



Measuring Tube and Bore ID Straightness with NOVACAM™ Non-Contact 3D Metrology Systems

Introduction

Inside diameter (ID) straightness affects the performance of tubes and bores in many high-precision industries. This is why manufacturers look to measure ID straightness with precision, to automate the measurement, and to perform the measurement in a fast and non-destructive manner. Responding to this need, NOVACAM non-contact 3D metrology systems provide fast and highly repeatable straightness¹ measurements on all sizes of tubes and bores.

Straightness Measurement – Precise, Efficient, Automated

NOVACAM™ TUBEINSPECT™ system measures tube and bore ID straightness with **sub-micron precision and accuracy**. Its small-diameter optical probe easily enters the ID to acquire 3 or more circular profiles at selected depths. From the obtained 3D point cloud, GD&T software calculates the axial straightness (Figure 1).

The measurement, analysis and reporting **process is fully automated**, with the operator simply pressing a start button. The process **takes seconds or minutes**, depending on the tube length and the number of circular profiles.

Straightness Measurement Precision Better than 0.5 μm (0.02 thou)

The accuracy and precision of straightness measurements with the TUBEINSPECT system is < 0.5 μm (0.00002”). Precision (measurement repeatability) is expressed here as standard deviation of test results.

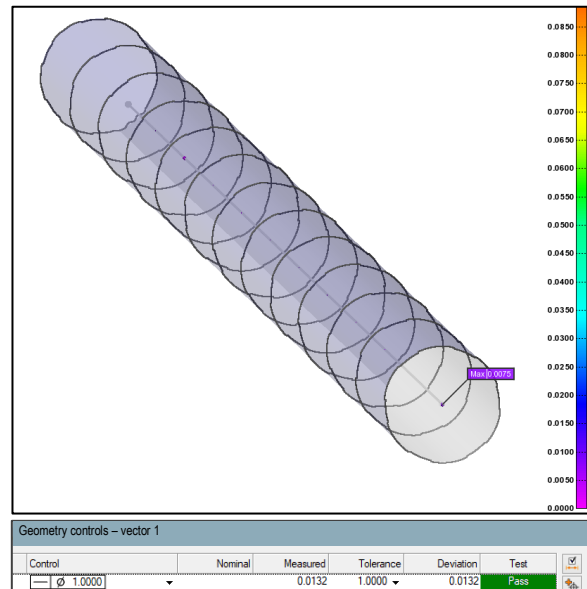


Figure 1: Once the TUBEINSPECT system acquires the 3D point cloud data, PolyWorks® Inspector is used to calculate and report the centerline axis straightness.

Example: GD&T straightness was measured on a 220 mm long section of a 5.6 mm diameter tube. An ID circumferential profile was acquired every 20 mm. The measurement was repeated 10 times. The following results were obtained:

Pass #	Bore 1 straightness	
	(μm)	(inches)
1	16.5932	0.000653276
2	16.6601	0.000655910
3	16.4591	0.000647996
4	16.6170	0.000654213
5	16.3722	0.000644575
6	16.5454	0.000651394
7	16.7292	0.000658630
8	17.1656	0.000675811
9	16.4850	0.000649016
10	16.5103	0.000650012
Standard deviation	0.21976	0.00000865209

¹ In this document, ID straightness is defined as the straightness of the tube/bore centerline axis.

Centerline Axis Useful to Measure Bore or Tube Coaxiality

For some TUBEINSPECT system users, the centerline axis obtained as part of straightness measurement also serves as a datum for measuring coaxiality of different tube sections.

Technology Advantages

The TUBEINSPECT system is based on low-coherence interferometry technology. It offers:

- Higher sensitivity, micron resolution, and excellent repeatability compared to triangulation or chromatic confocal
- Immunity to ambient lighting and higher sensitivity compared to laser interferometry. Higher sensitivity enables measurement and imaging of even some angled surfaces.

TUBEINSPECT System Benefits

The TUBEINSPECT system is a standard off-the-shelf product that provides:

- Non-contact micron-precision measurements of ID dimensions, including straightness, roundness, cylindricity, concentricity, runout, interior angles, etc.

- High measurement speed - up to 100,000 3D point measurements per second
- Measurement of high-aspect-ratio features such as O-ring grooves and cross-holes.

Bonus measurements that can be obtained with the same system and probe include:

- Outside diameter (OD) of tubes
- ID & OD surface defects, roughness, chatter.
- Thickness of transparent or semi-transparent materials.

BOREINSPECT™ System: Another Option for Measuring ID Straightness

NOVACAM BOREINSPECT system also provides bore/tube ID straightness measurements. Unlike the TUBEINSPECT system, which rotates the part, the BOREINSPECT system rotates its probe to acquire the ID.

Conclusion

NOVACAM encourages technicians and engineers in charge of manufacturing and quality control to contact us to discuss your inspection applications and metrology challenges.

NOVACAM 3D metrology systems for ID straightness measurement

System name	Type of optical sensor	Straightness measurement of	Range of ID sizes	Bore/Tube Length*
TUBEINSPECT system	Side-looking probe	ID or OD	> 1mm (0.04")	Up to 1,000 mm (40")
BOREINSPECT system	Side-looking rotational probe	ID	2 mm (0.08") to 131 mm (5.2")	Up to 260 mm (10")

* The listed tube/bore lengths are measured with standard probe models. Probes with non-standard diameters and lengths are custom-built upon request. Custom probes as long as 2 m have been built.

Notes:

- NOVACAM systems are based on low-coherence interferometry. Each system includes MICROCAM™-3D or 4D interferometer (19" rack-mountable instrument) and a mini desktop-size PC or laptop that hosts NOVACAM data acquisition software and, typically, PolyWorks® Inspector GD&T software for 3D data analysis
- Watch a short video on bore ID measurement measurements with the TUBEINSPECT system:

<https://www.novacam.com/resources/novacam-metrology-videos/3d-tube-id-measurement-video/>

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