Designation: B610 – 13

Standard Test Method for Measuring Dimensional Changes Associated with Processing Metal Powders[1]

This standard is issued under the fixed designation B610; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This standard covers a test method that may be used to measure the sum of the changes in dimensions that occur when a metal powder is first compacted into a test specimen and then sintered.

1.2 The dimensional change is determined by a quantitative laboratory procedure in which the arithmetic difference between the dimensions of a die cavity and the dimensions of a sintered test specimen produced from that die is calculated and expressed as a percent growth or shrinkage.

1.3 With the exception of the values for density and the mass used to determine density, for which the use of the gram per cubic centimetre (g/cm^3) and gram (g) units is the long-standing industry practice, the values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B925 Practices for Production and Preparation of Powder Metallurgy (PM) Test Specimens

B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

3. Terminology

3.1 *Definitions*—The definitions of the Powder Metallurgy (PM) terms that are used in this test method are found in Terminology B243. Additional descriptive information is available in the Related Material section of Vol. 02.05 of the *Annual Book of ASTM Standards*.

4. Summary of Test Method

4.1 Rectangular test specimens are compacted to a target green density from a metal powder or metal powder mixture and sintered under controlled conditions.

4.2 The absolute dimensional change, expressed as a growth or shrinkage percentage is calculated from the difference between the long dimension of the die cavity and the long dimension of the sintered test specimen.

4.3 The comparative dimensional change requires specimens from a reference metal powder lot agreed upon by the parties concerned to be produced and processed at the same time. The dimensional change of the specimens from the test powder is calculated and mathematically compared with the dimensional change of the specimens from the reference powder.

5. Significance and Use

5.1 *Dimensional Change When Compacting and Sintering Metal Powders:*

5.1.1 The dimensional change value obtained under specified conditions of compacting and sintering is a material characteristic inherent in the powder.

5.1.2 The test is useful for quality control of the dimensional change of a metal powder mixture, to measure compositional and processing changes and to guide in the production of PM parts.

5.1.3 The absolute dimensional change may be used to classify powders or differentiate one type or grade from another, to evaluate additions to a powder mixture or to measure process changes, and to guide in the design of tooling.

5.1.4 The comparative dimensional change is mainly used as a quality control test to measure variations between a lot or shipment of metal powder and a reference powder of the same material composition.

[1] This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.02 on Base Metal Powders.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

5.1.5 Factors known to affect size change are the base metal powder grade, type and lot, particle size distribution, level and types of additions to the base metal powder, amount and type of lubricant, green density, as well as processing conditions of the test specimen; heating rate, sintering time and temperature, sintering atmosphere, and cooling rate.

5.2 *Dimensional Change of Various PM Processing Steps:*

5.2.1 The general procedure of measuring the die or a test compact before and after a PM processing step, and calculating a percent dimensional change is also adapted for use as an internal process evaluation test to quantify green expansion, repressing size change, heat treatment changes or other changes in dimensions that result from a manufacturing operation.

6. Apparatus

6.1 *Balance,* a balance readable to 0.0001 g with a minimum capacity of 200 g to be used for determining the mass of the test specimens to the nearest 0.001 g.

6.2 *Compacting Tool Set,* a PM die and punches designed to produce the rectangular test specimen, an example of which is shown in Practices, B925, as Typical Laboratory Tooling – Transverse Rupture Test Specimen.

6.3 *Inside and Outside Micrometer Calipers,* or other suitable measuring apparatus of the size necessary to measure the long dimensions of the die cavity and sintered test specimens to 0.0001 in. (0.0025 mm).

6.4 *Universal Testing Machine or PM Compacting Press,* suitable for holding the tooling and having sufficient force to apply the pressure necessary to compact the test specimen to the target green density.

6.5 *Sintering Furnace,* a laboratory or production furnace capable of heating the specimens to a specified work temperature, holding them at that temperature and cooling to room temperature in a controlled atmosphere or vacuum.

7. Test Specimen

7.1 A rectangular compact, having dimensions of 0.500 in. (12.70 mm) wide by 1.250 in. (31.75 mm) long by 0.250 in. (6.35 mm) thick, as shown in Fig. 2 in Practices B925 as the PM Transverse Rupture Strength Test Specimen – thin, is the recommended test specimen.

7.2 The top and bottom faces of the green compact shall be parallel within 0.001 in. (0.03 mm).

7.3 The green density shall be within 0.05 g/cm^3 of the agreed target density.

7.4 Alternative test specimens that may be used to measure PM dimensional changes are the Cylindrical Powder Compressibility Test Specimen, the Radial Crushing Strength Test Specimen or the Ring Test Specimen for Measuring Magnetic Properties, all of which are shown in Practices B925. These other test specimens are primarily used for in-house testing by bearing and structural parts manufacturers to determine the change in dimensions of powder and parts at every step of their manufacturing process.

8. Procedure

8.1 *Preliminary:*

8.1.1 When this dimensional change test method is used to approve a shipment of metal powder, all testing conditions including the value of the target green density and the selection and performance criterion of the reference lot shall be agreed upon by the manufacturer and purchaser.

8.1.2 Using the nominal dimensions of the test specimen, calculate and note the mass of powder that will be needed to produce one test specimen to the target green density. (Formula #1).

8.1.3 Set up the tooling in the PM compacting press or universal testing machine.

8.1.4 Measure the long dimension of the die cavity, (L_D), to 0.0001 in. (0.0025 mm) and note for later use.

8.2 *Powder Preparation:*

8.2.1 Metal powders containing a lubricant are normally tested in the as-received condition. When testing unlubricated powders, the method of lubrication, either die-wall or admixing, shall be a matter of agreement between the parties concerned.

8.2.2 If an admixed lubricant is to be used to prepare the powder for compacting, the type, grade, percentage and mixing procedure shall be agreed upon between the concerned parties or shall closely follow accepted PM practice.

8.2.3 Following the procedure in Practices B215, take a gross sample from the lot of the lubricated or unlubricated metal powder that is to be tested (and reference metal powder, if used) of sufficient quantity to produce at least three test specimens.

8.2.4 Next, take three test portions of powder from the gross sample, each of which has a mass within 0.02 g of the mass calculated in 8.1.2.

8.3 *Compacting:*

8.3.1 If die-wall-lubrication is chosen for compacting unlubricated powders, it shall be applied prior to the compacting of each test specimen following the procedures in Practices B925.

8.3.2 Pour the test portion of the powder that is to be tested evenly into the die cavity.

8.3.3 Using the required pressure, compact the test specimen (and the reference specimen, if used) to the target green density in accordance with the procedure contained in Practices B925.

8.3.4 Eject the test specimen from the die, determine the mass to the nearest 0.001 g, measure the specimen dimensions to the nearest 0.001 in. (0.03 mm), identify and number the specimen.

8.3.5 Repeat to obtain three specimens of the test powder (and three reference specimens, if used).

8.3.6 Determine the green density of each test specimen (and each reference specimen, if used) following the procedure in Test Method B962, or

8.3.7 Calculate the green density from the measurements and mass of each specimen as follows:

$$D_G = 0.061 \frac{M}{WTL} \quad (1)$$

where:

D_G = green density of the test (reference) specimen, g/cm^3,
0.061 = conversion factor, in^3 to cm^3,
M = mass of the green test (reference) specimen, g,
W = width of green test (reference) specimen, in.,
T = thickness of the green test (reference) specimen, in., and
L = length of the green test (reference) specimen, in.

8.4 *Sintering:*

8.4.1 When the dimensional change test is conducted to approve a metal powder lot for production use, it is desirable to use the production furnace or at least sintering equipment that simulates or approximates production conditions.

8.4.2 Sinter the test specimens (with three reference specimens, if used) using the production conditions or a heating rate, sintering atmosphere, sintering time and temperature, and cooling rate suitable for the material being tested.

8.4.3 After cooling to room temperature, measure the long dimension of each sintered specimen to 0.0001 in. (0.0025 mm). Record this dimension, (L_T), [and (L_R) for the reference specimens, if used], for use later in the calculations.

9. Calculations

ABSOLUTE DIMENSIONAL CHANGE

9.1 Calculate the percent absolute dimensional change (DC_T) for the specimens produced from the test powder as follows:

$$DC_T, \% = \frac{(L_T - L_D) \times 100}{L_D} \quad (2)$$

where:

L_D = long dimension of the die cavity, in. (mm), (see 8.1.4).
L_T = long dimension of the sintered specimen produced from the test powder, in. (mm), (see 8.4.3).

COMPARATIVE DIMENSIONAL CHANGE

9.2 Calculate the percent absolute dimensional change (DC_R) for the specimens produced from the reference powder as follows:

$$DC_R, \% = \frac{(L_R - L_D) \times 100}{L_D} \quad (3)$$

where:

L_D = long dimension of the die cavity, in. (mm), (see 8.1.4), and
L_R = = long dimension of the sintered specimen produced from the reference powder, in. (mm), (see 8.4.3).

9.3 The percent absolute dimensional change of the specimens produced from the reference powder shall be within the limits agreed to between the powder producer and the purchaser in order to have a valid test.

9.4 Then, using the absolute dimensional change for the test powder from 9.1 calculate the percent comparative dimensional change (*DC*) as the difference between the specimens from the test powder and the reference powder as follows:

$$DC, \% = DC_T - DC_R \quad (4)$$

10. Report

10.1 The general reporting format shall be: *Dimensional Change at (specified) Green Density*.

10.1.1 Report the absolute dimensional change from die size for the specimens made from the test powder (DC_T), as the mathematical average of the three specimens, calculated to the nearest 0.01 %, including the sign of plus (+) for growth and minus (–) for shrinkage.

10.1.2 Report the comparative dimensional change between the test powder and the reference powder (*DC*), as the mathematical difference between the average absolute dimensional change from die size for the three specimens made from the test powder and those from the reference powder as a percent to the nearest 0.01 %, including the sign of (+) or (–) to indicate direction of the deviation.

NOTE 1—If the % dimensional change is divided by 100, the results then will be expressed in in/in (mm/mm) units.

10.1.3 Report the green density to the nearest 0.01 g/cm^3 as the average density of the three test specimens (and the three reference specimens, if used).

10.2 An alternative reporting method may be to graph the dimensional change as a function of the green density using the results obtained at a minimum of three data points.

10.3 The following supplementary information should also be reported in order to clarify and understand the test results.

10.3.1 Identification of the metal powder by brand, grade, and lot number,

10.3.2 Chemical composition of the powder mixture used, if other than elemental powder was being tested,

10.3.3 Type, brand and percent of the admixed lubricant (if used) and the mixing procedure or details of die-wall lubrication method (if used),

10.3.4 Compacting pressure,

10.3.5 Sintering temperature,

10.3.6 Sintering time, defined as the elapsed time that the test specimen is within ± 15 °F (± 8 °C) of the stated sintering temperature for iron-base and ± 10 °F (± 5 °C) for copper-base powders,

10.3.7 Furnace atmosphere,

10.3.8 Cooling rate, and

10.3.9 The absolute dimensional change of the reference powder (if used).

11. Precision and Bias

11.1 *Precision*—A precision for this test is impractical due to the wide range of material and testing conditions that may be involved and the fact that each material has a different dimensional change response. The acceptable comparative dimensional change is a matter of agreement between the parties concerned.

11.2 *Bias*—No information can be presented on the bias of the procedure in Test Method B610 for measuring Dimensional Change because no material having an accepted reference value is available.

12. Keywords

12.1 absolute; dimensional change; compacting; comparative dimensional change; due size; metal powders; sintering

SUMMARY OF CHANGES

Subcommittee B09.02 has identified the location of selected changes to this standard since the last issue (B610 – 08) that may impact the use of this standard. (Approved May 1, 2013.)

(1) Changed the statement on units in Section 1.3 to comply with the B09 Policy Guide.
(2) Deleted the reference to IEEE/ASTM S1 10 from Section 2.1.
(3) Modified the wording for the description of the balance in Section 6.1.
(4) Removed the reference to Test Method B328 that is obsolete and included Test Methods B962.
(5) Changed the precision statement.