

# Appendix I

## Measurement of deviation from spherical form

Deviation from spherical form on finished metal balls may occur in the form of two or more almost equally spaced waves around equatorial profiles. For balls having two waves or higher order of even numbers of waves, the measurement of single diameters of the balls may be an adequate measure provided several equatorial profiles are subjected to measurement. However as it is most usual, odd numbers of waves of considerable magnitude may also be present which cannot be fully detected by simple two point measurements.

Because of the wide range of nominal diameters from 0,3 to 4 1/2", measurement of these errors of form can be a slow and difficult process, particularly on the smaller size of balls. Two basic methods for detecting errors of spherical form are in use. Most recently developed involves the use of specially designed, highly precise equipment generally identified by the term "Roundness Measuring Equipment." Older equipment, still in common use today for the larger sizes of balls, involves the use of "Vee Blocks" and associated linear comparators of appropriate magnification.

Since metal balls are essentially quite uniform as to errors of form in any one lot, it is considered sufficient to explore not more than three profiles in three equatorial planes each oriented approximately 90° from the other on individual balls of the sample.

### A1.1 Method using roundness measuring

Two basic designs of roundness measuring equipment are in use today. One design operates on the basis of stylus and associated linear transducer rotating around the ball in contact with its surface, the other involves the rotation of the ball against a similar linear transducer. The extremely small motions of the stylus are, in both designs, suitably amplified and recorded on a polar chart which discloses the shape in the form of the number and extent of the waves but with radial deviations greatly magnified. The overall accuracy of the rotating spindle and associated amplifying and recording equipment must be very high, in the order of 0.025 micrometers or one (1) microinch. Extreme care must be taken in the interpretation of the polar charts. American National Standards B89.3.1 defines several methods of chart interpretation. For finished metal balls, the minimum circumscribed circle (MMC) method is considered adequate.

### A1.2 Method using vee blocks

For the larger sizes of balls, it is practical to use vee blocks having specific included angles and associated linear comparators or dial indicators of magnification appropriate for the grade of ball being measured. *Description of this method see Standard.* The most desirable angles for wave numbers up to 21 appear to be 90° and 120°.

The magnification factors for the ratio of the indicator reading to the height or deviation from spherical form are shown in table G. In certain cases, combinations of vee angles and numbers of waves present will show little or no indication—these are indicated by asterisks(\*)—and such readings should be disregarded. If the number of waves is known, the deviation from spherical form is obtained by dividing the indicator reading by the appropriate factor taken from this table.

If, as is usual, the number of waves is unknown, readings should be taken on the three equatorial planes at 90° to each other, first on a simple two point gage and then successively using the 90° and the 120° vee blocks. The deviation from spherical form is the highest of these three types of readings divided by two.