



Armed with Quality

CUSTOMER SERVICE DEPARTMENT *FAST FAX*

To: FaroArm User

From: Customer Service Department

FORM: 176-003

5 Pages total including this page. Contact us immediately if pages are missing or not legible.

TOPIC: FAROARM Accuracy

SOLUTIONS: SINGLE POINT VS. LINEAR DISPLACEMENT
SIGMAS VS (MIN-MAX)/2

NOTE: Please refer to your FaroArm Manual for complete details.

First, Here's a Little Statistics Review!

Accuracy is the amount by which the *result* differs from the *true value*. Accuracy can be expressed in several ways, for example:

1) Error bandwidth as standard deviations, such as 1, 2, or 3 sigma. The following table indicates how much of the error band is included for each sigma value:

Sigma	% of error band
+/- 1	67.3
+/- 2	95.5
+/- 3	99.7

This statistical representation of accuracy is often used to give the observer a more practical measure of how accurate the result will be.

2) Error bandwidth as (max-min)/2. This represents the error as the total error between the least value and the highest value. Because this representation only considers the extreme outside data points, it may over emphasize the expected error if there are a few outlying points in the data set which are not representative of the remainder.

The FaroArm accuracy is stated as the **+/- 2 sigma, single point error band**.

By comparison, the +/- (max-min)/2 value would be approximately +/-3 sigma (or 6 sigma).

As an example in the case of a silver 8' FaroArm we report single point +/- 2 sigma repeatability of +/-0.003". The expected +/- (max-min)/2 would be approximately +/- 3 Sigma or +/- 0.0045". Another way to express this

is to state the total error band for a single point of 0.009". We chose the +/- terminology since the true value is at the middle of the band and therefore the greatest deviation from the true value is 1/2 of the band.

The accuracy of a **linear displacement measurement** is the sum of the deviations of the single point. The standard deviation is the square root of the variance. Therefore, if the variance is the same for each of any two points, the standard deviation of the linear displacement is the square root of 2 (or 1.414) times the single point standard deviation. Therefore the displacement +/- 2 sigma is +/- 0.0042 and the displacement +/- 3 sigma is .0063", or total band of 6 sigma .0127".

Interim Certification

FaroArm Software contains certification testing programs to perform interim checks of Single Point repeatability, Volumetric performance, and Linear Displacement accuracy. The first two are measured using the Ball Bar Certification and the last using the Sphere to Sphere Certification or Step Gauge Certification.

The values measured in all of these certifications include 100% of the measured points. We will always refer to this as the "Max. minus Min. over Two," or the Maximum measurement subtracting from the Minimum measurement divided by two (Max-Min)/2. Don't forget that this is comparable to the +/- 3 Sigma error.

If this was far too complicated see the summary table below.

Suggestions and Expected Results from Interim Testing

Before performing any certification testing, the current probe must be calibrated correctly. Improper probe calibration will cause inaccurate measuring. We suggest using the standard 1/4" probe.

Volumetric repeatability (Bar Ball Certification), and Linear Displacement (Sphere to Sphere Certification) are detailed in the FAROARM users manual.

Repeatability

Perform the single point repeatability to check the probe and repeatability. We suggest using a firmly secured object with a hole .050" smaller than the ball probe. If a cone hole is used, extreme care must be taken to ensure that the probe is seated at each "hit." To perform a Single Point repeatability test, enter the Ball Bar certification test and measure points in a single hole from multiple directions.

When reviewing the data, remember the data will be dispersed over the entire permissible band. In the case of the 8' silver discussed above points will have a spread of .006" or +/- .003" from the average 95.5% of the time. Remember also that 99.7% of the data will be in the (Max-min)/2 or 3 sigma band of +/- .0045.

Linear Displacement Accuracy

The accuracy of a **linear displacement Measurement** is the sum of the variances of the single point. Next perform a step gauge or ball bar test in order to certify the linear displacement accuracy of the equipment. *When reviewing the data, remember the data will be dispersed over the entire permissible band. In the case of the 8' silver discussed above the linear displacement data will be within an error band of .0084" or +/- .0042" from the actual 95.5% of the time. Remember also that 99.7% of the data will be in the (Max-min)/2 or 3 sigma band of +/- .0063.*

Comments:

We know that this may be a little confusing and we encourage you to test the equipment and discuss the results with the Customer Service Department or the Research and Development department.

Gold Series 4

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0005 in	±0.013mm	±0.0010in	±0.025mm	±0.0015in	±0.038mm
Linear Displacement	±0.0007 in	±0.018mm	±0.0014in	±0.035mm	±0.0021in	±0.053mm
Volumetric Performance	±0.0007 in	±0.018mm	±0.0014in	±0.035mm	±0.0021in	±0.053mm

Gold Series 6

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0008in	±0.020mm	±0.0016in	±0.041mm	±0.0024in	±0.061mm
Linear Displacement	±0.0011in	±0.029mm	±0.0023in	±0.057mm	±0.0034in	±0.086mm
Volumetric Performance	±0.0011in	±0.029mm	±0.0023in	±0.057mm	±0.0034in	±0.086mm

Gold Series 8

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0010in	±0.025mm	±0.0020in	±0.051mm	±0.0030in	±0.076mm
Linear Displacement	±0.0014in	±0.036mm	±0.0028in	±0.072mm	±0.0042in	±0.108mm
Volumetric Performance	±0.0014in	±0.036mm	±0.0028in	±0.072mm	±0.0042in	±0.108mm

Gold Series 10

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0017in	±0.042mm	±0.0033in	±0.084mm	±0.0050in	±0.126mm
Linear Displacement	±0.0023in	±0.059mm	±0.0047in	±0.119mm	±0.0070in	±0.178mm
Volumetric Performance	±0.0023in	±0.059mm	±0.0047in	±0.119mm	±0.0070in	±0.178mm

Gold Series 12

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0024in	±0.060mm	±0.0047in	±0.119mm	±0.0071in	±0.179mm
Linear Displacement	±0.0033in	±0.084mm	±0.0066in	±0.169mm	±0.0100in	±0.253mm
Volumetric Performance	±0.0033in	±0.084mm	±0.0066in	±0.169mm	±0.0100in	±0.253mm

Sterling Series 4

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0010in	±0.025mm	±0.0020in	±0.051mm	±0.0030in	±0.076mm
Linear Displacement	±0.0014in	±0.036mm	±0.0028in	±0.072mm	±0.0042in	±0.108mm
Volumetric	±0.0014in	±0.036mm	±0.0028in	±0.072mm	±0.0042in	±0.108mm

Performance						
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Sterling Series 6

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0017in	±0.042mm	±0.0033in	±0.084mm	±0.0050in	±0.126mm
Linear Displacement	±0.0023in	±0.059mm	±0.0047in	±0.119mm	±0.0070in	±0.178mm
Volumetric Performance	±0.0023in	±0.059mm	±0.0047in	±0.119mm	±0.0070in	±0.178mm

Sterling Series 8

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0020in	±0.051mm	±0.0040in	±0.102mm	±0.0060in	±0.152mm
Linear Displacement	±0.0028in	±0.072mm	±0.0057in	±0.144mm	±0.0085in	±0.215mm
Volumetric Performance	±0.0028in	±0.072mm	±0.0057in	±0.144mm	±0.0085in	±0.215mm

Sterling Series 10 or 12

Accuracy Type	<i>One Sigma (67.3%)</i>		<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±0.0033in	±0.084mm	±0.0066in	±0.168mm	±0.0099in	±0.251mm
Linear Displacement	±0.0047in	±0.119mm	±0.0093in	±0.237mm	±0.0140in	±0.356mm
Volumetric Performance	±0.0047in	±0.119mm	±0.0093in	±0.237mm	±0.0140in	±0.356mm

Silver Series 6 or 8

Accuracy Type	<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±.0030 in	±.076mm	±.0045 in	±.114mm
Linear Displacement	±.0042 in	±.108mm	±.0063 in	±.161mm

Silver Series 12

Accuracy Type	<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±.0070 in	±.178mm	±.0105 in	±.267mm
Linear Displacement	±.0099 in	±.251mm	±.0148in	±.376mm

Bronze Series 6 or 8

Accuracy Type	<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±.012 in	±.305mm	±.018 in	±.457mm
Linear Displacement	±.017 in	±.432mm	±.026 in	±.660mm

Bronze Series 10

Accuracy Type	<i>Two Sigma (95.5%)</i>		<i>Three Sigma (99.7%)</i>	
Single Point	±.016 in	±.406mm	±.024 in	±.610mm
Linear Displacement	±.023 in	±.584mm	±.034 in	±.864mm

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