

DEFINITION OF AN OPTICAL SURFACE

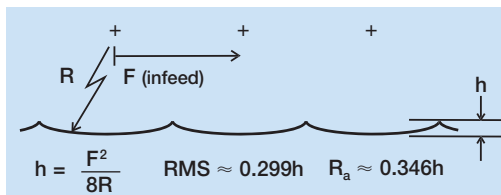
$$Z = \frac{CX^2}{1 + [1 - (K+1)C^2X^2]^{1/2}} + A_1X^4 + A_2X^6 + A_3X^8 + A_4X^{10} + \dots$$

- 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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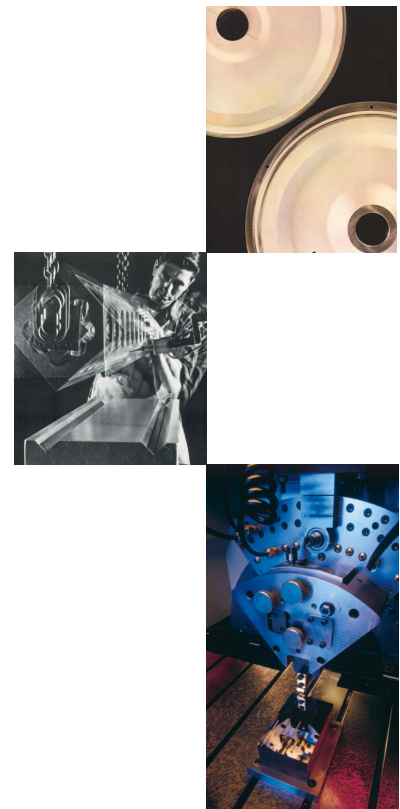
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PRECISION

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 μ inch | = | 10^{-6} inch | = | 25.4 nanometers |
| 1 micrometer | = | 1 μ m | = | 10^{-6} meter | \approx | 40.0 microinches |
| 1 nanometer | = | 1 nm | = | 10^{-9} meter | \approx | 0.04 microinches |

Angular

| | | | | |
|---------------|-----------|---|-----------|---|
| 1 arc minute | = | 1/60 degree | \approx | 0.01667 degrees |
| 1 arc second | = | 1/3600 degree | \approx | 0.000278 degrees |
| 1 arc minute | \approx | slope of 291 μ in/inch | | |
| 1 arc second | \approx | slope of 4.8 μ in/inch = 4.8 μ m/m | | |
| 1 radian | = | 1 rad | = | (360/2 π) degrees \approx 57.3 degrees |
| 1 milliradian | = | 1 mrad | = | 10^{-3} rad \approx 3.4 arc minute |
| 1 microradian | = | 1 μ rad | = | 10^{-6} rad \approx 0.21 arc seconds |
| 1 microradian | = | slope of 1 μ in/inch = slope of 1 μ m/m | | |

Miscellaneous

| | | | | |
|-----------------|-----------|-------------------|-----------|----------------|
| 1 lbf/ μ in | = | 1 x 10^6 lbf/in | \approx | 175 N/ μ m |
| 1 N/ μ m | \approx | 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 | \Rightarrow | 1 λ | = | 2 Fringes | = | 6328 Å | = | .6328 μ m | = | 24.913 μ " |
| CO ₂ Laser | \Rightarrow | 1 λ | = | 2 Fringes | = | 106000 Å | = | 10.6 μ m | = | 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 |