



Dual probe measurement of precision parts is an extension of the nature of our universe; two points determine the endpoints of a line segment, so two points determine the limits of a linear distance. This is true for diameters of plain ring gages, plug gages, thread wires, and the lengths of gage blocks or step gages. Pratt & Whitney Measurement Systems designs and manufactures the finest instruments for measurement of a linear dimension. Hence the instruments will typically utilize tracking of two probes that make contact with the dimensional extents that define the length in question. This is a straightforward approach that works well and delivers accurate data for myriad dimensional measurements: ring gage diameters, plug gage and pin gage diameters, thread wire diameters, ball bar, end standard and gauge block lengths. Of course no solution is without its problems. One problem with relying on two probes that track position along a measurement axis is that the two probes may not be in line with the measurement axis. When two probes are not in line with the measurement axis, Abbe error will result (the Pratt & Whitney Labmaster abides by the Abbe principle). When the line through the two probes is skewed relative to the measurement axis, measurement across curved surfaces will include error that is a function of the probe misalignment and the radius of the measured artifact. Of course, as probe misalignment increases, so does the measurement error. Measurement error will also increase as the artifact diameter decreases. Imagine stretching a string across the diameter of a circular dinner plate. Now imagine a line parallel to the diameter, but 2-inch away – you can probably visualize this length as being shorter than the diameter. Now imagine a string stretched across a circular swimming pool. If this string were then shifted by 2 inch from the diameter, the difference between this length and the diameter of the pool would be less than the difference between the diameter of the dinner plate and the length across the plate 2-inch away. (For actual numbers: if a dinner plate diameter is 11 inches, a parallel distance across the plate 2 inch away will measure about 0.183 inches shorter than the plate diameter whereas the distance across a circular swimming pool offset by two inches from a diameter of 18 ft will measure only 0.009 inches shorter than the diameter). So probe alignment becomes very important when measuring small diameters like those of small pins and small plain ring gages.

Several Pratt & Whitney Measurement Systems Dimensional Measurement instruments utilize dual probes for measurement of small diameters. The Labmaster Universal 175, the Labmaster Universal 1000A, the Labmaster Universal 1000M, the Universal Supermicrometer, and the Labmicrometer can all be fitted with probes designed for the measurement of small inside dimensions. In many cases those small inside dimensions will be curved like those on plain ring gages (ring gauges). The correct alignment of those probes becomes more and more significant as the diameter of the measurement artifact decreases. Many users use their Pratt & Whitney Measurement System instrument solely for the measurement of rounded artifacts like ring gages, pin gages, and plug gages. These users should know how to verify that the dual probes that they use are properly aligned for best performance of their measurement instrument. They should also know how much error probe misalignment might contribute to their measurement of the rounded artifacts (ring gages, plug gages, pins and thread wires). This information is important for making accurate estimates of measurement uncertainty.

PRATT & WHITNEY®
MEASUREMENT SYSTEMS, INC.
66 Douglas Street
Bloomfield, CT 06002-3619

Sales: 1.800.371.7174
Support: 1.860.286.8181
Fax: 1.860.286.7878

www.PRATTANDWHITNEY.com



Furthermore, users should know how to minimize error due to probe misalignment – the way that dual probes are used will influence the magnitude of errors due to probe misalignment.

Probes most susceptible to misalignment error is likely the 0.040 – 0.125 small ID probes. These probes are designed for measurement and calibration of ring gages and other artifacts with inside dimension between 0.040 inches and 0.125 inches. The measurement error that one would encounter when using these probes to measure a ring gauge would be a function of the diameter of the ring gauge being measured, the misalignment of the small diameter probes, and the diameter of the ring gauge used set the measurement datum. The smaller the diameter of the ring gauge that is being measured the larger the error. The greater the misalignment of the measurement probes, the larger the error. The greater the difference between the diameter of the ring gauge used for the measurement datum and the diameter of the measured ring gauge, the greater the measurement error. So, of the three factors related to probe misalignment that will influence the measurement error of small ring gauge measurement, two can be controlled by the user to minimize the measurement error when measuring small diameter ring gages. The user can select a measurement datum that is the same diameter as the ring gauge to be measured. If the datum ring gauge and the measured ring gauge have the same diameter, then the error of the probe position will be the same both when the datum is set in the master ring gauge and when the reading of the ring gauge under test is measured – so the errors will cancel out. This effect is true by degrees; the closer the datum ring gauge is to the measured ring gauge the smaller the error due to any probe misalignment. The second way that the user can minimize measurement error due to probe misalignment is to determine if probe misalignment exists, and to contact Pratt & Whitney Measurement Systems to have any misalignment corrected. A user can determine the worst case effect of probe misalignment, and determine if the probe misalignment is acceptable with the use of two ring gages. The sizes of the two ring gages should be at the limits of the selected probes' measurement range: If the user wants to measure the alignment of the probes designed to measure ring gages from 0.040 inch diameter to 0.125 inch diameter, the user should use a 0.040 inch ring gauge and a 0.125 inch ring gauge. If the user wants to measure the alignment of the probes designed to measure ring gages from 0.125 inch diameter to 0.250 inch diameter, the user should use a 0.125 inch ring gauge and a 0.250 inch ring gauge. If the user wants to measure the alignment of the probes designed to measure ring gages from 0.250 inch diameter to 1.000 inch diameter, the user should use a 0.250 inch ring gauge and a 1.000 inch ring gauge. The procedure for checking the alignment is the same regardless of the probe type that is being checked: Set a datum in the larger ring gauge. (Center for a maximum diameter, tilt for a minimum diameter only in ring gages larger than 0.5 inches diameter.) Measure the smaller ring gauge. Any misalignment error should be negative, the instrument readout will be lower than the expected value for the smaller ring gauge's diameter. If the reading of the smaller ring gauge is more than 20 micro-inches lower than the expected value (per the ring gauge's calibration certificate), then the user should contact Pratt & Whitney to order alignment service.

Users can avoid dual probe misalignment error entirely by using single probe measurement. Pratt & Whitney Measurement Systems offers accessory probes designed for single probe measurement of ring gages and any other internal dimension. Of course no solution is perfect, and single finger

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measurement does have its own error liabilities. Since a single probe only contacts one point of a measured artifact at a time, the measurements are more subject to idiosyncrasies of the artifact form. For example if the bore of a ring gage were not perpendicular to the base of the ring gage, the user would not be able to easily tilt the ring gage to find the minimum diameter and detect this problem with the ring gage's form. Such a determination would require several measurements of the ring gage – driving the single probe back and forth across the ring gage's diameter and tilting the ring gage differently for each measurement. Dual probe measurement, on the other hand, would allow the user to watch the instrument readout as the ring gage is tilted in order to find the minimum diameter.

About the author

Matt Noonan is Quality Manager for Pratt & Whitney Measurement Systems.

Pratt & Whitney is a leading manufacturer of precision dimensional metrology instruments. Product lines include: Supermicrometer®, LabMaster®, Labmicrometer®, Laseruler®, and Measuring Machines.

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