How Do You Choose the Right Bore Gage?

Selecting the correct bore gage begins with knowing as much as possible about your application.

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Bore gaging, already a significant factor in manufacturing, has become increasingly important in metrology because of the growing concern for total quality assurance (TQA). Compared with outside-diameter (OD) measurement, bore gaging creates more engineering challenges by the very nature of its special role in QA. This is especially true when measuring difficult-to-assess internal features such as splines, threads, and deep bores.

As machine capability increases, so does the demand for dimensional gaging to cope with tighter limits on tolerances and greater complexity of component parts. Some manufacturers are not so much concerned with making the component to a specific tolerance band as they are with size variation from component to component. This gives them better control of their process, but it also means that the gage they use must be able to discriminate size variation better than before.

Pistol-grip bore gages are very adaptable to measuring special features such as spline pitch diameter, ball races, and ball nuts.

Many manufacturers now require that any in-process or post-process gage record and send the measured size of a component to a statistical process control (SPC) or data collection system.

Making a gage choice

In choosing a bore gage, begin eliminating those types of bore gages that are least appropriate for a production environment. Noncontact measurement techniques, including optical and laser methods, tend to be bulky, relatively expensive, and inflexible when measuring special internal features. Such gaging requires the part to be taken to the gage. Not all types of noncontact systems are suitable for a production environment, and many entail high maintenance costs.

Coordinate measuring machines (CMM) are occasionally found in production situations, but many are expensive and they can be relatively slow. Parts cannot be checked while in the machine. CMMs also have high initial and maintenance costs.

Another gaging method is the use of plug gages. However, plug gages do not allow for electronic data collection for SPC systems. Each plug gage is suitable for only one specific bore size, and it has no working range. It only confirms if the part is good or bad and cannot identify subtle drifts of component size variation within the


spherical anvils help adjust for axial gage head misalignments of up to ± 10 degrees

tolerance band. As it is both the reference master and the working gage, it is subject to wear, and there is a subsequent cost for recalibration or replacement.

Two and three-point contact measurement is a popular solution as a production gage and provides many options. The gage is typically calibrated to a reference master, such as a setting ring, which means that only the setting ring itself must be calibrated regularly. For this reason, the reduction in operating costs compared to pin or plug gages is significant. Depending on the type chosen, gages under this description can have a wide working range. Moreover, they offer the best flexibility for adaptation to special feature measurement. Both two- and three-point contact methods can measure deep into bores, have lower initial and maintenance costs, and are portable. Digital versions can interface with SPC systems.

Two- and three-point bore-gage options

After a manufacturer has made the decision to use a bore gage for his application, there are still some choices to be made among the use of various two- and three-point devices.

Cylinder bore gages. As the name suggests, this gage was originally developed to measure cylinder bores in the automotive industry. It is a two-point contact measuring system for use on components that may be subject to ovality problems. The design includes a mechanism to centralize the measuring head in the bore. It is a cost-effective solution for simple bore measurement and can be easily adapted to measure bores up to 6 feet deep.

There are several cylinder bore gage limitations. There are many on the market with very poor linear accuracy. They have to be calibrated exactly at the size being checked. When purchasing a cylinder bore gage, always ask for the specification on linear accuracy.

Cylinder bore gages are not easily adapted to measure special features and require multiple setting masters. Analog versions require the operator to decide when he has established the minimum value, which can introduce variability from operator to operator. Unless a definite tendency towards ovality exists in the manufacturing process, a three-point system is a better solution.

Special applications

The following examples are a selection of the special, or nonstandard, applications that can be handled by two- and three-point bore gaging systems:

Micrometer bore gages. The traditional internal micrometer has many advantages in its flexibility, offering a choice of two- or three-point systems, a large working range on each measuring head, and adaptability to measuring special features. Depending on which design is chosen, it is possible to find systems that can

Threads. Threads down to 4 mm or 0.160 inch can be checked. Thread forms of UN, (UNC, UNF, UNJ, UNS) Metric, Acme, Whi2rth, Buttress, BSP, BA, BSF, and PG, in both standard and nonstandard pitches, can be measured in either left- or right-hand form.

Splines. Spline measurement is normally carried out with a two-point head, whether there is an even or odd number of splines.

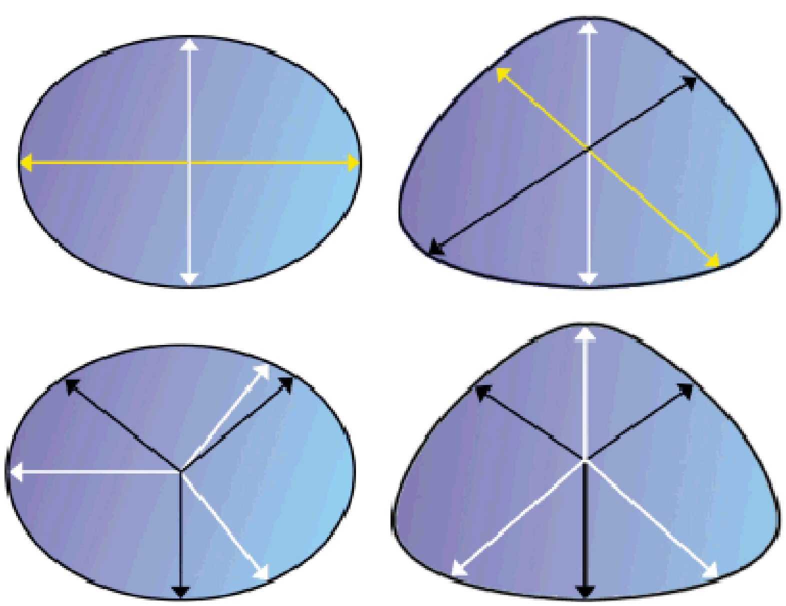
Deep bore measurement. Use a measuring head equipped with an internal transducer to measure anvil movement. Activation of the gaging force is achieved via a pneumatic cylinder inside the measuring head. The measuring anvils have a spherical form that results in an accurate reading, even if there is misalignment of the measuring head relative to the axis of the bore. The operator activates the gaging force via a foot switch and reads the bore size on a digital display unit, resolving down to 0.00001 inch and 0.0001 mm.

measure from 0.040 inch to 12 inches as a standard range. Both analog and digital versions are available, with the digital available as either mechanical or electronic. Only the electronic versions have the ability to send data to an SPC system, printer, or data collector.

Some manufacturers also offer a wide range of options, where features such as threads, splines, grooves, ball race, ball nuts, and bores as deep as 80 feet can be measured. Micrometer bore gages have to be calibrated to a setting ring. When selecting a gage, be aware that not all manufacturers include the cost of setting rings in their prices. This can make a considerable difference to the final purchase price, particularly if a calibration certificate is required with the setting ring.

Pistol-grip bore gages. This gage type offers all the advantages of the traditional internal micrometer, and it allows a fast, single-handed operation. The fact that there is a constant gaging force, independent of operator "feel," with the pistol-grip bore gage facilitates good gage repeatability and reproducibility results. It is very adaptable to measuring special features such as spline pitch diameter, ball races, and ball nuts.

To decide whether to choose a two- or three-point bore gage, it is important to understand the advantages and disadvantages of these two systems. The choice between two- and three-point systems centers around what type of geometry your manufacturing process generates, because no bore is perfectly round.



The best way to decide whether to use a two- or three-point bore-gage system is by measuring a series of components on a roundness checking device

The effect of lobing

In an instance where a two-point bore gage system collects the absolute minimum and maximum values in an oval bore, there may be a limitation when the two-point system is used on a bore with a trilobed form. In such a case, the two-point gage could give the same value of bore size even if the bore was checked in several positions. It misses both the absolute minimum and maximum bore sizes.

In the same instance, the three-point system shows its limitations when checking an oval hole because it cannot capture the absolute maximum and minimum. However, the correct minimum-maximum values are established when the three-point system is applied to the trilobed hole.

Most holes are neither truly oval nor perfectly trilobed, but are more a series of lobes of varying magnitude. The three-point system is the solution for the majority of cases because it offers the best "average" result. The only case when this is not true is where there is a definite tendency toward ovality within the manufacturing process.

It is very imortant to remember that bore gages do not measure geometry. The only correct way to establish what type of condition your manufacturing process generates is to measure a series of components on a roundness-checking device. From this, one can deduce whether a two- or three-point bore gaging system should be used.

Components of Gage Accuracy

The accuracy of a gage is determined by three factors:

Resolution. For a gage to accurately determine whether or not a component is in tolerance, the general rule is that the gage resolution should be near 10% of the tolerance.

Reproducability & Repeatability (R&R). Repeatability is the capability of a gage to give identical results for one operator taking several measurements of a single feature. Reproducibility is the capability of a gage to give identical results for several operators taking measurements of the same feature. Figures quoted by manufacturers usually refer to the maximum deviation one can expect. Gage R&R studies take both of these factors into account and introduce multiple components along with randomness in the sequence of measurement, to give a more detailed analysis of gage performance.

Linear Accuracy. This is the value of maximum deviation from the true size a gage will be capable of measuring across its entire working range. As this figure is intrinsically linked to the range of the gage, it means nothing unless considering both the value of deviation and the range together. Many manufacturers mistakenly use the 10% rule that establishes an appropriate resolution, and apply it to linear accuracy. This is incorrect, because it does not take into account the range of the gage.