Method for Testing Flange Seals to 500°C

FOREWORD

This Foreword is not a part of AVS 3.3–1968. This publication specifies practices tentatively approved as standard by the American Vacuum Society for determining the reliability of flange seals bakeable to 500°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 USA Standards Institute with the request that it be used as a basis for a USA 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.

The AVS Committees which drafted and approved this Standard had the following personnel at the time of approval.

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1. SCOPE

This standard specifies a method for determining the performance of flange seals intended for use on vacuum systems operating up to 500°C. It is meant to be used only as an approval test for a given type of flange as it is destructive in nature. Flange mounting, time and temperature of cycling, mechanical loading, and leak test procedures are specified. Convenience and cost are not evaluated by this test.

2. INTRODUCTION

The following test method is designed to evaluate bakeable flange seals under severe conditions which are actually encountered in use. The seals are cycled 25 times to 500°C for a total of 500 h at that temperature. After each 100 h, the seals are mechanically stressed at 500°C and at reduced temperature and leak tested after each stressing. A leak found at any time is considered to be a failure. Flange designs which have completed these tests without failure have proven highly reliable in actual use.

3. APPARATUS

Each of the flanges undergoing test shall be welded to tubing of the maximum outside diameter for which the flange is designed and of a wall thickness and minimum length given in Table I. (See p. 4). Pairs of flanges shall be assembled using hardware, gaskets, and procedures as specified by the manufacturer. The assembly shall be clamped to a firm support as shown in Fig. 1 using the clamping distance specified in Table I. The tubing end not connected to the vacuum system shall be capped with a welded plug and appropriate hardware designed to facilitate the application of a bending moment as shown in Fig. 1. No tightening of the flange bolts is permissible after the start of the bake tests. A suitable oven shall surround the flange assembly so that the flanges are heated and cooled uniformly

4. METHOD

4.1. Temperature Cycle.

4.1.1. Cycle Duration. Each flange seal shall be subjected to a minimum of 25 temperature cycles to 500°±20°C for an accumulated total of 500 h at that temperature. Except during leak testing, the seal is exposed to room air.

4.1.2. Heating and Cooling Rate. The flange seals shall be symmetrically heated at a rate of not less than 200°C nor greater than 300°C per h. They shall be symmetrically cooled from 500°C to less than 100°C in 1½–3 h.

4.2. Mechanical Stressing Testing.

4.2.1. Test Interval. Each flange seal shall be stressed as described below while at 500°C and while at 100°C after each approximately 100 h of bakeout.

TABLE I. Tubing dimensions for bake test.

Flange no. o.d. (in.)	Tubing max o.d. (in.)	Tubing wall thickness (in.)	Tubing length (in.)	Clamping distance (in.)
2-½	1	0.065	8	6
2-¾	1-½	0.065	8	6
3-⅜	2	0.065	10	8
4-½	2-½	0.065	10	8
4-⅝	3	0.065	12	10
6	4	0.083	12	10
6-¾	5	0.083	14	12
8	6	0.083	14	12
10	8	0.125	16	14

4.2.2. Test Method. Each flange seal shall be stressed to the bending moment specified in Table II. The moment may be produced by weight loading at the end of the tubing as in Fig. 1 or by means of a calibrated torque wrench as in Fig. 1. The loading moment shall be calculated for the interface plane between the test flanges (A–A). If a weight is used, the moment is given by

$$M = BW,$$

where B is the moment arm defined in Fig. 1. If a torque wrench is used, the moment is given by

$$M = \text{Indicated Torque } [1 + (B/L) \cos \theta],$$

where L is the length of the torque wrench as defined in Fig. 1.

The loading shall be smoothly applied in one direction and held for 30 sec, smoothly reduced to zero, and then smoothly applied in the opposite direction for 30 sec before it is smoothly reduced to zero.

4.3. Leak Testing.

4.3.1. Test Interval. Each flange seal under test shall be leak tested after each mechanical stressing at 500° and 100°C.

4.3.2. Test Method. Test gas, usually helium, shall be flowed over the seal area for a minimum of 5 min but not more than 15 min. This is best done by injecting the test gas directly into the leak test groove by means of a small diameter stainless steel tube.

TABLE II. Bending moments applicable to various flange seals.

Flange nom. o.d. (in.)	Bending moment (ft lbs.)
2-½	10
2-¾	22
3-⅜	38
4-½	60
4-⅝	90
6	210
6-¾	340
8	480
10	1280

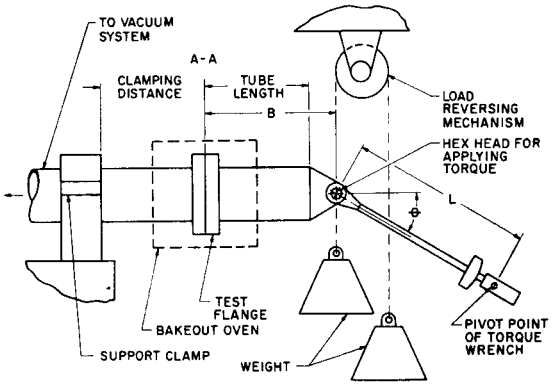

FIGURE 1. Flange mounting and stressing configuration.

4.3.3. Equipment. Leak testing shall be accomplished with an instrument whose sensitivity has been determined according to applicable AVS standards. The measured sensitivity shall be 5×10^{-10} std. cm³/sec air equivalent or better.

4.3.4. Failure Criteria. Leakage greater than 1×10^{-9} std. cm³/sec air equivalent observed at any time during the test constitutes a seal failure.

4.4 Flange Reseal Test. After completion of the 500 h at 500°C, the flange seal shall be dismantled and the seal remade according to the manufacturer's instructions. The seal shall then be subjected to three additional bake cycles as per 4.1–4.3.4 above including mechanical stressing and leak testing. The purpose of these three additional bake cycles is to determine if the quality of the flanges has been degraded by the 500-h test.

5. PRESENTATION OF RESULTS

A statement of test results shall include reference to the subject AVS standard, flange size, the number (N) of seals tested, and the percentage of life hours successfully completed. This performance percentage is computed as follows:

$$\text{Performance Percentage} = \text{Successful Life Hours} \times 100\%/N \times 500.$$

Successful life hours are the number of hours completed by a seal at 500°C without a detectable leak. All seals which begin the bake test must be included in the computation. Any flange pair which fails to produce a leak tight seal (4.4) after successful completion of the 500-h test shall be arbitrarily scored at 100 successful life hours.

6. APPENDIX

For ease of interpreting test results, it is best to use an individual oven around each flange assembly with separate gas flow lines to each assembly. Helium or

purge gas can be piped to each flange assembly by a simple arrangement of tubing and pinch clamps or valves.

One convenient method of fabricating inexpensive individual ovens for these tests is to roll a suitable diameter tube from stainless steel sheet. The tube is covered with a thin layer of asbestos paper. A suitable length of coiled resistance wire is then wrapped about the tube and covered with a cement such as Sauereisen cement No. DW 30. A 2-in. layer of rock wool batting is tied around the tube and covered with thick aluminum foil. The ends of the oven are insulated with two ½-in. thick disks of Transite with a layer of rockwool sandwiched between them. The disks are cut in two pieces for ease of assembly.

For temperature control, infinitely variable kitchen range switches can be used to set the temperature to the value desired. Where the line voltage fluctuates excessively, it may be necessary to use a voltage stabilizer to provide constant temperatures.

Temperature measurement is readily accomplished with one or more thermocouples attached to each flange assembly and switched into the measuring circuit with a multiposition switch.