



Equipment



Calibration



Repair



Inspection



Custom Solutions

# MSI VIKING

Total Metrology Solutions

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## Total Metrology Solutions

MSI Viking is your single-source comprehensive provider of precision metrology systems, services, and custom engineered solutions. We represent more than 100 of the world's leaders in precision measuring instruments, gaging, and process automation. This means providing the solutions you need rather than a limited handful of options.

In addition to precision measurement product sales and support, we are a leading provider of A2LA ISO 17025 accredited lab and on-site calibration and inspection services, and repair services. Our team of experts can also deliver custom engineered solutions leveraging advanced automation and control systems, machine vision, and robotic technologies.

MSI Viking is committed to understanding your needs and providing innovative, practical, on-budget solutions. Turn to MSI Viking for the most complete range of options, answers and expertise.

**Because we truly are Your Total Metrology Solution.**

## How Big is a Micron? ( $\mu\text{m}$ )

1  $\mu\text{m}$  = 1 Millionth of 1 Meter

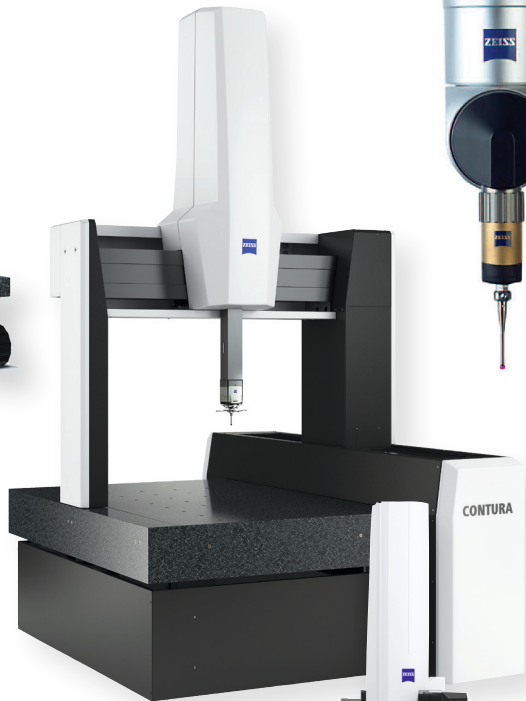
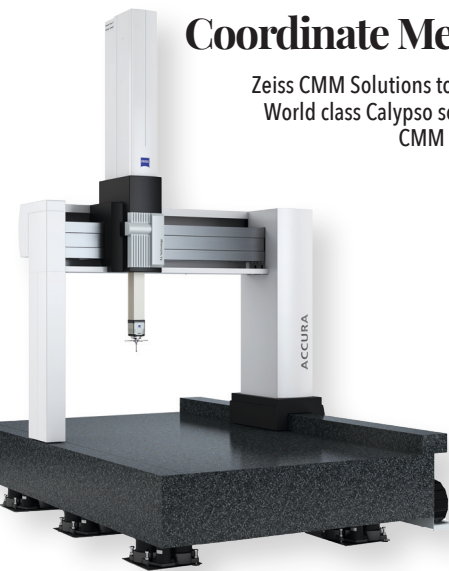
1  $\mu\text{m}$  = 40 Millionths of 1 Inch



Chart artwork compliments of Zeiss

### Coordinate Measurement Machines

Zeiss CMM Solutions to match every need and every budget.  
World class Calypso software is compatible across all Zeiss  
CMM and Optical systems.





## Standard Reference Chart

### Standard English Terminology in Terms of an Inch

1.0 = One Inch

0.5 = One half of an Inch

0.100 = One Hundredth of an inch

0.001 = One thousandth of an inch

0.0001 = One ten thousandth of an inch or "a tenth"

0.00001 = Ten Millionths of an Inch

0.000001 = One Millionth of an Inch

### Metric Terminology in Terms of a Millimeter

1.0 = One Millimeter

0.1 = 100 Microns

0.01 = 10 Microns

0.001 = 1 Micron

### Common Conversion Factors

1" = 25.4mm

1mm = .03937"

### Precision Hand Tools



# Dimensional Measuring Instruments



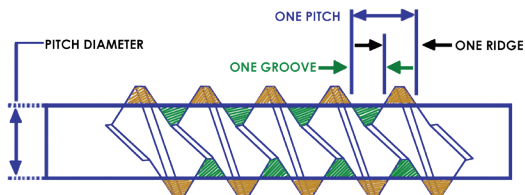
### Cylindrical and Tapered Plug, Ring and Thread Gages





COMMON SERIES THREADS - UN					
Threads Per Inch & Series					
Nominal Size inch		Basic Major Diameter	Coarse	Fine	Extra Fine
Primary	Secondary		UNC	UNF	UNEF
#0	---	0.0600	---	80	---
---	#1	0.0730	64	72	---
#2	---	0.0860	56	64	---
---	#3	0.0990	48	56	---
#4	---	0.1120	40	48	---
#5	---	0.1250	40	44	---
#6	---	0.1380	32	40	---
#8	---	0.1640	32	36	---
#10	---	0.1900	24	32	---
---	#12	0.2160	24	28	32
1/4	---	0.2500	20	28	32
5/16	---	0.3125	18	24	32
3/8	---	0.3750	16	24	32
7/16	---	0.4375	14	20	28
1/2	---	0.5000	13	20	28
9/16	---	0.5625	12	18	24
3/8	---	0.6250	11	18	24
---	11/16	0.6875	---	---	24
3/4	---	0.7500	10	16	20
---	13/16	0.8125	---	---	20
7/8	---	0.8750	9	14	20
---	15/16	0.9375	---	---	20
1	---	1.0000	8	12	18
---	11/16	1.0625	---	---	18
1 1/8	---	1.1250	7	12	18
---	13/16	1.1875	---	---	18
1 1/4	---	1.2500	7	12	18
---	15/16	1.3125	---	---	18
1 3/8	---	1.3750	6	12	18
---	17/16	1.4375	---	---	18
1 1/2	---	1.5000	6	12	18
---	19/16	1.5625	---	---	18
1 5/8	---	1.6250	---	---	18
---	111/16	1.6875	---	---	18
1 3/4	---	1.7500	5	---	---
---	113/16	1.8125	---	---	---
1 7/8	---	1.8750	---	---	---
---	115/16	1.9375	---	---	---
2	---	2.0000	4 1/2	---	---

**PITCH DIAMETER:**  
 The Diameter of an imaginary  
 Cylinder passing through  
 Thread Profile at such points that:  
 Width of the Ridge = Width of the Groove



### Measuring Thread Gages



## Geometric Tolerancing Reference Chart [ANSI/AMSE Y14.5M]\*

Type of Tolerance	Geometric Characteristic	Symbol	Can be applied to		Can affect worst case boundary	Datum reference used	Can use $\textcircled{1}$ or $\textcircled{2}$ modifier	Can use $\textcircled{1}$ modifier	Can be affected by a bonus tolerance	Can be affected by a shift tolerance	Can use $\textcircled{2}$ modifier
			Feature (surface)	Feature of size							
Form	Straightness		Yes	Yes	Yes*	No	Yes*	No	Yes♦	No	No
	Flatness		Yes	No	No	No	No	No	No	No	No
	Circularity		Yes	No	No	No	No	No	No	No	No
	Cylindricity		Yes	No	No	No	No	No	No	No	No
Orientation	Perpendicularity		Yes	Yes	Yes*	Yes	Yes*	Yes*	Yes♦	Yes†	Yes
	Angularity		Yes	Yes	Yes*	Yes	Yes*	Yes*	Yes♦	Yes†	Yes
	Parallelism		Yes	Yes	Yes*	Yes	Yes*	Yes*	Yes♦	Yes†	No
Location	Positional Tolerance		No	Yes	Yes	Yes	Yes	No	Yes♦	Yes†	No
	Concentricity		No	Yes	Yes	Yes	No	No	No	No	No
	Symmetry		No	Yes	Yes	Yes	No	No	No	No	No
Runout	Circular Runout		Yes	Yes	Yes	Yes	No	No	No	No	No
	Total Runout		Yes	Yes	Yes	Yes	No	No	No	No	No
Profile	Profile of a Line		Yes	No	No	Yes**	Yes‡	No	No	Yes†	No
	Profile of a Surface		Yes	No	No	Yes**	Yes‡	Yes*	No	Yes†	No

\* When applied to a feature-of-size

\*\* Can also be used as a form control without a datum reference

† When a datum feature-of-size is referenced with the MMC modifier

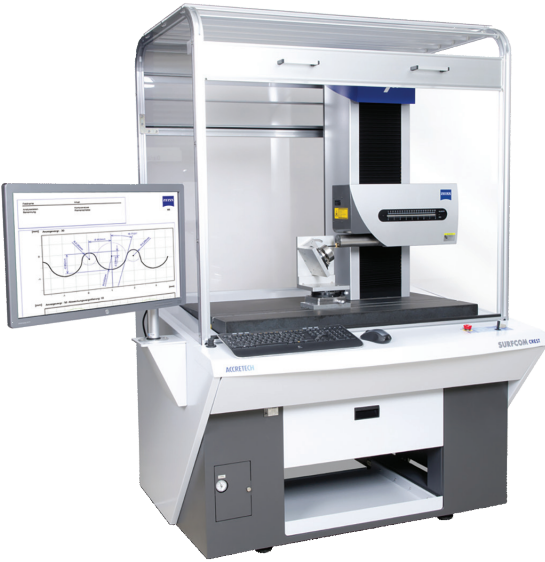
♦ When an MMC modifier is used

• When applied to a surface

‡ For a datum ref only

[\*] Reference Only

### Surface-Form-Geometry



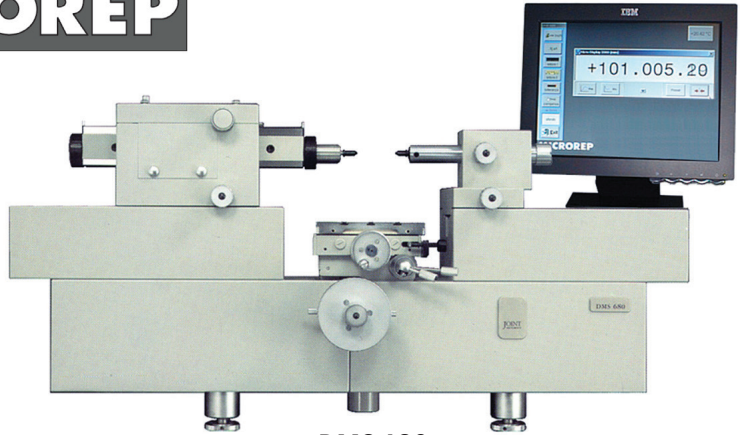


## METRIC to INCH CONVERSION TABLE

Metric	Inch	Metric	Inch	Metric	Inch	Metric	Inch
0.01	0.00039	0.51	0.02008	1	0.03937	51	2.00787
0.02	0.00079	0.52	0.02047	2	0.07874	52	2.04724
0.03	0.00118	0.53	0.02087	3	0.11811	53	2.08661
0.04	0.00157	0.54	0.02126	4	0.15748	54	2.12598
0.05	0.00197	0.55	0.02165	5	0.19685	55	2.16535
0.06	0.00236	0.56	0.02205	6	0.23622	56	2.20472
0.07	0.00276	0.57	0.02244	7	0.27559	57	2.24409
0.08	0.00315	0.58	0.02283	8	0.31496	58	2.28346
0.09	0.00354	0.59	0.02323	9	0.35433	59	2.32283
0.10	0.00394	0.6	0.02362	10	0.3937	60	2.3622
0.11	0.00433	0.61	0.02402	11	0.43307	61	2.40157
0.12	0.00472	0.62	0.02441	12	0.47244	62	2.44094
0.13	0.00512	0.63	0.0248	13	0.51181	63	2.48031
0.14	0.00551	0.64	0.0252	14	0.55118	64	2.51968
0.15	0.00591	0.65	0.02559	15	0.59055	65	2.55905
0.16	0.0063	0.66	0.02598	16	0.62992	66	2.59842
0.17	0.00669	0.67	0.02638	17	0.66929	67	2.63779
0.18	0.00709	0.68	0.02677	18	0.70866	68	2.67716
0.19	0.00748	0.69	0.02717	19	0.74803	69	2.71653
0.20	0.00787	0.7	0.02756	20	0.7874	70	2.7559
0.21	0.00827	0.71	0.02795	21	0.82677	71	2.79527
0.22	0.00866	0.72	0.02835	22	0.86614	72	2.83464
0.23	0.00906	0.73	0.02874	23	0.90551	73	2.87401
0.24	0.00945	0.74	0.02913	24	0.94488	74	2.91338
0.25	0.00984	0.75	0.02953	25	0.98425	75	2.95275
0.26	0.01024	0.76	0.02992	26	1.02362	76	2.99212
0.27	0.01063	0.77	0.03032	27	1.06299	77	3.03149
0.28	0.01102	0.78	0.03071	28	1.10236	78	3.07086
0.29	0.01142	0.79	0.0311	29	1.14173	79	3.11023
0.30	0.01181	0.8	0.0315	30	1.1811	80	3.1496
0.31	0.0122	0.81	0.03189	31	1.22047	81	3.18897
0.32	0.0126	0.82	0.03228	32	1.25984	82	3.22834
0.33	0.01299	0.83	0.03268	33	1.29921	83	3.26771
0.34	0.01339	0.84	0.03307	34	1.33858	84	3.30708
0.35	0.01378	0.85	0.03346	35	1.37795	85	3.34645
0.36	0.01417	0.86	0.03386	36	1.41732	86	3.38582
0.37	0.01457	0.87	0.03425	37	1.45669	87	3.42519
0.38	0.01496	0.88	0.03465	38	1.49606	88	3.46456
0.39	0.01535	0.89	0.03504	39	1.53543	89	3.50393
0.40	0.01575	0.90	0.03543	40	1.5748	90	3.5433
0.41	0.01614	0.91	0.03583	41	1.61417	91	3.58267
0.42	0.01654	0.92	0.03622	42	1.65354	92	3.62204
0.43	0.01693	0.93	0.03661	43	1.69291	93	3.66141
0.44	0.01732	0.94	0.03701	44	1.73228	94	3.70078
0.45	0.01772	0.95	0.0374	45	1.77165	95	3.74015
0.46	0.01811	0.96	0.0378	46	1.81102	96	3.77952
0.47	0.0185	0.97	0.03819	47	1.85039	97	3.81889
0.48	0.0189	0.98	0.03858	48	1.88976	98	3.85826
0.49	0.01929	0.99	0.03898	49	1.92913	99	3.89763
0.5	0.01969	1.00	0.03937	50	1.9685	100	3.937

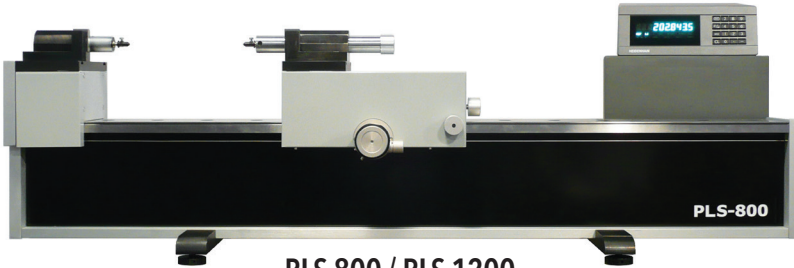
### Universal Length Measuring Machines

# MICROREP



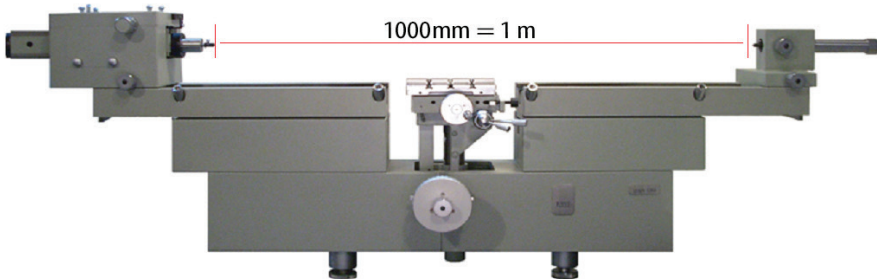
**DMS 680**

High accuracy. Fully equipped. Powerful software. Simple to use.



**PLS 800 / PLS 1200**

Absolute travel of 800mm | 1200mm



**DMS 1000**

Long gage block & large micrometer inspection

## Gagemaker's Tolerance Chart [ANSI/AMSE B89.1.5]\* INCH

Diameter Range Above-Including	XXX	XX	X	Y	Z	ZZ
<b>.010"- .825"</b>	.000010"	.000020"	.000040"	.000070"	.0001"	.0002"
<b>.825"- 1.510"</b>	.000015"	.000030"	.000060"	.000090"	.00012"	.00024"
<b>1.510"- 2.510"</b>	.000020"	.000040"	.000080"	.00012"	.00016"	.00032"
<b>2.510"- 4.510"</b>	.000025"	.000050"	.0001"	.00015"	.0002"	.0004"
<b>4.510"- 6.510"</b>	.000033"	.000065"	.00013"	.00019"	.00025"	.0005"
<b>6.510"- 9.010"</b>	.000040"	.000080"	.00016"	.00024"	.00032"	.00064"
<b>9.010"- 12.010"</b>	.000050"	.0001"	.0002"	.0003"	.0004"	.0008"

## Gagemaker's Tolerance Chart [ANSI/AMSE B89.1.5]\* METRIC

Diameter Range Above-Including	XXX	XX	X	Y	Z	ZZ
<b>.254mm-20.96mm</b>	.00025mm	.00051mm	.00102mm	.00178mm	.00254mm	.00508mm
<b>20.96mm-38.35mm</b>	.00038mm	.00076mm	.00152mm	.00229mm	.00305mm	.00610mm
<b>38.35mm-63.75mm</b>	.00051mm	.00102mm	.00203mm	.00305mm	.00406mm	.00813mm
<b>63.75mm-114.55mm</b>	.00064mm	.00127mm	.00254mm	.00381mm	.00508mm	.01016mm
<b>114.55mm-165.35mm</b>	.00084mm	.00165mm	.00330mm	.00483mm	.00635mm	.01270mm
<b>165.35mm-228.85mm</b>	.00102mm	.00203mm	.00406mm	.00610mm	.00813mm	.01626mm
<b>228.85mm-305.05mm</b>	.00127mm	.00254mm	.00508mm	.00762mm	.01016mm	.02032mm

\*Reference Only

### Optical Measuring Systems





## Gage Reproducibility & Repeatability Study GR&R Chart\*

INCH								
Part Tolerance INCH	2 TRIALS		3 TRIALS		5 TRIALS		ANOVA	
	10%	20%	10%	20%	10%	20%	10%	20%
0.0001	0.000002	0.000004	0.000003	0.000006	0.000005	0.00001	0.000003	0.000006
0.0002	0.000004	0.000008	0.000007	0.000014	0.000009	0.000018	0.000007	0.000014
0.0003	0.000007	0.000014	0.000009	0.000018	0.000014	0.000028	0.000009	0.000018
0.0004	0.000009	0.000018	0.000013	0.000026	0.000018	0.000036	0.000013	0.000026
0.0005	0.000011	0.000022	0.000016	0.000032	0.000023	0.000046	0.000016	0.000032
0.0006	0.000013	0.000026	0.00002	0.00004	0.000027	0.000054	0.00002	0.00004
0.0008	0.000018	0.000036	0.000026	0.000052	0.000036	0.000072	0.000026	0.000052
0.001	0.000022	0.000044	0.000033	0.000066	0.000045	0.00009	0.000032	0.000064
0.002	0.000044	0.000088	0.000066	0.000132	0.000091	0.000182	0.000065	0.00013
0.003	0.000066	0.000132	0.000098	0.000196	0.000136	0.000272	0.000096	0.000192
0.004	0.000088	0.000176	0.000131	0.000262	0.000181	0.000362	0.000128	0.000256
0.005	0.00011	0.00022	0.000164	0.000328	0.000226	0.000452	0.000161	0.000322

METRIC								
Part Tolerance MM	2 TRIALS		3 TRIALS		5 TRIALS		ANOVA	
	10%	20%	10%	20%	10%	20%	10%	20%
0.0025	0.00006	0.00012	0.00008	0.00016	0.00011	0.00022	0.00008	0.00016
0.005	0.00011	0.00022	0.00017	0.00034	0.00023	0.00046	0.00016	0.00032
0.0076	0.00017	0.00034	0.00025	0.0005	0.00034	0.00068	0.00024	0.00048
0.01	0.00022	0.00044	0.00033	0.00066	0.00045	0.0009	0.00032	0.00064
0.013	0.00029	0.00058	0.00043	0.00086	0.00059	0.00118	0.00042	0.00084
0.015	0.00033	0.00066	0.0005	0.001	0.00068	0.00136	0.00048	0.00096
0.02	0.00044	0.00088	0.00066	0.00132	0.0009	0.0018	0.00064	0.00128
0.025	0.00055	0.0011	0.00083	0.00166	0.00113	0.00226	0.00081	0.00162
0.05	0.0011	0.0022	0.00165	0.0033	0.00225	0.0045	0.0016	0.00322
0.076	0.00167	0.00334	0.00251	0.00502	0.0032	0.00684	0.00245	0.0049
0.1	0.0022	0.0044	0.0033	0.0066	0.0045	0.009	0.00322	0.00644
0.13	0.00286	0.00572	0.00429	0.00858	0.00585	0.0117	0.00419	0.00838

\*Reference Only

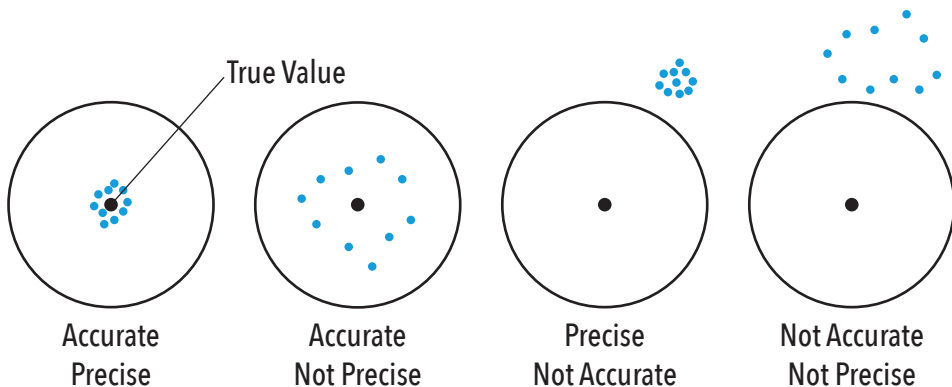
### Optical Measuring Systems



## Measurement System Characterization

Location (Average Measurement Value vs. Actual Value)	
<b>Stability</b>	The ability of a measurement system to produce the same values over time when measuring the same sample.
<b>Accuracy</b>	A measure of the distance between the average value of the measurement of a part and the True, certified, or assigned value of a part. Also referred to as bias.
<b>Linearity</b>	The consistency of accuracy (bias) over the range of measurement; a slope of one (unity) between measured and true value is perfect.
Variation (Spread of Measurement Values - Precision)	
<b>Repeatability</b>	The consistency of a single appraiser to measure the same part multiple times with the same measurement system; it is related to the standard deviation of the measured values.
<b>Reproducibility</b>	Assesses whether different appraisers can measure the same part/sample with the same measurement device and get the same value.
<b>Resolution</b>	The ability of a measurement system to discriminate between measurement values. The consistency of different appraisers in measuring the same part with the same measurement system; it is related to standard deviation of the distribution of appraiser averages.

The diagram below illustrates the difference between the terms "Accuracy" and "Precision". Efforts to improve measurement system quality are aimed at improving both accuracy and precision.



### Requirements

Following are general requirements of all capable measurement systems:

- Statistical stability over time.
- Variability small compared to the process variability.
- Variability small compared to the specification limits (tolerance).
- The resolution, or discrimination of the measurement device must be small relative to the smaller of either the specification tolerance or the process spread (variation). As a rule of thumb, the measurement system should have resolution of at least 1/10th the smaller of either the specification tolerance or the process spread. If the resolution is not fine enough, process variability will not be recognized by the measurement system, thus blunting its effectiveness.

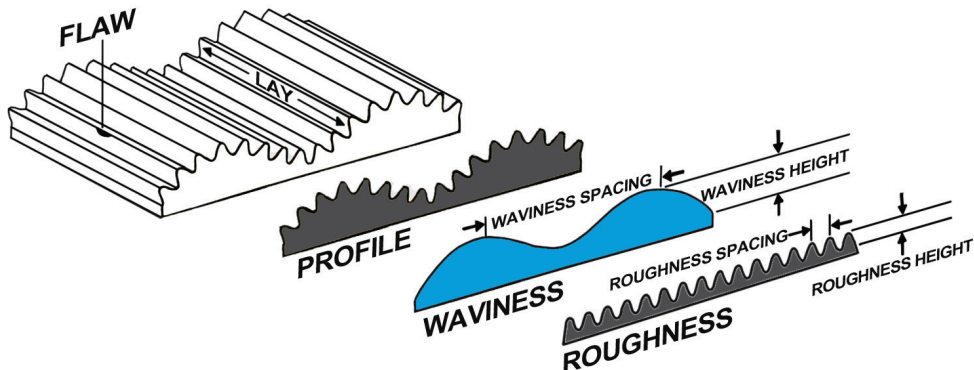
Definitions courtesy of Raytheon

### 3D Scanning Systems





## Basic Surface Finish



PROFILE	
Pt	Sum of Height of the largest profile peak height and largest profile valley in a evaluation length
Pa	Profile average arithmetic average of absolute values of the roughness profile ordinates
Pv	Depth of the lowest profile valley of the Profile curve in one sampling length
Pp	Height of the highest profile peak of the Profile curve in one sampling length
PSm*	Mean Width Of Profile Elements arithmetic mean value of the widths of profile elements of the Profile
WAVINESS	
Wt	Sum of Height of the largest Waviness profile peak height and largest Waviness valley in the evaluation length
Wp	Largest waviness profile peak in a sampling length
Wa	Waviness Average arithmetic average of absolute values of the waviness profile ordinates
Wsm	Mean Width Of Waviness Profile Elements arithmetic mean value of widths of waviness profile elements and waviness profile
Wq*	Root mean square average of the waviness profile ordinates
ROUGHNESS	
Ra	Roughness average arithmetic average of absolute values of the roughness profile ordinates
Rz	Single Roughness Depth vertical distance between the highest peak and deepest valley within a sampling length
Rmax	Maximum Roughness Depth largest single roughness depth within evaluation length
Rsm	Mean width of profile elements arithmetic mean value of widths of profile elements and roughness profile
Rq (RMS)*	Root mean square average of the roughness profile ordinates

### Shop Floor Surface Finish



## HARDNESS CONVERSION CHART

Rockwell				Superficial			Vickers	Knoop	Brinell	Tensile Strength
C	A	D	G	15-N	30-N	45-N	HV	HK	HB	ksi
150 kg Brale	60 kg Brale	100 kg Brale	150 kg 1/16" Ball	15 kg N Brale	30 kg N Brale	45 kg N Brale	Vickers 10 kg	500 gm & over	3000 kg 10-mm Ball	1000 psi
80	92	86.5	96.5	92	87	1865	---			
79	91.5	85.5	96.3	91.5	86.5	1787	---			
78	91	84.5	N/A	96	91	85.5	1710	---		
77	90.5	84		95.8	90.5	84.5	1633	---		
76	90	83		95.5	90	83.5	1556	---		
75	89.5	82.5		95.3	89	82.5	1478	---		
74	89	81.5		95	88.5	81.5	1400	---		
73	88.5	81		94.8	88	80.5	1323	---		
72	88	80		94.5	87	79.5	1245	---		
71	87	79.5		94.3	86.5	78.5	1160	---		
70	86.5	78.5		94	86	77.5	1076	972		
69	86	78		93.5	85	76.5	1004	946		
68	85.6	76.9		93.2	84.4	75.4	940	920		
67	85	76.1		92.9	83.6	74.2	900	895		
66	84.5	75.4		92.5	82.8	73.3	865	870	N/A	
65	83.9	74.5		92.2	81.9	72	832	846	739	
64	83.4	73.8		91.8	81.1	71	800	822	722	
63	82.8	73		91.4	80.1	69.9	772	799	706	
62	82.3	72.2		91.1	79.3	68.8	746	776	688	
61	81.8	71.5		90.7	78.4	67.7	720	754	670	
60	81.2	70.7	N/A	90.2	77.5	66.6	697	732	654	N/A
59	80.7	69.9	351	89.8	76.6	65.5	674	710	634	351
58	80.1	69.2	338	89.3	75.7	64.3	653	690	615	338
57	79.6	68.5	325	88.9	74.8	63.2	633	670	595	325
56	79	67.7	313	88.3	73.9	62	613	650	577	313
55	78.5	66.9	301	87.9	73	60.9	595	630	560	301
54	78	66.1	292	87.4	72	59.8	577	612	543	292
53	77.4	65.4	283	86.9	71.2	58.8	560	594	525	283
52	76.8	64.6	273	86.4	70.2	57.4	544	576	512	273
51	76.3	63.8	264	85.9	69.4	56.1	528	558	496	264
50	75.9	63.1	255	85.5	68.5	55	513	542	481	255
49	75.2	62.1	246	85	67.6	53.8	498	526	469	246
48	74.7	61.4	N/A	84.5	66.7	52.5	484	510	455	238
47	74.1	60.8	229	83.9	65.8	51.4	471	495	443	229
46	73.6	60	221	83.5	64.8	50.3	458	480	432	221
45	73.1	59.2	215	83	64	49	446	466	421	215
44	72.5	58.5	208	82.5	63.1	47.8	434	452	409	208
43	72	57.7	201	82	62.2	46.7	423	438	400	201
42	71.5	56.9	194	81.5	61.3	45.5	412	426	390	194
41	70.9	56.2	188	80.9	60.4	44.3	402	414	381	188
40	70.4	55.4	182	80.4	59.5	43.1	392	402	371	182
39	69.9	54.6	177	79.9	58.6	41.9	382	391	362	177
38	69.4	53.8	171	79.4	57.7	40.8	372	380	353	171
37	68.9	53.1	166	78.8	56.8	39.6	363	370	344	166
36	68.4	52.3	161	78.3	55.9	38.4	354	360	336	161
35	67.9	51.5	156	77.7	55	37.2	345	351	327	156
34	67.4	50.8	152	77.2	54.2	36.1	336	342	319	152
33	66.8	50	149	76.6	53.3	34.9	327	334	311	149
32	66.3	49.2	146	76.1	52.1	33.7	318	326	301	146
31	65.8	48.4	N/A	75.6	51.3	32.5	310	318	294	141
30	65.3	47.7	92	75	50.4	31.3	302	311	286	138
29	64.6	47	91	74.5	49.5	30.1	294	304	279	135
28	64.3	46.1	90	73.9	48.6	28.9	286	297	271	131
27	63.8	45.2	89	73.3	47.7	27.8	279	290	264	128
26	63.3	44.6	88	72.8	46.8	26.7	272	284	258	125
25	62.8	43.8	87	72.2	45.9	25.5	266	278	253	123
24	62.4	43.1	86	71.6	45	24.3	260	272	247	119
23	62	42.1	84.5	71	44	23.1	254	266	243	117
22	61.5	41.6	83.5	70.5	43.2	22	248	261	237	115
21	61	40.9	82.5	69.9	42.3	20.7	243	256	231	112
20	60.5	40.1	81	69.4	41.5	19.6	238	251	226	110

NOTE #1: A 10mm steel ball was used for 450 BHN and below; a 10mm carbide ball was used above 450 BHN.

NOTE #2: The tensile strength relation to hardness is inexact, even for steel unless it is determined for a specific material.

### Hardness Testers and Standards



# Total Metrology Solutions



Force Measurement		
Element or Alloy	GF	LBF
Actinium	10	10070
Aluminum	8.5	8525
Anitmony	6.68	6680
Babbitt	7.27	7270
Barium	3.62	3595
Beryllium	1.85	1850
Bismuth	9.79	9790
Cadmium	8.69	8690
Caesium	1.87	1870
Calcium	1.54	1540
Cerium	6.77	6770
Cesium	1.93	1930
Chromium	7.15	7150
Cobalt	8.86	8860
Constantan	8.9	8900
Columbium	8.55	8550
Copper	8.96	8960
Cupronickel	8.9	8900
Duralumin	2.78	2780
Dysprosium	8.55	8550
Erbium	9.07	9070
Europium	5.24	5240
Galdolinium	7.90	7900
Gallium	5.91	5910
Germanium	5.3	5300
Gold	19.3	19300
Hafnium	13.3	13300
Hatelloy	9.25	9250
Holmium	8.80	8800
Indium	7.31	7310
Inconel	8.5	8500
Incoloy	8.03	8003
Iridium	22.5	22500
Iron	7.87	7870

Force Measurement		
Element or Alloy	GF	LBF
Lanthanum	6.15	6150
Lead	11.3	11300
Lithium	.53	530
Lutetium	9.84	9840
Magnesium	1.74	1740
Manganse	7.3	7300
Manganin	8.55	8550
Mercury	13.53	13530
Molybdenum	10.2	10200
Neodymium	7.01	7010
Neptunium	20.2	20200
Nichrome	8.45	8450
Nickel	8.90	8900
Nickeline	8.7	8700
Nimonic	8.1	8100
Niobium	8.57	8570
Osmium	22.59	22590
Palladium	12.0	12000
Platinum	21.5	21500
Plutonium	19.7	19700
Polonium	9.20	9200
Potassium	.89	890
Praseodymium	6.77	6770
Promethium	7.26	7260
Protactinium	15.4	15400
Radium		
Red Brass	8.75	
Rhenium	20.8	20800
Rhodium	12.4	12400
Rubidium	1.53	15300
Ruthenium	12.1	12100
Samarium	7.52	7520
Scandium	2.99	2990
Silver	10.5	10500

Force Measurement		
Element or Alloy	GF	LBF
Sodium	.97	970
Steel	7.86	7860
Strontium	2.64	2640
Tantalum	16.4	16400
Technetium	11	
Terbium	8.23	8230
Thallium	11.8	11800
Thorium	11.7	11700
Thulium	9.32	9320
Tin	7.26	7260
Titanium	4.51	4510
Tungsten	19.3	19300
Uranium	19.1	19100
Vanadium	6.0	6000
White Metal	7.05	7050
Wrought Iron	7.74	7740
Yellow Brass	8.47	8470
Ytterbium	6.90	6900
Yttrium	4.47	4470
Zinc	7.14	7140
Zirconium	6.52	6520



## Sample Preparation



Torque Measurement					
IN-OZ	G-CM	IN-LB	FT-LB	KG-M	N-M
48	3456	3	0.25	0.03458	0.339
192	13830	12	1	0.1383	1.356
800	57600	50	4.167	0.5763	5.65
1600	115200	100	8.334	1.1526	11.3
3200	230400	200	16.668	2.3052	22.6

Torque Conversion Multipliers						
	IN-OZ	G-CM	IN-LB	FT-LB	KG-M	N-M
in-oz	1	72.01	0.0625	0.005208	0.0007203	0.007063
g-cm	0.01389	1	0.000868	0.00007233	0.00001	0.00009808
in-lb	16	1152	1	0.08333	0.01153	0.113
ft-lb	192	3456	12	1	0.1383	1.356
kg-m	1388	99960	86.77	7.231	1	9.805
n-m	141.6	10200	8.85	0.7375	0.102	1

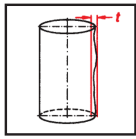
Force Measurement					
OZF	GF	LBF	KGF	N	
16	453.6	1	0.4536	4.448	
80	2268	5	2.268	22.24	
160	4536	10	4.536	44.48	
400	11340	25	11.34	111.2	
800	22680	50	22.68	222.4	
1600	45360	100	45.36	444.8	
3200	90720	200	90.72	889.6	
8000	226800	500	226.8	2224	
16000	453600	1000	453.6	4448	


Force Conversion Multipliers					
	OZF	GF	LBF	KGF	N
OZF	1	28.35	0.0625	0.02835	0.278
GF	0.03527	1	0.002205	0.001	0.009806
LBF	16	453.6	1	0.4536	4.448
KGF	35.27	1000	2.205	1	9.806
N	3.597	102	0.2248	0.102	1

### Torque and Force Measuring Systems

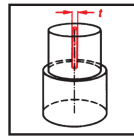


## Form Parameter Tolerances



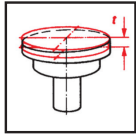
 **Straightness, ISO 1101**


The tolerance zone is limited in the measuring plane by two parallel straight lines a distance  $t$  apart.



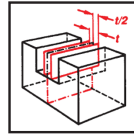
 **Concentricity/Coaxiality, ISO 1101**

The tolerance zone is limited by a cylinder of diameter  $t$ , the axis of which coincides with the datum axis.



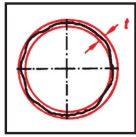
 **Flatness, ISO 1101**

The tolerance zone is limited by two parallel planes a distance  $t$  apart.



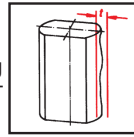
 **Symmetry, ISO 1101**

The tolerance zone is limited by two parallel planes a distance  $t$  apart and symmetrically disposed to the median plane with respect to the datum axis or datum plane.



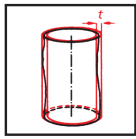
 **Roundness, ISO 1101**

The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance  $t$  apart.



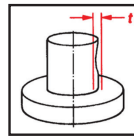
 **Parallelism, ISO 1101**

The tolerance zone is limited in the measuring plane by two straight lines a distance  $t$  apart and parallel to the datum.



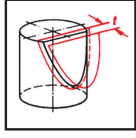
 **Cylindricity, ISO 1101**

The tolerance zone is limited by two coaxial cylinders a distance  $t$  apart.



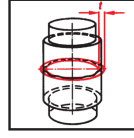
 **Perpendicularity, ISO 1101**

The tolerance zone is limited in the measuring plane by two parallel, straight lines a distance  $t$  apart and perpendicular to the datum.



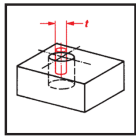
 **Angularity, ISO 1101**


The tolerance zone is limited by two parallel planes a distance  $t$  apart and inclined at the specified angle to the surface.



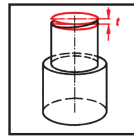
 **Radial run-out, ISO 1101**


The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance  $t$  apart, the common center of which lies on the datum axis.



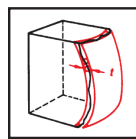
 **Position, ISO 1101**


If the tolerance value is preceded by the sign, the tolerance zone is limited by a cylinder of diameter  $t$ , the axis of which is theoretically in the exact position of the toleranced line.



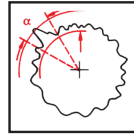
 **Total run-out, ISO 1101**

The tolerance zone is limited by two parallel planes a distance  $t$  apart and perpendicular to the datum axis.



 **Profile any surface, ISO 1101**

The tolerance zone is limited by two surfaces enveloping spheres of diameter  $t$ , the centres of which are situated on a surface having the true geometrical form.



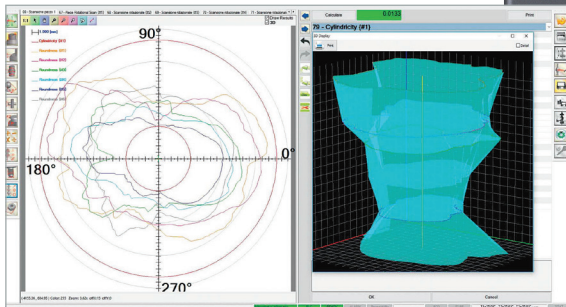
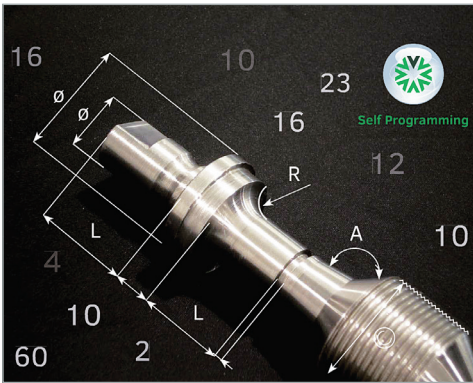
 **Angular sector roundness, ISO 1101**

The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance  $t$  apart. The measured circumference shall be contained in any angular sector  $\alpha$  starting from the profile centre within the tolerance zone.



### Shaft Measuring Systems

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## Color Coding of Carl Zeiss Objectives

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### Labeling of the Objective

Objective class, special designations are used for this, e.g. LD for Long Working Distance

### Magnification/Numerical Aperture plus additional details on

- immersion medium (Oil /W/ Glyc)
- adjustable cover glass correction (Korr.)
- contrast method

### Tube Length/Cover Glass Thickness (mm)

ICS optics:  $\infty$   
 Infinity Color Corrected System  
 standard cover glass: 0.17  
 without cover glass: 0  
 insensitive: -

### Mechanical Correction Collar for

- cover glass thickness correction
- different immersion
- different temperature
- adjusting an iris diaphragm



### Color of Writing Contrast Method

- Standard
- Pol / DIC
- Ph 0 1 2 3

### Color Coding of Magnification

- 1.0/1.25
- 2.5
- 4/5
- 6.3
- 10
- 16/20/25/32
- 40/50
- 63
- 100/150

### Immersion Fluid

- Oil
- Water
- Glycerin
- Oil/Water/Glycerin

Chart artwork compliments of ZEISS

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# Periodic Table of Elements

1 IA 1A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008	2 He Helium 4.003	3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180	11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine 209	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium [unknown]	114 Fl Flerovium [289]	115 Uup Ununpentium [unknown]	116 Lv Livermorium [293]	117 Uus Ununseptium [unknown]	118 Uuo Ununoctium [unknown]
Atomic Number		Lanthanide Series															
Symbol		Actinide Series															
Name		Atomic Mass															

Alkali Metals	Alkaline Earth Metals	Transition Metals	Basic Metals	Semi-metals	Nonmetals	Halogenes	Noble Gases	Lanthanides	Actinides
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Set-Up Tables  
Automation Solutions  
Retrofit Solutions

#### APPLICATIONS

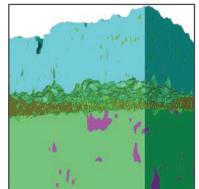
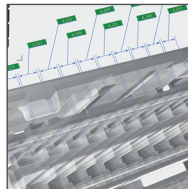
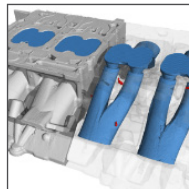
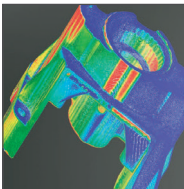
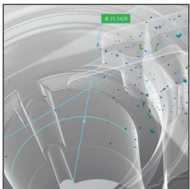
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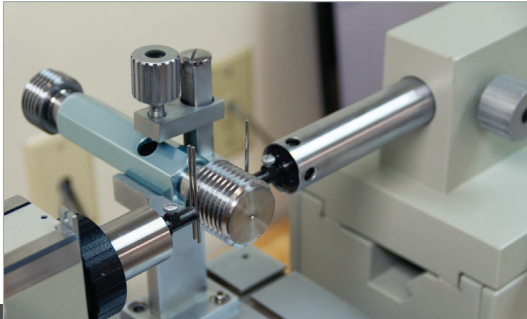
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Feeler Gages  
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Gage Blocks  
Gapman Gages  
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Hand Tools  
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Kinematic Viscosity  
Laser Micrometers  
Length Standards  
Levels  
Load Cells (120,000lbs)  
LVDT Probes

Master Balls  
Master Discs  
Micrometers  
Optical Flats  
Pin Gages  
Plug Gages  
Pressure Calibrators  
Pressure Gauges  
Protractors  
Radius gages  
Ring Gages  
Roundness Testers  
Scales/Balances  
Sine Bars  
Snap Gages  
Spheres and Balls  
Squares  
Steel Rules/Tapes  
Stop Watches  
Surface Finish Testers  
Surface Finish Roughness Patches  
Surface Plates  
Testing Sieves  
Thread Wires  
Thread Gages  
Torque Wrenches  
Torque Analyzers and Meters  
Ultrasonic Thickness Meters  
Universal Measuring Machines  
Weights/Mass

*...and much more. Don't see it? Call us!*



## Electronics Calibration Services

Electronics A2LA Accredited Calibration Services\*

Ammeters  
Amplifiers  
Analog Meters  
Battery Dischargers  
Chart/Strip Recorders  
Clamp Meters  
(up to 550 Amps)  
Conductivity Meters  
Counters  
Curve Tracers  
Current Probes  
Data Loggers  
Decade Resistors/Boxes  
Electronic Loads  
ESD Testers  
Frequency Counters to 18GHz  
Freezers  
Function Generators  
Hygrometers  
Insulation Testers  
IR under Temp Indicators  
Light Meters  
Magnetic Flux Density (Gauss Meters)

Meggers  
Multifunction Calibrators  
Multimeters  
Oscillators  
Oscilloscopes  
Ovens  
Panel Meters  
Power Supplies  
Pulse Generators  
Radar Guns X-K Bands  
Safety Analyzers  
Sound Level Meters  
Tachometers  
Temperature Controllers  
Temperature Indicators  
(meters/RTD thermocouple/  
thermistor sensors/ probes)  
Thermometers  
Timers  
Voltmeters  
Volt-Ohm Meters  
Volume  
Waveform Generators  
Welders  
X-Y Recorders

*...and much more. Don't see it? Call us!*



\*Accreditation may vary by model and manufacturer

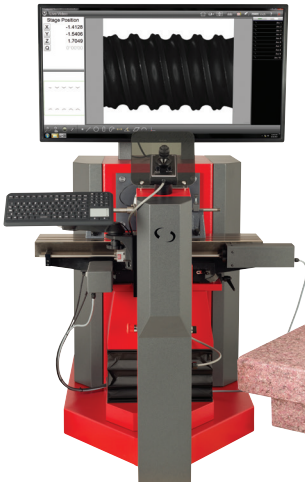
## On-Site Field Calibration Services

A2LA Accredited for On-Site Calibration

- Amplifiers
- Bore Gages
- Calipers
- Chamfer & Hole Check Gages
- Chart Recorders
- Concentricity Gages
- CMMs (Verification Only)
- Contour/Contrace Systems
- Crimping Tools
- Cylindricity Measuring Machines
- Flatness
- Force Gages
- Freezers
- Gage Block Comparators
- GO/NO-GO Gages
- Hardness Testers
- Height Gages
- ID/OD Comparators
- Indicators
- Laser Micrometer Systems
- Levels
- LVDT Probes and Readouts
- Micrometers
- Microscopes
- (Metallographic/Metallurgical)

- Multimeters
- Optical & Video Comparators
- Optical Shaft Measurement Systems
- Ovens
- Panel Meters
- Pin Gages Class ZZ
- Portable Arm CMMs
- Precision Hand Tools-all
- Pressure Gages
- Protractors
- Radar Guns
- Roundness Measuring Machines
- Snap Gages
- Stop Watches
- Super Micrometers
- Surface Finish Machines
- Surface Plates
- Temperature & Humidity Recorders
- Thermocouple Systems
- Tool Makers Measuring Microscopes
- Torque Calibration Systems
- Torque Wrenches
- Universal Measuring Machines
- Vacuum Gages
- Vision Systems

*...and much more.  
Don't see it? Call us!*



## Dimensional & Electronic Gage Repair Services

Factory Trained and Certified Repair Services. Send Everything to One Place!

MSI Viking has one of the largest precision instruments Repair Lab in the southeast US. We use only genuine OEM replacement parts and factory-trained technicians with years of experience. Our repair work and replacement parts are accompanied by a 30-day warranty.

*Below is only a partial list of brands and items we repair. Call us if you don't see it!*



### Dimensional Instruments

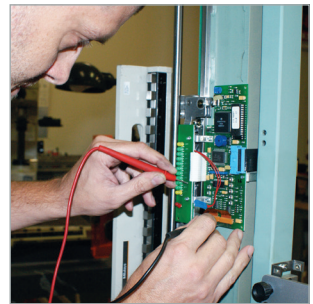
- Bore Gages
- Bench Micrometers
- Calipers
- Co-ax Indicators
- Countersink Gages
- Depth Gages
- Flushness Gages
- Force Gages
- Height Gages
- Height Masters
- I/D Micrometers
- Indicators
- Laser Micrometers
- Lever Heads
- Linear Scales
- Levels
- LVDT Probes/Heads
- Micro-Hite
- Micrometers
- Protractors
- Precision Levels
- Pressure Gages
- Snap Gages
- Surface Testers/Gages
- Surface Styli/Drive Units
- Test Indicators
- Thickness Gages
- Torque Wrenches
- Torque Drivers
- Torque Transducers
- Verniers
- and more!

### Electronic Instruments

- Servos
- Circuit Boards
- Amplifiers
- Durometers
- Gauss Meters
- Indicator Checkers/Calibrators
- Multimeters
- Force Gages
- Load Cells
- AC/DC Drives
- Spindle Drives
- Tachometers
- Chart Recorders
- Counters
- Flow Controllers
- Level Controllers
- Pressure Controllers
- Signal Conditioners
- Timers
- Temperature Controllers
- Meg ohmmeters
- Oscilloscopes
- Servo Amplifiers
- Card Racks
- Transducers
- Ultrasonic Controllers
- and more!

### Spindle Repair

- OEM Quality Repairs
- Fast Delivery
- Competitive Pricing



### Embedded Calibration Services

Cost Effective • 17025 Accredited • Always Compliant

MSI Viking's Embedded Services provides trained and experienced quality personnel right in your facility to manage your lab and gage assets. Services include fully accredited 17025 calibrations and inspections done in-house, reducing gages and parts from leaving your facility and increasing production up time.

We also provide complete audit support so that traceability is intact and complete, and your lab is always compliant.

Eliminate QC Staffing & Training

In-house Calibrations & Repair

Accredited Inspection

Faster Turnaround

GageCloud Asset Management

Preventive Maintenance

Customized Flexibility

50+ Years of Experience

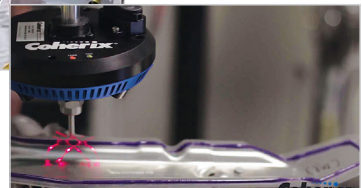
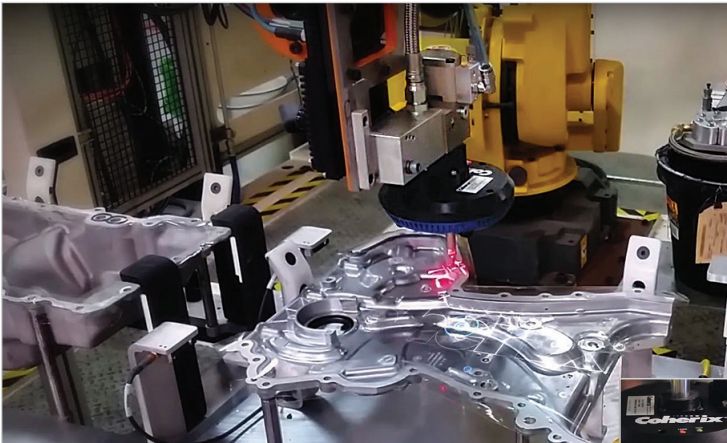




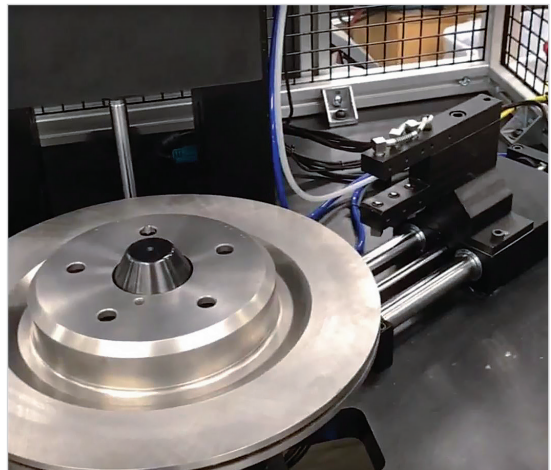
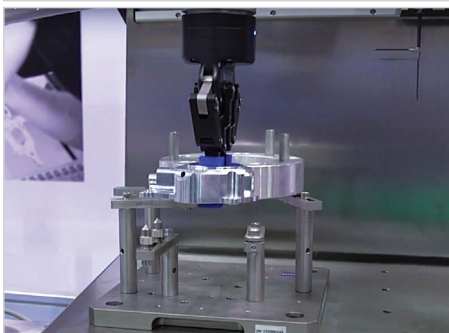
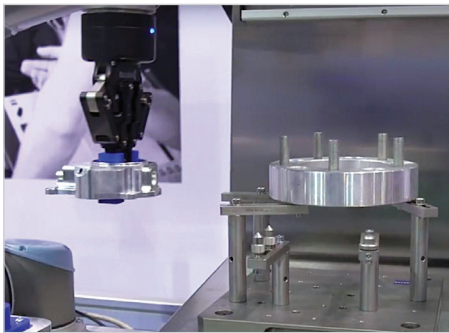
## Solutions Engineered for Today's Manufacturing Processes

MSI Viking delivers custom solutions that address our customer's goals of reducing costs, increasing production and improving product quality through 'smart' automation. We take advantage of the latest technologies to maximize value and deliver custom measurement solutions, including solutions integrated into existing systems and processes, whether that be through robotics, machine vision, or advanced automation and control systems.

Yes, we truly are Your Total Metrology Solution.



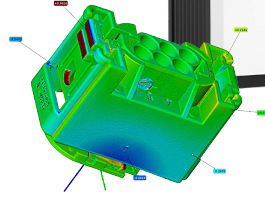
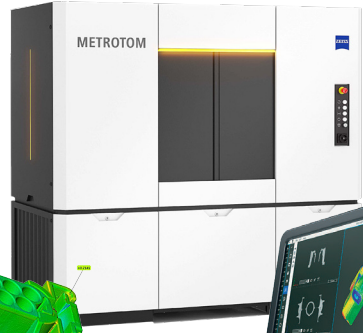
### Solutions Engineered for Today's Manufacturing Processes



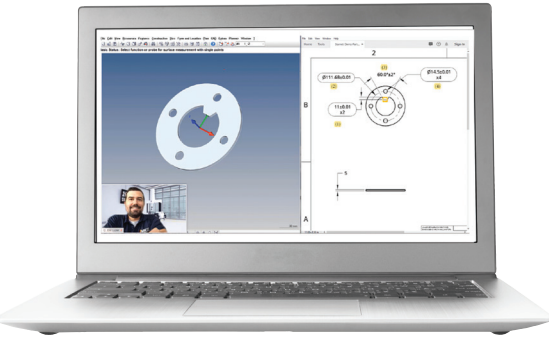
## Advanced Metrology Services

### Accredited Contract Inspection Services

Fully equipped and accredited labs, we're able to take on projects large and small, whether it be a First Article Inspection or picking up the overflow from your regular operations.



### Engineering Services



### Popular

- Contact and Non-Contact Surface Roughness
- Hardness Testing
- Force Testing
- Roundness and Form Analysis
- Metallurgical Analysis
- First Article Inspection (FAI)
- Production Part Approval (PPAP)
- Fixture Qualification
- Reverse Engineering
- Process Capability Studies
- Gage R&R Studies
- Custom Fixture Design
- CMM Programming
- CMM Calibration
- CMM Training
- ... and so much more

### Equipment Services



Find out more about MSI Viking's comprehensive Metrology Services



**MSI**   
**VIKING**

Total Metrology Solutions