Measuring the diameter of a hole is one of the most common measuring tasks in a production environment. And given the kind and number of tolerances for diameters, there are many different gaging techniques available to do these checks. From calipers to air gaging and everything in between, there is an appropriate gage for the application.

But what if the hole you need to measure is not a complete circle? What if it's a partial circle with less than 180 degrees of the arc available, or a combination of partial circles? In some hydraulic pump configurations, there are such holes (Figure 1) that cannot be measured with a conventional bore gage, as most bore gages measure strictly on the diameter.

The solution is to use a gage that measures chordal drop rather than diameter. We have written before about bench ID/OD gages that come in "T" and "V" plate configurations. In the "T" plate version, part diameter is read directly across the diameter. However, the "V" plate design incorporates two reference stops one at the top of each arm of the "V" in addition to a sensitive contact. These reference contacts must be adjusted symmetrically to assure that the part is staged on the center plane of the "V." This double stop has a locating effect similar to that of a vee block, and provides positive and precise location of the part on the gage. But as a result, the gage does not directly measure diameter. It measures chord height, which is the distance between the sensitive contact and the chord formed by the two reference contacts.

There are a couple of things to bear in mind about chordal measurements. The first is that since the sensitive and reference contacts are not in a direct line, there is not a one-to-one relationship between sensitive contact movement and the diameter to be measured. Rather, the measurement is determined by a multiplier which varies with the angle between the reference and sensitive contacts, just like the multiplier used when measuring a diameter on a vee block. The angle chosen depends on the size of the hole, the portion of the hole available to measure, and the ease of using a multiplier to get the correct results.

Some chordal gages use an angle of 53° that produces a requirement for a 4:5 ratio or a 1.25 multiplier to get the correct result. This means that for every four units of chord height measured by the gage, 5 units are shown by the indicator. This style of bench gage is great for small bearings or parts that can be brought to the gage.

But pump housings are a little too large and heavy to be brought to the bench gage. For these applications, portable chordal gages are available to take measurements on the part. In these gages two reference contacts, one on each side of the sensitive contact set up the vee to make the chordal drop measurement. Often the reference contacts span much less than the partial arc available, and thus there is some room available to "explore" the measured diameter. Depending on the size of the part, the reference contacts can be set to various angles. This changes the multiplier needed to produce the correct result, but this is easily done with electronic readout devices.
The other thing to keep in mind about this chordal measurement is that these configurations work only for comparative readings and cannot be stretched into the "absolute measurement" world. This is because there is a rather tight "window" of accuracy wrapped around the angle setup for the reference contacts. Moving the sensitive contact significantly away from or toward the reference contacts as would normally happen in an absolute measurement scenario changes the angle relationship. This changes the multiplier needed to get correct results. A scaling multiplier could be applied based on the measurement size and the location of the contact, but that's pretty complicated for a bench fixture gage.

Fortunately, for most applications, the user need not worry about all these angles, ratios, and chordal measurements. The gages take all the details into account, and have been for a long time with proven success. However, there are a number of things you need to keep in mind when using chordal gages:

- Make sure the parts to be measured are clean and free from oil/cooling fluid and measurable debris;
- Make sure the gage is seated on both references: most chordal gages have the two reference contacts plus a reference surface almost like a stop collar that sits on the face of the hole to square up the gage;
- Don't force the gage too much when seating. Depending on the gage design, this can distort the reference contacts and influence the diameter reading;
- Master the gages with span masters to help verify operation and improve accuracy.

Figure 1. The solution to measuring partial circles is to use a gage that measures chordal drop rather than diameter.