Designation: D 3103 – 99

Standard Test Method for Thermal Insulation Quality of Packages[1]

This standard is issued under the fixed designation D 3103; 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 test method covers the determination of the thermal insulation quality of a package and its enclosed packaging from temperature differentials between the packaged item and the outside environment. It is suitable for testing packages with and without various internal refrigerants and with or without interior packaging. Representative test conditions covered are indicated by Fig. 1 and Fig. 2. Depending upon the type of insulation material used, a water-vaporproof barrier might be used just inside the exterior packages of Fig. 1.

1.2 *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.* Specific precautionary statements are given in 5.2.3 and 9.2.2.

2. Referenced Documents

2.1 *ASTM Standards:*

D 996 Terminology of Packaging and Distribution Environments[2]

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing[2]

3. Terminology

3.1 *Definitions*—General definitions for packaging and distribution environments are found in Terminology D 996.

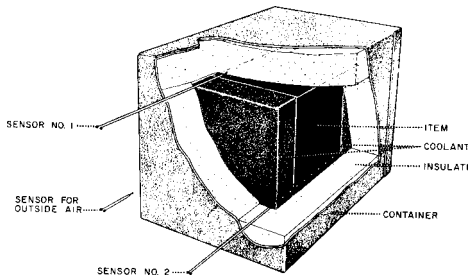
3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *draft-free atmosphere*—a relatively stationary atmosphere where the test specimens are remote from air currents.

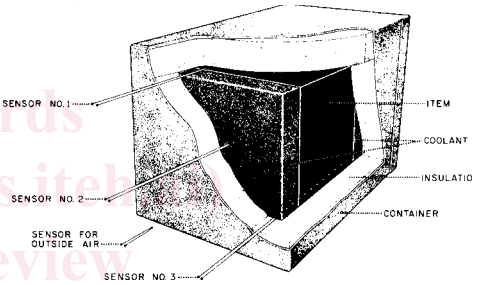
3.2.2 *eutectic system*, *n*—a mixture or compound in which pure solid phases changes occur at a well-defined specific temperature.

3.2.3 *exterior atmosphere*—the atmosphere in contact or near the exterior surface of a package.

3.2.4 *exterior package*—the outermost container of a package.



a—Containers Having Usable Inside Volume of 1 ft^3(0.03 m^3) or Less.



b—Containers Having a Usable Volume of More Than 1 ft^3(0.03 m^3)

FIG. 1 Thermally Insulated Packages with Sensors Positioned

3.2.5 *interior atmosphere*—the atmosphere in contact or near the packaged item.

3.2.6 *interior package*—a package (often of corrugated fiberboard) located within another.

3.2.7 *thermal conductivity, homogeneous material*—the rate of heat flow, under steady conditions through unit area, per unit temperature gradient in the direction perpendicular to the area.

4. Significance and Use

4.1 Certain items, such as biological materials, pharmaceuticals, industrial adhesives, gyroscopes, blood, and some foods, must be shipped inside temperature-controlled packages. Factors affecting the rate of heat transfer of the package include the moisture content of the different package components and the thickness, continuity, density, position, and uniformity of the insulation.

4.2 Because of the variety of factors affecting the performance of a thermally insulated package, testing should be

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[2] *Annual Book of ASTM Standards*, Vol 15.09.

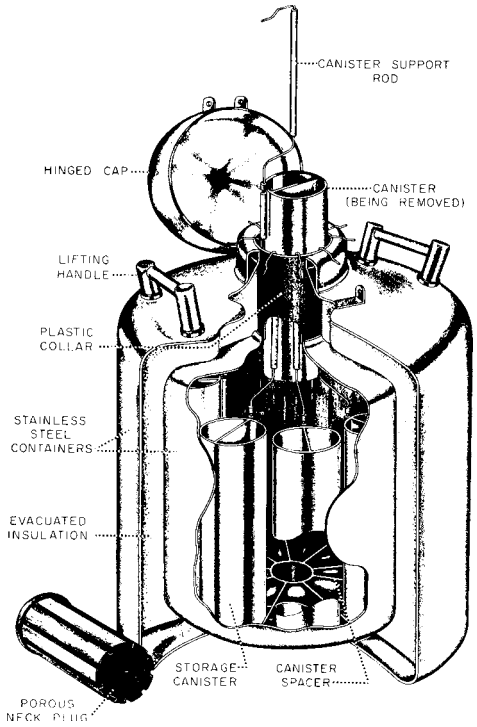

FIG. 2 Liquid Nitrogen Refrigerator

conducted with the actual package whenever possible. When simulated packages are used, special care must be exercised so that the simulated payload and coolant of the model will be as close as possible to the actual materials in temperature and other relevant physical properties.

5. Test Conditions and Apparatus

5.1 *Temperature of Exterior Atmosphere*— Draft-free environments large enough to accommodate the packages, but not necessarily the recorder, are required. Usual evaluation of the packaging materials will involve simple refrigerated or ambient exterior atmospheric conditions. These may be established as 4 ± 2°C (39 ± 4°F), 37.8 ± 2°C (100 ± 4°F), and 23 ± 2°C (73± 4°F). Additionally, other temperature extremes or cycles between various temperatures expected during shipment might be used as an exterior atmosphere.

5.2 *Temperature of Interior Atmosphere of Package*—When no refrigerant is used, interior package temperature may serve as a measure of the thermal insulation quality of the package. If it is desired to control the interior temperature of the atmosphere, use one of the following:

5.2.1 *Refrigerant Gel, Water Ice, or Other Refrigerant Source*, for internal temperatures above 0°C (32°F),

5.2.2 *Solid Carbon Dioxide CO_2 (Dry Ice or Euctectic Systems)*, wrapped as used in shipments for maintaining internal temperatures down to – 73°C (–108.4°F), or

5.2.3 *Liquid Nitrogen*, for temperatures to – 195°C (–319°F).

NOTE 1—**Caution:** Gaseous CO_2 and nitrogen are colorless, odorless, and noncombustible. In well-ventilated uses they present few problems, but evaporation or sublimation in airtight enclosures for prolonged periods (for example, 12 h) can produce sprung doors and asphyxiation of operating personnel. Usually these refrigerants can be used if provisions are made to evacuate the built-up gas periodically.

5.3 *Temperature Indicators*:

5.3.1 *Multi-Channel Recorder with Thermocouples*—The recording capability should be as a datalog by thermocouple number with date and time of reading, that can be presented in a continuous graph form as a secondary presentation. Resolution of the device shall be 0.1°C or greater. Accuracy over the range tested should be ± 1°C. The printer or associated computer datafile shall be activated by a voltage from an insulated pair of copper-constantan or other suitable wires 30 AWG B&S gage (0.255 mm) or less in diameter (not including the thickness of insulation). The recorder and chart shall have a capability that extends beyond the temperature values encountered in the test.

5.3.2 *Thermistor-Recorder*—A thermistor sensor may be used, instead of a thermocouple, for sensing interior temperatures of the package. The thermistor may be attached to recording equipment, as described in 5.3.1, with supplementary electrical circuitry as needed, or it may be a wireless, battery operated, computer programmable unit that stores digital temperature readings at specified time intervals. Programming and data downloading of the units is done through a suitable computer interface with appropriate software. Accuracy over the range tested should be ± 1°C with resolution to 0.1°C. Response time over range should be determined prior to use and suitable for the reading interval of the test.

6. Sampling

6.1 Experimental package designs shall be made in accordance with the specifications and methods that will be used during actual production. When possible, choose the test packages by random sampling.

7. Test Specimens

7.1 A single test specimen shall consist of a package enclosing the actual item or a dummy load simulating the item. The package shall be closed, taped, or sealed in the same manner as will be used for actual shipment.

7.2 The mass, configuration, and location of refrigerant, if used, must be the same in each pack.

7.3 For development or screening evaluation of the overall insulation effectiveness of the container and insulation material, the interior cavity and package wall thickness shall be kept constant (for example, a 12 by 12 by 12-in. (305 by 305 by 305-mm) interior cavity surrounded by a 1-in. (25-mm) thickness of insulation and a 14 by 14 by 14-in. (356 by 356 by 356-mm) container. Test a minimum of three such packages at each exposure listed in 5.1 to obtain an average result and range of performance.

7.4 When testing packages having known or previously established performance data, a minimum of three identical samples shall be tested to determine reproducibility and repeatability.

8. Conditioning

8.1 Condition materials in accordance with Practice D 4332 or for 24 h at the conditions expected during actual production packing.