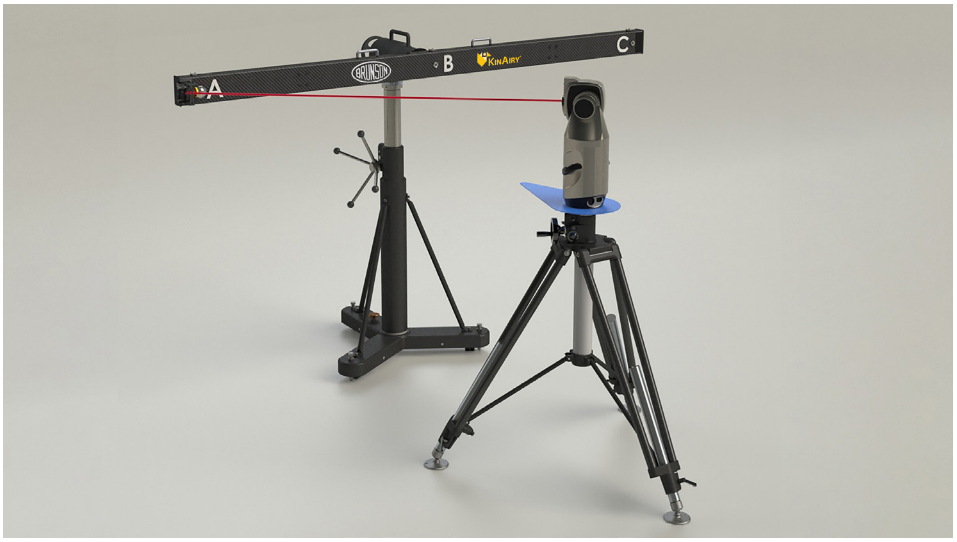
metrology.news
DIMENSIONING MEASUREMENT TECHNOLOGY

Maintaining Confidence in Laser Tracker Performance

February 3, 2020 • Written by Mark Meuret



Laser trackers have been widely used in industry for over two decades. From their original design in the late 1980's, trackers have been well accepted and adopted into the metrology workspace. The combination of industry needs and R&D innovations has created a recipe for some really cool advances in the technology—advances which push the accuracy envelope, improve the flexibility and ease of use, and lower the costs of ownership.

Along with a maturing product there is a need to have industry standards for that product. This need is typically driven by quality departments and standards organizations. These standards lag behind the advances of the product for 3 primary reasons:

1. Product advances must first be "accepted" by industry

2. Standards are driven by organizations other than those developing the technology

3. The process to develop a standard and gain approval can be lengthy

There are few published technical standards that address measuring the performance of a laser tracker. Even though there are similarities between these standards, they are not the same because of the different governing bodies that developed them. The American Society of Mechanical Engineers (ASME) standard is more recognized in the United States. In Germany there is a standard developed by an association of German engineers (VDI/VDE). In addition, there is an International Organization for Standardization (ISO) standard for laser trackers. These standards were developed by dedicated experts coming from varied backgrounds including Original Equipment Manufacturers (OEMs), users, government agencies, academia, and standards organizations.

Some of the individuals who serve on these committees represent multiple standards organizations. This helps share the expertise and development efforts between those organizations so they can leverage each other's ideas.

Laser tracker standards benefit industry in many ways:

First, standards can be employed by quality management systems (QMS) which are designed to control the equipment and processes used in manufacturing. Application of standards by QMS offers 3 clear benefits:

1. Promotion of accountability as a consistent and controllable evaluation of instrument performance

2. An "apples-to-apples" comparison and evaluation of tracker specifications

3. An acceptance process for tracker buyers making significant capital investments

Second, standards allow manufacturers to prove that their tracker meets the published specifications. Running a successful standards test achieves measurement traceability for the instrument as it is inherent in the process.

Lastly, standards protect the consumer. If there were a lapse in tracker performance, decisions made using suspect data could create a rippling effect of issues. For example, if a tracker is used in a production environment fails its periodic standards test, all the data taken since the prior successful standards test could be suspect. This might have resulted in acceptance of bad parts during this period which could lead to product failures in the field.

Scheduling And Environmental Controls

Performing a standards test is typically done on a scheduled basis and can be part of the process used in the tracker's routine calibration. Usually done in a controlled laboratory environment, these routine calibrations can be conducted by the instrument's manufacturer, service providers, or in some cases even the tracker owner's own quality lab engineers.

The effort and environmental controls required for such a test are not trivial. Therefore, typical end users are often not capable of performing a standards test and must take their tracker off-line and send it in for testing. Doing so has some related issues, such as:

• Loss of use of the instrument during the calibration period

• Not knowing the performance of the instrument since its last routine calibration

• Costs associated with the process

• Risks associated with transporting the laser tracker to and from the calibration site—did the tracker return in a calibrated condition after handling by the freight company?

Interim Tracker Testing

Periodic performance testing of laser trackers is important because they are mechanical systems which can change over time due to numerous factors. Tracker accuracies rely heavily on the relative positions of components within the instrument. Any changes in their relative positions can create misalignment that show up as geometric error sources in the tracker. Such changes can be the result of temperature cycles in operation and storage; environmental impurities that enter the system; mishandling, vibration, or physical shocks; and simply the wear of moving parts over time.

Because of these known opportunities for tracker accuracy to deteriorate, frequent performance testing of trackers is important. But due to the issues previously mentioned related to routine calibrations, there is some resistance to performing these types of calibrations frequently. Delaying routine calibrations may result in a degradation of data integrity—along with peace of mind—regarding laser tracker performance between test cycles. This creates a need for interim testing. Interim testing, sometimes referred to as field testing, is conducted between routine calibration cycles and is typically done in the tracker's environment of use.

There are many forms of interim testing with varying degrees of thoroughness and required effort. Tests range from a simple two-face test, to the measurement of a known length standard, to an elaborate "home brewed" test developed by the user that measures a reference artifact in various orientations. All of these tests are conducted with the intent of gaining confidence in the tracker's performance. However, the problem with many of these tests is that they aren't comprehensive and as such could give an incomplete or even false understanding of how the tracker is performing.

This problem has prompted the developers of the standards to incorporate more comprehensive interim testing procedures. In the initial releases of the various tracker performance standards, more emphasis was placed on the full routine calibrations done in laboratories than on interim testing procedures. However, as the technology has continued to mature, the need to develop a better controlled and more informative interim test became apparent.

Industry users asked the National Institute for Standards and Technology (NIST) to develop a process to address this need. NIST's efforts focused on developing a process that was comprehensive but easy to execute and didn't take long to perform – making it appropriate for use in the field. NIST modeled all of the geometric error sources in the tracker, developed measurements that were sensitive to these error sources, and limited the number of measurements so that redundancy was not required. As a result, in 2014, NIST published NIST IR-8016 – A Proposed Interim Check for Field Testing a Laser Tracker's 3-D Length Measurement Capability Using a Calibrated Scale Bar as a Reference Artifact. The IR-8016 process has given guidance to the various standards organizations as they consider including interim testing within their standards.

As a result of NIST's efforts and industry's need for better guidance on interim testing, the ASME standard for measuring tracker performance (B89.4.19-2006) is currently being revised to include a comprehensive interim testing procedure. This procedure is based on the NIST IR-8016 whitepaper but improved by the collective efforts of the committee members who are modifying the standard. At this writing, these updates are in draft mode and are expected to work their way through the ASME standards approval process later this year.

The ISO standards committee is also paying close attention to the developments in interim testing. ASME B89.4.19 committee members present progress updates to the ISO committee at their regular meetings. The ISO committee is planning to incorporate a similar, if not the same process for interim testing into the ISO standard (ISO 10360-10) once the ASME updated standard has been finalized. As a result of this lengthy process, it may take 2-3 years to see comprehensive interim testing incorporated into the ISO 10360-10 document.

$$u^2(L_{ref}) = \left(\frac{\partial L_{ref}}{\partial L^0_{ref}}\right)^2 u^2(L^0_{ref}) + \left(\frac{\partial L_{ref}}{\partial CTE}\right)^2 u^2(CTE) + \left(\frac{\partial L_{ref}}{\partial T}\right)^2 u^2(T)$$

$$\frac{\partial L_{ref}}{\partial L^0_{ref}} + [1 + (CTE)(T - T_0)] \approx 1$$

NIST applied analytical tools from the B89 Standard to guide the creation of the IR-8016 interim laser tracker field test.

An Interim Laser Tracker Field-Test Solution

As NIST was developing the IR-8016 Interim Field Test, the organization partnered with Brunson Instrument Company to develop the tight-tolerance reference artifact required for the process. The Brunson product is called KinAiry and features a 2.3-meter carbon-composite reference bar, KINematically mounted at its AIRY points to a heavy-duty Brunson positioning device. The KinAiry solution is complete with data analysis and procedural guidance software.

KinAiry allows the user to execute a full volumetric test for a laser tracker or laser radar in just 20-30 minutes—right on the shop floor or in the metrology lab. KinAiry delivers objective, traceable results in a graphical analysis, comparing directly to the specific instrument's Maximum Permissible Errors.

KinAiry has proven popular with quality and metrology engineers who seek to bolster their confidence in their laser tracker's performance after shipping or heavy usage, or before a particularly critical measurement. The KinAiry process is customarily run on a weekly or monthly basis to ensure proper laser tracker or laser radar operation.

As laser trackers continue to mature in industry, so must the standards that help support them. These standards are beneficial to consumer protection, supporting quality and data integrity, and giving ongoing guidance to OEMs. These efforts are necessarily and appropriately guided by industry needs. Future releases of laser tracker performance standards should reflect the comprehensive interim testing procedures currently being developed.

For more information: www.brunson.us