AMERICAN VACUUM SOCIETY STANDARD

(Tentative)

AVS 3.6 —1973

Procedure for Rating All-Metal Valves Bakable to above 250°C

FOREWORD

This Foreword is not a part of AVS 3.6 This publication specifies practices tentatively approved as standard by the American Vacuum Society for determining the reliability of valves bakable to above 250°C and is one of a series published by the American Vacuum Society. It contains data secured from many sources and represents the best thinking of a number of experts in the field. It is the first issuance of a standard for this topic. After several years of use, this standard will be forwarded to the American National Standards Institute with the request that it be used as a basis for an ANSI Standard. Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American Vacuum Society, 335 East 45th Street, New York, N. Y. 10017.

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1. SCOPE

This standard specifies methods and procedures for testing ultrahigh vacuum valves which are capable of being baked to above 250°C. These valves have no organic material in contact with the vacuum and can be closed to leak rates less than 1×10^{-9} std. cm^3/sec, air equivalent under all conditions of test. It specifies the test configuration, bakeout tests, and life tests.

2. INTRODUCTION

The following test method has been developed to evaluate the performance of vacuum valves under the severe conditions which may be encountered in use Means are specified for baking the valve open or closed and measuring the leak rate. Ten bake cycles open or closed are specified. Life of the main and stem seals is determined in a separate test which is continued for hundreds of cycles (main seal is the term used to indicate the seal made at the valve seat as the stem is actuated). All sealing tests are specified to be made while the sealing surfaces are clean and dry.

All tests will be made within the limitations specified by the manufacturer unless the deviations are specifically enumerated in the "Presentation of Data."

3. APPARATUS

3.1 System Arrangement

The component layout for all the sealing and bakeout tests is shown in Fig. 1. Trace amounts of vapors con-

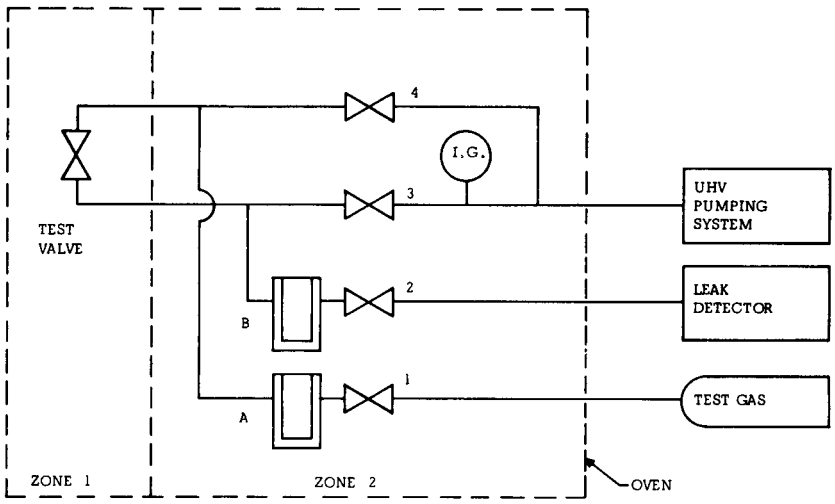

FIGURE 1. Bake test configuration.

densed on the closure seal surfaces may produce a temporary, unreliable seal. Therefore, a principal aim in the design of this system is the exclusion from the test valve of vapors which are condensible at room temperature. To this end, the four auxiliary valves shall be of such construction as to allow no exposure of organic materials to the vacuum. Liquid nitrogen traps A and B shall be located as shown in Fig. 1 to isolate the test valve from possible sources of contamination.

3.2 Equipment

The components shall be chosen in accordance with the need to exclude condensible vapors. Pumps employing fluids shall be appropriately trapped to virtually eliminate contamination. The helium mass spectrometer leak detector shall have a rated sensitivity 2×10^{-10} std. cm³/sec or better, air equivalent as determined by AVS 2.1. Its zero indication level shall not shift by more than 2×10^{-10} std cm³/sec in 15 min. Sensitivity shall be determined to be at least 2×10^{-10} std cm³/sec for helium according to the manufacturer's instructions once a day during the sealing tests.

A bakeout oven shall surround the test apparatus as shown in Fig. 1. The oven shall be capable of uniformly heating the test valve to the required temperature as measured on the test valve body. The oven shall also be capable of heating the rest of the indicated components to at least 200°C. If two temperature zones are to be used, as designated zone 1 and zone 2 in Fig. 1, the vacuum connections between the two zones shall be baked to at least 200°C.

3.3 Test Lot

A minimum of two complete valve assemblies of the same size and type shall constitute a test lot. The valves shall be mounted according to the manufacturer's instructions and, unless thereby prohibited, one shall be tested with the plane of the seal in the vertical and the other with the plane in the horizontal position.

4. Method

4.1 Bakeout Test—Open Position

4.1.1 Bake Cycle

Bake the test valve in its fully open position with auxiliary valves 1 and 2 closed and 3 and 4 open, temperature specified by the manufacturer and at a pressure which shall not exceed 1×10^{-3} Torr and which shall be less than 5×10^{-5} Torr before cooling. Observe the manufacturer's recommendations on heating rate. Bake for 4 h at rated maximum temperature. Cool the test valve from rated maximum temperature to 125°C at the maximum cooling rate allowed by the manufacturer.

4.1.2. Valve Closure

Seal the test valve as specified by the manufacturer at a system pressure of 1×10^{-9} Torr or less at a temperature less than 50°C within 8 h after the oven is turned off. Record the closing torque or other appropriate force measurement.

4.1.3 Leak Test—Main Seal

Cool traps A and B to liquid nitrogen temperature. The main seal shall be leak tested by opening valve 2 to the leak detector, closing valves 3 and 4 to the pumping system and opening valve 1 to fill the system up to the test valve with 99.99% pure helium to a pressure of 760 ± 100 Torr. Record the leak rate after 10 min.

4.1.4 Leak Test—Envelope

Reduce system pressure to below 1×10^{-6} Torr by closing valve 2 to the leak detector and valve 1 to the test gas and opening the test valve and valve 3 to the pumping system. Cycle the test valve five times from fully open to fully closed as specified by the manufacturer. With the test valve open, activate trap B, close valve 3, and open valve 2. If the output indication of the leak detector is not zero, close valve 2 and reopen valve 3. After ten minutes of pumping close valve 3 and

open valve 2. If the leak detector indication is not zero, repeat the pumping process until the indication is zero. Test the valve envelope, with valve 3 closed and valve 2 open, by surrounding the valve with 760 ± 100 Torr pressure of test gas, either by flooding the oven or bagging the valve. Record the leak rate after 10 min.

4.1.5 Duration of Test

Ten cycles of 4.1.1 through 4.1.4 constitute a complete open position bake test. The test on an individual valve is terminated if a leak greater than 5×10^{-10} std cm^3/sec is detected through the valve envelope.

4.2 Bakeout Test—Closed Position

4.2.1 Leak Test before Bakeout

With the test valve properly installed in the system of Fig. 1, close valves 1, 2, 4 and open 3 and the test valve. Pump the system to below 1×10^{-6} Torr, seal the test valve according to the manufacturer's instructions, and leak test the seal as per 4.1.3. Record the sealing torque or other appropriate force measurement.

4.2.2 Bake Cycle

With the test valve and valves 1 and 2 closed, and with valves 3 and 4 open, bake the test valve in the closed position maintaining the maximum temperature specified by the manufacturer for 4 h. The pressure during the bake shall be less than 1×10^{-3} Torr and less than 10^{-3} Torr when the oven is turned off.

4.2.3 Leak Tests

No tightening of the valve closure is permitted during any of the leak tests below.

4.2.3.1 Leak test the test valve main seal when the maximum temperature has been attained and again just before cooling as per 4.1.3 with valves 3 and 4 closed. Reexhaust the test gas manifold between leak tests.

4.2.3.2 Cool the valve to room temperature and repeat the leak test at least twice at equal increments of temperature during cooling. Leak test again at room temperature. Record all maximum detected leak rates.

4.2.3.3 Cycle the test valve from fully sealed to fully opened five times and then leak test the valve envelope as per 4.1.4.

4.2.4 Duration of Test

Ten cycles of 4.2.2 through 4.2.3.3 constitute a complete closed position bake test.

4.3 Determination of Main Seal Cycling Life

4.3.1 Preconditioning the Valve

With valves 1, 2, and 4 closed and the test valve and valve 3 open, bake the test valve to the highest temperature recommended by the manufacturer for 4 h at a pressure less than 1×10^{-3} Torr and attaining 5×10^{-5} Torr before turning off the oven. Cool the valve to room temperature.

4.3.2 Leak Test

Close the test valve as specified by the manufacturer and make initial leak test as per 4.1.3.

4.3.3 Duration of Test

Cycle the test valve for one hundred cycles from fully opened to fully sealed and repeat the leak test as per 4.1.3. Also leak test as per 4.1.4, neglecting the 5 closure cycles. Continue leak testing after each 100 closure cycles until the leak exceeds 1×10^{-5} std. cm^3/sec or the valve otherwise fails. Record leak values.

5. PRESENTATION OF DATA

Significant changes in the design or fabrication of the valves shall warrant a new test. While preliminary tests may be conducted to establish appropriate closure torque values, all failures encountered during the bake tests must be reported in the data presentation including any envelope failures. If failures do occur, the number of samples tested may be arbitrarily increased to improve the percentage of successful cycles. The statement of results will include the bakeout temperature, the number of sample valves tested, the percentage of cycles successfully completed, and a description of closure torque progression over the span of the tests (graphical presentation may be used).

$$\%\ \text{Bake Cycles Open (or Closed)} = \frac{\text{No. Successful Cycles} \times 100\%}{\text{No. Valves Tested} \times 10\ \text{cycles}}.$$

An example of data presentation is shown in the following table.

TABLE I.

Valve bakeout test per AVS 3.6

Valve model No. D5 Serial Nos. 101, 102, 109, and 112
Bakeout temperature = 450°C

No. of valves	% Bake cycles open	% Bake cycle closed	Average No. cycles seal life
4			
3	100%	85%	450

Closing torque progression: Bake test, linear increase from 15 to 45 ft lb
Seal life, linear increase from 15 to 60 ft lb

Remarks: One leak of 10^{-6} liters/sec in envelope weld during closed bakeout cycle.

Average leakage rate, main seal

Bake cycles	Open bake	Closed bake
1	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
2	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
3	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
4	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
5	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
6	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
7	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
8	2×10^{-10} std. cm^3/sec	2×10^{-10} std. cm^3/sec
9	2×10^{-10} std. cm^3/sec	4×10^{-10}
10	2×10^{-10} std. cm^3/sec	8×10^{-10}