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By Jeffrey Finkernagel, technical sales engineer, Rotor Clip Company Inc

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Calculating endplay take-up for beveled retaining rings

By Jeffrey Finkernagel, technical sales engineer, Rotor Clip Company Inc

In many assemblies, dimensional tolerances in ring thickness, groove location or the overall length of the components being retained add up to a degree of clearance, or endplay between the abutting surfaces of the ring and retained part.

In some cases, the endplay can be eliminated by shims, washers and similar devices or by 'selective assembly' in which parts with plus or minus tolerances are matched carefully to provide the desired tight fit. But in high-speed production these alternatives can be prohibitively expensive both for materials and assembly labour.

Manufacturers have benefitted from substituting beveled retaining rings for these other alternatives. Beveled rings provide all of the cost savings benefits of conventional rings with an added advantage – they compensate for accumulated tolerances or wear in the retained parts and provide rigid endplay take-up in the assembly. This permits manufacturers to work with larger tolerances in the parts being assembled and still achieve required performance characteristics.

Design features: Rigid endplay take-up

Beveled retaining rings are similar in construction to the standard internal and external types. They differ from the standard rings in that the groove engaging edge is beveled to a 15° angle (the bevel is located around the outer circumference of the internal rings, around the inner circumference of the external rings).

The rings are designed to be used in grooves having a corresponding 15° bevel on the load bearing groove wall. The ring should be seated at least halfway down into the groove to provide sufficient contact area with the load-bearing groove wall.

When a beveled ring is installed in its groove, it acts as a wedge between the outer groove wall and the part being retained. When there is endplay between the ring and the abutting face of the retained part the ring's spring action causes the fastener to seat more deeply in the groove, compensating for the endplay.

Beveled grooves differ from standard ring grooves in two important respects. As indicated previously, they have a 15° angle on the outer wall of the groove and they are considerably deeper than standard ring grooves. The beveled wall matching the beveled edge of the ring is necessary for maximum ring effectiveness. The groove loads listed in the manufacturer's data charts are based upon minimum ring engagement; i.e., with the ring seated halfway into the groove. For this reason, the groove loads are somewhat less than the maximum loads for equivalent sizes of flat rings.

If the 'A' dimension is maintained and the cut is made accurately from the fixed shoulder to where the beveled portion of the groove intersects the housing or shaft diameter, the listed plus tolerance for groove width 'W' may be held or increased as required. If the beveled edge of the groove is located by establishing the 'A' dimension from the fixed shoulder to the straight wall of the groove, the listed plus tolerance for 'W' must be reduced (See Figure 1c) and will be referred to as the 'F' dimension (Figure 2). Note: It is not recommended to locate a groove using the 'F' dimension as it introduces extraneous tolerances.

In order to determine if a beveled ring will be functional in an assembly, a comparison must be made between the total tolerance of the assembly and the capability of the ring to fulfil this requirement. This fulfillment is achieved when the ring seats anywhere between halfway down to all the way down in the groove depending on the tolerance build up in a particular assembly. This is shown in Figures 1a and 1b and may be expressed as follows:

$$\text{Ring Take-up} = \frac{d}{2} \tan 15^\circ \geq \Delta A + \Delta B + \Delta U$$

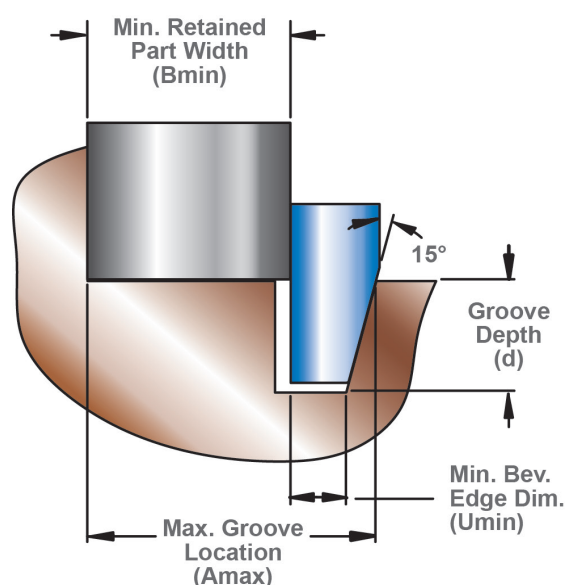


Figure 1a – Ring seated at maximum depth (near groove bottom)

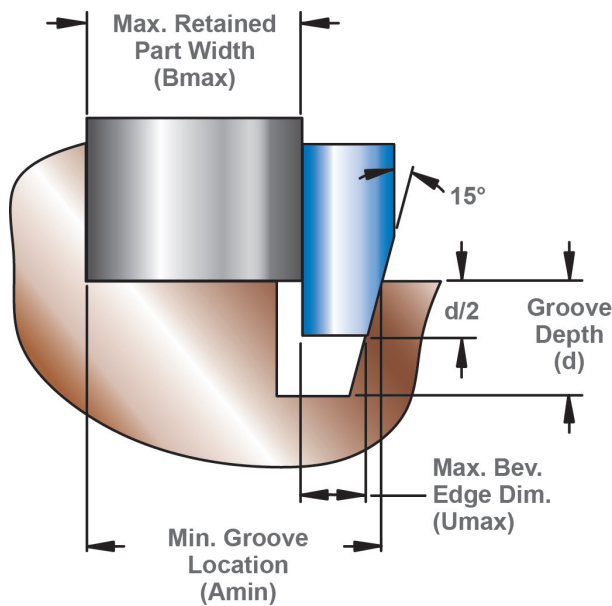


Figure 1b – Ring seated at minimum depth

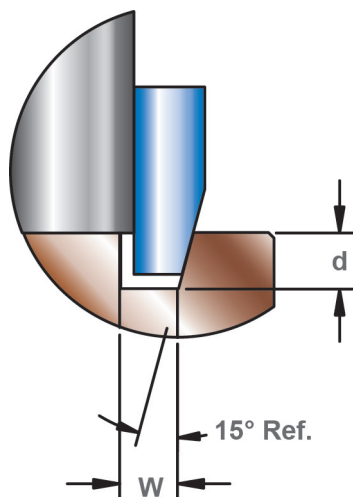


Figure 1c

Calculation of groove location and analysis of end-play take-up

The recommended procedure for calculating the groove location is:

$$A^1 \geq B_{\max} + U_{\max} + \frac{d}{2} \tan 15^\circ$$

$$A^2 \leq B_{\min} + U_{\min} + d \tan 15^\circ$$

Example of calculation technique

Determining the location of a groove for an 80mm (VHO-315) internal beveled ring, which will retain a 6208 ball bearing against a shoulder. The width of a 6208 bearing is 0.704 – 0.709 inches and we will assume a standard machine tolerance of ± 0.001 inches for groove location.

$$B_{\max} - B_{\min} = \Delta B$$

$$0.709 - 0.704 = 0.005$$

Minimum desired tolerance on groove location is:

$$\Delta A = 0.002 \text{ mm}$$

$$U_{\max} - U_{\min} = \Delta U$$

$$0.0845 - 0.0795 = 0.005 \text{ inches}$$

$$\text{Total assembly tolerance } \Delta A + \Delta B + \Delta U = 0.012 \text{ inches}$$

Take-up of VHO-315 ring:

$$\frac{d}{2} \tan 15^\circ = \text{Take-up}$$

$$\frac{.116}{2} \tan 15^\circ = 0.016 \text{ inches}$$

Even under extreme conditions this ring will maintain a rigid assembly. To determine location of groove:

$$A^1 \geq B_{\max} + U_{\max} + \frac{d}{2} \tan 15^\circ$$

$$A^2 \leq B_{\min} + U_{\min} + d \tan 15^\circ$$

$$A^1 \geq 0.709 + 0.0845 + \frac{.116}{2} \tan (15^\circ) = 0.809 \text{ inches}$$

$$A^2 \leq 0.704 + 0.0795 + .116 \tan (15^\circ) = 0.815 \text{ inches}$$

$$A = \frac{A^1 + A^2}{2} \pm .001 = \frac{.809 + .815}{2} \pm 0.001 = 0.812 \pm 0.001 \text{ inches}$$

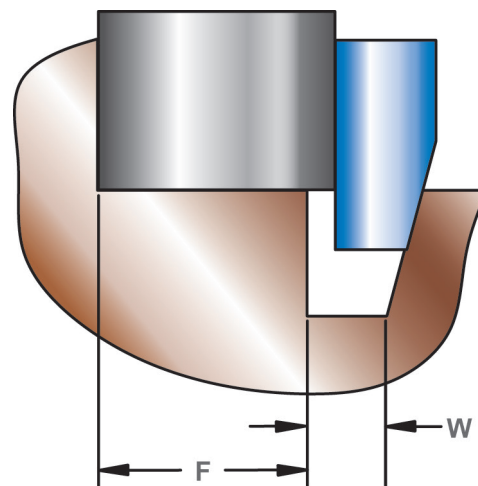


Figure 2

To determine the location of a groove from a 1.25 inches external beveled ring, which will retain against a shoulder part whose width is equal to 0.590 ± 0.002 inches and whose minimum desired groove location tolerance is 0.003 inches.

$$B_{\max} - B_{\min} = 0.592 - 0.588 = 0.004 \text{ inches}$$

$$A_{\max} - A_{\min} = 0.003 \text{ inches}$$

$$U_{\max} - U_{\min} = 0.041 - 0.039 = 0.002 \text{ inches}$$

$$\text{Total assembly tolerance} = 0.009 \text{ inches}$$

$$\text{Take up of VSH-125} = \frac{d}{2} \tan 15^\circ = \frac{.042}{2} \tan (15^\circ) = 0.006 \text{ inches}$$

It may be concluded that an external beveled ring, under the extreme conditions illustrated above, will not sufficiently take up the endplay in this application. However, based on accepted probability statistics such extreme conditions may be counted on to occur three times in 1,000 random assemblies. Therefore, the ring take-up need not be larger than the square root of the sum of the squares of the tolerances. Total range of tolerances according to probability is:

$$\sqrt{\Delta A^2 + \Delta B^2 + \Delta U^2} = \sqrt{0.004^2 + 0.002^2 + 0.003^2} = 0.005 \text{ inches}$$

The take-up of this ring is 0.006 inches as shown previously. Then we may safely conclude that in 997 cases out of 1,000 this ring will adequately retain the application rigidly. The three remaining extreme cases can be overcome merely by the substitution of any other corresponding machined part taken from stock. To determine location of groove:

$$A^1 \geq 0.592 + 0.041 + \frac{.042}{2} \tan(15^\circ) = 0.639 \text{ inches}$$

$$A^2 \leq 0.588 + 0.039 + 0.042 \tan(15^\circ) = 0.638 \text{ inches}$$

$$A = \frac{A^1 + A^2}{2} \pm 0.01 = \frac{.639 + .638}{2} \pm 0.001 = 0.6385 \pm 0.001 \text{ inches}$$

Inspection of ring beveled edge ('U' dimension)

As is noted on the manufacturer's data sheets for both internal and external beveled rings, the beveled edge width, designated as the 'U' dimension (see Figure 3) should only be used for calculating the groove location and take-up requirement as was illustrated in the previous section. No attempt should be made to directly measure this dimension since the point at which the measurement should be taken is not clearly defined due to the blanking crown and die clearance taper on the ring edge. During the manufacture of these rings,

techniques other than the direct measurement of this dimension are utilised to be sure that the dimensional integrity of the parts has been maintained.

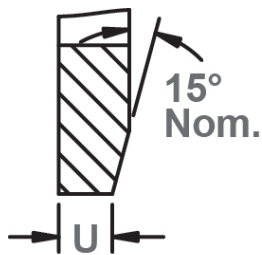


Figure 3

Checking ring installation: Dimensions 'G' and 'Gd'

As indicated previously, beveled rings must be seated at least halfway in the groove to provide sufficient contact area with the load-bearing groove wall. The dimensions for minimum gap width 'G' (internal rings – see Figure 4) and maximum gauging diameter 'Gd' (external rings – see Figure 4) provide a quick means to determine if beveled rings are seated at least half way in their grooves. If the gap measured on an installed internal ring is less than the listed dimension, the ring is not seated properly and may fail. If the maximum gauging diameter measured on an installed external ring is greater than the listed dimension, once again the ring is seated improperly and may fail. In either case, the ring should be removed and another installed. If the condition persists, the entire assembly should be checked for excessive tolerances on the retained parts.

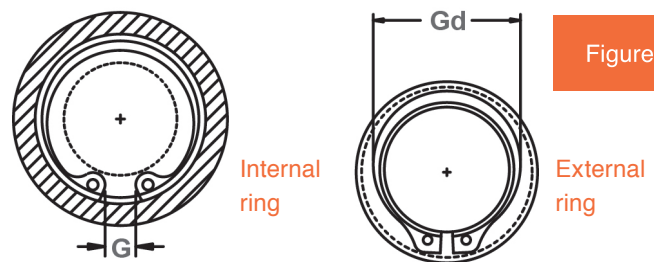


Figure 4

Today's demands for reduced costs extend to every component of an assembly. Fastening methods that require multiple components like shims and washers should be re-evaluated to determine feasible alternatives. Beveled retaining rings are a clear option paving the way for effective retention with a minimum cost in materials and labour. Following the guidelines above can help customers determine if this fastening method is right for their application. ■

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