Designation: E 294 – 72 (Reapproved 1999)

Standard Test Method for Effective Pumping Speed of Vacuum Chamber Systems[1]

This standard is issued under the fixed designation E 294; 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 measurement of effective pumping speed of complete vacuum-chamber systems. The test method is suitable for all types of vacuum systems operating at pressures below 1×10^{-4} torr and for chambers larger than approximately 10 ft^3 (0.3 m^3).

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *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:*

E 296 Practice for Ionization Gage Application to Space Simulators[2]

E 297 Methods for Calibrating Ionization Vacuum Gage Tubes[3]

3. Symbols

3.1 decade = one logarithmic cycle of pressure.

3.2 P_{G1} = test-zone pressure, torr, as read on Bayard-Alpert gage No. 1.

3.3 P_{G2} = test-zone pressure, torr, as read on Bayard-Alpert gage No. 2.

3.4 $P = (P_{G1} + P_{G2})/2$ = average test-zone pressure, torr.

3.5 P_o = background pressure, torr. The chamber pressure (P) at the end of any 4-h period during which the pressure change is less than 0.2 decade with the gas shut-off valve closed (that is, from 2 to 4×10^{-5} torr or 7 to 5×10^{-7} torr).

3.6 Q = measured flow rate of test gas, torr L/s.

3.7 $S_{eff} = Q/(P - P_o)$ = effective pumping speed, L/s.

3.8 torr = 1/760 standard atm ≈ 1 mm Hg.

4. Summary of Test Method

4.1 The chamber under test is fitted with nude Bayard-Alpert pressure gages, a gas-inlet system, and gas-flow measuring devices. The chamber is pumped to a pressure (P_o), then gas is admitted at a measured flow rate (Q) to a point near the center of the test zone. The chamber pressure (P) is allowed to stabilize. This establishes the effective pumping speed (S_{eff}) by the equation:

$$S_{eff} = Q/(P - P_o) \quad (1)$$

4.2 The flow of gas is increased in increments for each pressure decade above the ultimate pressure to 1×10^{-4} torr.

4.3 Two separate test runs are conducted. Nitrogen is the gas for the first test, followed by a similar run using atmospheric air.

5. Significance and Use

5.1 This test method is suitable for specification acceptance, service evaluation, and for comparative evaluation between vacuum-chamber systems.

5.2 The effects of system leakage, materials out-gassing, flow impedance, pump operating deficiencies, and physical arrangement of the chamber and pump system components are integrated by this test method. The effective pumping speed measured is the basic vacuum performance of the overall facility.

6. Apparatus

6.1 The arrangement of test apparatus is shown schematically in Fig. 1. A detailed arrangement of the gas-discharge assembly is shown in Fig. 2.

6.2 The gas-discharge assembly shall include a 3-in. (76-mm) diameter spherical gas diffuser, as shown by Fig. 2. The gas diffuser shall be welded to the end of a ¾-in. (19-mm) diameter gas-inlet tube of sufficient length to extend from the center of the test zone to a point at least 12 in. (305 mm) outside the test chamber shell. The ¾-in. gas-inlet tube shall be vacuum sealed at the chamber-vacuum shell by a device that will permit no in-leakage of atmospheric gas to the test zone at static conditions.

6.3 Calibrated gas-flow measuring devices, with ranges suitable for the capacity and range of the system under test, shall be provided.

6.3.1 Flow rates less than 5×10^{-4} torr L/s may be determined by a conductance method in which the test gas at a known pressure is admitted through a known conductance.

6.3.2 Flows greater than 5×10^{-4} torr L/s but less than about 5 torr L/s may be measured with some type of constant-pressure displacement tube, using low-vapor pressure fluids.

[1] This test method is under the jurisdiction of ASTM Committee E-21 on Space Simulation and Applications of Space Technology and is the direct responsibility of Subcommittee E 21.04 on Space Simulation Test Methods.

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[2] *Annual Book of ASTM Standards*, Vol 15.03.

[3] Discontinued, see *1984 Annual Book of ASTM Standards*, Vol 15.03.

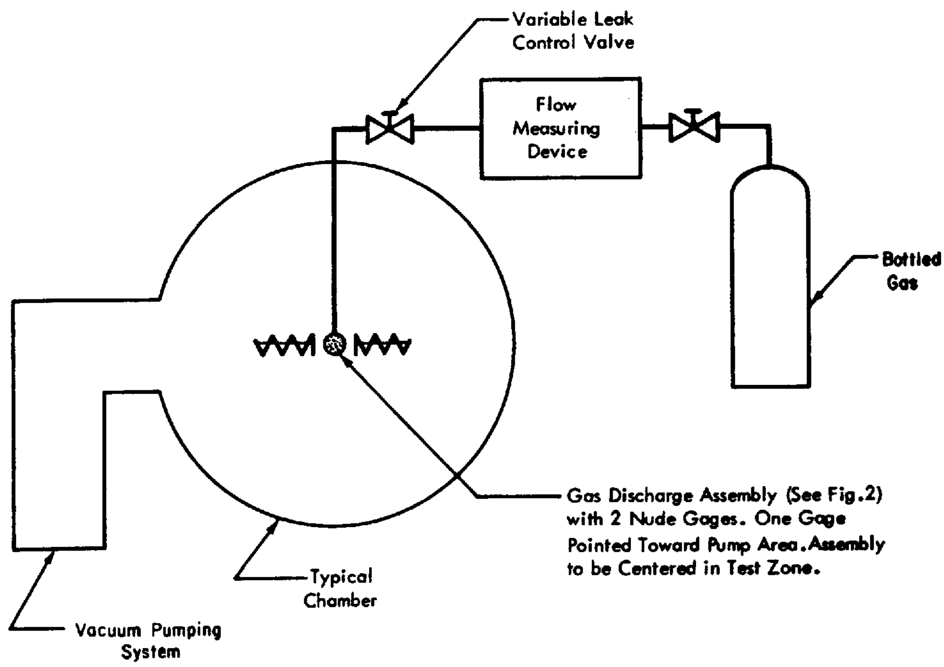
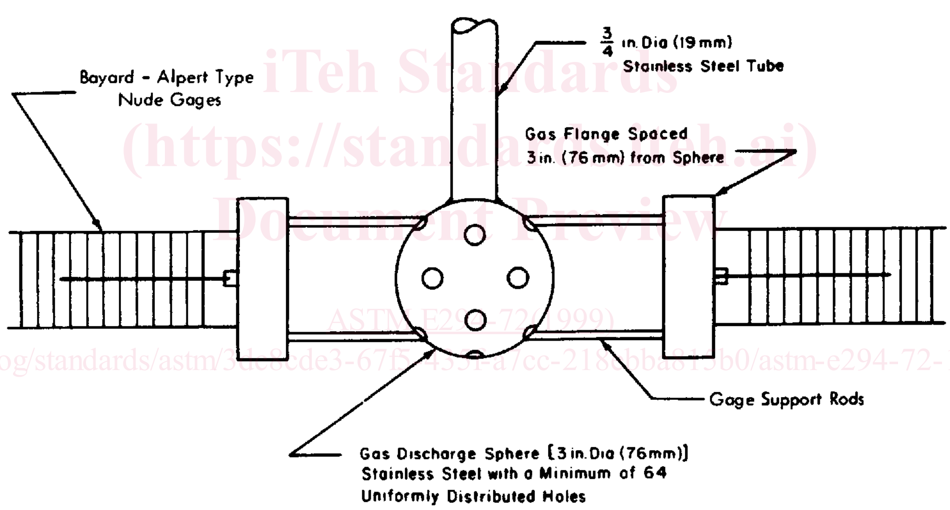


FIG. 1 Test Arrangement



NOTE 1—Diameter of gas discharge sphere holes are to measure ⅛ in. (3.2 mm).

FIG. 2 Gas Discharge Assembly

6.3.3 Flows greater than 5 torr L/s may be measured by variable area flowmeters (rotameters).

6.3.4 Flow-measuring equipment shall provide "overlap" between ranges so that the upper or lower 10 % of any range will not be required for determination of Q. Flow-metering valves shall be placed downstream from variable flow-measuring devices to permit close regulation of the test gas flow.

6.4 The pressure-monitoring system shall include two Bayard-Alpert-type nude ionization gages (G1 and G2) with suitable separate power supplies and pressure indicators. The nude gages shall be attached to the gas diffuser as shown in Fig. 2 with the axes of the gages on the centerline of the gas diffuser sphere and at right angles to the axis of the gas-inlet tube. The mounting flanges of the gages shown in Fig. 2 are large enough to prevent direct impingement of the discharge gas on the gage element. When the gages used do not provide such shielding, a metal disk 3 in. in diameter shall be placed at the gage flange position.

6.5 The gas discharge assembly shall be so located in the test zone center that by 180° rotation of the gas-inlet tube either of the two gage elements may be oriented to the principal vacuum-pumping element (ion pump, cryopanel, diffusion pump, and so forth) as indicated in Fig. 1.

7. Test Gases

7.1 Gases specified below shall be used for testing. Effective pumping speed shall be determined for each gas.

7.1.1 Nitrogen, commercial grade, water pumped and dried, shall be the test gas for the first test.

7.1.2 Atmospheric air at normal laboratory conditions shall be used as the test gas for the second evaluation run. The