

# Calibration Certificate

Part Description: FARO Laser Line Probe

Certification Date: 11/7/2018

Serial#: \_\_\_\_\_

LLP001720411

Accuracy Specification: .025mm (.0010 in.)

Certificate#: \_\_\_\_\_

L20411-20181107-314P

## Measurement Standards Traceability

Laser Calibration Fixture

Asset Number: 4650

Calibration Due: 10/11/2019

\*SI Traceability: 43384-4650

\*The artifact above has been calibrated with a device traceable to the International System of Units (SI) through a National Metrological Institute (NMI) or through an ISO17025 Accredited Laboratory.

## Calibration Results\*

Mean deviation of diameter throughout entire field of view.

**PASSED**

2 Sigma standard deviation of diameter throughout entire field of view.

**PASSED**

\*See attached for measurement results.

## Instrument condition as received:

Within specification

## Instrument condition outgoing:

Within specifications

Technician: \_\_\_\_\_

Daniel Wanner

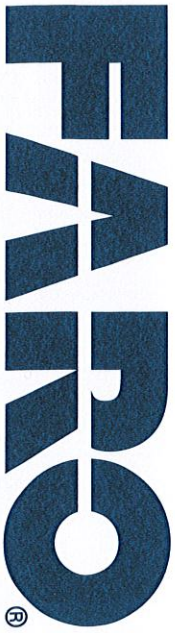
Date \_\_\_\_\_

11/7/18

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The results of this certificate relate only to the items calibrated or tested.  
Calibration was performed following procedure MO-FR-3005

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Certificate of Calibration Report

Laser Line Probe Number: LLP001720411  
 Calibration Date: 2018-11-07  
 Firmware Version: 650.8

		Spec	Result
Nominal Diameter:	25.4638		
Diameter Accuracy:	-0.0010	0.0250	PASS
Diameter Repeatability:	0.0103	0.0250	PASS
Average Z Accuracy:	0.0022	0.0125	PASS
Average Z Repeatability:	0.0039	0.0125	PASS

Pass/Fail: Pass  
 Test Type: Product Calibration  
 Fixture Asset: 4650

All units are in millimeters.

The LLP is pointed at the same cylinder as it is moved throughout the entire field of view of the LLP from left to right and from far to near. The average results of each diameter measurement are listed on the "XZ" and "Circle Error" sheets.

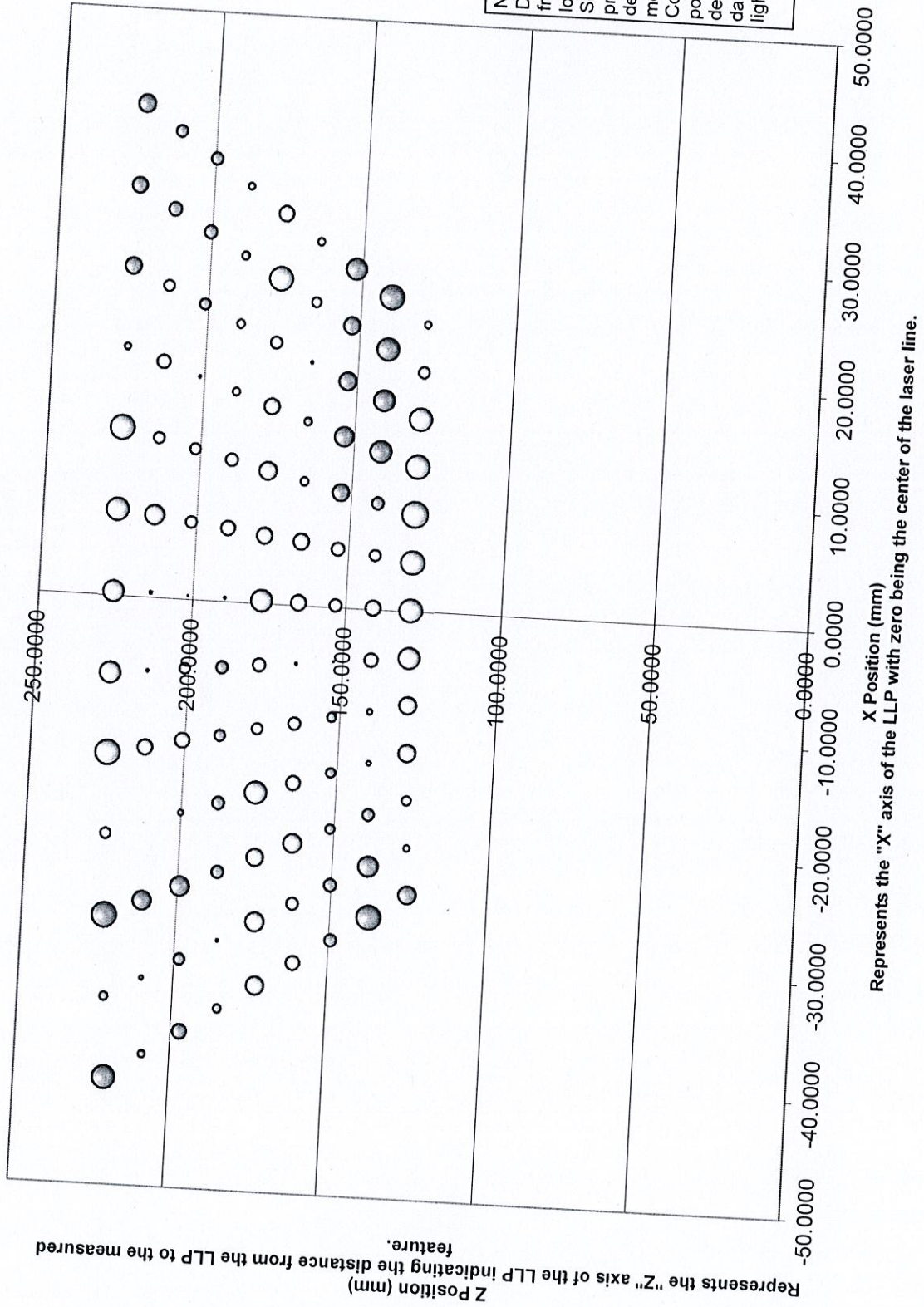
Average Z measurements are taken on a flat plane.  
 The LLP is pointed at a flat plane as it is moved from far to near. The results of each measurement are listed on the "Line Error" sheet.

Measurement accuracy is calculated as mean deviation from nominal measurement.  
**Diameter Accuracy:** Average diameter measured minus the nominal diameter.  
**Average Z accuracy:** average deviation from nominal for each point on a laser line. Nominal is defined by position in the calibration fixture.

Measurement repeatability is calculated as the 2-sigma standard deviation of all measurements.  
**Diameter Repeatability:** 2 Sigma calculation of all measured diameters.  
**Average Z Repeatability:** 2 Sigma calculation of deviation in Z distance. Z distance is calculated by averaging all points in the line.

NOTE: For calibration, LLP is set up on an automated fixture that moves the LLP and captures data through its full field of view.

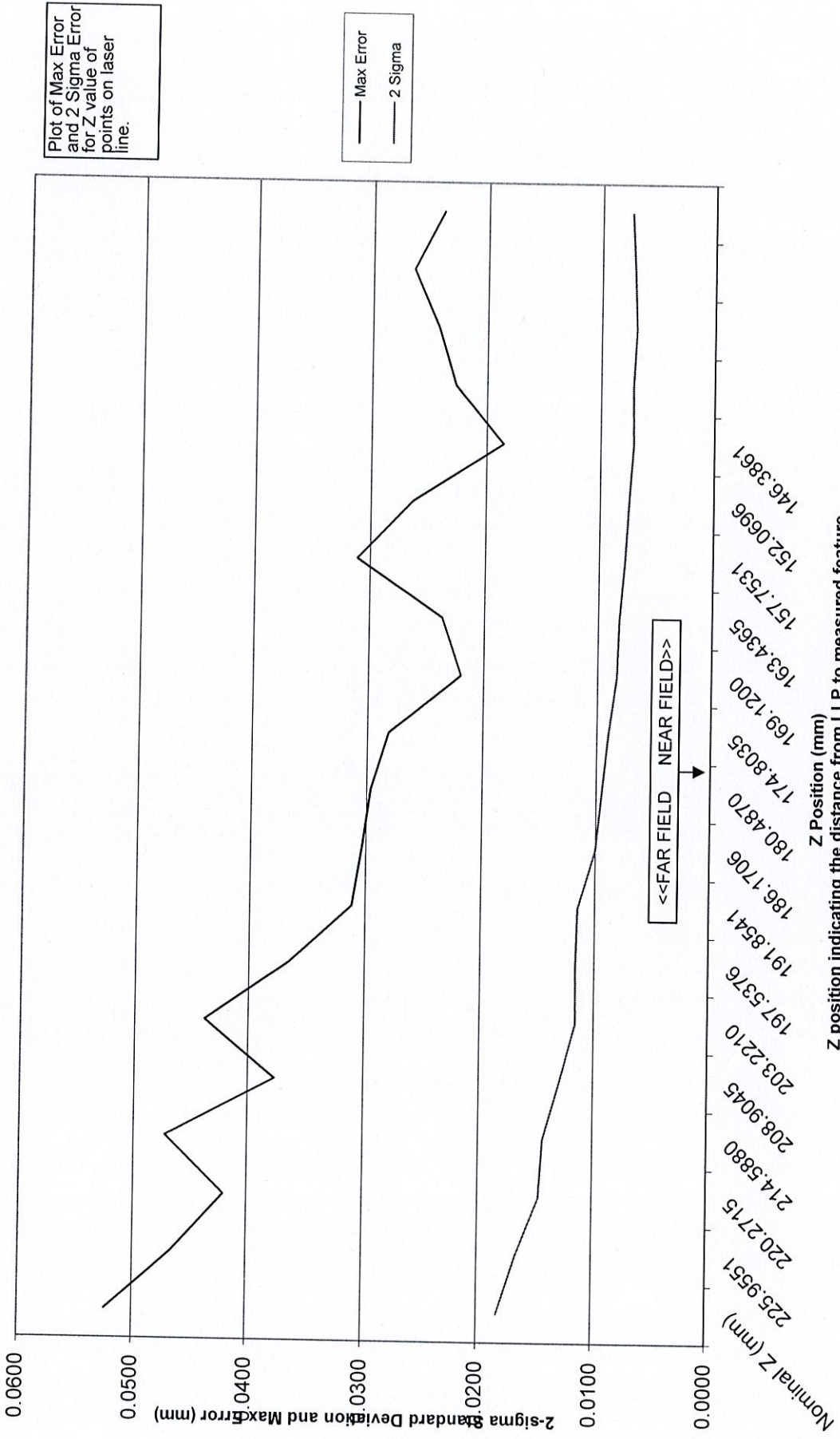
## Diameter Error







# Line Fit







**Raw diameter data for all measured positions**

**Max Error:** Worst point in circle fit

**2 Sigma:** 2 Standard deviation of circle fit

**Diameter:** Measured Diameter

**X:** X coordinate of center of circle

**Z:** Z coordinate of center of circle

**Diameter Error:** Difference between measured diameter and nominal diameter

MaxError (mm)	2Sigma (mm)	Diameter (mm)	X (mm)	Z (mm)	Diameter Error (mm)
0.0201	0.0138	25.4696	41.8469	223.5397	0.0058
0.0201	0.0131	25.4684	34.8935	224.4510	0.0046
0.0203	0.0128	25.4689	28.0289	225.1447	0.0052
0.0198	0.0123	25.4649	21.1892	225.6293	0.0011
0.0206	0.0120	25.4536	14.2884	225.9102	-0.0101
0.0150	0.0111	25.4548	7.2987	225.9971	-0.0090
0.0204	0.0118	25.4558	0.3529	225.8751	-0.0079
0.0206	0.0121	25.4557	-6.5178	225.5521	-0.0080
0.0198	0.0118	25.4531	-13.3418	225.0280	-0.0106
0.0184	0.0112	25.4614	-20.2065	224.3028	-0.0024
0.0177	0.0112	25.4745	-27.1341	223.3666	0.0107
0.0175	0.0125	25.4654	-34.0253	222.2068	0.0016
0.0174	0.0129	25.4731	-40.8566	220.8610	0.0093
0.0208	0.0112	25.4650	-38.7416	208.9858	0.0013
0.0169	0.0109	25.4643	-32.3081	210.2699	0.0005
0.0158	0.0112	25.4703	-25.7625	211.3815	0.0065
0.0151	0.0111	25.4638	-19.2204	212.2837	0.0000
0.0168	0.0107	25.4593	-12.7324	212.9835	-0.0045
0.0147	0.0104	25.4634	-6.2119	213.4978	-0.0003
0.0151	0.0098	25.4641	0.3805	213.8204	0.0004
0.0149	0.0102	25.4568	6.9928	213.9424	-0.0070
0.0149	0.0108	25.4612	13.5443	213.8752	-0.0026
0.0181	0.0108	25.4602	20.0696	213.6144	-0.0036
0.0160	0.0106	25.4611	26.5244	213.1674	-0.0026
0.0199	0.0107	25.4674	33.0394	212.5282	0.0036
0.0211	0.0117	25.4666	39.6651	211.6743	0.0029
0.0153	0.0101	25.4668	37.5155	199.7793	0.0030
0.0180	0.0104	25.4672	31.2591	200.5741	0.0035
0.0148	0.0096	25.4663	25.1150	201.1692	0.0025
0.0137	0.0093	25.4640	18.9689	201.5815	0.0003
0.0207	0.0092	25.4612	12.7895	201.8138	-0.0025
0.0178	0.0099	25.4610	6.5403	201.8656	-0.0028
0.0140	0.0090	25.4639	0.3101	201.7339	0.0001
0.0121	0.0080	25.4614	-5.8534	201.4193	-0.0024
0.0148	0.0086	25.4595	-11.9700	200.9276	-0.0043
0.0131	0.0083	25.4646	-18.1415	200.2519	0.0009
0.0165	0.0097	25.4705	-24.3722	199.3809	0.0068
0.0128	0.0093	25.4664	-30.5509	198.3199	0.0026
0.0140	0.0102	25.4679	-36.6655	197.0854	0.0042
0.0150	0.0086	25.4654	-34.5391	185.1931	0.0016
0.0123	0.0093	25.4634	-28.8062	186.3636	-0.0003



## Diameter and Circle Fit Data



0.0132	0.0083	25.4668	-22.9932	187.3757	0.0031
0.0175	0.0095	25.4670	-17.1621	188.2090	0.0032
0.0121	0.0089	25.4664	-11.3735	188.8610	0.0027
0.0120	0.0083	25.4667	-5.5732	189.3414	0.0030
0.0171	0.0093	25.4635	0.2921	189.6513	-0.0003
0.0147	0.0085	25.4597	6.2021	189.7871	-0.0040
0.0137	0.0094	25.4606	12.0540	189.7501	-0.0032
0.0118	0.0091	25.4623	17.8792	189.5441	-0.0014
0.0137	0.0092	25.4622	23.6370	189.1691	-0.0016
0.0142	0.0087	25.4653	29.4347	188.6233	0.0016
0.0150	0.0094	25.4649	35.3212	187.8903	0.0012
0.0147	0.0091	25.4593	33.1720	175.9967	-0.0045
0.0139	0.0091	25.4539	27.6428	176.6673	-0.0098
0.0148	0.0087	25.4609	22.2151	177.1711	-0.0028
0.0109	0.0083	25.4590	16.7748	177.5103	-0.0048
0.0147	0.0087	25.4578	11.2763	177.6910	-0.0060
0.0222	0.0095	25.4589	5.7469	177.7113	-0.0049
0.0118	0.0087	25.4556	0.2404	177.5639	-0.0082
0.0135	0.0085	25.4604	-5.2036	177.2632	-0.0033
0.0140	0.0086	25.4612	-10.6170	176.8029	-0.0026
0.0117	0.0078	25.4551	-16.0863	176.1699	-0.0087
0.0128	0.0076	25.4583	-21.5880	175.3714	-0.0054
0.0107	0.0072	25.4573	-27.0471	174.4073	-0.0064
0.0098	0.0073	25.4579	-32.4457	173.2889	-0.0059
0.0156	0.0079	25.4599	-30.3376	161.3903	-0.0039
0.0243	0.0075	25.4607	-25.3238	162.4443	-0.0031
0.0162	0.0079	25.4574	-20.2186	163.3593	-0.0063
0.0199	0.0070	25.4598	-15.0959	164.1235	-0.0040
0.0106	0.0078	25.4606	-10.0063	164.7267	-0.0031
0.0239	0.0080	25.4640	-4.9245	165.1794	0.0003
0.0107	0.0079	25.4592	0.2199	165.4798	-0.0046
0.0208	0.0081	25.4590	5.4082	165.6309	-0.0048
0.0140	0.0085	25.4622	10.5466	165.6289	-0.0016
0.0149	0.0091	25.4652	15.6607	165.4763	0.0015
0.0149	0.0087	25.4634	20.7187	165.1732	-0.0003
0.0138	0.0088	25.4616	25.7978	164.7210	-0.0021
0.0144	0.0092	25.4624	30.9521	164.1094	-0.0014
0.0150	0.0091	25.4715	28.8065	152.2170	0.0077
0.0137	0.0089	25.4691	24.0020	152.7694	0.0054
0.0151	0.0094	25.4697	19.2801	153.1733	0.0059
0.0150	0.0088	25.4707	14.5418	153.4400	0.0070
0.0151	0.0075	25.4691	9.7603	153.5659	0.0054
0.0164	0.0081	25.4604	4.9480	153.5454	-0.0034
0.0136	0.0078	25.4607	0.1750	153.3881	-0.0030
0.0141	0.0082	25.4636	-4.5697	153.0944	-0.0001
0.0121	0.0078	25.4657	-9.2799	152.6627	0.0019
0.0114	0.0071	25.4658	-14.0505	152.0822	0.0021
0.0131	0.0077	25.4657	-18.8341	151.3547	0.0020
0.0110	0.0073	25.4669	-23.5826	150.4861	0.0032
0.0129	0.0076	25.4667	-28.2604	149.4855	0.0030
0.0115	0.0070	25.4739	-26.1500	137.5923	0.0102
0.0127	0.0074	25.4710	-21.8390	138.5298	0.0073



Diameter and Circle Fit Data



0.0136	0.0073	25.4666	-17.4504	139.3492	0.0028
0.0202	0.0077	25.4631	-13.0483	140.0347	-0.0006
0.0109	0.0079	25.4646	-8.6562	140.5887	0.0009
0.0155	0.0084	25.4602	-4.2878	141.0062	-0.0035
0.0162	0.0084	25.4593	0.1316	141.3006	-0.0044
0.0117	0.0081	25.4612	4.5875	141.4653	-0.0025
0.0148	0.0079	25.4667	9.0184	141.4994	0.0029
0.0159	0.0082	25.4720	13.4288	141.4035	0.0083
0.0160	0.0081	25.4715	17.8009	141.1754	0.0078
0.0141	0.0081	25.4726	22.1603	140.8223	0.0088
0.0155	0.0082	25.4738	26.5897	140.3307	0.0100
0.0147	0.0080	25.4626	24.4326	128.4241	-0.0012
0.0157	0.0082	25.4611	20.3624	128.8562	-0.0026
0.0162	0.0084	25.4548	16.3488	129.1599	-0.0090
0.0143	0.0082	25.4542	12.3102	129.3500	-0.0095
0.0120	0.0082	25.4523	8.2294	129.4198	-0.0114
0.0138	0.0085	25.4543	4.1359	129.3716	-0.0095
0.0126	0.0080	25.4546	0.0802	129.2018	-0.0092
0.0129	0.0081	25.4558	-3.9472	128.9158	-0.0079
0.0137	0.0077	25.4583	-7.9530	128.5132	-0.0055
0.0120	0.0080	25.4582	-12.0199	127.9822	-0.0056
0.0133	0.0082	25.4619	-16.0810	127.3297	-0.0019
0.0135	0.0081	25.4627	-20.1116	126.5566	-0.0011
0.0119	0.0082	25.4696	-24.0767	125.6772	0.0059




**Raw line data for all measured positions**

**Max Error:** Worst point in line fit

**2 Sigma:** 2 Standard deviation of line fit

**Average Z:** The average Z value of all points.

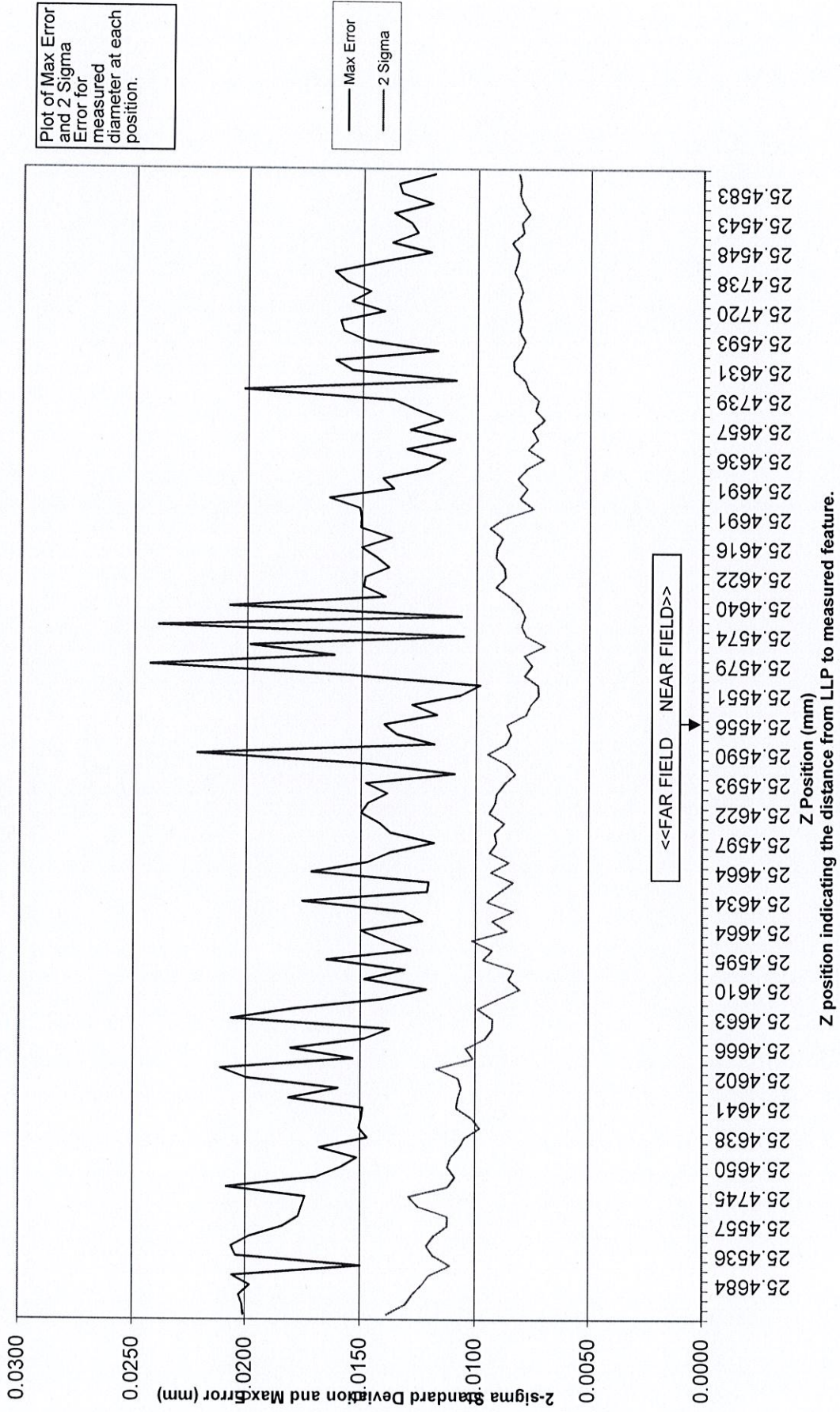
**Nominal Z:** The nominal Z distance.

**Z Error :** Average Z minus Nominal Z

MaxError (mm)	2Sigma (mm)	Average Z (mm)	Nominal Z (mm)	Z Error (mm)
0.0524	0.0182	225.9566	225.9551	0.0015
0.0467	0.0166	220.2764	220.2715	0.0049
0.0420	0.0147	214.5910	214.5880	0.0029
0.0472	0.0143	208.9069	208.9045	0.0024
0.0377	0.0129	203.2251	203.2210	0.0040
0.0438	0.0116	197.5398	197.5376	0.0022
0.0365	0.0116	191.8551	191.8541	0.0011
0.0312	0.0115	186.1725	186.1706	0.0020
0.0304	0.0100	180.4862	180.4870	-0.0008
0.0297	0.0095	174.8057	174.8035	0.0021
0.0281	0.0090	169.1243	169.1200	0.0042
0.0220	0.0083	163.4390	163.4365	0.0025
0.0237	0.0081	157.7524	157.7531	-0.0007
0.0311	0.0077	152.0714	152.0696	0.0018
0.0263	0.0075	146.3853	146.3861	-0.0007
0.0185	0.0071	140.7030	140.7025	0.0004
0.0227	0.0072	135.0255	135.0190	0.0065
0.0242	0.0069	129.3403	129.3355	0.0048
0.0265	0.0071	123.6540	123.6520	0.0020
0.0239	0.0073	117.9685	117.9685	0.0000



## Circle Fit





Certificate of Calibration Report

Laser Line Probe Number: LLP001720411  
 Calibration Date: 2018-07-19  
 Firmware Version: 650.8

		Spec	Result
Nominal Diameter:	25.4638		
Diameter Accuracy:	0.0021	0.0250	PASS
<i>Expanded Uncertainty of Measurement 3.8 μm</i>			
Diameter Repeatability:	0.0037	0.0125	PASS
<i>Expanded Uncertainty of Measurement 3.8 μm</i>			
Average Z Accuracy:			Fail
<i>Expanded Uncertainty of Measurement 2.9 μm</i>			
Average Z Repeatability:			Fail
<i>Expanded Uncertainty of Measurement 2.9 μm</i>			

Pass/Fail: Pass  
 Test Type: Incoming Calibration  
 Fixture Asset: 4650

All units are in millimeters.

The LLP is pointed at the same cylinder as it is moved throughout the entire field of view of the LLP from left to right and from far to near. The average results of each diameter measurement are listed on the "XZ" and "Circle Error" sheets.

Average Z measurements are taken on a flat plane.  
 The LLP is pointed at a flat plane as it is moved from far to near. The results of each measurement are listed on the "Line Error" sheet.

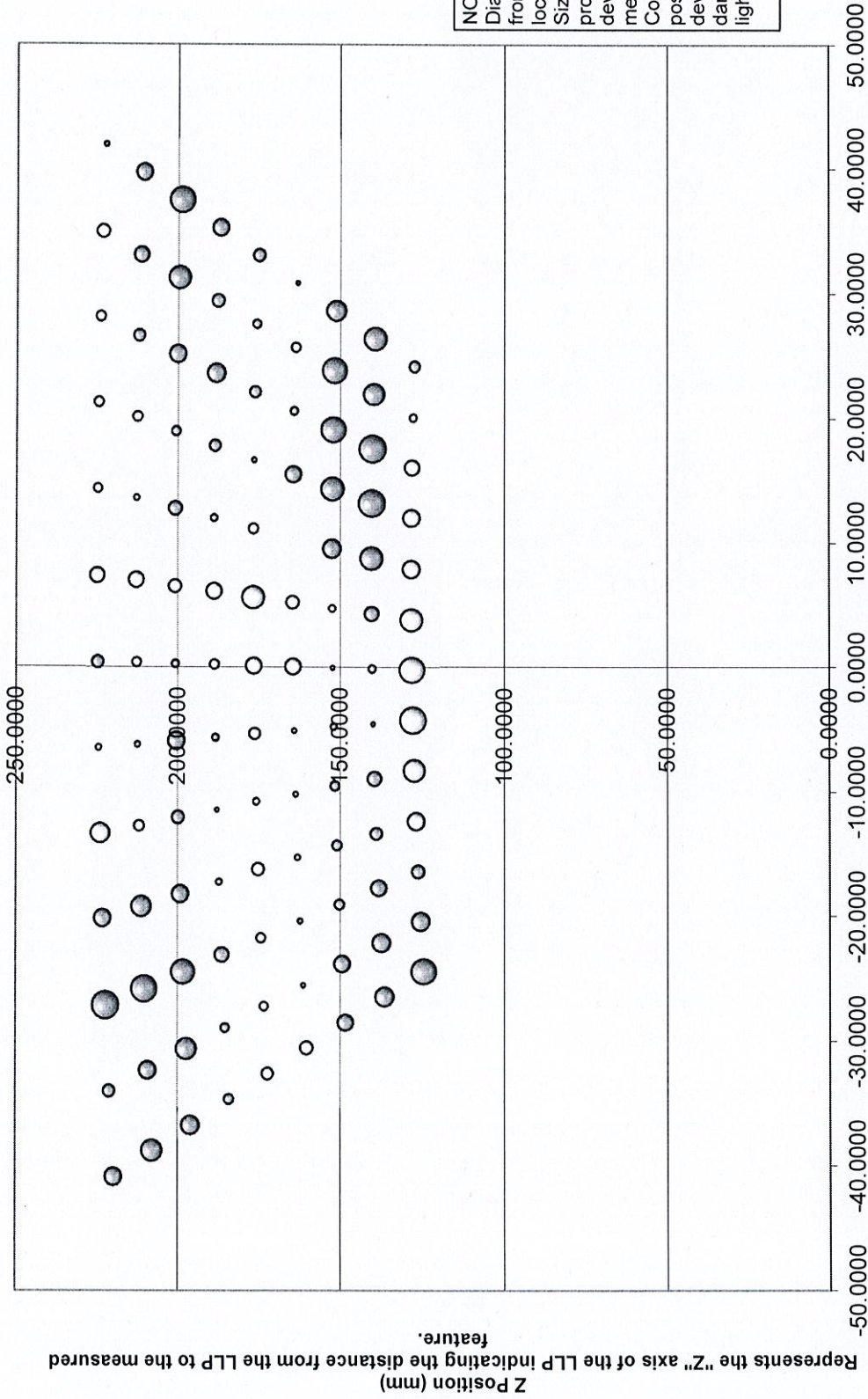
Measurement accuracy is calculated as mean deviation from nominal measurement.  
**Diameter Accuracy:** Average diameter measured minus the nominal diameter.  
**Average Z accuracy:** average deviation from nominal for each point on a laser line. Nominal is defined by position in the calibration fixture.

Measurement repeatability is calculated as the 2-sigma standard deviation of all measurements.  
**Diameter Repeatability:** 2 Sigma calculation of all measured diameters.  
**Average Z Repeatability:** 2 Sigma calculation of deviation in Z distance. Z distance is calculated by averaging all points in the line.

NOTE: For calibration, LLP is set up on an automated fixture that moves the LLP and captures data through its full field of view.



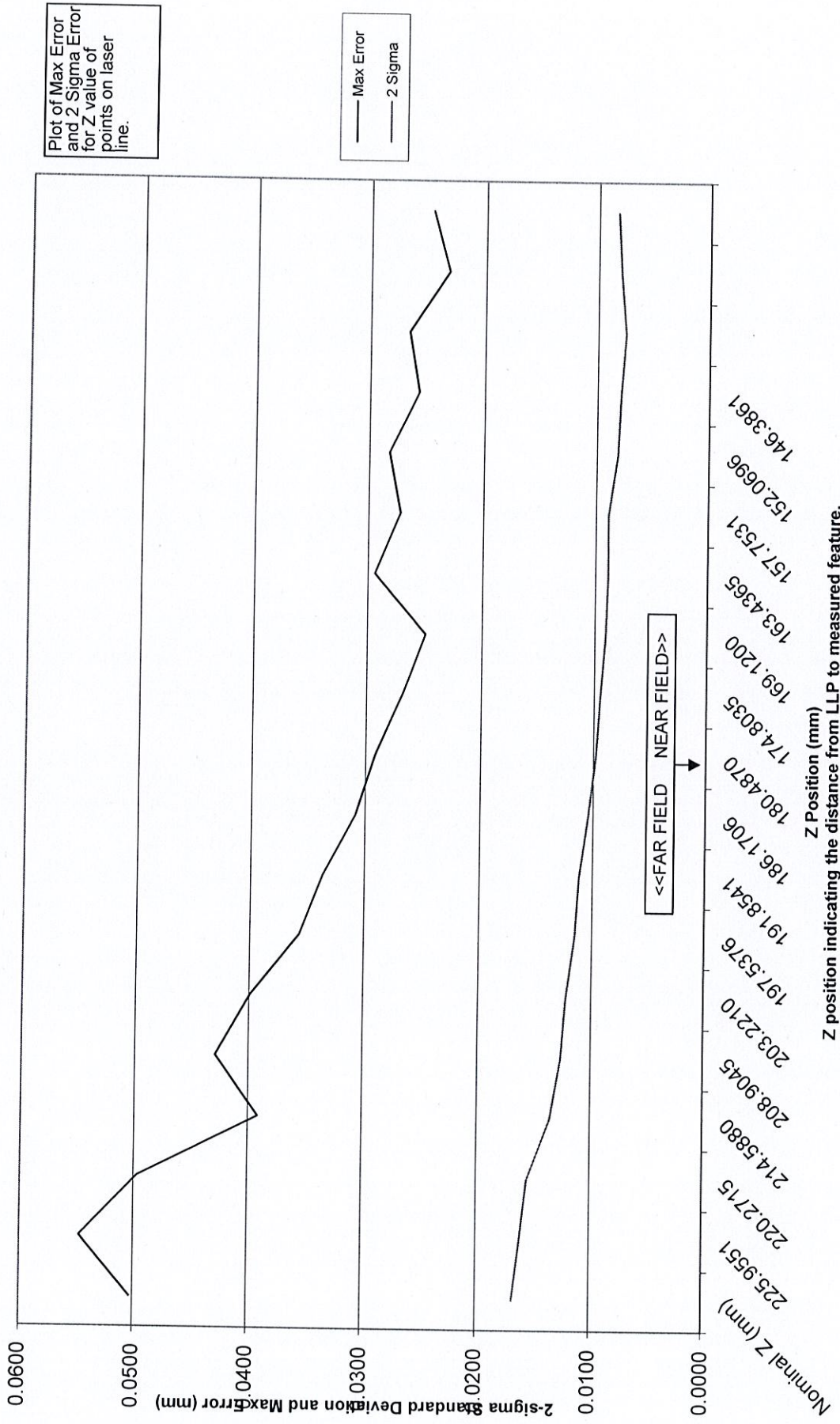
## Diameter Error







# Line Fit







Raw diameter data for all measured positions

- Max Error:** Worst point in circle fit
- 2 Sigma:** 2 Standard deviation of circle fit
- Diameter:** Measured Diameter
- X:** X coordinate of center of circle
- Z:** Z coordinate of center of circle

**Diameter Error:** Difference between measured diameter and nominal diameter

**CTE (ppm/C)** 10.2  
**Reference Temperature (T<sub>REF</sub>)(°C)** 21.6  
**Calibrated Diameter (D<sub>CAL</sub>)(mm)** 25.4638

$$* D_{REF} = D_{CAL} \times (1 + ((CTE / 1,000,000) \times (T_{MEAS} - T_{REF})))$$

MaxError (mm)	2Sigma (mm)	Measurement Temperature (T <sub>MEAS</sub> ) (°C)	Adjusted Diameter (D <sub>REF</sub> )* (mm)	Measured Diameter (D <sub>M</sub> )(mm)	X (mm)	Z (mm)	Diameter Error (mm)
0.0208	0.0141	21.6300	25.4638	25.4647	41.9237	222.5855	0.0009
0.0193	0.0130	21.6300	25.4638	25.4595	34.9690	223.4966	-0.0042
0.0228	0.0127	21.6400	25.4638	25.4612	28.1076	224.1914	-0.0026
0.0191	0.0124	21.6400	25.4638	25.4612	21.2639	224.6802	-0.0026
0.0180	0.0119	21.6400	25.4638	25.4616	14.3425	224.9727	-0.0022
0.0162	0.0119	21.6400	25.4638	25.4584	7.3708	225.0562	-0.0054
0.0191	0.0116	21.6400	25.4638	25.4675	0.3887	224.9383	0.0038
0.0180	0.0125	21.6400	25.4638	25.4626	-6.4738	224.6119	-0.0012
0.0191	0.0133	21.6400	25.4638	25.4554	-13.3082	224.0846	-0.0084
0.0232	0.0134	21.6400	25.4638	25.4706	-20.1692	223.3655	0.0069
0.0226	0.0135	21.6400	25.4638	25.4793	-27.1154	222.4232	0.0155
0.0189	0.0135	21.6400	25.4638	25.4675	-33.9923	221.2658	0.0037
0.0223	0.0126	21.6400	25.4638	25.4706	-40.8477	219.9088	0.0068
0.0217	0.0125	21.6400	25.4638	25.4734	-38.7683	208.0295	0.0097
0.0218	0.0115	21.6500	25.4638	25.4708	-32.3345	209.3175	0.0071
0.0159	0.0111	21.6500	25.4638	25.4782	-25.8032	210.4290	0.0145
0.0174	0.0117	21.6500	25.4638	25.4729	-19.2290	211.3384	0.0092
0.0169	0.0121	21.6500	25.4638	25.4609	-12.7298	212.0359	-0.0029
0.0164	0.0109	21.6500	25.4638	25.4649	-6.2130	212.5510	0.0011
0.0185	0.0128	21.6500	25.4638	25.4614	0.3795	212.8719	-0.0024
0.0190	0.0118	21.6500	25.4638	25.4580	7.0140	212.9976	-0.0058
0.0182	0.0114	21.6500	25.4638	25.4626	13.5851	212.9311	-0.0012
0.0166	0.0108	21.6500	25.4638	25.4611	20.1183	212.6688	-0.0026
0.0167	0.0105	21.6500	25.4638	25.4674	26.5814	212.2252	0.0036
0.0171	0.0109	21.6500	25.4638	25.4695	33.0903	211.5839	0.0057
0.0168	0.0109	21.6500	25.4638	25.4702	39.7149	210.7289	0.0064
0.0169	0.0096	21.6500	25.4638	25.4776	37.5086	198.8425	0.0138
0.0141	0.0101	21.6500	25.4638	25.4747	31.2593	199.6319	0.0110
0.0172	0.0100	21.6600	25.4638	25.4707	25.1064	200.2219	0.0069
0.0199	0.0107	21.6600	25.4638	25.4661	18.9678	200.6308	0.0024
0.0171	0.0105	21.6600	25.4638	25.4685	12.7509	200.8658	0.0047
0.0193	0.0106	21.6600	25.4638	25.4596	6.5033	200.9105	-0.0042
0.0188	0.0108	21.6600	25.4638	25.4656	0.2516	200.7790	0.0018



Diameter and Circle Fit Data



0.0186	0.0101	21.6600	25.4638	25.4706	-5.9124	200.4656	0.0069
0.0190	0.0097	21.6600	25.4638	25.4678	-12.0330	199.9696	0.0040
0.0144	0.0097	21.6600	25.4638	25.4707	-18.2099	199.2892	0.0069
0.0122	0.0094	21.6600	25.4638	25.4760	-24.4466	198.4121	0.0122
0.0145	0.0090	21.6600	25.4638	25.4734	-30.6072	197.3524	0.0097
0.0127	0.0093	21.6600	25.4638	25.4714	-36.7338	196.1096	0.0076
0.0152	0.0088	21.6600	25.4638	25.4663	-34.6380	184.2023	0.0026
0.0143	0.0082	21.6600	25.4638	25.4660	-28.9136	185.3772	0.0022
0.0170	0.0083	21.6600	25.4638	25.4688	-23.0801	186.3959	0.0050
0.0129	0.0087	21.6600	25.4638	25.4651	-17.2444	187.2326	0.0013
0.0130	0.0084	21.6600	25.4638	25.4631	-11.4450	187.8884	-0.0007
0.0175	0.0092	21.6600	25.4638	25.4654	-5.6535	188.3729	0.0016
0.0166	0.0100	21.6700	25.4638	25.4613	0.2061	188.6863	-0.0025
0.0156	0.0098	21.6700	25.4638	25.4578	6.1080	188.8256	-0.0059
0.0156	0.0096	21.6700	25.4638	25.4653	11.9829	188.7977	0.0015
0.0167	0.0100	21.6700	25.4638	25.4671	17.8033	188.5941	0.0034
0.0158	0.0100	21.6700	25.4638	25.4715	23.5811	188.2255	0.0077
0.0186	0.0102	21.6700	25.4638	25.4678	29.3828	187.6782	0.0040
0.0168	0.0092	21.6700	25.4638	25.4702	35.2755	186.9501	0.0064
0.0149	0.0092	21.6700	25.4638	25.4676	33.0523	175.0625	0.0039
0.0125	0.0086	21.6700	25.4638	25.4659	27.5229	175.7305	0.0021
0.0141	0.0094	21.6700	25.4638	25.4671	22.0912	176.2259	0.0033
0.0145	0.0090	21.6700	25.4638	25.4646	16.6472	176.5592	0.0008
0.0176	0.0094	21.6700	25.4638	25.4611	11.1378	176.7340	-0.0027
0.0151	0.0089	21.6700	25.4638	25.4528	5.6092	176.7420	-0.0109
0.0157	0.0082	21.6700	25.4638	25.4577	0.0922	176.5938	-0.0060
0.0131	0.0097	21.6700	25.4638	25.4605	-5.3450	176.2867	-0.0033
0.0159	0.0091	21.6700	25.4638	25.4624	-10.7604	175.8217	-0.0014
0.0109	0.0085	21.6700	25.4638	25.4599	-16.2324	175.1856	-0.0038
0.0109	0.0077	21.6700	25.4638	25.4613	-21.7473	174.3761	-0.0024
0.0131	0.0086	21.6700	25.4638	25.4617	-27.1933	173.4106	-0.0021
0.0118	0.0076	21.6700	25.4638	25.4602	-32.6008	172.2825	-0.0035
0.0115	0.0076	21.6700	25.4638	25.4595	-30.5251	160.3696	-0.0042
0.0118	0.0077	21.6700	25.4638	25.4630	-25.5107	161.4342	-0.0008
0.0135	0.0080	21.6700	25.4638	25.4647	-20.4030	162.3601	0.0009
0.0121	0.0082	21.6700	25.4638	25.4627	-15.2808	163.1280	-0.0011
0.0126	0.0085	21.6700	25.4638	25.4628	-10.1868	163.7376	-0.0009
0.0130	0.0088	21.6700	25.4638	25.4629	-5.1087	164.1929	-0.0009
0.0140	0.0085	21.6700	25.4638	25.4578	0.0343	164.5001	-0.0060
0.0131	0.0085	21.6800	25.4638	25.4596	5.2062	164.6591	-0.0042
0.0134	0.0085	21.6800	25.4638	25.4637	10.3798	164.6655	-0.0001
0.0139	0.0091	21.6800	25.4638	25.4699	15.4989	164.5206	0.0062
0.0145	0.0095	21.6800	25.4638	25.4656	20.5774	164.2213	0.0019
0.0138	0.0093	21.6800	25.4638	25.4614	25.6478	163.7746	-0.0023
0.0142	0.0097	21.6800	25.4638	25.4631	30.8074	163.1689	-0.0007
0.0219	0.0105	21.6800	25.4638	25.4726	28.5942	151.2819	0.0089
0.0173	0.0096	21.6800	25.4638	25.4768	23.7988	151.8294	0.0130
0.0172	0.0098	21.6800	25.4638	25.4768	19.0818	152.2247	0.0130
0.0194	0.0097	21.6800	25.4638	25.4753	14.3259	152.4808	0.0116
0.0163	0.0091	21.6800	25.4638	25.4715	9.5236	152.5980	0.0077
0.0164	0.0092	21.6800	25.4638	25.4623	4.7108	152.5687	-0.0015
0.0137	0.0089	21.6800	25.4638	25.4630	-0.0699	152.4038	-0.0007



## Diameter and Circle Fit Data



0.0138	0.0090	21.6800	25.4638	25.4651	-4.8033	152.1015	0.0013
0.0117	0.0082	21.6800	25.4638	25.4662	-9.5131	151.6619	0.0024
0.0144	0.0080	21.6800	25.4638	25.4664	-14.2866	151.0728	0.0026
0.0125	0.0076	21.6800	25.4638	25.4664	-19.0677	150.3361	0.0027
0.0128	0.0077	21.6800	25.4638	25.4700	-23.8082	149.4631	0.0063
0.0117	0.0085	21.6800	25.4638	25.4698	-28.4918	148.4521	0.0060
0.0102	0.0070	21.6800	25.4638	25.4718	-26.4399	136.5360	0.0080
0.0116	0.0070	21.6800	25.4638	25.4712	-22.1373	137.4839	0.0075
0.0136	0.0077	21.6800	25.4638	25.4697	-17.7453	138.3151	0.0059
0.0139	0.0079	21.6800	25.4638	25.4674	-13.3485	139.0123	0.0037
0.0130	0.0084	21.6800	25.4638	25.4686	-8.9398	139.5784	0.0048
0.0120	0.0085	21.6800	25.4638	25.4645	-4.5773	140.0054	0.0007
0.0121	0.0084	21.6800	25.4638	25.4654	-0.1621	140.3109	0.0017
0.0137	0.0088	21.6800	25.4638	25.4688	4.2975	140.4869	0.0050
0.0193	0.0086	21.6800	25.4638	25.4747	8.7510	140.5319	0.0109
0.0188	0.0089	21.6800	25.4638	25.4788	13.1703	140.4437	0.0150
0.0195	0.0093	21.6800	25.4638	25.4791	17.5555	140.2248	0.0153
0.0160	0.0089	21.6800	25.4638	25.4733	21.9110	139.8765	0.0095
0.0218	0.0091	21.6800	25.4638	25.4749	26.3339	139.3952	0.0111
0.0140	0.0081	21.6800	25.4638	25.4669	24.1166	127.4934	0.0031
0.0110	0.0082	21.6800	25.4638	25.4621	20.0521	127.9116	-0.0017
0.0121	0.0088	21.6800	25.4638	25.4584	16.0403	128.2065	-0.0053
0.0147	0.0085	21.6800	25.4638	25.4572	11.9837	128.3858	-0.0066
0.0137	0.0088	21.6800	25.4638	25.4567	7.8888	128.4462	-0.0070
0.0133	0.0084	21.6800	25.4638	25.4532	3.7956	128.3826	-0.0106
0.0137	0.0077	21.6800	25.4638	25.4503	-0.2462	128.2005	-0.0134
0.0112	0.0076	21.6800	25.4638	25.4494	-4.2724	127.9017	-0.0143
0.0130	0.0079	21.6800	25.4638	25.4536	-8.2853	127.4881	-0.0102
0.0124	0.0078	21.6800	25.4638	25.4569	-12.3488	126.9467	-0.0068
0.0128	0.0077	21.6800	25.4638	25.4680	-16.4139	126.2860	0.0042
0.0129	0.0081	21.6800	25.4638	25.4712	-20.4363	125.5054	0.0075
0.0142	0.0083	21.6800	25.4638	25.4769	-24.4101	124.6113	0.0131





## Raw line data for all measured positions

**Max Error:** Worst point in line fit

**2 Sigma:** 2 Standard deviation of line fit

**Average Z:** The average Z value of all points.

**Nominal Z:** The nominal Z distance.

**Z Error :** Average Z minus Nominal Z

**CTE (ppm/C) 17.2**  
**Reference Temperature (T<sub>REF</sub>)(°C) 20.0**

$$* D_{REF} = D_{CAL} \times (1 + ((CTE / 1,000,000) \times (T_{MEAS} - T_{REF})))$$

MaxError (mm)	2Sigma (mm)	Measurement Temperature (T <sub>MEAS</sub> ) (°C)	Nominal Z (D <sub>CAL</sub> ) (mm)	Adjusted Z (D <sub>REF</sub> )* (mm)	Average Z (mm)	Z Error (mm)
0.0649	0.0192	21.5900	225.9354	225.0440	225.0476	0.0036
0.0503	0.0168	21.5900	220.2497	219.3582	219.3621	0.0039
0.0548	0.0161	21.5900	214.5619	213.6702	213.6760	0.0058
0.0497	0.0155	21.5900	208.8778	207.9860	207.9889	0.0030
0.0391	0.0136	21.5900	203.1926	202.3006	202.3029	0.0022
0.0429	0.0126	21.5900	197.5052	196.6131	196.6178	0.0047
0.0399	0.0123	21.5900	191.8199	190.9276	190.9296	0.0020
0.0357	0.0115	21.5900	186.1326	185.2402	185.2457	0.0055
0.0336	0.0112	21.5900	180.4445	179.5519	179.5582	0.0063
0.0308	0.0104	21.5900	174.7611	173.8684	173.8745	0.0061
0.0291	0.0098	21.5900	169.0787	168.1858	168.1924	0.0066
0.0269	0.0095	21.5900	163.3937	162.5006	162.5061	0.0055
0.0249	0.0090	21.5900	157.7075	156.8143	156.8174	0.0032
0.0294	0.0089	21.5800	152.0240	151.1307	151.1331	0.0024
0.0272	0.0089	21.5800	146.3368	145.4432	145.4442	0.0009
0.0282	0.0081	21.5800	140.6532	139.7595	139.7598	0.0003
0.0257	0.0079	21.5800	134.9707	134.0769	134.0817	0.0049
0.0266	0.0075	21.5800	129.2839	128.3899	128.3951	0.0053
0.0232	0.0080	21.5800	123.5991	122.7049	122.7063	0.0014
0.0246	0.0082	21.5800	117.9149	117.0206	117.0206	0.0000

## Circle Fit

