



Designation: **E2712–09**^{ε1} **E2712 – 15**

Standard Test Methods for Bulge-Forming Superplastic Metallic Sheet¹

This standard is issued under the fixed designation E2712; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

^{ε1} NOTE—The title was editorially corrected in October 2009.

1. Scope

1.1 These test methods describe procedures for determining the biaxial formability of a superplastic metallic sheet in a circular die.

1.2 The intent of these test methods are primarily to be used as tests of superplasticity as measured by the ability to form to a prescribed depth in a die cavity without rupturing. These test methods can also be used to generate material for the measurement of cavitation in the formed part. These can be used as go/no go criteria for qualification to a specification.

1.3 These test methods have been used successfully with aluminum alloys. The use of these test methods on other metals should be verified.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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

E2448 Test Method for Determining the Superplastic Properties of Metallic Sheet Materials

3. Summary of Test Method

3.1 Two methods of bulge forming are included in these test methods.

3.1.1 In the first test method, the sheet is formed into a die of a fixed depth as prescribed in a specification. If it touches the base of the die without rupturing, then it is considered to have met the specification.

3.1.2 In the second test method, the depth of the die is reduced so that the material fills the die. A portion excised from the center of the formed part can be examined for internal cavitation within the sheet.

4. Significance and Use

4.1 When a superplastic material is regularly being used in industrial production, it is often convenient to use the bulge test to qualify a batch or heat lot to an acceptance criterion. Comparing these test methods with Test Method **E2448**, the bulge test does not require a machined coupon, it is more convenient to perform, and it most closely simulates the multiaxial stresses and strains present in forming parts. These test methods do not measure the intrinsic superplastic properties of a material. Test Method **E2448** should be used in that instance.

5. Apparatus

5.1 The bulge test consists of forming a sheet of material into a right circular cylindrical die using pressurized gas. The apparatus is shown in **Fig. 1**. The die cavity has a 100-mm diameter and a specified depth in a vessel suitably designed for the pressure and temperature envisaged for the test. The surface finish of the die cavity shall be $\leq 4R_A$ micrometer $\leq 0.4 \mu\text{m}$.

¹ This test method is under the jurisdiction of ASTM Committee **E28** on Mechanical Testing and is the direct responsibility of Subcommittee **E28.02** on Ductility and Formability.

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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.

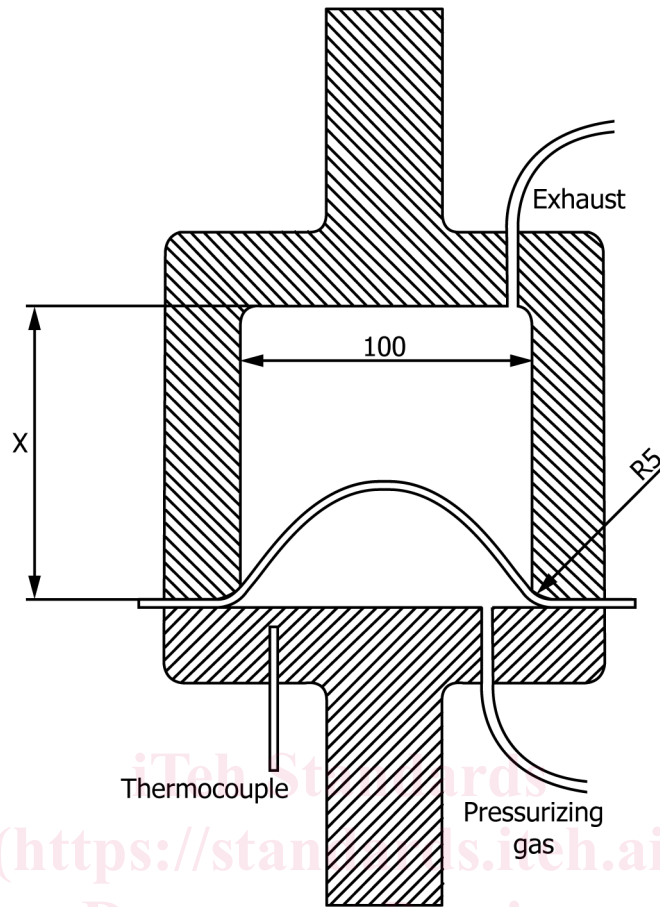


FIG. 1 Bulge-Forming Apparatus

5.2 The depth of the die (X in Fig. 1), can be varied by means of inserts or other methods to the depth set by the specification. A depth of 55 mm has been successfully used on superplastic-forming (SPF) 5083 aluminum alloy. For convenience, a series of inserts of different heights can be installed in the die to provide different depths according to the bulge test requirements. The insert must allow the free passage of gas around its periphery to the exhaust hole in the die.

NOTE 1—A depth of 55 mm has been successfully used on superplastic-forming (SPF) 5083 aluminum alloy.

5.2.1 The insert shall allow the free passage of gas around its periphery to the exhaust hole in the die.

5.3 The die entry radius is 5 mm. A lower plate with a control thermocouple can be moved to press against the die. The plate has a gas seal bead 0.7 mm high by 8 mm wide and a 136-mm inside diameter. A gas pressurization system with a gauge or other suitable means of measuring pressure and detecting sheet failure shall be provided at the lower plate to form the material into the cavity. The pressure tolerance up to 1 MPa shall be $50 \text{ kPa} \pm 50 \text{ kPa}$, and above 1 MPa shall be $5 \pm 5 \%$ of pressure. An exhaust port in the die can be connected either to the atmosphere or to a second gas pressurization system that provides a back pressure to the forming sheet.

5.4 The apparatus is provided with a means of heating it to the specified temperature for the material being tested. Usually, it is enclosed in a furnace equipped with doors opening in the front. The allowed tolerance between indicated and nominal test temperature is $\pm 3^\circ\text{C}$ up to 700°C and $\pm 6^\circ\text{C}$ above 700°C . The apparatus is provided with a means of moving the die or lower plate to insert and remove sheets of material and also to provide a force on the plate to counteract the force exerted by the pressurized gas. Usually, it is installed in a hydraulic press or clamping mechanism.

6. Procedure

6.1 Dome Rupture Test:

6.1.1 ~~A Clean~~ a sheet of superplastic material sized at least 160 by 160 mm ~~is first cleaned~~ so that it is free of surface contaminants. The die and plate shall be clean and free of any lubricant. No lubricant shall be used in the test unless specifically required by the lot acceptance criteria. If desired, the rolling direction can be marked in one corner of the specimen.

NOTE 2—The presence of lubricant greatly affects the depth to which the material forms before rupturing. Although very important for production, lubricant adds an unnecessary variable to the test method, which is why it should not generally be used. It follows that the apparent superplasticity of