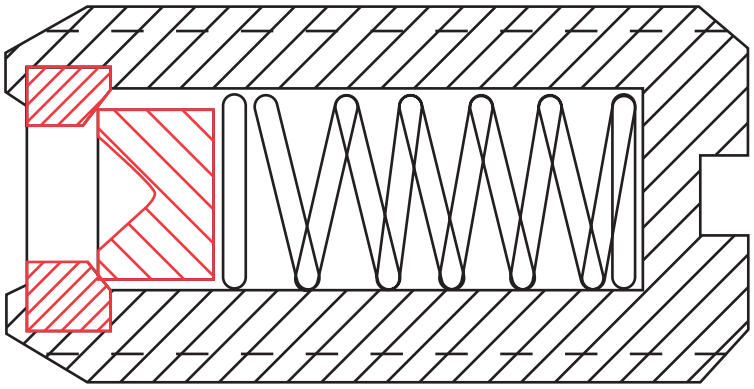
SCREWS FOR FIXED SAPPHIRE VEE JEWEL ASSEMBLIES

PART NUMBER	THREAD SIZE	CLASS	MATERIAL	TYPE	STANDARD ASSEMBLY VEE RADIUS
RB 51135	0-200	UNS-2A	BRASS	SLOT	.140” length
RB 51138	2-80	CLASS 3	BRASS	SLOT	.100” length, RB21008, RB83817, .003/.004”R
RB 53025	2-80	CLASS 3	303 SS	SLOT	.130” length, RB21125, RB82250, .003/.004”R
RB 51033	2-80	CLASS 3	BRASS	SLOT	.135” length
RB 51036	2-80	CLASS 3	BRASS	SLOT	.187” length
RB 51021	M2.5	X 0.45-6g	BRASS	SLOT	.262” length
RB 51006	M3	X 0.5	BRASS	SLOT	.120” length
RB 51085	3-56	CLASS 3	BRASS	SLOT	.130” length
RB 51044	3-56	CLASS 3	BRASS	SLOT	.187” length
RB 53391	3-56		BRASS	SLOT	this is a complete brass vee screw RB91653
RB 51003	100-100	CLASS 3	BRASS	SLOT	.090” length
RB 51039	100-100	CLASS 3	BeCu	SLOT	.120” length
RB 51123	100-100	CLASS 3	BRASS	SLOT	.145” length, RB21125, RB82151, .003/.004”R
RB 51008	100-100	CLASS 3	BRASS	SLOT	.187” length
RB 51009	100-100	CLASS 3	BRASS	SLOT	.205” length
RB 51010	100-100	CLASS 3	BRASS	SLOT	.225” length
RB 51012	100-100	CLASS 3	BRASS	SLOT	.285” length
RB 51001	4-40	CLASS 2A	BRASS	SLOT	.177” length
RB 51028	4-40	CLASS 3	BRASS	hex socket	.189” length
RB 51140	4-40	CLASS 3A	303SS	SLOT	.187” length, RB21008, RB82534, .003/.004”R
RB 53349	4-48	UNF2A	316SS	SLOT	.170” length for any 1.5mm vee jewel RB82161
RB 51050	4-90	CLASS 3A	BRASS	SLOT	.115” length
RB 51051	4-90	CLASS 3A	BRASS	SLOT	.170” length
RB 51053	4-90	CLASS 3A	BRASS	SLOT	.200” length
RB 51114	6-32	CLASS 3	BRASS	SLOT	.190” length
RB 51045	6-32	CLASS 2A	BRASS	SLOT	.195” length for 1.5mm vee jewels
RB 51067	6-48	CLASS 3	BRONZE		.130” length
RB 51043	8-64	CLASS 3	BRASS	SLOT	.341” length for 2mm vee jewels
RB 51048	8-32	CLASS NF3	BRASS	SLOT	.195” length for 1.5mm vee jewels
RB 51014	8-32	CLASS NF3	303SS	hex socket	.195” length
RB 51083	8-32	CLASS NF3	303SS	SLOT	.195” length for 1.5mm vee jewels
RB 51074	8-40	CLASS 3	BRASS	SLOT	.200” length
RB 51071	10-32	CLASS NF3	303SS	SLOT	.250” length for 2mm vee jewel RB82671
RB 53033	10-32	CLASS NF2A	BRASS	SLOT	.312” length for 1.5 or 2mm vee jewels
RB 51208	10-40		BRASS	SLOT	.155” length for 2mm vee jewels
RB 53191	¼-28	UNF 303	303SS	hex socket	Nylon Pellet, up to .125 Dia Vee

Wind speed indicator with Vee Jewels and pivot

SPRING LOADED VEE JEWEL ASSEMBLY

FIG. 7



choose thread size and vee size from listing

LIST OF AVAILABLE SCREWS FOR SPRING LOADED OR CUSHION VEE JEWEL BEARINGS

PART NUMBER	THREAD SIZE	CLASS	CLASS	MATERIAL	DIA	ASSEMBALY	TYPE
RB 51112	060-200		.148”	BRASS	1 mm	VEE	SPRING LOADED
RB 51042	2-80		.175/.170”		1.2 mm	VEE	SPRING LOADED
RB 51037	2-80		.159/.153”		.049”	VEE RB77006	SPRING LOADED
RB 52050	2-80	3A	.156”	BRASS	.049”	VEE RB77093	SPRING LOADED
RB 51121	3-56	3A	.230”	BRASS	1.2 mm		SPRING LOADED
RB 52040	100-100	3	.156”	BRASS	.049”	VEE RB77063	SPRING LOADED
RB 51020	100-100	3	.168”	BRASS	.049”	VEE RB77029	SPRING LOADED
RB 52001	100-100	3	.190”	BRASS	.049”	VEE RB77020	SPRING LOADED
RB 52006	100-100	3	.195”		1.2 mm	VEE RB77004	SPRING LOADED
RB 52027	100-100	3	.220”	BRASS	.049”	VEE RB77147	SPRING LOADED
RB 51010	100-100		.222”	BRASS	.070”	VEE RB75019	SILICONE CUSHIONED
RB 53348	4-48	NF2	.316”	SS	1.5 mm	VEE RB87013	SPRING LOADED
RB 52019	4-90	2	.140”	BRASS	.049”	VEE RB77152	SPRING LOADED
RB 51018	6-40	UNC-2A	.235”	BRASS	2 mm	VEE RB87022	SPRING LOADED
RB 52024	8-40	3A	.187”	BRASS	2.2 mm	VEE RB75011	SILICONE CUSHIONED
RB 51061	10-32	NF3	.380”	BRASS	.115”	RB87003 SAPPHIRE VEE RB21062	SPRING LOADED

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STANDARD STOCK GLASS VEE BEARINGS

PART NUMBER	VEE RADIUS	VEE DEPTH	ANGLE	OUTSIDE DIAMETER	GROUND THICKNESS
RB05001	.0030/.0040	.0150/.0180	75/85	0.0490/0.0500	.0400/.0410
RB05002	.0030/.0040	.0170/.0230	75/85	0.0485/.04950	.0390/.0410
RB05007	.0040/.0060	.0100/.0120	75/85	0.0485/0.0495	.0400/.0440
RB05101	.0030/.0040	.0150/.0180	75/80	0.0485/0.0495	.0350/.0360
RB05117	.0020/.0030	.0150/.0200	70/80	0.0485/0.0495	.0370/.0380
RB05703	.0040/.0050	.0170/.0230	75/85	0.0485/0.0495	.0350/.0360
RB07001	.0030/.0040	.0150/.0180	75/80	0.0660/0.0670	.0450/.0460
RB07135	.0020/.0030	.0120/.0150	75/85	0.0660/0.0670	.0350/.0360
RB07503	.0050/.0060	.0250/.0280	75/85	0.0740/0.0750	.0500/.0510
RB07506	.0040/.0050	.0250/.0300	80/90	0.0740/0.0780	.0620/.0650
RB08002	.0063/.0094	.0216/.0256	90/100	0.0795/0.0805	.0500/.0510
RB09004	.0060/.0090	.0280/.0320	85/95	0.0890/0.0910	.0500/.0510
RB09005	.0064/.0096	.0200/.0250	95/100	0.0980/0.0990	.0560/.0580
RB10503	.0060/.0080	.0280/.0330	80/95	0.1040/0.1070	.0530/.0550
RB10505	.0020/.0030	.0320/.0380	75/85	0.1040/0.1055	.0650/.0670
RB11502	.0060/.0090	.0290/.0350	100/105	0.1125/0.1175	.0700/.0750

STANDARD STOCK SAPPHIRE VEE JEWELS

PART NUMBER	VEE RADIUS	VEE DEPTH	ANGLE	OUTSIDE DIAMETER	GROUND THICKNESS
RB21001	.0030/.0040	.0090/.0100	85/95	0.0318/0.0322	.0270/.0290
RB21015	.0020/.0040	.0120/.0140	60/75	0.0390/0.0395	.0380/.0410
RB21002	.0030/.0040	.0100/.0150	80/85	0.03940/.0404	.0320/.0330
RB21125	.0012/.0028	.0142/.0177	80/88	0.0469/0.0472	.0382/.0398
RB21126	.0024/.0039	.0142/.0177	80/88	0.0469/0.0472	.0382/.0398
RB21127	.0031/.0047	.0142/.0177	80/88	0.0469/0.0472	.0382/.0398
RB21008	.0030/.0040	.0150/.0200	80/85	0.0488/0.0493	.0390/.0400
RB21009	.0040/.0050	.0150/.0200	75/85	0.0487/0.0492	.0400/.0410
RB21011	.0050/.0060	.0150/.0200	80/85	0.0487/0.0492	.0400/.0410
RB21014	.0040/.0050	.0180/.0230	80/95	0.0590/0.0600	.0450/.0460
RB21019	.0070/.0090	.0180/ .0230	75/85	0.0590/0.0600	.0450/.0460
RB21021	.0060/.0090	.0220/.0250	75/85	0 .0788/0.0798	.0550/.0600
RB21027	.0060/.0090	.0220/.0250	75/85	0.0788/0.0798	.0550/.0600
RB21062	.0075/.0105	.0290/.0350	100/110	0.1120/0.1170	.0730/0770