



## Precision Balls

[www.bibus.de](http://www.bibus.de)

**BIBUS<sup>®</sup>**  
■■■■ SUPPORTING YOUR SUCCESS

[www.thomsonlinear.com](http://www.thomsonlinear.com)

**THOMSON<sup>®</sup>**

## Thomson – the Choice for Optimized Motion Solutions

Often the ideal design solution is not about finding the fastest, sturdiest, most accurate or even the least expensive option. Rather, the ideal solution is the optimal balance of performance, life and cost.

### The Best Positioned Supplier of Mechanical Motion Technology

Thomson has several advantages that makes us the supplier of choice for motion control technology.

- Thomson own the broadest standard product offering of mechanical motion technologies in the industry.
- Modified versions of standard product or white sheet design solutions are routine for us.
- Choose Thomson and gain access to over 70 years of global application experience in industries including packaging, factory automation, material handling, medical, clean energy, printing, automotive, machine tool, aerospace and defense.
- As part of Fortive Corporation, we are financially strong and unique in our ability to bring together control, drive, motor, power transmission and precision linear motion technologies.

### A Name You Can Trust

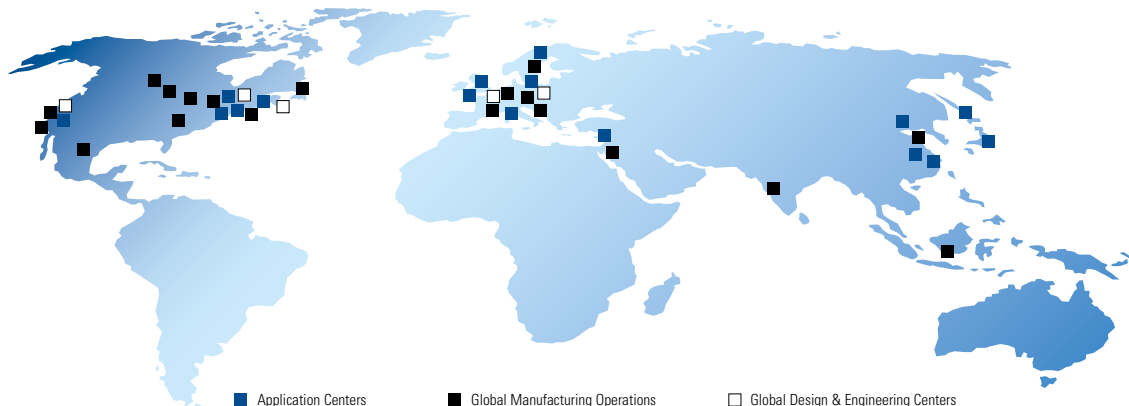
A wealth of product and application information as well as 3D models, software tools, our distributor locator and global contact information is available at [www.thomsonlinear.com](http://www.thomsonlinear.com). For assistance in Europe, contact us at +44 1271 334 500 or e-mail us at [sales.uk@thomsonlinear.com](mailto:sales.uk@thomsonlinear.com).

Talk to us early in the design process to see how Thomson can help identify the optimal balance of performance, life and cost for your next application. And, call us or any of our 2000+ distribution partners around the world for fast delivery of replacement parts.

### The Fortive Business System

The Fortive Business System (FBS) was established to increase the value we bring to customers. It is a mature and successful set of tools we use daily to continually improve manufacturing operations and product development processes. FBS is based on the principles of Kaizen which continuously and aggressively eliminate waste in every aspect of our business. FBS focuses the entire organization on achieving breakthrough results that create competitive advantages in quality, delivery and performance – advantages that are passed on to you. Through these advantages Thomson is able to provide you faster times to market as well as unsurpassed product selection, service, reliability and productivity.

### Local Support Around the Globe



## Table of Contents

## Table of Contents

|                                                                                   |         |
|-----------------------------------------------------------------------------------|---------|
| Introduction,<br>Material Characteristics, How to Order. ....                     | 4 and 5 |
| Ball Hardness Correction Chart .....                                              | 6       |
| Corrosion Resistance Properties Chart .....                                       | 7       |
| ABMA Definitions .....                                                            | 8       |
| Ball Grade Charts .....                                                           | 9       |
| 52100 Chrome Steel Balls .....                                                    | 10      |
| 440C stainless Steel Balls .....                                                  | 12      |
| 302, 302HQ, 316 and 316L Stainless Steel Balls .....                              | 14      |
| Monel and K-Monel Balls .....                                                     | 15      |
| Brass and Bronze Balls .....                                                      | 16      |
| Burnishing Media .....                                                            | 17      |
| Nylon and Specialty Plastic Balls .....                                           | 18      |
| Ceramic Balls .....                                                               | 19      |
| Titanium and Hollow 440A Stainless Steel/<br>Type 430 Stainless Steel Balls ..... | 20      |
| Metric Equivalents Dimensional Conversion Chart .....                             | 21      |
| Quick Quote Fax Form .....                                                        | 22      |
| A2LA Accredited Calibration Lab .....                                             | 23      |

### Choose Thomson as your Precision Ball Supplier.

THE ONLY BALL MANUFACTURER MEETING THESE CRITERIA:

ISO 9001:2000 Registered

- A2LA Accredited Calibration Lab (Spheres)
- Three-Time GM Supplier of the Year
- Two-Time ITT Supplier Gold Award Recipient
- Hollow, Ceramic and Specialty Balls
- Worldwide Service and Support

The Most Complete Variety of Precision Balls, Ball Materials and Technologies

## Overview

# Quality Ball Technology from Danaher Motion

Expect only the finest in quality ball technology from Danaher Motion. Danaher Motion offers ball sphericity within 3 millionths of an inch (0.077 micron), 100% quality inspection, and a choice of 27 high performance materials—all guaranteed to meet or exceed the standards of the American Bearing Manufacturers Association (ANSI/ABMA Std. 10-1989).

The specifications for each Thomson quality ball are presented in this guide. Material characteristics are explained below. Each material's compositional analysis, mechanical properties and various testing standards are described with the ball engineering specifications within the guide.

In addition, a fraction - to - decimal - to - millimeter conversion chart is provided for your convenience. For more detailed information on Thomson quality ball technology, contact us directly at 1-540-633-3400.

### How to Order:

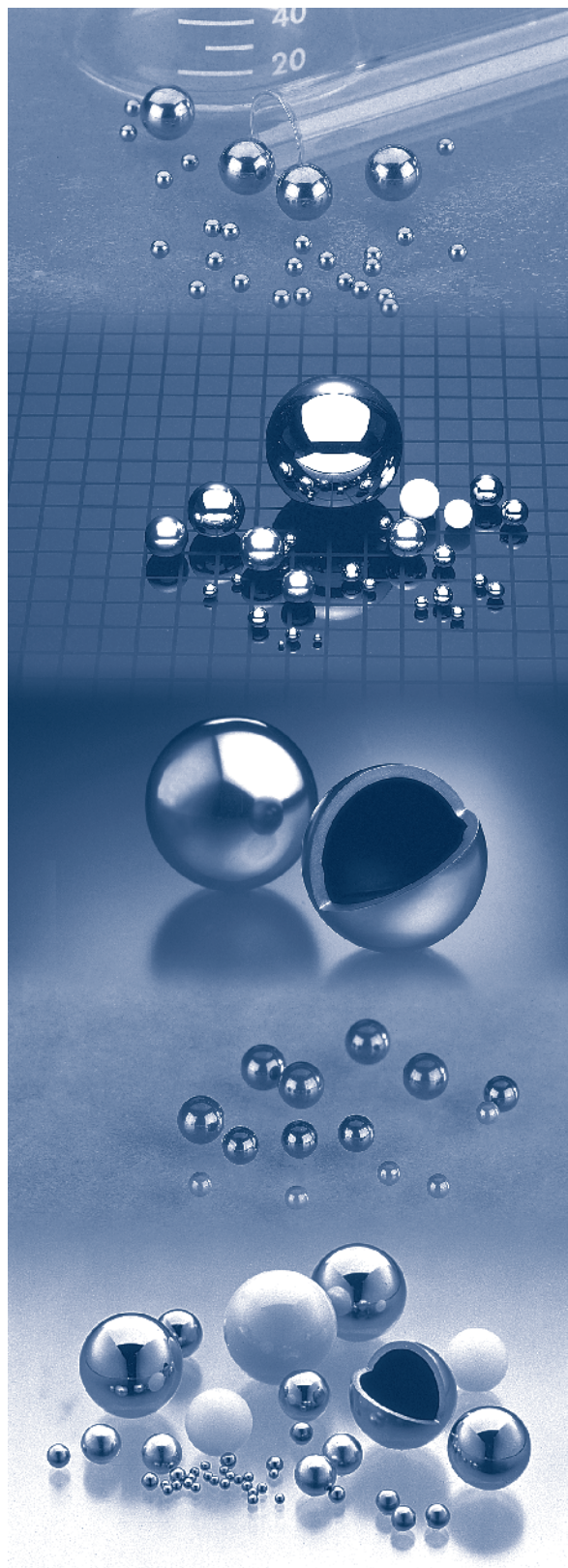
When ordering balls, please specify the following:

- Nominal ball diameter
- Type of material
- Grade
- Ball Gage† (if applicable)

All standard balls are always in stock and ready for immediate off-the-shelf delivery. If your application calls for custom balls, send us your specifications and we'll gladly meet them.

To place your order, call us: 540-633-3400,  
or fax: 540-639-4162  
or email at [ballrfqs@danahermotion.com](mailto:ballrfqs@danahermotion.com)

†Since the ball gage is the desired amount by which the lot mean diameter should differ from the nominal diameter, it must be expressed with the proper algebraic sign (+ or -).



## Hardness Correction

### Hardness Correction Table

Corrections to be added to Rockwell "C" readings taken on the spherical surface for equivalent measure on parallel flats. These correction factors apply only to chrome and AISI-Type 440 stainless steel balls.

Hardness readings of balls taken on spherical surfaces are affected by the curvature and hardness of the ball. Because of these factors, corrections are necessarily added to the hardness read on ball surface to obtain the equivalent hardness on a flat surface. For ball sizes not shown, interpolate between values at right.

| Rockwell "C" Readings |                |      |       |      |       |      |        |      |        |      |        |    |
|-----------------------|----------------|------|-------|------|-------|------|--------|------|--------|------|--------|----|
| (Curved surface)      | Ball Diameters |      |       |      |       |      |        |      |        |      |        |    |
|                       | 5/16"          | 3/8" | 7/16" | 1/2" | 9/16" | 5/8" | 11/16" | 3/4" | 13/16" | 7/8" | 15/16" | 1" |
| 55                    | 3.1            | 2.5  | 2.1   | 1.8  | 1.6   | 1.4  | 1.3    | 1.1  | 1.0    | 1.0  | .8     | .8 |
| 56                    | 2.9            | 2.4  | 2.0   | 1.6  | 1.5   | 1.3  | 1.2    | 1.0  | .9     | .9   | .7     | .7 |
| 57                    | 2.7            | 2.2  | 1.8   | 1.5  | 1.4   | 1.2  | 1.1    | .9   | .8     | .8   | .7     | .6 |
| 58                    | 2.6            | 2.1  | 1.7   | 1.4  | 1.2   | 1.1  | 1.0    | .8   | .7     | .7   | .6     | .5 |
| 59                    | 2.4            | 1.9  | 1.6   | 1.3  | 1.1   | 1.0  | .9     | .7   | .7     | .6   | .5     | .4 |
| 60                    | 2.2            | 1.8  | 1.5   | 1.2  | 1.0   | .9   | .8     | .7   | .6     | .5   | .5     | .4 |
| 61                    | 2.0            | 1.6  | 1.3   | 1.0  | .9    | .8   | .7     | .6   | .5     | .5   | .4     | .3 |
| 62                    | 1.8            | 1.5  | 1.2   | .9   | .8    | .7   | .6     | .5   | .4     | .4   | .4     | .3 |
| 63                    | 1.7            | 1.3  | 1.0   | .8   | .7    | .5   | .5     | .4   | .4     | .3   | .3     | .2 |
| 64                    | 1.5            | 1.2  | .9    | .6   | .5    | .4   | .3     | .3   | .3     | .2   | .2     | .2 |
| 65                    | 1.3            | 1.0  | .7    | .5   | .4    | .3   | .2     | .2   | .2     | .2   | .1     | .1 |
| 66                    | 1.1            | .8   | .6    | .4   | .3    | .2   | .1     | .1   | .1     | .1   | —      | —  |

**Hardness Conversion Table: (Conversions are only valid for readings taken on parallel flats.)**

| Rockwell "C" Scale | Brinell <sup>†</sup> 3000 Kilogram Load | Rockwell "C" Scale | Rockwell "B" Scale | Brinell <sup>†</sup> 3000 Kilogram Load | Rockwell "B" Scale | Brinell <sup>†</sup> 3000 Kilogram Load |
|--------------------|-----------------------------------------|--------------------|--------------------|-----------------------------------------|--------------------|-----------------------------------------|
| 66                 | —                                       | 40                 | —                  | 371                                     | 94                 | 205                                     |
| 65                 | 739                                     | 39                 | —                  | 362                                     | 93                 | 200                                     |
| 64                 | 722                                     | 38                 | —                  | 353                                     | 92                 | 195                                     |
| 63                 | 705                                     | 37                 | —                  | 344                                     | 91                 | 190                                     |
| 62                 | 688                                     | 36                 | —                  | 336                                     | 90                 | 185                                     |
| 61                 | 670                                     | 35                 | —                  | 327                                     | 89                 | 180                                     |
| 60                 | 654                                     | 34                 | —                  | 319                                     | 88                 | 176                                     |
| 59                 | 634                                     | 33                 | —                  | 311                                     | 87                 | 172                                     |
| 58                 | 615                                     | 32                 | —                  | 301                                     | 86                 | 169                                     |
| 57                 | 595                                     | 31                 | —                  | 294                                     | 85                 | 165                                     |
| 56                 | 577                                     | 30                 | —                  | 286                                     | 84                 | 162                                     |
| 55                 | 560                                     | 29                 | —                  | 279                                     | 83                 | 159                                     |
| 54                 | 543                                     | 28                 | —                  | 271                                     | 82                 | 156                                     |
| 53                 | 525                                     | 27                 | —                  | 264                                     | 81                 | 153                                     |
| 52                 | 500                                     | 26                 | —                  | 258                                     | 80                 | 150                                     |
| 51                 | 487                                     | 25                 | —                  | 253                                     | 79                 | 147                                     |
| 50                 | 475                                     | 24                 | —                  | 247                                     | 78                 | 144                                     |
| 49                 | 464                                     | 23                 | 100.0              | 243                                     | 77                 | 141                                     |
| 48                 | 451                                     | 22                 | 99.0               | 237                                     | 76                 | 139                                     |
| 47                 | 442                                     | 21                 | 98.5               | 231                                     | 75                 | 137                                     |
| 46                 | 432                                     | 20                 | 97.8               | 226                                     | 74                 | 135                                     |
| 45                 | 421                                     | (19)               | 97.0               | 222                                     | 73                 | 132                                     |
| 44                 | 409                                     | (18)               | 96.7               | 219                                     | 72                 | 130                                     |
| 43                 | 400                                     | (17)               | 96.1               | 215                                     | 71                 | 127                                     |
| 42                 | 390                                     | (16)               | 95.5               | 212                                     | 70                 | 125                                     |
| 41                 | 381                                     | (15)               | 94.7               | 208                                     | —                  | —                                       |

## Corrosion Resistance Properties

| BALL MATERIALS | Industrial Atmosphere | Hydraulic Oils (Petroleum) | Fresh Water | Salt Water | Food Products | Fruit & Veg. Juices | Milk | Alcohol | HCl -40% | Sulfuric Acid-40% | Phosphoric Acid-40% | Nitric Acid-50% | Citric Acid | Ammonia Liquids |
|----------------|-----------------------|----------------------------|-------------|------------|---------------|---------------------|------|---------|----------|-------------------|---------------------|-----------------|-------------|-----------------|
| 52100 CHROME   | C                     | A                          | D           | D          | —             | —                   | —    | C       | —        | —                 | —                   | —               | C           | B               |
| 440C STAINLESS | B                     | A                          | C           | C          | B             | —                   | A    | A       | D        | D                 | A                   | A               | A           | A               |
| 302 STAINLESS  | B                     | A                          | B           | B          | A             | —                   | A    | —       | —        | —                 | A                   | —               | —           | —               |
| 316 STAINLESS  | B                     | A                          | A           | A          | A             | A                   | A    | A       | D        | D                 | A                   | A               | A           | A               |
| BRASS          | C                     | B                          | C           | C          | D             | —                   | C    | C       | —        | D                 | D                   | —               | D           | —               |
| MONEL          | C                     | A                          | A           | B          | D             | C                   | C    | A       | D        | —                 | C                   | —               | —           | A               |
| NYLON          | A                     | A                          | A           | A          | —             | A                   | A    | A       | D        | D                 | D                   | D               | C           | —               |
| VITON®         | A                     | A                          | A           | A          | A             | A                   | A    | A       | A        | A                 | A                   | A               | A           | D               |
| CERAMIC        | A                     | A                          | A           | A          | A             | A                   | A    | A       | C        | D                 | C                   | A               | A           | A               |
| TITANIUM       | —                     | —                          | —           | —          | —             | —                   | —    | A       | C        | C                 | —                   | A               | A           | —               |

Numbers indicating order of preference

A = excellent B = good C = fair D = poor — = test data not available

## ABMA Definitions

### Grades and Tolerances (ABMA STD-10)

(2.12) Grade: A specific combination of dimensional form and surface roughness tolerance. A ball grade is designated by a grade number.

(2.4) Ball Diameter Variation: The difference between the largest and the smallest actual single diameter of one ball.

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

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

### Mechanical Characteristics

Hardness: The measure of resistance to penetration of the ball surface or truncated flat of the ball by a specific indenting shape.

Ball Diameter (ABMA STD-10)

(2.1) Nominal Ball Diameter: The diameter value that is used for the purpose of general identification of a ball size, e.g., 1/4", 6mm, etc.

(2.13) Ball Gage: 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. A ball gage, in combination with the ball grade and nominal ball diameter, should be considered as the most exact ball size specification to be used by a customer for ordering purposes.

(2.11) Specific Diameter: The amount by which the lot mean diameter differs from the nominal diameter, accurate to the container marking increment for that grade. The specific diameter should be marked on the unit container.

(2.10) Container Marking Increment: The standard unit steps in micrometers or in millionths of an inch, used to express the specific diameter.

### How Ball Diameter Is Indicated

Example:

Nominal Ball Diameter . . . . . 1/2"

Ball Gage . . . . . 1/2" + .0003

Specific Diameter . . . . . 1/2" + .000325

### Surface Qualities

Surface Roughness: Surface roughness consists of all those irregularities which form surface relief and which are conventionally defined within the area where deviations of form and waviness are eliminated.

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

### Danaher Motion Statement of Standard Measurement Conditions:

Diameter: Between two parallel flat carbide gage surfaces under 4 oz. gage force with size corrected to zero gage pressure per ABMA Std. 10.

Deviation from Spherical Form: Determined by rotation of the ball against a linear transducer with less than 4 grams gage force. The resulting polar chart is interpreted using the minimum circumscribed circle method (MCC) per ABMA Std. 10, Appendix A1.1 and AMS 889.3.

Surface Roughness: Determined by a stylus type instrument with the ball stationary. Compliance with Ra limits specified in ABMA Std. 10, Table 3 will be interpreted using a cutoff of .003 for ball radii up to .050, .01 for ball radii up to .130, and .03 over .130, with filtration to optimize the number of cutoffs used to calculate the results.

## Grading Charts

| Grades and Tolerances – Inches |            |                               |                        |                               |                                 |                    |                                                            |
|--------------------------------|------------|-------------------------------|------------------------|-------------------------------|---------------------------------|--------------------|------------------------------------------------------------|
| Grade                          | Size Range | Deviation from Spherical Form | Lot Diameter Variation | Allowable Ball Gage Variation | Nominal Ball Diameter Tolerance | Marking Increments | Maximum Surface Roughness <sup>†</sup> in Microinches "Ra" |
| 3                              | .006-1/2"  | .000003                       | ±.000003               | ±.00003                       | —                               | 0.00001            | 0.5                                                        |
| 5                              | .006-1/2"  | .000005                       | ±.000005               | ±.00005                       | —                               | 0.00001            | 0.8                                                        |
| 10                             | .006-7/8"  | .000010                       | ±.000010               | ±.00005                       | —                               | 0.00001            | 1.0                                                        |
| 25                             | .006-1"    | .000025                       | ±.000025               | ±.00010                       | —                               | 0.00001            | 2.0                                                        |
| 50                             | .006-1"    | .000050                       | ±.000050               | —                             | ±.000200                        | 0.00005            | 3.0                                                        |
| 100                            | .006-1"    | .000100                       | ±.000100               | —                             | ±.000500                        | —                  | 5.0                                                        |
| 200                            | .006-1"    | .000200                       | ±.000200               | —                             | ±.001000                        | —                  | 8.0                                                        |
| 1000                           | .006-1"    | .001000                       | ±.001000               | —                             | ±.005000                        | —                  | —                                                          |

† Maximum surface roughness arithmetic average.

| Grades and Tolerances – Metric (Millimeter) |            |                               |                        |                               |                                 |                    |                                                            |
|---------------------------------------------|------------|-------------------------------|------------------------|-------------------------------|---------------------------------|--------------------|------------------------------------------------------------|
| DIN Grade                                   | ABMA Grade | Deviation from Spherical Form | Lot Diameter Variation | Allowable Ball Gage Variation | Nominal Ball Diameter Tolerance | Marking Increments | Maximum Surface Roughness <sup>†</sup> in Micrometers "Ra" |
| —                                           | 3          | .00008                        | ±.000080               | ±.0008                        | —                               | .00025             | 0.012                                                      |
| —                                           | 5          | .00013                        | ±.000013               | ±.0013                        | —                               | .00025             | 0.020                                                      |
| I                                           | 10         | .00025                        | ±.000250               | ±.0013                        | —                               | .00025             | 0.025                                                      |
| II                                          | 25         | .00060                        | ±.000600               | ±.0025                        | —                               | .00025             | 0.051                                                      |
| III                                         | 50         | .00120                        | ±.001200               | —                             | ±.0051                          | .00127             | 0.076                                                      |
| IV                                          | 100        | .00250                        | ±.002500               | —                             | ±.0381                          | —                  | 0.127                                                      |
| —                                           | 200        | .00500                        | ±.005000               | —                             | ±.0250                          | —                  | 0.203                                                      |
| V                                           | 1000       | .02500                        | ±.025000               | —                             | ±.1270                          | —                  | —                                                          |

† Maximum surface roughness arithmetic average.



## 52100 Chrome Steel Balls

### Material Characteristics

Found primarily in ball bearing designs and a variety of demanding industrial applications. A vacuum-degassed AISI E52100 chrome steel is used to obtain a superior ball with a fine surface finish, through-hardness and high load capacity. Also available in consumable electrode vacuum melt material.

### Hardness

Our modern heat treating facilities, complete with controlled atmosphere and temperature, allow us to maintain Rockwell hardness within three (3) points in any production run and to attain any specific hardness designated by the customer. AISI E52100 Chrome Steel Balls are made with a through hardness of RC 60 to 67†, depending on requirements. (A table correcting Rockwell “C” values for the curved surface to parallel flats appears on page 6.)

†Per ABMA Std 10, Table 1

### Material Analysis†

|                  |                  |
|------------------|------------------|
| Carbon.....      | 0.98 to 1.10%    |
| Manganese .....  | 0.25 to 0.45%    |
| Silicon .....    | 0.15 to 0.35%    |
| Phosphorus ..... | Maximum of .025% |
| Sulphur .....    | Maximum of .025% |
| Chromium .....   | 1.30 to 1.60%    |
| Nickel .....     | Maximum of 0.25% |
| Molybdenum ..... | Maximum of 0.10% |
| Copper.....      | Maximum of 0.35% |

†Per AMS 6440

### Mechanical Properties

|                                |                     |
|--------------------------------|---------------------|
| Tensile Strength .....         | 325,000 psi         |
| Yield Strength .....           | 295,000 psi         |
| Elongation in two inches ..... | 5%                  |
| Reduction in area .....        | 8%                  |
| Modulus of Elasticity .....    | 29,500,000 psi      |
| Density .....                  | .283 lb./cubic inch |

| Material Conversion |        |             |            |      |       |         |        |        |                          |
|---------------------|--------|-------------|------------|------|-------|---------|--------|--------|--------------------------|
| Material            | AISI   | Federal     | Military   | ASTM | JIS   | UNS     | DIN    | AMS    | Military and Gov't Stds. |
| 52100<br>Chrome     |        |             |            |      |       |         |        | 6440   | MS 19059                 |
|                     | E52100 | FED-STD-66D | MIL-B-1083 | A295 | SUJ-2 | G-52986 | 100Cr6 | 6444†  | MS 19059                 |
|                     |        |             |            |      |       |         |        | 6444†† |                          |

† Premium aircraft quality, consumable electrode vacuum melted.

†† Balls, low chromium, high-carbon steel, hardened and tempered.

## 52100 Chrome Steel Balls

| Size in Inches | Metric Sizes | Minimum Crushing Load in Pounds | Balls per Pound | Balls per Carton <sup>†</sup> | Metric Balls per Carton | Weight per Carton Pounds |
|----------------|--------------|---------------------------------|-----------------|-------------------------------|-------------------------|--------------------------|
| .006           |              | —                               | 45,045,000      | —                             |                         | —                        |
| .008           |              | —                               | 13,192,612      | —                             |                         | —                        |
| .01            |              | —                               | 6,802,721       | —                             |                         | —                        |
| .015           |              | —                               | 1,996,007       | —                             |                         | —                        |
| .02            |              | —                               | 841,751         | —                             |                         | —                        |
| .025           |              | —                               | 431,406         | —                             |                         | —                        |
| 1/32           | 1mm          | —                               | 221,141         | —                             | 150,000                 | —                        |
| 3/64           |              | —                               | 65,496          | —                             |                         | —                        |
| 1/16           | 2mm          | 275                             | 27,600          | 300,000                       | 200,000                 | 10.9                     |
| 5/64           |              | 345                             | 14,286          | 100,000                       | 80,000                  | 10.5                     |
| 3/32           |              | 618                             | 8,200           | 60,000                        |                         | 12.2                     |
| 7/64           | 3mm          | 842                             | 5,150           | 60,000                        | 50,000                  | 11.6                     |
| 1/8            |              | 1,100                           | 3,460           | 40,000                        |                         | 11.6                     |
| 9/64           | 4mm          | 1,392                           | 2,425           | 30,000                        | 20,000                  | 12.4                     |
| 5/32           |              | 1,718                           | 1,770           | 20,000                        |                         | 11.3                     |
| 11/64          |              | 2,080                           | 1,330           | 15,000                        |                         | 11.3                     |
| 3/16           | 5mm          | 2,475                           | 1,020           | 12,500                        | 10,000                  | 12.2                     |
| 13/64          |              | 2,905                           | 805             | 10,000                        |                         | 12.4                     |
| 7/32           | 6mm          | 3,368                           | 645             | 8,000                         | 6,000                   | 12.4                     |
| 15/64          |              | 3,867                           | 524             | 6,000                         |                         | 11.4                     |
| 1/4            |              | 4,400                           | 432             | 5,000                         |                         | 11.6                     |
| 17/64          | 7mm          | 4,730                           | 360             | 4,000                         | 4,000                   | 11.1                     |
| 9/32           |              | 5,568                           | 303             | 3,500                         |                         | 11.5                     |
| 5/16           | 8mm          | 6,875                           | 221             | 2,500                         | 2,500                   | 11.3                     |
| 11/32          |              | 8,318                           | 166             | 2,600                         |                         | 12.0                     |
| 3/8            | 9mm          | 9,900                           | 128             | 1,500                         | 1,750                   | 11.7                     |
| 13/32          | 10mm         | 11,618                          | 101             | 1,250                         | 1,250                   | 12.4                     |
| 7/16           | 11mm         | 13,475                          | 81              | 1,000                         | 1,000                   | 12.4                     |
| 15/32          | 12mm         | 15,468                          | 66              | 750                           | 750                     | 11.4                     |
| 1/2            |              | 17,600                          | 54              | 500                           |                         | 11.1                     |
| 17/32          |              | 18,062                          | 45              | 500                           |                         | 11.1                     |
| 9/16           |              | 20,250                          | 38              | 450                           |                         | 11.9                     |
| 19/32          |              | 22,562                          | 32              | 350                           |                         | 10.9                     |
| 5/8            |              | 25,000                          | 28              | 300                           |                         | 10.9                     |
| 21/32          |              | 27,562                          | 24              | 250                           |                         | 10.5                     |
| 11/16          |              | 30,250                          | 21              | 250                           |                         | 12                       |
| 23/32          |              | 33,062                          | 18              | 200                           |                         | 11                       |
| 3/4            |              | 36,000                          | 16              | 250                           |                         | 12.5                     |
| 13/16          |              | 42,250                          | 13              | 150                           |                         | 11.9                     |
| 7/8            |              | 49,000                          | 10              | 100                           |                         | 9.9                      |
| 15/16          |              | 56,250                          | 8               | 75                            |                         | 9.2                      |
| 1              |              | 64,000                          | 6.7             | 70                            |                         | 10.4                     |

<sup>†</sup> Grade 10 and better packed in smaller quantities in bubble pack.

## 440C Stainless Steel Balls

### Material Characteristics

Three quality stainless steels are available for applications in corrosive environments. AISI Type 440C offers the greatest hardness and surface finish, and is available in double vacuum melted materials. AISI Type 302 provides extreme toughness and corrosion resistance from oxidizing solutions and many organic chemicals in an unhardened state.

### Hardness

Our modern heat treating facilities, complete with controlled atmosphere and temperature, allow us to maintain Rockwell hardness within three (3) points in any production run and to attain any specific hardness designated by the customer. AISI 440C corrosion resistant, hardened steel balls are made with a through hardness from RC 58 to 65†, depending on requirements. (A table correcting Rockwell “C” values for the curved surface to Rockwell “C” for parallel flats may be found on page 6).

†Per ABMA Std 10, Table 1

### Material Analysis†

|                  |                  |
|------------------|------------------|
| Carbon.....      | 0.95 to 1.20%    |
| Manganese .....  | Maximum of 1.00% |
| Silicon .....    | Maximum of 1.00% |
| Phosphorus ..... | Maximum of .40%  |
| Sulphur .....    | Maximum of .30%  |
| Chromium .....   | 16.00 to 18.00%  |
| Molybdenum ..... | Maximum of .75%  |
| Nickel .....     | Maximum of .75%  |
| Copper.....      | Maximum of .50%  |

†Per AMS 5630

### Mechanical Properties

|                                |                     |
|--------------------------------|---------------------|
| Tensile Strength .....         | 285,000 psi         |
| Yield Strength .....           | 275,000 psi         |
| Elongation in two inches ..... | 2%                  |
| Reduction in area .....        | 10%                 |
| Modulus of Elasticity .....    | 29,000,000 psi      |
| Density .....                  | .277 lb./cubic inch |

NOTE: All stainless steel balls are passivated. 420 stainless steel balls available on request.

| Material Conversion |      |          |          |      |         |         |            |        |                          |
|---------------------|------|----------|----------|------|---------|---------|------------|--------|--------------------------|
| Material            | AISI | Federal  | Military | ASTM | JIS     | UNS     | DIN        | AMS    | Military and Gov't Stds. |
| Type 440C           |      |          |          |      |         |         |            | 5630   |                          |
|                     | 440C | QQ-S-763 | —        | A276 | SUS440C | S-44004 | X105CrMo17 | 5618†  | MS 19060                 |
|                     |      | CL 440C  |          |      |         |         |            | 7445†† |                          |

† Consumable electrode vacuum melted.

†† Balls, corrosion resistant steel, 17Cr, hardened.

## 440C Stainless Steel Balls

| Size in Inches | Metric Sizes | Balls per Pound | Metric Balls per Carton <sup>†</sup> | Metric Balls per Carton | Carton in Approximate Pounds |
|----------------|--------------|-----------------|--------------------------------------|-------------------------|------------------------------|
| .006           |              | 45,871,000      | —                                    |                         | —                            |
| .008           |              | 13,477,082      | —                                    |                         | —                            |
| .010           |              | 6,944,444       | —                                    |                         | —                            |
| .015           |              | 2,040,816       | —                                    |                         | —                            |
| .020           |              | 861,326         | —                                    |                         | —                            |
| .025           |              | 440,723         | —                                    |                         | —                            |
| 1/32           | 1mm          | 225,938         | —                                    | 400,000                 | —                            |
| 3/64           |              | 66,916          | —                                    |                         | —                            |
| 1/16           | 2mm          | 28,200          | 200,000                              | 150,000                 | 9.0                          |
| 3/32           |              | 8,380           | 60,000                               |                         | 12.2                         |
| 7/64           | 3mm          | 5,263           | 60,000                               | 60,000                  | 11.6                         |
| 1/8            |              | 3,530           | 40,000                               |                         | 11.6                         |
| 9/64           |              | 2,481           | 30,000                               |                         | 12.4                         |
| 5/32           | 4mm          | 1,810           | 20,000                               | 20,000                  | 11.3                         |
| 11/64          |              | 1,359           | 15,000                               |                         | 11.3                         |
| 3/16           | 5mm          | 1,050           | 12,500                               | 10,000                  | 12.2                         |
| 13/64          |              | 822             | 10,000                               |                         | 12.4                         |
| 7/32           |              | 659             | 8,000                                |                         | 12.4                         |
| 15/64          | 6mm          | 536             | 6,000                                | 6,000                   | 11.4                         |
| 1/4            |              | 441             | 5,000                                |                         | 11.6                         |
| 17/64          | 7mm          | 368             | 4,000                                | 4,000                   | 11.1                         |
| 9/32           |              | 310             | 3,500                                |                         | 11.5                         |
| 5/16           | 8mm          | 226             | 2,500                                | 2,500                   | 11.3                         |
| 11/32          |              | 170             | 2,600                                |                         | 12.0                         |
| 3/8            | 9mm          | 131             | 1,500                                | 1,750                   | 11.7                         |
| 13/32          | 10mm         | 103             | 1,250                                | 1,250                   | 12.4                         |
| 7/16           | 11mm         | 82              | 1,000                                | 1,000                   | 12.4                         |
| 15/32          | 12mm         | 67              | 750                                  | 750                     | 11.4                         |
| 1/2            |              | 51              | 500                                  |                         | 11.1                         |
| 17/32          |              | 46              | 500                                  |                         | 11.1                         |
| 9/16           |              | 39              | 450                                  |                         | 11.9                         |
| 5/8            |              | 28              | 300                                  |                         | 10.6                         |
| 11/16          |              | 21              | 250                                  |                         | 11.8                         |
| 3/4            |              | 16              | 150                                  |                         | 12.5                         |
| 13/16          |              | 13              | 150                                  |                         | 11.9                         |
| 7/8            |              | 10              | 100                                  |                         | 9.9                          |
| 15/16          |              | 8               | 75                                   |                         | 9.2                          |
| 1              |              | 7               | 50                                   |                         | 10.4                         |

<sup>†</sup> Grade 10 and better packed in smaller quantities in bubble pack.

## 302, 302HQ, 316, 316L Stainless Steel Balls

### Material Characteristics

For resistance to sulfuric acid compounds and other severely corrosive environments, Type 316 austenitic steel with increased nickel is available. If required, Thomson can also provide a quality ball in Types 410, 420, and 430 stainless steels.

#### Hardness

Non-annealed hardness, uniform throughout, as measured on parallel flats, is typically Rockwell "C" 25 to 39†. Annealed hardness, available on request, is typically Rockwell "B" 75 to 90. (A table converting Rockwell "C" to Rockwell "B" and Brinell ratings may be found on page 6.)

†Per ABMA Std 10, Table 1

#### Material Analysis† – 302/302HQ

|            |                   |
|------------|-------------------|
| Carbon     | Maximum of 0.15%  |
| Manganese  | Maximum of 2.00%  |
| Phosphorus | Maximum of 0.045% |
| Sulphur    | Maximum of 0.030% |
| Silicon    | Maximum of 1.00%  |
| Chromium   | 17.00 to 19.00%   |
| Nickel     | 8.00 to 10.00%    |
| Nitrogen   | Maximum of 0.10%  |
| Copper††   | 3.00 to 4.00%     |

†Per ASTM A276-89

††Type HQ

#### Mechanical Properties (Type 302) (At Rockwell "B" 75-90)

|                          |                        |
|--------------------------|------------------------|
| Tensile Strength         | 100,000 to 180,000 psi |
| Yield Strength           | 50,000 to 150,000 psi  |
| Elongation in two inches | 55 to 60%              |
| Reduction in area        | 55 to 65%              |
| Modulus of Elasticity    | 29,000,000 psi         |
| Density                  | .286 lb./cubic inch    |

#### Material Analysis† – 316/316L

|            |                            |
|------------|----------------------------|
| Carbon     | Maximum of 0.08% (0.03%)†† |
| Manganese  | Maximum of 2.00%           |
| Phosphorus | Maximum of 0.045%          |
| Sulphur    | Maximum of 0.030%          |
| Silicon    | Maximum of 1.00%           |
| Chromium   | 16.00 to 18.00%            |
| Nickel     | 10.00 to 14.00%            |
| Nitrogen   | Maximum of 0.10%           |
| Molybdenum | 2.00 to 3.00%              |

†Per ASTM A276-89

††Type 316L

#### Mechanical Properties (Type 316)

|                          |                   |
|--------------------------|-------------------|
| Tensile Strength         | 90,000 psi        |
| Yield Strength           | 45,000 psi        |
| Elongation in two inches | 35%               |
| Reduction in area        | 60%               |
| Modulus of Elasticity    | 28,000,000 psi    |
| Density                  | 29 lb./cubic inch |

NOTE: All stainless steel balls are passivated. 420 stainless steel balls available on request.

| Material Conversion |          |          |      |               |         |        |      |
|---------------------|----------|----------|------|---------------|---------|--------|------|
| Material            | AISI     | Federal  | ASTM | DIN           | UNS     | JIS    | AMS  |
| Stainless Steel     | Type 302 | QQ-S-763 | A276 | —             | S-30200 | —      | 5636 |
|                     |          | CL 302   |      |               |         |        |      |
|                     | Type 316 | QQ-S-763 | A276 | X5CrNiMo17122 | S-31603 | SUS316 | 5648 |
|                     |          | CL 316   |      |               |         |        |      |

## Monel and K-Monel Balls

### Material Characteristics

Monel: The ultimate in resistance to corrosion from steam, gas, salt water, ammonia, calcium chloride, acidic foods, high temperatures and other extreme environments. A low-hardness ball made from a special nickel-copper alloy.

#### Hardness: Monel 400

Typical hardness, as measured on parallel flats, is: Rockwell "B" 85 to 95†.

†Per ABMA Std 10, Table I

#### Material Analysis† – Monel

Nickel ..... Minimum of 63.0%  
 Copper ..... 28.0 to 34.0%  
 Iron ..... Maximum of 2.50%  
 Manganese ..... Maximum of 0.20%  
 Carbon ..... Maximum of 0.30%  
 Silicon ..... Maximum of 0.50%

†Per ASM Metals Handbook

### Material Characteristics

K-Monel: A slightly harder material with corrosion resistance equal to Monel.

#### Hardness: K-Monel 500

Typical hardness, as measured on parallel flats, is: Rockwell "C" 27 minimum †.

†Per ABMA Std 10, Table I

#### Material Analysis† – K-Monel

Nickel ..... Minimum of 63.0%  
 Copper ..... 27.0 to 33.0%  
 Iron ..... Maximum of 2.00%  
 Manganese ..... Maximum of 1.50%  
 Carbon ..... Maximum of 0.25%  
 Silicon ..... Maximum of 0.50%  
 Aluminum ..... 2.0 to 4.0%

†Per ASM Metals Handbook

| Material Conversion |      |          |      |         |      |
|---------------------|------|----------|------|---------|------|
| Material            | AISI | Federal  | ASTM | UNS     | AMS  |
| Monel 400           | —    | QQ-N-281 | B164 | N-04400 | 4730 |
|                     |      | Class A  |      |         |      |
| K-Monel 500         | —    | QQ-N-286 | —    | N-05500 | 4676 |
|                     |      | Class B  |      |         |      |

## Monel and K-Monel Balls

| General Data   |              |                 |                  |                                     |                             |
|----------------|--------------|-----------------|------------------|-------------------------------------|-----------------------------|
| Size in Inches | Metric Sizes | Balls per Pound | Balls per Carton | Metric Balls per Carton             | Weight per Carton in Pounds |
| 1/16           |              | 25,564          | 200,000          |                                     | 9.8                         |
| 3/32           |              | 7,574           | 60,000           |                                     | 13.2                        |
| 7/64           | 3mm          | 4,762           | 60,000           | 50,000                              | 12.6                        |
| 1/8            |              | 3,195           | 40,000           |                                     | 12.5                        |
| 9/64           |              | 2,247           | 30,000           |                                     | 13.4                        |
| 5/32           | 4mm          | 1,636           | 20,000           | 20,000                              | 12.2                        |
| 11/64          |              | 1,228           | 15,000           |                                     | 12.2                        |
| 3/16           | 5mm          | 946             | 12,500           | 10,000                              | 13.2                        |
| 13/64          |              | 745             | 10,000           |                                     | 13.4                        |
| 7/32           |              | 596             | 8,000            |                                     | 13.4                        |
| 15/64          | 6mm          | 485             | 6,000            | 6,000                               | 12.4                        |
| 1/4            |              | 399             | 5,000            |                                     | 12.5                        |
| 17/64          | 7mm          | 333             | 4,000            | 4,000                               | 12.0                        |
| 9/32           |              | 280             | 3,500            |                                     | 12.5                        |
| 5/16           |              | 204             | 2,500            |                                     | 12.2                        |
| 11/32          | 8mm          | 153             | 2,000            | 2,500<br>1,750<br>1,250, 1,000, 750 | 13.0                        |
| 3/8            | 9mm          | 118             | 1,500            |                                     | 12.7                        |
| 7/16           | 10, 11, 12mm | 74              | 1,000            |                                     | 13.4                        |
| 1/2            |              | 50              | 500              |                                     | 10.0                        |
| 9/16           |              | 35              | 300              |                                     | 8.6                         |
| 5/8            |              | 25              | 250              |                                     | 9.8                         |
| 3/4            |              | 15              | 150              |                                     | 10.1                        |

## Brass and Bronze Balls

### Material Characteristics

Corrosion resistant material similar to bronze, with greater tensile and yield strength.

#### Hardness – (Brass)

Typical hardness, as measured on parallel flats, is approximately Rockwell "B" 75 to 87†.

†Per ABMA Std 10, Table I

#### Material Analysis† – (Brass) CDA 270

|                |               |
|----------------|---------------|
| Copper         | 63.0 to 68.5% |
| Zinc           | 33.5 to 36.5% |
| Other Elements | Trace, Max.   |

†Per ASM Metals Handbook

NOTE: Brass balls available in CDA 260

### Material Characteristics

A high quality alloy created for environments attacked by water, gasoline, and certain solvents.

#### Hardness – (Bronze)

Typical hardness, as measured on parallel flats, is approximately Rockwell "B" 75-98†.

†Per ABMA Std 10, Table I

#### Material Analysis† – (Bronze) CA 220

|                |               |
|----------------|---------------|
| Copper         | 89.0 to 91.0% |
| Zinc           | 08.5 to 10.5% |
| Other Elements | Trace, Max.   |

† Per ASM Metals Handbook

| Material Conversion |      |          |      |         |      |
|---------------------|------|----------|------|---------|------|
| Material            | AISI | Federal  | ASTM | UNS     | AMS  |
| Yellow Brass        | —    | QQ-W-321 | B134 | C-27000 | 4712 |
| Commercial Bronze   | —    | AA-W-321 | B134 | C-22000 | —    |

| General Data (Brass Balls)† |                            |                 |                  |                                     |                             |
|-----------------------------|----------------------------|-----------------|------------------|-------------------------------------|-----------------------------|
| Size in Inches              | Metric Sizes               | Balls per Pound | Balls per Carton | Metric Balls per Carton             | Weight per Carton in Pounds |
| 1/16                        |                            | 25,600          | 200,000          |                                     | 9.7                         |
| 3/32                        |                            | 7,570           | 60,000           |                                     | 13.1                        |
| 7/64                        | 3mm                        | 4,800           | 60,000           | 50,000                              | 12.5                        |
| 1/8                         |                            | 3,200           | 40,000           |                                     | 12.4                        |
| 9/64                        |                            | 2,225           | 30,000           |                                     | 13.3                        |
| 5/32                        | 4mm                        | 1,630           | 20,000           | 20,000                              | 12.2                        |
| 11/64                       |                            | 1,235           | 15,000           |                                     | 12.1                        |
| 3/16                        | 5mm                        | 947             | 12,500           | 10,000                              | 13.1                        |
| 13/64                       |                            | 749             | 10,000           |                                     | 13.4                        |
| 7/32                        |                            | 596             | 8,000            |                                     | 13.3                        |
| 15/64                       | 6mm                        | 487             | 6,000            | 6,000                               | 12.3                        |
| 1/4                         |                            | 400             | 5,000            |                                     | 12.4                        |
| 17/64                       | 7mm                        | 335             | 4,000            | 4,000                               | 11.9                        |
| 9/32                        |                            | 281             | 3,500            |                                     | 12.4                        |
| 5/16                        | 8mm<br>9mm<br>10, 11, 12mm | 205             | 2,500            | 2,500<br>1,750<br>1,250, 1,000, 750 | 12.2                        |
| 11/32                       |                            | 154             | 2,000            |                                     | 12.9                        |
| 3/8                         |                            | 118             | 1,500            |                                     | 12.6                        |
| 7/16                        |                            | 74              | 1,000            |                                     | 13.3                        |
| 1/2                         |                            | 50              | 500              |                                     | 10.0                        |
| 9/16                        |                            | 35              | 300              |                                     | 8.5                         |
| 5/8                         |                            | 26              | 250              |                                     | 9.7                         |
| 11/16                       |                            | 19              | 200              |                                     | 10.4                        |
| 3/4                         |                            | 15              | 150              |                                     | 10.1                        |
| 1                           |                            | —               | 50               |                                     | 8.0                         |

† Note: Other analyses of Brass and Bronze available upon request.

## Nylon and Specialty Plastic Balls

### Zytel® Nylon 101 Balls

Made in sizes from 3/32" to 3/4"

Size Tolerance ..... ± .001 (SPH) .0005  
 ..... ± .002 (SPH) .001

#### Physical Properties

Coefficient of linear thermal expansion in./in./°F 4.5 x 10<sup>-5</sup>  
 Heat Distortion temp. at 264 psi ..... 170° F  
 ..... at 66 psi ..... 400° F  
 Water Absorption (24 hrs.) ..... 1.5%  
 Specific Gravity ..... 1.14  
 Hardness ..... (Rockwell R118)  
 Tensile strength at 77° F 10,900 psi  
 Modulus of elasticity at 77° F ..... 400,000 psi  
 Shear strength ..... 9,600 psi

### Lexan® Balls

Polycarbonate Resin

Sizes 1/8" to 3/4"

SPH ± ..... .001

Tolerance ± ..... .002

#### Physical Properties

Color ..... Light Amber  
 Specific Gravity ..... 1.20  
 Rockwell Hardness ..... M70, R118  
 Tensile strength ..... 8,000 to 9,000 psi  
 Water Absorption (24 hrs.) ..... 0.2%  
 Heat Distortion temp. at 66 psi ..... 283° F  
 Tabor abrasion (C5-17 Wheel) ..... 7-11/1000 cycle  
 Flammability ..... Self-Extinguishing  
 Impact Strength ..... Izod 12-16 ft. lb./in.

### Delrin® Acetal Balls

Acetal Resin

Sizes 1/8" to 3/4"

SPH ..... ± .001

Tolerance ..... ± .002

#### Physical Properties

Color ..... Natural (white)  
 Specific Gravity ..... 1.425  
 Rockwell Hardness ..... M94, R120  
 Tensile strength ..... 7,500 to 10,000 psi  
 Water Absorption (24 hrs.) ..... 0.12%  
 Heat Distortion temp. at 66 psi ..... 338° F  
 Tabor abrasion (CS-17 Wheel) ..... .20 mg/1000 cycles  
 Flammability ..... Flammable  
 Impact Strength ..... Izod 1.2-1.4 ft. lb./in.

#### Available Grades and Tolerances

| Grade† | Tolerance†† | Sphericity |
|--------|-------------|------------|
| 0      | ±.0005"     | .0005"     |
| I      | ±.001       | .0005      |
| II     | ±.002       | .001       |
| III    | ±.005       | .005       |
| IV     | ±.015       | —          |

†Tolerance to +/- .0005 inches is possible for certain materials such as Nylon® and Acetal®. Surfaces can be tailored from rough to highly polished finishes. ††Grades apply to plastic balls only.

#### Special Balls (Available on Request)

1. Haynes Star-J
2. Haynes® 25
3. Hastelloy® Alloys
4. Haynes Stellite®
5. Tungsten Carbide

## Ceramic Balls

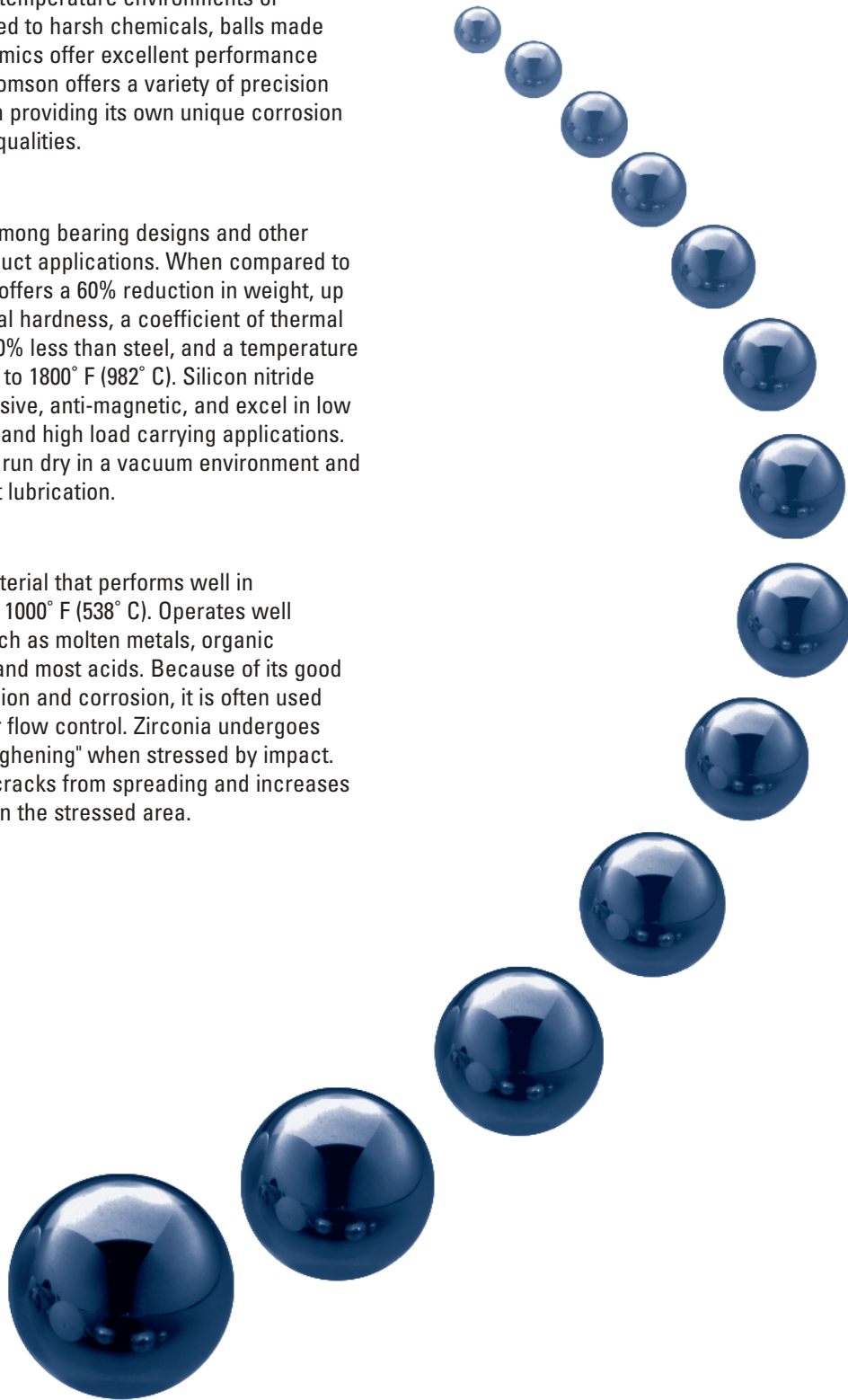
For extremely high temperature environments or applications exposed to harsh chemicals, balls made of engineered ceramics offer excellent performance characteristics. Thomson offers a variety of precision ceramic balls, each providing its own unique corrosion and heat resistant qualities.

### Silicon Nitride

A popular choice among bearing designs and other high precision product applications. When compared to steel, this material offers a 60% reduction in weight, up to twice the material hardness, a coefficient of thermal expansion that is 70% less than steel, and a temperature operating range up to 1800° F (982° C). Silicon nitride balls are non-corrosive, anti-magnetic, and excel in low noise, high rigidity, and high load carrying applications. These balls can be run dry in a vacuum environment and up to 500° F without lubrication.

### Zirconia

A high-strength material that performs well in temperatures up to 1000° F (538° C). Operates well in environments such as molten metals, organic solvents, caustics and most acids. Because of its good resistance to abrasion and corrosion, it is often used as check valves for flow control. Zirconia undergoes "transformation toughening" when stressed by impact. This tends to stop cracks from spreading and increases the ball's strength in the stressed area.



## Titanium/Precision 440A/430

### Material Characteristics

This highly inert material is lightweight, offers exceptional anti-corrosive properties, operates effectively in high temperature applications, provides a high level of tension/compression strength, and has expansion characteristics similar to steel. Titanium is used extensively in aerospace applications as well as in the chemical, food processing, and medical implant industries.

### Precision 440A Stainless Steel Hollow Balls

The one-inch hollow ball is utilized in weight sensitive applications requiring a combination of high surface hardness with material fracture toughness. Minimum crush strength is 6,000 lbs. Typical weight is 23 grams as compared to 65 grams for a solid ball, a reduction in weight of over 60%. Available in Grade 1000 tolerance or higher. Typical applications include aircraft ball transfer units, liquid float systems, and custom ball valves.

#### Hardness

440A stainless steel hardness as measured on parallel flats is Rockwell "C" 52-60.

#### Material Analysis – (Type 440A Stainless Steel)

|            |                   |
|------------|-------------------|
| Carbon     | 0.60 to 0.75%     |
| Manganese  | Maximum of 1.00%  |
| Phosphorus | Maximum of 0.040% |
| Sulphur    | Maximum of 0.030% |
| Silicon    | Maximum of 1.00%  |
| Chromium   | 16.00 to 18.00%   |
| Molybdenum | Maximum of 0.75%  |

### 430 Stainless Steel Balls

Type 430 stainless steel is an economical stainless material that provides corrosion resistance at low cost. Typical applications for this product include cosmetic mixing media, decorative trim, and light duty ball valves.

#### Hardness

430 stainless steel is a non-hardenable stainless steel.

#### Material Analysis – (Type 430 Stainless Steel)

|            |                   |
|------------|-------------------|
| Carbon     | Maximum of 0.12%  |
| Manganese  | Maximum of 1.00%  |
| Phosphorus | Maximum of 0.040% |
| Sulphur    | Maximum of 0.030% |
| Silicon    | Maximum of 1.00%  |
| Chromium   | 14.00 to 18.00%   |

## Metric Equivalents - Dimensional Conversions

| Millimeter / Decimal / Fraction Conversion Chart† |         |                   |             |         |                   |             |         |                   |             |         |                   |             |         |                   |             |         |                   |
|---------------------------------------------------|---------|-------------------|-------------|---------|-------------------|-------------|---------|-------------------|-------------|---------|-------------------|-------------|---------|-------------------|-------------|---------|-------------------|
| Milli-Meter                                       | Decimal | Fraction (inches) | Milli-Meter | Decimal | Fraction (inches) | Milli-Meter | Decimal | Fraction (inches) | Milli-Meter | Decimal | Fraction (inches) | Milli-Meter | Decimal | Fraction (inches) | Milli-Meter | Decimal | Fraction (inches) |
| 0.1                                               | .0039   |                   | 4.366       | .1719   | 11/64             | 8.6         | .3386   |                   | 12.9        | .5079   |                   | 17.1        | .6732   |                   | 21.4        | .8425   |                   |
| 0.2                                               | .0079   |                   | 4.4         | .1732   |                   | 8.7         | .3425   |                   | 13.0        | .5118   |                   | 17.2        | .6772   |                   | 21.431      | .8438   | 27/32             |
| 0.3                                               | .0118   |                   | 4.5         | .1772   |                   | 8.731       | .3438   | 11/32             | 13.097      | .5156   | 33/64             | 17.3        | .6811   |                   | 21.5        | .8465   |                   |
| 0.397                                             | .0156   | 1/64              | 4.6         | .1811   |                   | 8.8         | .3465   |                   | 13.1        | .5157   |                   | 17.4        | .6850   |                   | 21.6        | .8504   |                   |
| 0.4                                               | .0157   |                   | 4.7         | .1850   |                   | 8.9         | .3504   |                   | 13.2        | .5197   |                   | 17.463      | .6875   | 11/16             | 21.7        | .8543   |                   |
| 0.5                                               | .0197   |                   | 4.763       | .1875   | 3/16              | 9.0         | .3543   |                   | 13.3        | .5236   |                   | 17.5        | .6890   |                   | 21.8        | .8583   |                   |
| 0.6                                               | .0236   |                   | 4.8         | .1890   |                   | 9.1         | .3583   |                   | 13.4        | .5276   |                   | 17.6        | .6929   |                   | 21.828      | .8594   | 55/64             |
| 0.7                                               | .0276   |                   | 4.9         | .1929   |                   | 9.128       | .3594   | 23/64             | 13.494      | .5313   | 17/32             | 17.7        | .6968   |                   | 21.9        | .8622   |                   |
| 0.794                                             | .0313   | 1/32              | 5.0         | .1969   |                   | 9.2         | .3622   |                   | 13.5        | .5315   |                   | 17.8        | .7008   |                   | 22.0        | .8661   |                   |
| 0.8                                               | .0315   |                   | 5.1         | .2008   |                   | 9.3         | .3661   |                   | 13.6        | .5354   |                   | 17.859      | .7031   | 45/64             | 22.1        | .8701   |                   |
| 0.9                                               | .0354   |                   | 5.159       | .2031   | 13/64             | 9.4         | .3701   |                   | 13.7        | .5394   |                   | 17.9        | .7047   |                   | 22.2        | .8740   |                   |
| 1.0                                               | .0394   |                   | 5.2         | .2047   |                   | 9.5         | .3740   |                   | 13.8        | .5433   |                   | 18.0        | .7087   |                   | 22.225      | .8750   | 7/8               |
| 1.1                                               | .0433   |                   | 5.3         | .2087   |                   | 9.525       | .3750   | 3/8               | 13.891      | .5469   | 35/64             | 18.1        | .7126   |                   | 22.3        | .8780   |                   |
| 1.191                                             | .0469   | 3/64              | 5.4         | .2126   |                   | 9.6         | .3780   |                   | 13.9        | .5472   |                   | 18.2        | .7165   |                   | 22.4        | .8819   |                   |
| 1.12                                              | .0472   |                   | 5.5         | .2165   |                   | 9.7         | .3819   |                   | 14.0        | .5512   |                   | 18.256      | .7188   | 23/32             | 22.5        | .8858   |                   |
| 1.3                                               | .0512   |                   | 5.556       | .2188   | 7/32              | 9.8         | .3858   |                   | 14.1        | .5551   |                   | 18.3        | .7205   |                   | 22.6        | .8898   |                   |
| 1.4                                               | .0551   |                   | 5.6         | .2205   |                   | 9.9         | .3898   |                   | 14.2        | .5591   |                   | 18.4        | .7244   |                   | 22.622      | .8906   | 57/64             |
| 1.5                                               | .0591   |                   | 5.7         | .2244   |                   | 9.922       | .3906   | 25/64             | 14.288      | .5625   | 9/16              | 18.5        | .7283   |                   | 22.7        | .8937   |                   |
| 1.588                                             | .0625   | 1/16              | 5.8         | .2283   |                   | 10.0        | .3937   |                   | 14.3        | .5630   |                   | 18.563      | .7323   | 47/64             | 22.8        | .8976   |                   |
| 1.6                                               | .0630   |                   | 5.9         | .2323   |                   | 10.1        | .3976   |                   | 14.4        | .5669   |                   | 18.6        | .7344   |                   | 22.9        | .9016   |                   |
| 1.7                                               | .0669   |                   | 5.953       | .2344   | 15/64             | 10.2        | .4016   |                   | 14.5        | .5709   |                   | 18.7        | .7362   |                   | 23.0        | .9055   |                   |
| 1.8                                               | .0709   |                   | 6.0         | .2362   |                   | 10.3        | .4055   |                   | 14.6        | .5748   |                   | 18.8        | .7402   |                   | 23.019      | .9063   | 29/32             |
| 1.9                                               | .0748   |                   | 6.1         | .2402   |                   | 10.319      | .4063   | 13/32             | 14.684      | .5781   | 37/64             | 18.9        | .7441   |                   | 23.1        | .9094   |                   |
| 1.984                                             | .0781   | 5/64              | 6.2         | .2441   |                   | 10.4        | .4094   |                   | 14.7        | .5787   |                   | 19.0        | .7480   |                   | 23.2        | .9134   |                   |
| 2.0                                               | .0787   |                   | 6.3         | .2480   |                   | 10.5        | .4134   |                   | 14.8        | .5827   |                   | 19.050      | .7500   | 3/4               | 23.3        | .9173   |                   |
| 2.1                                               | .0827   |                   | 6.350       | .2500   | 1/4               | 10.6        | .4173   |                   | 14.9        | .5866   |                   | 19.1        | .7520   |                   | 23.4        | .9213   |                   |
| 2.2                                               | .0866   |                   | 6.4         | .2520   |                   | 10.7        | .4213   |                   | 15.0        | .5906   |                   | 19.2        | .7559   |                   | 23.416      | .9219   | 59/64             |
| 2.3                                               | .0906   |                   | 6.5         | .2559   |                   | 10.716      | .4219   | 27/64             | 15.081      | .5938   | 19/32             | 19.3        | .7598   |                   | 23.5        | .9252   |                   |
| 2.381                                             | .0938   | 3/32              | 6.6         | .2598   |                   | 10.8        | .4252   |                   | 15.1        | .5945   |                   | 19.4        | .7638   |                   | 23.6        | .9291   |                   |
| 2.4                                               | .0945   |                   | 6.7         | .2638   |                   | 10.9        | .4291   |                   | 15.2        | .5984   |                   | 19.447      | .7656   | 49/64             | 23.7        | .9331   |                   |
| 2.5                                               | .0984   |                   | 6.747       | .2656   | 17/64             | 11.0        | .4331   |                   | 15.3        | .6024   |                   | 19.5        | .7677   |                   | 23.8        | .9370   |                   |
| 2.6                                               | .1024   |                   | 6.8         | .2677   |                   | 11.1        | .4370   |                   | 15.4        | .6063   |                   | 19.6        | .7717   |                   | 23.813      | .9375   | 15/16             |
| 2.7                                               | .1063   |                   | 6.9         | .2717   |                   | 11.113      | .4375   | 7/16              | 15.478      | .6094   | 39/64             | 19.7        | .7756   |                   | 23.9        | .9409   |                   |
| 2.778                                             | .1094   | 7/64              | 7.0         | .2756   |                   | 11.2        | .4409   |                   | 15.5        | .6102   |                   | 19.8        | .7795   |                   | 24.0        | .9449   |                   |
| 2.8                                               | .1102   | 71                | 7.1         | .2795   |                   | 11.3        | .4449   |                   | 15.6        | .6142   |                   | 19.844      | .7813   | 25/32             | 24.1        | .9488   |                   |
| 2.9                                               | .1142   |                   | 7.144       | .2813   | 9/32              | 11.4        | .4488   |                   | 15.7        | .6181   |                   | 19.9        | .7835   |                   | 24.2        | .9567   |                   |
| 3.0                                               | .1181   |                   | 7.2         | .2835   |                   | 11.5        | .4528   |                   | 15.8        | .6220   |                   | 20.0        | .7874   |                   | 24.209      | .9531   | 61/64             |
| 3.1                                               | .1220   |                   | 7.3         | .2874   |                   | 11.509      | .4531   | 29/64             | 15.875      | .6250   | 5/8               | 20.1        | .7913   |                   | 24.3        | .9567   |                   |
| 3.175                                             | .1250   | 1/8               | 7.4         | .2913   |                   | 11.6        | .4567   |                   | 15.9        | .6260   |                   | 20.2        | .7953   |                   | 24.4        | .9606   |                   |
| 3.2                                               | .1260   |                   | 7.5         | .2953   |                   | 11.7        | .4606   |                   | 16.0        | .6299   |                   | 20.241      | .7969   | 51/64             | 24.5        | .9646   |                   |
| 3.3                                               | .1299   |                   | 7.541       | .2969   | 19/64             | 11.8        | .4646   |                   | 16.1        | .6339   |                   | 20.3        | .7992   |                   | 24.6        | .9685   |                   |
| 3.4                                               | .1339   |                   | 7.6         | .2992   |                   | 11.9        | .4685   |                   | 16.2        | .6378   |                   | 20.4        | .8031   |                   | 24.606      | .9688   | 31/32             |
| 3.5                                               | .1378   |                   | 7.7         | .3031   |                   | 11.906      | .4688   | 15/32             | 16.272      | .6406   | 41/64             | 20.5        | .8071   |                   | 24.7        | .9724   |                   |
| 3.572                                             | .1406   | 9/64              | 7.8         | .3071   |                   | 12.0        | .4724   |                   | 16.3        | .6417   |                   | 20.6        | .8110   |                   | 24.8        | .9764   |                   |
| 3.6                                               | .1417   |                   | 7.9         | .3110   |                   | 12.1        | .4764   |                   | 16.4        | .6457   |                   | 20.638      | .8125   | 13/16             | 24.9        | .9803   |                   |
| 3.7                                               | .1457   |                   | 7.938       | .3125   | 5/16              | 12.2        | .4803   |                   | 16.5        | .6496   |                   | 20.7        | .8150   |                   | 25.0        | .9843   |                   |
| 3.8                                               | .1496   |                   | 8.0         | .3150   |                   | 12.3        | .4843   |                   | 16.6        | .6535   |                   | 20.8        | .8189   |                   | 25.003      | .9844   | 63/64             |
| 3.9                                               | .1535   |                   | 8.1         | .3189   |                   | 12.303      | .4844   | 31/64             | 16.669      | .6563   | 21/32             | 20.9        | .8228   |                   | 25.1        | .9882   |                   |
| 3.969                                             | .1563   | 5/32              | 8.2         | .3228   |                   | 12.4        | .4882   |                   | 16.7        | .6575   |                   | 21.0        | .8268   |                   | 25.2        | .9921   |                   |
| 4.0                                               | .1575   |                   | 8.3         | .3268   |                   | 12.5        | .4921   |                   | 16.8        | .6614   |                   | 21.034      | .8281   | 53/64             | 25.3        | .9961   |                   |
| 4.1                                               | .1614   |                   | 8.334       | .3281   | 21/64             | 12.6        | .4961   |                   | 16.9        | .6654   |                   | 21.1        | .8307   |                   | 25.400      | 1.00001 |                   |
| 4.2                                               | .1654   |                   | 8.4         | .3307   |                   | 12.7        | .5000   | 1/2               | 17.0        | .6693   |                   | 21.2        | .8346   |                   |             |         |                   |
| 4.3                                               | .1693   |                   | 8.5         | .3346   |                   | 12.8        | .5039   |                   | 17.066      | .6719   | 43/64             | 21.3        | .8386   |                   |             |         |                   |

## Quick Quote Fax Form

To receive your quote, please complete this form and fax it to us at: 1-540-639-4162. You can also email the information requested in this quote to BALLRFQS@DANAHERMOTION.COM or call our customer service group at 1-540-633-3400.

|                               |  |  |  |  |
|-------------------------------|--|--|--|--|
| <b>Material Type</b>          |  |  |  |  |
| <b>Size</b>                   |  |  |  |  |
| <b>Grade</b>                  |  |  |  |  |
| <b>Quantity</b>               |  |  |  |  |
| <b>Estimated Annual Usage</b> |  |  |  |  |
| <b>Other Specifications</b>   |  |  |  |  |

Please provide detailed contact information in case we need clarifications on your quote:

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Company: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ ZIP: \_\_\_\_\_ Country: \_\_\_\_\_

Phone: \_\_\_\_\_

Fax: \_\_\_\_\_

E-mail: \_\_\_\_\_

## Quality Assurance

### Thomson's A2LA Certified Calibration Lab

The Thomson's A2LA accredited calibration laboratory offers a unique blend of the finest environment of metrology for the calibration of spheres and forty-five years of experience manufacturing Thomson precision balls. The experience assures our customers that the spheres we calibrate for them do not contain any hidden damage which might go undetected by a calibration lab inexperienced in working with spheres.

### How Can Our Lab Help You?

If an organization is required to be compliant or registered to TS-16949, it shall meet 7.6.3 for testing, inspection and and calibration.

For external laboratories, 7.3.3.2 states that external/commercial/independent laboratory facilities used for inspection, test or calibration services by the organization shall have a defined laboratory scope that includes the capability to perform the required inspection, test or calibration, and that laboratory shall either.

- provide evidence that it is acceptable to the customer, or
- be accredited to ISO/IEC 17025 or national equivalent.

When it is decided that an ISO/IEC accredited lab is preferred, Danaher can meet that obligation.

For example: suppose a facility uses a coordinate axis measuring machine and the check standard is a ball bar. An ISO 17025 accredited calibration laboratory, whose scope of accreditation includes spheres, must calibrate that sphere. The manufacturer of the ball bar may have supplied a calibration for that sphere. However, unless the manufacturer is ISO 17025 compliant and their scope of accreditation includes spheres, their certificate does not meet the requirements of TS-16949.

Danaher Motion's calibration laboratory management system has been audited and found to comply with A2LA guidelines and ISO 17025.

### How To Determine Competency

A good indicator of competency for a calibration laboratory is the degree of uncertainty that lab is able to demonstrate. Danaher Motion's metrology lab demonstrates an uncertainty of:

- 8 microinches for diameter calibration
- 0.56 microinches for roundness calibration
- a dead band of less than 4 nanometers for surface finish calibration.

### How Do We Achieve These Results?

Our laboratory comparison masters are Tungsten Carbide and have been calibrated by the National Institute of Standards and Technology (NIST) for minimum uncertainty and maximum accuracy. Our gage environment is controlled to be between Class 1000 and Class 10,000 cleanliness levels and temperature is regulated to +/- 0.5 degrees Fahrenheit.

### Calibrating Diameter

We measure diameter in accordance with the requirements of ABMA Standard 10.

The instrumentation system consists of proprietary gage amplifiers operating at a range of +/- 0.001 inches with a resolution of +/- 0.000001 inches. The gage heads are mounted on precision comparator stands with a capacity of over 9 inches. The stands have rugged bases for stability and the gage heads are mounted units which allow friction free straight-line motion.

The specimen balls are positioned in custom crafted fixtures that assure the ball will return to the same gage location for each reading. This minimizes any adverse effect of surface condition or parallelism.

### Calibrating Ball Sphericity

We measure ball sphericity on our proprietary geometrical gage system. This system uses a design specifically engineered to gage spheres. The holding system for this measurement will accommodate balls from 0.020 inch diameter to 10.00-inch diameter, with the appropriate fixturing. The active elements of the gage system are engineered to minimize any vibration.

### Calibrating Surface Finish

We calibrate surface finish on our state of the art surface finish measuring equipment. This equipment is mounted on a vibration isolation table. The standard stylus is conical diamond. However, surface finish metrology is limited only by the ingenuity of the holding fixture. Our gage travel is limited to 50mm. The wavelength of the roughness filter can be as small as 0.0001 inches or as large as 1.0 inches. We are able to evaluate surface finish in as many as 27 different surface finish parameters.

The resolution is approximately four nm, which is only one nm less than the resolution NIST uses to measure surface finish. A NIST calibrated Tungsten Carbide check standard is used to verify the continued performance of the instrument.

ENTWICKLUNG  
LOGISTIK  
SERVICE



■ **BIBUS GmbH**

■ BIBUS Vertriebsregionen

BIBUS GmbH  
Max-Eyth-Straße 41/1  
DE-89231 Neu-Ulm

Telefon: +49 731 20769-0  
Telefax: +49 731 20769-620

E-Mail: [info@bibus.de](mailto:info@bibus.de)  
[www.bibus.de](http://www.bibus.de)

[www.thomsonlinear.com](http://www.thomsonlinear.com)

Worm\_Gear\_Screw\_Jacks\_CTDE-0007-02 | 20181023SK  
Irrtümer und technische Änderungen vorbehalten. Es obliegt dem Anwender, darüber zu entscheiden, ob das Produkt für eine bestimmte Anwendung geeignet ist. Alle in diesem Katalog verwendeten Markennamen sind geschützt.  
© Thomson Industries, Inc. 2018

**THOMSON**

*Linear Motion. Optimized.™*