

DEFINITION OF AN OPTICAL SURFACE

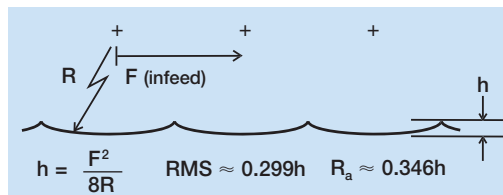
$$Z = \frac{CX^2}{1 + [1 - (K+1)C^2X^2]^{1/2}} + A_1X^4 + A_2X^6 + A_3X^8 + A_4X^{10} + \dots$$

- Z** = Sag of surface parallel to Z axis
X = Radial distance from axis
C = Curvature = 1/R = 1/Radius of curvature
A₁, A₂, A₃, A₄ = Aspheric deformation constants
K = Conic constant
K < -1 ⇒ Hyperboloid
K = -1 ⇒ Paraboloid
-1 < K < 0 ⇒ Prolate ellipsoid (major)
K > 0 ⇒ Oblate ellipsoid (minor)
K = 0 ⇒ Sphere

VISIBLE SPECTRUM

Red	.622 – .770 μm
Orange	.597 – .622 μm
Yellow	.577 – .597 μm
Green	.492 – .577 μm
Blue	.455 – .492 μm
Violet	.390 – .455 μm

THEORETICAL SURFACE FINISH



SURFACE FINISH AND PROFILE

- R_a** = Arithmetic Average Roughness
R_q = RMS = Root Mean Square Roughness
R_t = Peak to Valley Roughness
R_{sk} = Skewness
R_{ku} = Kurtosis

REFERENCES

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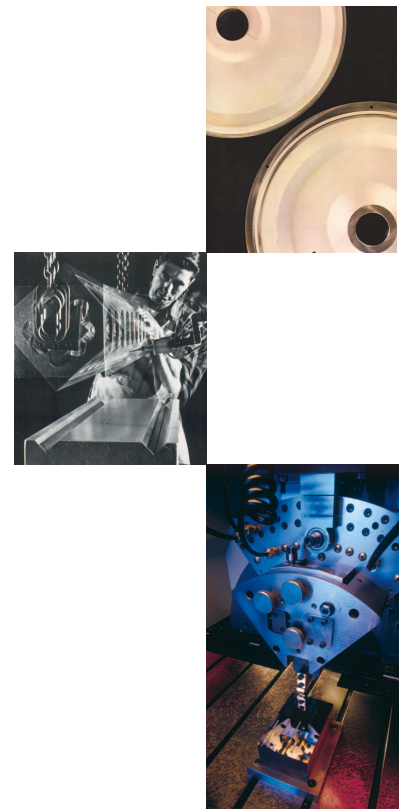
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PRECISION










ENGINEERING

REFERENCE

GUIDE



GEOMETRY

- Roundness 
- Concentricity 
- Position 
- Cylindricity 
- Straightness 
- Parallelism 
- Perpendicularity 
- Flatness 
- Circular Runout 
- Total Runout 



PRECISION ENGINEERING CONVERSION FACTORS

Displacement

		.001 inch	=	10 ⁻³ inch	=	25.4 micrometers
1 microinch	=	1 μinch	=	10 ⁻⁶ inch	=	25.4 nanometers
1 micrometer	=	1 μm	=	10 ⁻⁶ meter	≈	40.0 microinches
1 nanometer	=	1 nm	=	10 ⁻⁹ meter	≈	0.04 microinches

Angular

1 arc minute	=	1/60 degree	≈	0.01667 degrees
1 arc second	=	1/3600 degree	≈	0.000278 degrees
1 arc minute	≈	slope of 291 μin/inch		
1 arc second	≈	slope of 4.8 μin/inch = 4.8 μm/m		
1 radian	=	1 rad	=	(360/2π) degrees ≈ 57.3 degrees
1 milliradian	=	1 mrad	=	10 ⁻³ rad ≈ 3.4 arc minute
1 microradian	=	1 μrad	=	10 ⁻⁶ rad ≈ 0.21 arc seconds
1 microradian	=	slope of 1 μin/inch = slope of 1 μm/m		

Miscellaneous

1 lbf/μin	=	1 x 10 ⁶ lbf/in	≈	175 N/μm
1 N/μm	≈	5710 lbf/in		
1 lbf	=	4.448 N		
1 N	=	0.2248 lbf		
1 lbm	=	0.4536 kg		
1 kg	=	2.2046 lbm		

METROLOGICAL LASERS

HeNe Laser	⇒	1 λ =	2 Fringes =	6328 Å =	.6328 μm =	24.913 μ"
CO ₂ Laser	⇒	1 λ =	2 Fringes =	106000 Å =	10.6 μm =	417.3 μ"

MATERIAL PROPERTIES

	Mass Density Mg/m ³	Elastic Modulus GPa	Thermal Expansion 10 ⁻⁶ /°C	Thermal Conductivity W/m/°C	Specific Heat KJ/kg/°C
Aluminum 6061	2.71	71.0	23.0	177.0	0.896
Aluminum Oxide	3.9	380.0	8.5	25.0	0.79
Beryllium	1.85	304.0	11.6	180.0	1.9
Brass	8.4	105.0	20.0	120.0	0.38
Bronze	8.4	120.0	19.0	85.0	0.38
Gray Cast Iron	7.4	125.0	11.0	46.0	0.525
Copper	8.9	117.0	17.0	397.0	0.38
Fused Silica	2.2	72.0	0.56	1.4	0.741
Granite	2.6	76.0	6.0	1.6	0.82
Invar	8.03	148.0	1.2	11.0	0.46
Nickel	8.9	210.0	13.0	86.0	0.45
PMMA	1.2	3.3	70.0	0.2	1.5
Polycarbonate	1.2	2.2	120.0	0.2	1.9
Polystyrene	1.1	3.2	70.0	0.43	1.4
PTFE	2.2	3.5	100.0	0.25	1.05
Silicon (single crys.)	2.33	130.0	2.3	148.0	0.75
Silicon Carbide	3.2	410.0	4.3	84.0	1.4
Silicon Nitride	3.2	310.0	3.2	17.0	0.63
Stainless Steel 304	8.0	193.0	17.3	16.2	0.5
Steel	7.8	210.0	12.0	54.0	0.46
Super Invar	8.15	144.0	0.5	11.0	0.46
Titanium	4.4	115.0	10.0	7.2	0.565
Tungsten Carbide	14.5	550.0	5.1	108.0	0.23
ULE® glass	2.21	67.6	0.02	1.3	0.767
Zerodur®	2.53	91.0	0.05	1.6	0.821
Zirconium Oxide	5.6	200.0	10.5	1.5	0.67