Having provided tailored solutions for Precision Balls for more than 3 decades, N. Gandhi & Co. is considered as a trusted source for industries like the Automobile, Aeronautic Sector, Cosmetic, Chemical and Mechanical domains. NGC balls are used in a multitude of ways: ball bearings, safety valves, body jewellery, steering column, safety belt applications, and so on.

The company has broadened its product base over the years to include Grinding media and Rollers along with metallic and non-metallic balls including ceramic, glass & plastic. The long standing commitment to excellence and dedication to our customers has earned us advanced expertise and a thorough understanding of hundreds of very specific applications and processes in industries which has helped us in providing customized solutions in all materials, sizes and tolerances.

All the balls we provide are produced in accordance with the standards required by the (DIN), (ABMA) and (ISO). Our quality assurance is also certified by the International Organization of Standardization, Standard 9001 : 2008 by Bureau Veritas.

The company’s commitment to its customers and business integrity reflects in its widespread popularity - with a client base that’s not only spread all across India but also in other parts of the world.
APPLICATIONS

- Aerosol Pumps
- Automotive Door Assembly
- Ball Bearings
- Ball Pen
- Ball Screw
- Ball Transfer Unit
- Ball Valves
- Bicycles
- Bobbin Holder
- Body Jewellery
- Castor Wheels
- Cosmetics
- Gas Regulator
- Household Appliances
- Jewellery
- Linear Motion Bearing
- Rod End
- Steering Column
- Safety Belts
- Toys
- Watches
- Wind Mill Bearing
QUALITY CONTROL

The Company is ISO 9001:2008 certified and our QC Dept is equipped with high tech control machines to meet a broad spectrum of needs and guarantee best quality at all times. We follow Intensive Quality Analysis and provide certificates for each batch inspected.
WAREHOUSE

The specific strength and power of our Group is as a one point contact to respond to all your needs and demands. Equipped with all essential infrastructures, our warehouses are constantly filled with more than 1,500 Tons of inventory in the widest range of sizes, materials and grades, completely available in one source of supply to satisfy the requirements of our worldwide customers in the shortest terms.

In addition to special and open orders, we have over 250 standard balls of different types and sizes in stock.
PRECISION BALLS - FERROUS METALS

Low Carbon Steel (Case Hardened)

General Information
Balls of this type are generally used in applications where there are only moderate loads and slow rotating parts, for example Castors, Conveyors and Non-Precision Bearings.
The main feature of this type of ball is the Carburised case with a soft core giving resistance to surface wear.

International Equivalents
ABI 1010, JIS SWP 12, EN 92, ASTM A 29, Wks 1.0010

Composition
C: 0.10 - 0.15%
Mn: 0.30 - 0.60%
P: 0.045% Max
S: 0.045% Max
Si: 0.1 - 0.4% Max

Hardness
HRC: 60 min

Mechanical Properties
Tensile Strength: 53,000 psi
Yield Strength: 44,000 psi
Density: 0.284 lbs/in³

Size Range - 1.588mm (1/16") to 12.700mm (1/2")
Standard Grades Available
100, 200, 300, 1000

High Carbon Steel (Through Hardened)

General Information
Balls of this material have the advantage of being through hardened to HRC 60 min and will take higher loads and provide longer life than case hardened carbon balls, for such applications as the Cycle Industry.

International Equivalents
ABI 1095-86, EN805, C18 Wks 1.1269

Composition (AISI 1085)
C: 0.85%
Mn: 0.65%
P: 0.027%
S: 0.022%

Hardness
HRC: 60 min

Mechanical Properties
Tensile Strength: 106,400 psi
Density: 0.284 lbs/in³

Size Range - 3.175mm (1/8") to 38.1mm (1 1/2")
Standard Grades Available
100, 300, 1000

Minimum Case Depth

<table>
<thead>
<tr>
<th>Ball Dia</th>
<th>Case Depth</th>
<th>Ball Dia</th>
<th>Case Depth</th>
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<tr>
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Crushing Loads

<table>
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<td>ø9/32&quot;</td>
<td>2200 lbs</td>
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<td>ø5/16&quot;</td>
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<td>ø3/8&quot;</td>
<td>3900 lbs</td>
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</table>
**High Carbon Chrome Alloy**

**General Information**
This is an oil hardened steel, which is universally used by the ball and roller bearing industry. The steel has high hardness and good resistance to deformation and excellent wear resistance. Usually vacuum degassed and uniformly through hardened in atmospherically controlled electric furnaces.

**International Equivalents**
AS 1572.10/ 5U2ASTM 109Cr6/6, W.1 3505

**Composition**
<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Cr</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Precision</th>
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<tbody>
<tr>
<td>%</td>
<td>0.95-1.1%</td>
<td>1.20 - 1.50%</td>
<td>0.25 - 0.45%</td>
<td>0.17 - 0.30%</td>
<td>0.025%</td>
<td>Max</td>
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**Hardness**
HRC: 56 - 67

**Mechanical Properties**
- Tensile Strength: 325,000 psi
- Yield Strength: 295,000 psi
- Density: 8.28 g/cm³

**Size Range**
0.635 mm (0.025") to 1.016 mm (4")

**Standard Grades Available**
5, 10, 20, 100, 500

---

**Stainless Steel AISI 440C (Martensitic)**

**General Information**
These balls give maximum hardness with good corrosion resistance to fresh water, steam, crude oil, gasoline, alcohol, food environment, blood and perspiration. In addition, this material is ferromagnetic and makes a fair permanent magnet. Balls are deep freeze stabilized after heat treatment.

**International Equivalents**
AISI 440C, DIN 1.4031 Cr Mo, SUS 440C, W.1 4125

**Composition**
<table>
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<tr>
<th>Element</th>
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<th>Ni</th>
<th>Mn</th>
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<tr>
<td>%</td>
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<td>15 - 18%</td>
<td>0.025% Max</td>
<td>1.00 Max</td>
<td>0.004% Max</td>
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**Hardness**
HRC: 58 - 63

**Mechanical Properties**
- Tensile Strength: 81,000 psi
- Yield Strength: 68,000 psi
- Density: 0.277 lbs/cu in

**Size Range**
0.635 mm (0.025") to 1.016 mm (4")

**Standard Grades Available**
10, 25, 50, 1000

---

**Stainless Steel AISI 420, 420C (Martensitic)**

**General Information**
Balls of this material have a lower chrome content than 440C and are used in applications where the more rigid corrosion resistance requirements can be relaxed. They have fair resistance to fresh water, steam, oil, gasoline, blood, perspiration, alcohol and food environment. However, will not pass 40 hours salt spray test.

**International Equivalents**
AISI 420, SUS 420, X10CrMoMn7-4/1, EN12701: W.1 3540

**Composition**
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<th>Mn</th>
<th>Si</th>
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<th>S</th>
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<tr>
<td>%</td>
<td>0.15% Max</td>
<td>0.40 - 0.50%</td>
<td>1.0% Max</td>
<td>0.1% Max</td>
<td>0.3% Max</td>
<td>0.025% Max</td>
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**Hardness**
HRC: 48 - 53

**Mechanical Properties**
- Tensile Strength: 55,000 psi
- Yield Strength: 43,000 psi
- Density: 0.280 lbs/cu in

**Size Range**
0.65 mm (0.026") to 7.38 mm (0.3")

**Standard Grades Available**
10, 16, 24, 48, 100, 200

---

**Stainless Steel AISI 302, 304L (Austenitic)**

**General Information**
Similar to AISI 302, 304 but with the addition of molybdenum improves corrosion resistance particularly to sulphuric acid compounds. These balls are used extensively in applications where contact is made with inks, photographic chemicals, bleaches, dyes and nitric acids. This is the only austenitic stainless steel ferrous ball manufacture and can be Magnetic and Non Magnetic.

**International Equivalents**
DIN 1.4301 Cr Ni 18-9.0/ JIS 3454, W.1 4140

**Composition**
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<th>Mn</th>
<th>Si</th>
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<th>S</th>
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<tbody>
<tr>
<td>%</td>
<td>0.12% Max</td>
<td>17 - 19%</td>
<td>8 - 11%</td>
<td>8 - 10%</td>
<td>8 - 10%</td>
<td>8 - 10%</td>
<td>8 - 10%</td>
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**Hardness**
Soft (Annealed)

**Mechanical Properties**
- Tensile Strength: 100,000 to 180,000 psi
- Yield Strength: 60,000 to 150,000 psi
- Density: 0.280 lbs/cu in

**Size Range**
1.588 mm (1/16") to 7.62 mm (0.3")

**Standard Grades Available**
24, 48, 100, 200, 1000

---

**Stainless Steel AISI 316, 316L (Austenitic)**

**General Information**
Similar to AISI 302, 304 but with the addition of molybdenum improves corrosion resistance particularly to sulphuric acid compounds. These balls are used extensively in applications where contact is made with inks, photographic chemicals, bleaches, dyes and nitric acids. This is the only austenitic stainless steel ferrous ball manufacture and can be Magnetic and Non Magnetic.

**International Equivalents**
DIN 1.4404 Cr Ni Mo 17-4-PH, W.1 4401, JIS SUS 316

**Composition**
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<th>S</th>
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<tbody>
<tr>
<td>%</td>
<td>0.08% Max</td>
<td>10 - 12%</td>
<td>16 - 18%</td>
<td>0.05% Max</td>
<td>0.03% Max</td>
<td>0.03% Max</td>
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</tbody>
</table>

**Hardness**
Soft (Annealed)

**Mechanical Properties**
- Tensile Strength: 300,000 psi
- Yield Strength: 350,000 psi
- Density: 0.290 lbs/cu in

**Size Range**
1.588 mm (1/16") to 7.62 mm (0.3")

**Standard Grades Available**
24, 48, 100, 200, 1000
### Non Ferrous Metals

#### Tungsten Carbide Cobalt Binder

**General Information**
Tungsten Carbide materials have unique combinations of properties: high compressive strength, hardness and resistance to wear, as well as an ability to withstand shock and impact. Typical applications are Valves, Flowmeters, Ball Screws and Linear Bearings. Balls from this material are also used for Ballizing, Gauging and Ball Pens.

**Composition**
- Tungsten Carbide: 99 - 95%
- Co: 5 - 7%

**Hardness**
- HRC: 90.5 - 91.5

**Mechanical Properties (Typical)**
- Density: 14,947 - 15,020 kg/m³
- Thermal Conductivity: 100 W/mK
- Electrical Resistivity: 20 µΩm

**Size Range**
- 0.6 mm (0.024”) to 50.8 mm (2”)

**Standard Grades Available**
- 5, 10, 25, 100

#### Tungsten Carbide Nickel Binder

**General Information**
Conventional Tungsten Carbides (with Cobalt binder) has limited corrosion resistance, which makes them unsuitable for applications in which the wear parts are operating under both severe abrasive and corrosive conditions. As a general rule straight Tungsten Carbide (with Cobalt Binder) is resistant to corrosion down to pH 7. By comparison, tests have shown that our Tungsten Carbide (with Nickel binder) material is resistant to corrosion down to pH 2 or 3.

**Composition (8%) - R16C**
- Tungsten Carbide: 90 - 92%
- Nickel Base Binder: 8 - 10%

**Hardness**
- HRA: 88 - 89

**Size Range**
- 0.635 mm (0.025”) to 50.8 mm (2”)

**Standard Grades Available**
- 10, 25, 100

#### Titanium Alloys

**General Information**
Titanium balls provide low weight, good mechanical features, thermal properties and corrosion resistance. They are used even in aesthetic applications. Grade 1 and Grade 2 belongs to the Commercially pure Titanium Alloys family.

**Applications**
Titanium balls are used in Aviation, Aerospace, Military, Chemical, Petrochemical Industry, In the Medical Field, Jewelry, Calibration of Measurement Instruments, Piercing purposes.

**Chemical Composition**
- C: 0.08% Max
- N: 0.08% Max
- Ti: Balance
- Fe: 0.20% Max
- O: 0.18% Max
- H: 0.015% Max

**Hardness**
- HRC: 28-42

**Size Range**
- 1mm - 12mm

**Standard Grades Available**
- 100, 200

#### Hastelloy C276 Alloy Balls

**General Information**
Ni-based alloy balls, they show very good crevice, pitting and stress corrosion resistance, both on oxidising and reducing environments. Good wear resistance. Balls are provide in the passivated condition.

**Applications**
Special pumps and valves, they are applied in the Foodstuff, Paper, Chemical, Pharmaceuticals, Naval, Petrol, Textile industry. Devices for Waste Treatment, Pollution Check, Flue Gas Desulfurization, Turbines.

**Chemical Composition**
- C: 0.10 - 0.15%
- Mo: 14-16.5%
- W: 8-12%
- Fe: 6.5 - 7.5%
- Co: 2.5 % max.
- Ni: Balance

**Hardness**
- HRC: 32-48

**Size Range**
- 3/64” - 4” max

**Standard Grades Available**
- 100, 200
### PRECISION BALLS - NON FERROUS METALS

#### Inconel 625 Alloy Balls
**General Information**
Inconel 625 alloy balls, known for their high corrosion resistance, are well-suited for aggressive environments and provide excellent performance in various industries.

**Applications**
Inconel 625 alloy balls are used in aerospace, chemical, naval, military, nuclear, oil and gas industry, and high-temperature applications.

**Chemical Composition**
- C: 0.010% Max
- Si: 0.25% Max
- Mn: 1.00% Max
- P: 0.012% Max
- S: 0.030% Max
- Cr: 21.50 - 23.50%
- Ni: 38.00 - 41.00% (Max)
- Mo: 6.50 - 7.50%
- Cu: 3.50 - 3.95%
- Al: 0.25 - 1.00%
- Fe: 22.00 % Min

**Mechanical Properties**
- Tensile Strength: 580-650 Mpa
- Density: 8.34 g/cm³

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 100, 200, 500, 1000

#### Inconel 625 Alloy Balls
**General Information**
Inconel alloy ball are well-suited for high-temperature applications in various industries.

**Applications**
Inconel alloy balls are used in aerospace, chemical, naval, military, nuclear, oil and gas industry, and high-temperature applications.

**Chemical Composition**
- C: 0.010% Max
- Si: 0.10% Max
- Mn: 0.50% Max
- P: 0.017% Max
- S: 0.015% Max
- Cr: 20.00 - 23.00%
- Ni: 58.00% Min
- Cu: 0.10% Max
- Mo: 8.00 - 10.00%
- Nb: 3.15 - 3.71%
- Co: 1.00% Max
- Al: 0.40% Max
- Ti: 0.40% Max
- Fe: 5.00 % Max

**Mechanical Properties**
- Tensile Strength: 1000-1100 Mpa
- Density: 8.42 g/cm³

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 100, 200, 500, 1000

### PRECISION BALLS - NON FERROUS METALS

#### Copper Balls
**General Information**
Copper balls are known for their good mechanical properties and corrosion resistance, providing excellent electrical conductivity.

**Applications**
Copper balls are used in galvanic applications and in the field of electronic industry.

**Chemical Composition**
- Cu: 99.9% Min
- Other: 0.01% Max

**Mechanical Properties**
- Tensile Strength: 270-320 Mpa
- Density: 8.95 g/cm³

**Size Range**
- 3/64" - 1.5/8" max

**Standard Grades Available**
- 100, 200, 500, 1000

#### Brass Balls
**General Information**
Brass balls are known for their good mechanical properties and corrosion resistance, offering excellent electrical properties.

**Applications**
Brass balls are used in various applications such as bearings, pumps, valves, electronic devices, safety switches, heating units, appliances, furniture, and more.

**Chemical Composition**
- Cu: 68.00 - 70.50% (C36000)
- Zn: 30.00 - 31.50% (C36020)
- Pb: 0.010 Max (C36020)
- Fe: 0.010 Max (C36020)
- Sn: 0.030 Max (C36020)
- As: 0.010 Max (C36020)
- Sb: 0.010 Max (C36020)
- Bi: 0.010 Max (C36020)

**Mechanical Properties**
- Tensile Strength: 100 - 200 Mpa
- Density: 8.49 g/cm³

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 28, 40, 100, 200

### Monel K 400 Alloy Balls
**General Information**
Monel K 400 alloy balls are known for their good mechanical characteristics and excellent corrosion resistance.

**Applications**
Monel K 400 alloy balls are used in the aerospace, pharmaceutical, naval, petroleum and textile industries.

**Chemical Composition**
- C: 0.052% Max
- Mn: 2.00% Max
- S: 0.020% Max
- Ni: 63.00 - 70.00%
- Cu: 29.00 - 34.00%
- Co: 1.00% Max
- Fe: 2.50% Max

**Mechanical Properties**
- Tensile Strength: 470-770 Mpa
- Density: 8.82 g/cm³

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 25, 100, 200

### Monel K 500 Alloy Balls
**General Information**
Monel K 500 alloy balls are known for their good mechanical characteristics and excellent corrosion resistance.

**Applications**
Monel K 500 alloy balls are used in the aerospace, pharmaceutical, naval, petroleum and textile industries.

**Chemical Composition**
- C: 0.25% Max
- Si: 0.10% Max
- Mn: 1.50% Max
- S: 0.010% Max
- Ni: 63.00 - 70.00% Max
- Cu: 27.00 - 32.00% Max
- Co: 1.00 - 1.50%
- Fe: 2.00 - 2.50%

**Mechanical Properties**
- Tensile Strength: 590-1000 Mpa
- Density: 8.42 g/cm³

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 78, 100, 200, 100, 500, 1000

### Alloy 28 Balls
**General Information**
Alloy 28 is a nickel-titanium austenitic alloy that is known for its resistance to stress corrosion cracking.

**Applications**
Alloy 28 balls are used in various applications where high wear, corrosion and temperature resistance are required.

**Chemical Composition**
- Ni: 72.00 - 73.00%
- Fe: Balance
- Cu: 1.20 - 1.40%
- Mg: 0.80 - 1.00%
- Cu: 0.70 - 1.00%
- Mn: 0.20% Max
- Si: 0.10% Max
- Sn: 0.10% Max
- Bi: 0.10% Max
- Mechanical Properties
  - Tensile Strength: 80 ksi
  - Yield Min: (2% Offset): 35 ksi
  - Elasticity Min: 50%
  - Reduction of Area Min: 50%

**Size Range**
- 3/64" - 4" max

**Standard Grades Available**
- 28, 40, 100, 200
### Dimensional Conversion Chart

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<tr>
<th>Inch Fractions</th>
<th>Inch Decimals</th>
<th>Metric mm</th>
<th>Weight per 1000 lbs kg</th>
<th>Inch Fractions</th>
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<td>3/4</td>
<td>9.7547</td>
<td>24.615</td>
<td>5877/64</td>
<td>63/32</td>
<td>4.3214</td>
<td>11.4765</td>
<td>6337/64</td>
</tr>
<tr>
<td>7/8</td>
<td>14.1994</td>
<td>35.952</td>
<td>9219/64</td>
<td>67/32</td>
<td>4.6563</td>
<td>12.4615</td>
<td>9219/64</td>
</tr>
<tr>
<td>11/16</td>
<td>17.8284</td>
<td>45.778</td>
<td>1262/64</td>
<td>13/16</td>
<td>5.3125</td>
<td>13.7938</td>
<td>1562/64</td>
</tr>
<tr>
<td>3/4</td>
<td>19.7547</td>
<td>49.470</td>
<td>2477/64</td>
<td>15/16</td>
<td>6.2143</td>
<td>16.4765</td>
<td>2937/64</td>
</tr>
<tr>
<td>15/16</td>
<td>23.125</td>
<td>58.750</td>
<td>3237/64</td>
<td>17/16</td>
<td>6.9375</td>
<td>18.1994</td>
<td>3595/64</td>
</tr>
<tr>
<td>23/32</td>
<td>27.8125</td>
<td>68.1994</td>
<td>4768/64</td>
<td>25/32</td>
<td>8.1250</td>
<td>20.3750</td>
<td>5625/64</td>
</tr>
<tr>
<td>5/4</td>
<td>29.3750</td>
<td>74.3750</td>
<td>5877/64</td>
<td>27/16</td>
<td>8.4375</td>
<td>21.4815</td>
<td>6375/64</td>
</tr>
<tr>
<td>7/4</td>
<td>37.03125</td>
<td>93.8281</td>
<td>9219/64</td>
<td>29/16</td>
<td>9.0625</td>
<td>23.0625</td>
<td>1188/64</td>
</tr>
</tbody>
</table>

The weight shown are based on chrome alloy steel balls, approximate weight for other materials can be obtained by multiplying the weight per 1000 lbs by the following figures:

<table>
<thead>
<tr>
<th>Material</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>1.000</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1.021</td>
</tr>
</tbody>
</table>

### Technical Data

#### Tolerances by Grade for Individual Balls

<table>
<thead>
<tr>
<th>Ball Grade</th>
<th>Allowable Ball Diameter Variation</th>
<th>Allowable Deviation From Spherical Form</th>
<th>Maximum Surface Roughness Arithmetic Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.05</td>
</tr>
<tr>
<td>Grade 2</td>
<td>0.00003</td>
<td>0.00003</td>
<td>0.15</td>
</tr>
<tr>
<td>Grade 3</td>
<td>0.00010</td>
<td>0.00010</td>
<td>0.30</td>
</tr>
<tr>
<td>Grade 4</td>
<td>0.00016</td>
<td>0.00016</td>
<td>0.45</td>
</tr>
<tr>
<td>Grade 5</td>
<td>0.00024</td>
<td>0.00024</td>
<td>0.60</td>
</tr>
<tr>
<td>Grade 6</td>
<td>0.00040</td>
<td>0.00040</td>
<td>0.80</td>
</tr>
<tr>
<td>Grade 7</td>
<td>0.00080</td>
<td>0.00080</td>
<td>1.00</td>
</tr>
</tbody>
</table>

#### Definitions

**Nominal Ball Diameter**: The diameter value that is used for the purpose of general identification of a ball size, e.g., 1/4", 5/32", etc.

**Single Diameter of a Ball**: The distance between two parallel planes tangent to the surface of the ball.

**Mean Diameter of a Ball**: The arithmetic mean of the largest and the smallest actual diameters of the ball.

**Ball Diameter Variation**: The difference between the largest and the smallest actual diameters of one ball.

**Deviation from Spherical Form**: The greatest radial distance in any radial plane across a sphere circumscribed around the ball surface and any point on the ball surface.

**Lot Definition**: Quantities of balls manufactured under conditions which are presumed uniform and which is considered and identified as an entity.

**Lot Mean Diameter**: The arithmetic mean of the mean diameter of the largest ball and that of the smallest ball in the lot.

**Lot Diameter Variation**: The difference between the mean diameter of the largest ball and that of the smallest ball in the lot.

**Nominal Ball Diameter Tolerance**: The maximum allowable deviation of any ball lot mean diameter from the nominal Ball Diameter.

**Specific Diameter**: The amount by which the lot mean diameter differs from the nominal diameter, accurate to the marking increment for that grade.

#### Ball Grade

A specific combination of dimensional form and surface roughness tolerances. A ball grade is designated by a grade number.

**Ball Gauge**: The prescribed small amount by which the lot mean diameter should differ from nominal diameter, this amount being one of an established series of amounts.

**Ball Gauge Deviation**: The difference between the lot mean diameter and the sum of the nominal diameter and the ball gauge.

**Ball Diameter**: The distance between two parallel planes tangent to the surface of the ball.

**Mean Ball Diameter**: The arithmetic mean of the diameter of the largest ball and that of the smallest ball in the lot.

**Deviation Form Spherical Form**: The greatest radial distance in any radial plane around a sphere circumscribed around the ball surface and any point on the ball surface.

**Surface Roughness**: A measure of surface finish quality that is determined by the roughness of the surface. It is typically expressed as the peak-to-valley height.

**Waviness**: The more widely spaced circumferential component of surface texture.

**Hardness**: A measure of the hardness of the material, which is typically measured using a hardness tester such as a Rockwell or Brinell hardness tester.

**Case Depth**: The depth of the case that has been produced by a hardening process such as heat treatment.
CERAMIC BALLS

Ceramic Balls

Ceramic balls are particularly suited to harsh environments. Their main advantages over steel is that they have a density of 40% lower than steel. Have 29% lower thermal expansion and are 150% harder. In certain high-speed applications their life is extended by as much as a hundred times. The three main materials used are Alumina Oxide, Zirconia Oxide and Silicon Nitride.

Si₃N₄, Silicon Nitride:
The most widely used type of ceramic due to very high resistance to wear and abrasion in general. It has a micro - structure specially designed for applications subject to great stress. It does not require lubrication, is resistant to corrosion, anti magnetic and electrically insulating, and it continues to be efficient at high temperatures up to +1400 °C. It combines extreme hardness with a high precision ball. Si₃N₄ balls are widely used in high precision bearings in the aerospace industry, for machine tools, measurement instruments, mechanical centrifuges, radar and missiles, pumps and compressors.

Al₂O₃, 99.50% Alumina (Alumina Oxide):
The material has a multi-crystal structure and excellent resistance to abrasion and high temperatures. It is resistant to most corrosive agents, but it is not recommended for use in contact with hydrochloric and hydrofluoric acid or strong alkaline solutions. Al₂O₃ balls are used in valves, pumps and ball bearings.

ZrO₂, Zirconium Oxide:
The material, compared has a high degree of compactness and considerable flexural strength, which makes it very reliable. It also has a low modulus of elasticity, close to that of steel, together with an extraordinarily low thermal conductivity.

Al₂O₃, 99.99% Ruby:
This material has a non porous single crystal structure used where particular hardness and extreme resistance to wear are required together with a low specific weight and properties of chemical inertia. The material consists of pure aluminium oxide with a small percentage of chromo oxide which gives it its characteristic red colour, which is the most visible feature of these balls in many applications as measurement and control instruments, valves and pumps.

Al₂O₃, 99.99% Sapphire:
This material has a single crystal structure and unlike ruby is transparent. Because of its optical properties and high refraction index. Balls made of this material are currently used as chemically inert lenses.

CERAMIC BALLS - PROPERTIES OF MATERIALS

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES</th>
<th>SAPPHIRE AND RUBY</th>
<th>ALUMINA OXIDE</th>
<th>SILICON NITRIDE</th>
<th>ZIRCONIUM OXIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE</td>
<td>single crystal</td>
<td>multi-crystal</td>
<td>multi-crystal</td>
<td>multi-crystal</td>
</tr>
<tr>
<td>CHEMICAL FORMULA</td>
<td>Al₂O₃</td>
<td>Al₂O₃</td>
<td>Si₃N₄</td>
<td>ZrO₂</td>
</tr>
<tr>
<td>PURITY %</td>
<td>99.99</td>
<td>99.8</td>
<td>95.00</td>
<td>97.00</td>
</tr>
<tr>
<td>DENSITY g/cm³</td>
<td>3.99</td>
<td>3.90</td>
<td>3.20</td>
<td>5.50</td>
</tr>
<tr>
<td>OPERATING TEMPERATURE °C</td>
<td>1800</td>
<td>1100</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>MELTING POINT</td>
<td>2050 °C</td>
<td>2050 °C</td>
<td>1900 °N</td>
<td></td>
</tr>
<tr>
<td>SOFTENING POINT</td>
<td>1800 °C</td>
<td>1775 °N</td>
<td>1400 °N</td>
<td></td>
</tr>
<tr>
<td>SPECIFIC HEAT AT 25 °C (J/g·°C)</td>
<td>0.18</td>
<td>0.25</td>
<td>0.17</td>
<td>9</td>
</tr>
<tr>
<td>THERMAL CONDUCTIVITY</td>
<td>36 W/m·K</td>
<td>29 W/m·K</td>
<td>29 W/m·K</td>
<td></td>
</tr>
<tr>
<td>MECHANICAL PROPERTIES</td>
<td>SAPPHIRE AND RUBY</td>
<td>ALUMINA OXIDE</td>
<td>SILICON NITRIDE</td>
<td>ZIRCONIUM OXIDE</td>
</tr>
<tr>
<td>VICKERS HARDNESS (N/mm²)</td>
<td>17000</td>
<td>16500</td>
<td>24000</td>
<td>20000</td>
</tr>
<tr>
<td>MODULUS OF ELASTICITY (N/mm²)</td>
<td>4,3610¹⁰</td>
<td>3,5610¹⁰</td>
<td>3,1610¹⁰</td>
<td>2810¹⁰</td>
</tr>
<tr>
<td>BENDING MODULUS AT 25 °C (N/mm²)</td>
<td>392</td>
<td>470</td>
<td>700</td>
<td>800</td>
</tr>
<tr>
<td>COMpressive STRENGTH AT 25 °C (N/mm²)</td>
<td>2060</td>
<td>2354</td>
<td>2500</td>
<td>2100</td>
</tr>
</tbody>
</table>

CHEMICAL RESISTANCE

SAPPHIRE / RUBY: Inert to most acids at very high temperatures.

ALUMINA (OXIDE): Inert to most acids, but not recommended in environments with hydrochloric or hydrofluoric acids or strong alkaline solutions.

SILICON NITRIDE: Inert to most acids.

ZIRCONIUM OXIDE: Inert except to hydrofluoric acid and strong concentrations of sulphuric acid.
**Plastic Balls**

Plastic balls are manufactured from standard and specially polymer resins in sizes from 3/32" - (2.38 mm) to 5" - (127 mm). Balls above 1" - (25.4 mm) are manufactured from extruded rod.

Plastic balls are a cost-effective substitute for metallic balls in low load bearings. They are also used as agitators in aerosol spray cans, lightweight check valves, medical diagnostics, and a wide variety of other applications.

Tolerances to +/- 0.0005" (+/- 0.0125 mm) are possible for certain materials such as nylon and acetal. Surfaces can be tailored from rough to highly polished finishes.

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>ACETAL</th>
<th>POLYAMIDE</th>
<th>POLYETHYLENE LOW DENSITY</th>
<th>POLYETHYLENE HIGH DENSITY</th>
<th>PTFE FLUOROCARBON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHYSICAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPECIFIC GRAVITY</td>
<td>1.42</td>
<td>1.13-1.15</td>
<td>0.910-0.925</td>
<td>0.943-0.965</td>
<td>2.14-2.20</td>
</tr>
<tr>
<td>WATER ABSORPTION (IN. IN. THICK SPECIMEN SATURATION)</td>
<td>0.25-0.40</td>
<td>1.0-1.3</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>DIELECTRIC STRENGTH (IN. IN. THICK SPECIMEN SHORT TIME V/MIL)</td>
<td>500 (90mil)</td>
<td>600²</td>
<td>450-1000</td>
<td>450-500</td>
<td>480</td>
</tr>
<tr>
<td><strong>MECHANICAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TENSILE STRENGTH AT BREAK (PSI)</td>
<td>12,000 (1,000)</td>
<td>800-2,300</td>
<td>3,100-5,500</td>
<td>2,000-5,000</td>
<td></td>
</tr>
<tr>
<td>ELONGATION AT BREAK (%)</td>
<td>25-75</td>
<td>60⁰, 300⁰</td>
<td>90-800</td>
<td>20-180</td>
<td>100-400</td>
</tr>
<tr>
<td>TENSILE YIELD STRENGTH (PSI)</td>
<td>9500-12,000</td>
<td>800⁰, 650⁰</td>
<td>800-1200</td>
<td>3000-4000</td>
<td></td>
</tr>
<tr>
<td>COMPRESSIVE STRENGTH (MILLION OF YIELD) (PSI)</td>
<td>18,000 (10%)</td>
<td>15,000 (10,000, P.D.)</td>
<td>2,700-3,400</td>
<td>3,700</td>
<td></td>
</tr>
<tr>
<td>FLEXURAL STRENGTH (MILLION OF YIELD) (PSI)</td>
<td>14,000</td>
<td>17,000 (2,100⁰)</td>
<td>1,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TENSILE MODULUS 10⁷ PSI</td>
<td>520</td>
<td>14-38</td>
<td>50-180</td>
<td>58-80</td>
<td></td>
</tr>
<tr>
<td>COMPRESSIVE MODULUS 10⁶ PSI</td>
<td>670</td>
<td></td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLEXURAL MODULUS 10⁶ PSI</td>
<td>130-430</td>
<td>420 (185⁰)</td>
<td>8-60</td>
<td>100-260</td>
<td></td>
</tr>
<tr>
<td>150 IMPACT FT-LB (FULL THICK SPECIMEN)</td>
<td>1-2.3</td>
<td>0.8-1.0 (7.2-11)</td>
<td>NO BREAK</td>
<td>0.25-20</td>
<td></td>
</tr>
<tr>
<td>HARDNESS</td>
<td>ROCKWELL HARDNESS</td>
<td>M94</td>
<td>R120³ MBR³</td>
<td>D40-51</td>
<td>D60-70</td>
</tr>
<tr>
<td><strong>THERMAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTE. OF LINEAR THERMAL EXPANSION 10⁵ IN./IN.¹⁰ C</td>
<td>100</td>
<td>80</td>
<td>100-2200</td>
<td>110-130</td>
<td></td>
</tr>
<tr>
<td>DEFLECTION TEMPERATURE (FLEXURAL LOAD) -¹⁰⁰⁰°C</td>
<td>264⁰</td>
<td>167⁰</td>
<td>90-105</td>
<td>110-130</td>
<td></td>
</tr>
<tr>
<td>66³PSI</td>
<td>338</td>
<td>474⁰</td>
<td>100-121</td>
<td>140-190</td>
<td></td>
</tr>
<tr>
<td>THERMAL CONDUCTIVITY 50³ C (W/M/°C)</td>
<td>5.5</td>
<td>5.8</td>
<td>8</td>
<td>11-12</td>
<td>6.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPHERICITY</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE</td>
<td>INCHES</td>
</tr>
<tr>
<td>0⁺</td>
<td>0.0805</td>
</tr>
<tr>
<td>I</td>
<td>0.0805</td>
</tr>
<tr>
<td>II</td>
<td>0.005</td>
</tr>
<tr>
<td>III</td>
<td>0.005</td>
</tr>
</tbody>
</table>

*Only available in certain materials*
Glass Balls

Glass Balls are dimensionally stable, resist corrosion and chemical absorption and can withstand high temperatures (up to 600° F.). Density varies depending on the type of glass used to manufacture the ball. We provide high precision balls from the following types of glass:

**SODA-LIME GLASS**

Material resistant to high alkaline solutions. Soda-lime glass balls are mainly used for applications not subjected to strong mechanical or thermal shocks, such as plastic bearings, flow meters, measurement and control equipment, instruments and ink cartridges.

**BOROSILICATE GLASS**

Due to its excellent chemical inertia to most acids, this kind of glass is particularly suitable for metering pumps and valves against strong oxidising concentrations.

**BLACK GLASS**

A kind of glass often used for medical and chemical flow meters and for general measurement and control instruments.

<table>
<thead>
<tr>
<th>CHEMICAL COMPOSITION %</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>SIO₂</td>
<td>NAO₂</td>
<td>CaO</td>
<td>Al₂O₃</td>
<td>A₂O₅</td>
<td>MgO</td>
</tr>
<tr>
<td>Soda-Lime Glass</td>
<td>67</td>
<td>16</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Borosilicate Glass</td>
<td>81</td>
<td>4</td>
<td>-</td>
<td>2</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Black Glass</td>
<td>69.7</td>
<td>15.2</td>
<td>3.4</td>
<td>-</td>
<td>1.3</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>SODA-LIME GLASS</th>
<th>BOROSILICATE GLASS</th>
<th>BLACK GLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Weight</td>
<td>2.50</td>
<td>2.23</td>
<td>2.55</td>
</tr>
<tr>
<td>Hardness (KNOOP-KHN)</td>
<td>465</td>
<td>418</td>
<td>405</td>
</tr>
<tr>
<td>Melting Point °C</td>
<td>695</td>
<td>820</td>
<td>650</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAX TEMPERATURE USE (mechanical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal °C</td>
</tr>
<tr>
<td>Extreme °C</td>
</tr>
<tr>
<td>Resistance to Thermal Stress</td>
</tr>
</tbody>
</table>
Burnishing Media

Burnishing Media can be balls or peculiar shapes which are used for polishing the rough surfaces of many different metal components. The different shapes are designed to get into the varying crevices and contours of diverse metal products.

| CASE HARDENED CARBON STEEL | AISI 1010 / 1018 | HARDNESS HRC 60 |
| THROUGH HARDNESS CARBON STEEL | AISI 1070 | HARDNESS HRC 80 |
| CHROME STEEL | EN31 / AISI E 52100 | HARDNESS HRC 60-66 |
| STAINLESS STEEL | AISI 420 | HARDNESS HRC 48-55 |
| STAINLESS STEEL | MAGNETIC | AISI 304 / 316 | HARDNESS HRC 25-39 |
| STAINLESS STEEL | NON MAGNETIC | AISI 304 / 316 | HARDNESS - NA |
| ZIRCONIA CERAMIC | ZrO2 | HARDNESS 1100 HV |

Shapes

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIZE RANGE</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALLS</td>
<td>1” to 4”</td>
<td>ALL</td>
</tr>
<tr>
<td>BALL CONES</td>
<td>1” to 3”</td>
<td>AISI 1010 / 1018 AISI 1070 AISI 420 AISI 304 / 316</td>
</tr>
<tr>
<td>BARRELS</td>
<td>1” to 3”</td>
<td>AISI 1070 AISI 304 / 316</td>
</tr>
<tr>
<td>OVALS</td>
<td>1” to 5/8”</td>
<td>AISI 1010 / 1018 AISI 420 AISI 304 / 316</td>
</tr>
<tr>
<td>DIAGONALS</td>
<td>1” to 3/4”</td>
<td>AISI 1010 / 1018 AISI 420 AISI 304 / 316</td>
</tr>
<tr>
<td>PINS</td>
<td>1.5 mm x 10 mm</td>
<td>EN 31 AISI 420 AISI 304 / 316</td>
</tr>
<tr>
<td>FLAT PINS</td>
<td>1.2mm x 2.5mm x 10mm</td>
<td>EN 31 AISI 420 AISI 304 / 316</td>
</tr>
</tbody>
</table>
## CERAMIC BALLS - GRINDING MEDIA

### Zirconia Toughened Alumina
**Description:**
Zirconia Toughened Alumina bead was sintered from alumina powder and zirconium silicate powder. Compared to the alumina beads, it is an economic ceramic bead to replace kaolin bead, silica sand and other natural grinding media.

**Chemical Composition:**
Composition: Al₂O₃, ZrO₂, SiO₂
With: 65-75 6-12 6-8

**Physical Properties:**
- Specific Gravity: 3.1-3.2kg/dm³
- Bulk Density: 2.0-2.2kg/L
- Micro hardness: 9000kg/mm²
- Strength: 120kgf/10mm
- Wear Rate: <100kg/L
- Color: Shell

### Zirconium Silicate Beads
**Description:**
Zirconium silicate beads are made from the high grade Australian zircon sand with granulating shaped method and hardened by sintering. The unique formula and producing procedure offer you a middle density and hardness, high wear resistance middle hard particles in the low to middle viscosity range slurry.

**Chemical Composition:**
Composition: Al₂O₃, SiO₂, ZrO₂
With: 60-64 36-33 5-9

**Physical Properties:**
- Specific Gravity: 4.0-4.2kg/dm³
- Bulk Density: 2.5-2.8kg/L
- Micro hardness: 1000kg/mm²
- Strength: 7-8

### Microcrystal Alumina Beads
**Description:**
Microcrystal alumina bead is made from high purity alumina powder and silica powder with sintering method. The micro size of polycrystals contributes high wear resistance and idea strength. It is a wear choice to replace the carbon steel beads to grind the metallic and non-metallic minerals.

**Chemical Composition:**
Composition: Al₂O₃, SiO₂, Others
With: 95-99 6 1-2

**Physical Properties:**
- Specific Gravity: 3.5-3.7kg/dm³
- Bulk Density: 2.2-2.3kg/L
- Micro hardness: 1300kg/mm²
- Strength: 120kgf/10mm
- Wear Rate: <200kg/L
- Color: White

### Alumina Toughened Zirconia
**Description:**
Alumina Toughened Zirconia bead was granulated from the ultra fine zirconium dioxide and alumina powder. The consistent micro powndrystal contributes high compressive strength and wear resistance of beads. Although there is a lower density than ZTGP (ytsylit-tetragonal Zirconia polycrystal), the lower unit cost is an obvious plus. It can replace it in more application and is competent the mills with high tip speed up to 14m/s.

**Chemical Composition:**
Composition: Al₂O₃, ZrO₂, SiO₂
With: 65-75 6-12 6-8

**Physical Properties:**
- Specific Gravity: 3.1-3.2kg/dm³
- Bulk Density: 2.0-2.2kg/L
- Micro hardness: 9000kg/mm²
- Strength: 7-8

## GLASS BALLS - GRINDING MEDIA

### Soda Lime Glass Balls
**Chemical Composition:**
<table>
<thead>
<tr>
<th>SiO₂</th>
<th>Na₂O</th>
<th>CaO</th>
<th>MgO</th>
<th>Al₂O₃</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>73.58%</td>
<td>3.64%</td>
<td>9.06%</td>
<td>4.22%</td>
<td>0.58%</td>
<td></td>
</tr>
</tbody>
</table>

### Aluminium BoroSilicate Balls
**Chemical Composition:**
<table>
<thead>
<tr>
<th>SiO₂</th>
<th>Na₂O</th>
<th>CaO</th>
<th>MgO</th>
<th>Al₂O₃</th>
<th>B₂O₃</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.58%</td>
<td>10.18%</td>
<td>54.80%</td>
<td>3.66%</td>
<td>2.33%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Soda Lime
**Chemical Composition:**
<table>
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<th>SiO₂</th>
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<th>MgO</th>
<th>Al₂O₃</th>
<th>B₂O₃</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>66.76%</td>
<td>14.66%</td>
<td>7.59%</td>
<td>4.67%</td>
<td>2.90%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figures are reference values.**

### Available Standard Sizes

#### Glass Balls

<table>
<thead>
<tr>
<th>Size Range (mm)</th>
<th>Bulk Density (kg/l)</th>
<th>Pieces/1000 gr</th>
<th>Size Range (mm)</th>
<th>Bulk Density (kg/l)</th>
<th>Pieces/1000 gr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50-0.75</td>
<td>1.55</td>
<td>320370</td>
<td>2.00-2.50</td>
<td>1.55</td>
<td>64730</td>
</tr>
<tr>
<td>0.75-1.00</td>
<td>1.54</td>
<td>110070</td>
<td>2.50-3.00</td>
<td>1.53</td>
<td>83540</td>
</tr>
<tr>
<td>1.00-1.40</td>
<td>1.53</td>
<td>426700</td>
<td>3.00-3.50</td>
<td>1.52</td>
<td>24750</td>
</tr>
<tr>
<td>1.40-1.70</td>
<td>1.53</td>
<td>234800</td>
<td>3.50-4.00</td>
<td>1.50</td>
<td>10310</td>
</tr>
<tr>
<td>1.70-2.10</td>
<td>1.53</td>
<td>107500</td>
<td>4.00-4.50</td>
<td>1.50</td>
<td>8380</td>
</tr>
</tbody>
</table>

#### Alumina Toughened Zirconia

<table>
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<th>Size Range (mm)</th>
<th>Bulk Density (kg/l)</th>
<th>Pieces/1000 gr</th>
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<th>Pieces/1000 gr</th>
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</tr>
</tbody>
</table>

*Special sizes are available upon request. Figures of Bulk Density are reference Values.*
**AISI S-2 TOOL STEEL BALLS**

**General Information**
S-2 Tool steel balls are designed to achieve extreme ruggedness. The ball surface has a smooth ground and polished finish. These balls provide the toughness and strength necessary for severe shock loads. S-2 Tool steel balls are hardened throughout and have unusually good wear characteristics. S-2 Tool Steel Balls find most frequent use in oil field equipment and offshore drilling operations. They provide good service in withstanding the abrasion of pulverized rock and mud slurries.

**International Equivalents**
ASTM A681, UNS T-4190

**Chemical Composition**
- C: 0.47-0.52%
- Si: 0.16-1.30%
- Mn: 0.46-0.50%
- P: 0.025% Max
- S: 0.25% Max
- Cr: 0.20% Max
- Mo: 0.045% Max
- Ni: 0.50% Max
- V: 0.025% Max

**Hardness**
HRC: 55-58

**AISI S2 TOOL STEEL ROLLERS**

**Types of Rollers**
- Cylindrical Rollers
- Taper Rollers
- Needle Rollers

**Applications**
- Bearings for construction and heavy duty machinery
- Hinge in technical applications
- Offshore, wind energy
- Linear slide – guidance
- Directional valve
- Shafts, arbour or axles