NEW CONCEPT GEOSTEP

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The Geostep is a new concept in Coordinate Measuring Machine calibration. It uses several fundamental concepts of physics to achieve the ultimate in calibration accuracy. It uses multiple spherical artifacts that are of almost perfect geometry and of exactly the same diameter. These spheres are made of high chrome, high carbon stainless steel that is hardened to 58 HRC and thermal cycled for long-term dimensional stability.

The spherical geometry by definition has one point in three-dimensional space that defines its perfect position. The variety of vector forces generated when measuring a sphere applies forces to the test probe from all directions so it truly evaluates the probes performance in all circumstances. Probing a nearly perfect sphere tests the entire machines ability to measure and document its perfect position in the x – y and z coordinates.

By probing two spheres that are rigidly mounted a well-known distance apart, the three scales are added to the calibration equation. By carrying this concept further and adding a whole series of balls on the same centerline, additional basic principles of physics apply themselves. As the artifact gets longer, more of the C. M. M.'s error sources begin to show up. Systematic scale errors are made manifest because the line of balls are intentional spaced varying distances apart. All of the fundamentals of ball bar technology apply to the Geostep.

The simple act of measuring the Geostep in a series of well-chosen positions will check all 18 of the possible geometry errors of a Coordinate Measuring Machine. This is based on the fact that the dimensions of the Geostep are fixed so that any variations from position to position are errors in the measuring machine. The longer geometry lends itself to reversal technology, which enhances the accuracy and can even detect original calibration errors. First the Geostep is placed in a compound attitude, such as an inclined position across a body diagonal and then it is reversed 180 degrees. This simple test accurately evaluates a whole series of potential scale errors and shows up squareness and straightness errors if they exist. When the same test is performed on the other body diagonal you have a very quick, interim or Monday morning evaluation of the entire machine.

This is an archival test artifact that requires an occasional traceable calibration.

The line of balls is placed on the neutral bending plane of the extremely rigid beam construction. This reduces small bending moments to second order cosign errors that are of insignificant magnitude.

During the eight years of development many features of this device were perfected. The large 3-inch diameter window around the ball provides more than enough pre-travel for accurate, repeatable measurements of each ball’s position, by any make of C.M.M.

Unlike the ball mounting techniques used on other artifacts the balls of the Geostep retain their almost perfect sphericity and original size.

To prevent elastic deflection of the balls true position, by the probing force, during measurements, a deep hole is drilled into the ball and into the post that supports the ball. A solid Tungsten Carbide shaft is used to mount the ball to the body of the Geostep. This gives the ball the same rigidity as the body of the beam itself. Remember that tungsten carbide has a stiffness or young’s modules of 98,000,000 psi, which is more than four times that of cast iron.

Although virtual CMM evaluation shows that this device does evaluate straightness of the machine axii, the edges of one side rail can be flat lapped to provide a straight reference datum. This arrangement lends itself to reversal verification of the artifacts straightness.

The body of the Geostep is produced to near net shape by the “stable cast” process, from a special alloy iron to assure long-term dimensional stability. The entire body of the artifact is sealed with a hard metal coat that is very corrosive resistant.

The thermal coefficient of expansion for the materials that are used to construct the Geostep is 6.4 microinches per inch per degree ferinheigth, at temperatures near the 68-degree standard. This expansion rate is the same as most steel parts.

The device is rigidly supported by a precision honed 2-inch diameter hole (50 mm) in the very center of the part. This well-balanced arrangement divides the bending moments in half so any deflections caused by the probing forces are minute. The position of the Geostep is rigidly fixed by clamping two annular flat parallel rings surrounding the two-inch diameter hole. This isolates the clamping force, to prevent distortion of the Geostep.

The standard support mechanism allows a full 360-degree of rotation and 120 degrees of articulation. This basically depicts a large spherical shell from each location of the rigid support mechanism on the C.M.M. table.

There is also a NIST developed version of the support stand that is somewhat more sophisticated. It will index the Geostep to pre-selected positions in both planes and can be relocated in the same place on the machine table time after time. Learning procedures can be used so that re-measurements of the artifact can be made automatically.

For a through machine evaluation very low horizontal measurements must be made. For this application a rugged Kinematically coupled base plate is available.

The Geostep is the culmination of eight years of research. It is a simple, single, element calibration device that will give a total calibration of all 21 rigid body errors as well as the meriod of the flexible or elastic errors. The only limitation to the perfection of the Coordinate Measuring Machine evaluation and calibration by the Geostep is the accuracy of the original calibration of the artifact.

This device has been commercially available for three years and is well on its way of becoming the world standard for C.M.M. calibration.

NIST is providing a calibration service for this artifact that is accurate to less than one part per million. The full size artifact is 34 inches (860 mm) long with 10 ultra precise spheres placed on a common centerline in an uneven pattern that avoids synchronistic errors.

Two shorter versions of the Geostep are available for calibration of smaller machines. A 26 5/8-inch (676 mm) version with 8 spheres and a 16 5/8-inch (424 mm) version with 6 spheres. All three versions use identical construction. They are one and one half inch thick and four inches wide.

A big factor in the function of the Geostep is the things that the Geostep doesn't depend on. There is no laser with its dependency on due point, or barometric pressure and it requires no power, and it does not generate any heat.

The device weighs less than 20 pounds so that a single technician can perform the entire machine calibration.

The device is extremely rugged so it can be safely transported in a simple container.

This Geostep costs only a small fraction of any other complete calibration system. It has all of their advantages and none of their limitations.

A 60-inch version and an 8-inch version of the device are in development.

In addition to the routine calibration procedures this single device is long enough to check thermal drift effect and to perform repeatability tests.