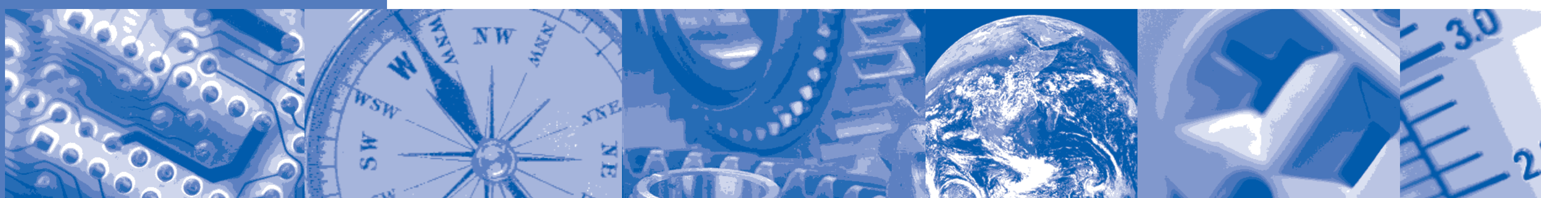
AMERICAN NATIONAL STANDARD

ANSI/ISA–93.00.01–1999

Formerly ANSI/ISA–S93.00.01–1999



Standard Method for the Evaluation of External Leakage of Manual and Automated On-Off Valves

Approved 15 January 2000

ISA

ANSI/ISA–93.00.01–1999
Standard Method for the Evaluation of External Leakage of Manual and Automated On-Off Valves

ISBN: 1-55617-712-7

ISA
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, North Carolina 27709

Preface

This preface, as well as all footnotes and annexes, is included for information purposes and is not part of ANSI/ISA-93.00.01-1999.

This document has been prepared as part of the service of ISA, the international society for measurement and control, toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: standards@isa.org.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards, recommended practices, and technical reports to the greatest extent possible. *Standard for Use of the International System of Units (SI): The Modern Metric System*, published by the American Society for Testing & Materials as IEEE/ASTM SI 10-97, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all concerned individuals and interests in the development of ISA standards, recommended practices, and technical reports. Participation in the ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual, of ISA, or of any of the standards, recommended practices, and technical reports that ISA develops.

CAUTION — ISA ADHERES TO THE POLICY OF THE AMERICAN NATIONAL STANDARDS INSTITUTE WITH REGARD TO PATENTS. IF ISA IS INFORMED OF AN EXISTING PATENT THAT IS REQUIRED FOR USE OF THE STANDARD, IT WILL REQUIRE THE OWNER OF THE PATENT TO EITHER GRANT A ROYALTY-FREE LICENSE FOR USE OF THE PATENT BY USERS COMPLYING WITH THE STANDARD OR A LICENSE ON REASONABLE TERMS AND CONDITIONS THAT ARE FREE FROM UNFAIR DISCRIMINATION.

EVEN IF ISA IS UNAWARE OF ANY PATENT COVERING THIS STANDARD, THE USER IS CAUTIONED THAT IMPLEMENTATION OF THE STANDARD MAY REQUIRE USE OF TECHNIQUES, PROCESSES, OR MATERIALS COVERED BY PATENT RIGHTS. ISA TAKES NO POSITION ON THE EXISTENCE OR VALIDITY OF ANY PATENT RIGHTS THAT MAY BE INVOLVED IN IMPLEMENTING THE STANDARD. ISA IS NOT RESPONSIBLE FOR IDENTIFYING ALL PATENTS THAT MAY REQUIRE A LICENSE BEFORE IMPLEMENTATION OF THE STANDARD OR FOR INVESTIGATING THE VALIDITY OR SCOPE OF ANY PATENTS BROUGHT TO ITS ATTENTION. THE USER SHOULD CAREFULLY INVESTIGATE RELEVANT PATENTS BEFORE USING THE STANDARD FOR THE USER'S INTENDED APPLICATION.

HOWEVER, ISA ASKS THAT ANYONE REVIEWING THIS STANDARD WHO IS AWARE OF ANY PATENTS THAT MAY IMPACT IMPLEMENTATION OF THE STANDARD NOTIFY THE ISA STANDARDS AND PRACTICES DEPARTMENT OF THE PATENT AND ITS OWNER.

ADDITIONALLY, THE USE OF THIS STANDARD MAY INVOLVE HAZARDOUS MATERIALS, OPERATIONS OR EQUIPMENT. THE STANDARD CANNOT ANTICIPATE ALL POSSIBLE APPLICATIONS OR ADDRESS ALL POSSIBLE SAFETY ISSUES ASSOCIATED WITH USE IN

HAZARDOUS CONDITIONS. THE USER OF THIS STANDARD MUST EXERCISE SOUND PROFESSIONAL JUDGMENT CONCERNING ITS USE AND APPLICABILITY UNDER THE USER'S PARTICULAR CIRCUMSTANCES. THE USER MUST ALSO CONSIDER THE APPLICABILITY OF ANY GOVERNMENTAL REGULATORY LIMITATIONS AND ESTABLISHED SAFETY AND HEALTH PRACTICES BEFORE IMPLEMENTING THIS STANDARD.

The following people served as members of ISA Committee SP93:

NAME	COMPANY
R. Davis, Chairman	Garlock Valves & Industrial Plastics
W. Weidman, Managing Director	Parsons Energy and Chemicals Group, Inc.
R. Aaron	Watts Industries, Inc.
E. Bake	Edward Valves, Inc.
G. Barb	Consultant
S. Benson	Occidental of Bangladesh Ltd.
J. Byko	Mobil Research & Development Corporation
A. Carlstrom	Union Carbide Chemicals
M. Cohen	Senior Flexonics
D. Cornelsen	Walworth Company
S. Esteban	ARCO Products Company
C. Falknor	South Coast Supply Co.
D. Frikken	Monsanto Chemical Co.
T. Gardner	Orbit Valve Co.
M. Glavin	Tyco Valves and Controls
L. Gorman	McCanna Valve
M. Hama*	Kitz Corporation of America
T. Hannafin*	Kitz Corporation of America
F. Hart	Calder Testers, Inc.
B. Hurst	Exxon Research & Engineering Company
K. Kingsford	Furon Fluid Handling
B. Kirkman	BP Chemicals
E. Knerr	Keystone Valve
C. Koloboff	Koloboff Consulting
D. Lakatos	American Shear & Knife
T. Lechinger	Stress Engineering Services Co.
A. Lennon	Neles Automation
A. Libke	DeZurik Valve Company
R. Lineberry	Consultant
R. McCamish	DOW Chemical USA
R. McEver, Jr.	Bettis Corporation
D. Monroe	SEPCO
K. Mracek	Swagelok Co.
N. Nath	E .I. duPont
J. O'Connor	HPS Inc.
R. Osthues	Worcester Controls
J. Pease	Bonney Forge
H. Sonderegger	Tyco Flow Control
J. Spahr	Anderson Greenwood & Company

* One vote per company.

S. Stephens	Ladish Company
H. Storey	Equilon Enterprises LLC
C. Sumner	TBV Newman
J. Thomas	Parker Hannifin Corporation
R. Walsh	Stockham Valve & Fittings
S. Ward	Coltec Industries
M. Wasielewski	Yarmouth Research & Technology
Z. White	Crane Valve Group

This Standard was approved for publication by the ISA Standards and Practices Board on 15 September 1999.

NAME	COMPANY
H. Dammeyer	The Ohio State University
H. Baumann	H. D. Baumann, Inc.
D. Bishop	Chevron Petroleum Technology Co.
P. Brett	Honeywell, Inc.
M. Cohen	Senior Flexonics, Inc.
M. Coppler	Ametek, Inc.
W. Holland	Southern Company
A. Iverson	Ivy Optiks
R. Jones	Dow Chemical Co.
V. Maggioli	Feltronics Corp.
T. McAvinew	Instrumentation & Control Engineering LLC
A. McCauley, Jr.	Chagrin Valley Controls, Inc.
R. McFarland	Honeywell, Inc.
R. Reimer	Rockwell Automation
J. Rennie	Factory Mutual Research Corp.
R. Webb	Altran Corp.
W. Weidman	Parsons Energy & Chemicals Group
J. Weiss	EPRI
J. Whetstone	National Institute of Standards & Technology
M. Widmeyer	EG&G Defense Materials
R. Wiegle	CANUS Corp.
C. Williams	Eastman Kodak Co.
G. Wood	Graeme Wood Consulting
M. Zielinski	Fisher-Rosemount Systems, Inc.

CONTENTS

1 Scope

This Standard applies to the classification of valve design and provides the methods for the testing of valve stem(s) and body seal(s). This Standard is not intended for production testing and excludes control valves.

1.1 The results of the test methods shall classify valve designs to performance levels per the following selections:

a) Test temperature

b) Pressure rating

c) Leakage (concentration, parts per million)

d) Mechanical cycles (number of)

e) Thermal cycles (number of)

f) Adjustment(s) to seal(s) and/or number of adjustments

1.2 Test methods per this Standard shall apply only to valves with the following stem motion designs:

a) Rotating and rising

b) Rotating and non-rising

c) Non-rotating and rising

1.3 The classification shall apply only to the stem(s) motion design of 1.2, which is tested.

1.4 The test results of a particular valve may be used to extend the classification to other valves per the following guidelines:

a) To valves with identical stem(s) and body seal(s) material, geometry, and loading characteristics, when the stem(s) and body seal(s) diameters are within ±25% of the tested diameters

b) To valves otherwise identical, meeting the criteria of 1.4a, which are applied below the tested temperature, down to ambient temperature

c) To valves otherwise identical, meeting the criteria of 1.4.a, which are of a lower pressure rating

1.5 Valves intended for vacuum service are beyond the scope of this Standard.

2 Purpose

The purpose of this Standard is to establish a uniform process for assuring that manual and automated on-off valves are tested using uniform methods and will meet user needs in complying with volatile organic compounds (VOC) fugitive emissions requirements. The test method is not intended to be a pass-fail criteria.

3 Definitions

Definitions in this Standard apply to this Standard only.

3.1 ambient temperature:
temperature in the range of 40°F to 100°F (4°C to 38°C).

3.2 automated on-off valve:
a valve that utilizes an external power source such as electric, pneumatic, hydraulic, or other mechanical means to operate the valve from the full open to full closed to the full open position.

3.3 body seal(s):
applies to and includes all pressure containing seals inboard of the valve ends, excluding the stem seal(s). Valve end flanges or other end seals are not included in this definition. Hereinafter, body seal shall include multiple seals or seals on multiple body joints if applicable.

3.4 body seal temperature:
that temperature measured adjacent to the body seal.

3.5 leakage:
the test media being emitted past the stem or body seal under the defined test conditions, as reported in parts per million (ppm) concentration of methane. Methane equivalent leakage in parts per million is an acceptable alternate.

3.6 leak rate category:
Allowable limits of leakage in ppm as identified by this Standard.

3.7 manual valve:
a valve operated manually with a lever, handwheel, gearbox, or similar device without any additional external power source.

3.8 mechanical cycle:
movement of the valve stem(s) from the full open to the full closed and back to the full open position. Hereinafter, the word stem includes similar functional devices such as shafts, rods, and so forth, and includes multiple stems if applicable.

3.9 pressure rating:
the pressure rating of the valve as defined in ASME B16.34, the Manufacturer's Pressure Rating, or similar standards, at the test temperature.

3.10 proof of design:
a test or series of tests to classify a valve, including the stem seal and/or body seal design, as meeting a particular test requirement identified in clause 4 (and clause 5).

3.11 standard test temperature:
the selected test temperature as defined in table 1. The standard test temperature is the stabilized valve body temperature measured along the flow line of the body.

3.12 stem seal(s):
the means of preventing leakage to the atmosphere where the stem protrudes from the valve body assembly, including any seal loading or retaining mechanism(s), or both. Hereinafter, stem seal shall include multiple seals or seals on multiple stems, if applicable.

3.13 stem seal adjustment:
manual adjustment of any mechanism that retains or applies force to any of the various stem seal components.

3.14 stem seal temperature:
that temperature measured adjacent to the stem seal.

3.15 stem travel:
the full stroke (linear or rotary) of the valve open or closed.

3.16 thermal cycle:
a change in temperature from ambient temperature to selected test temperature and the return to ambient temperature.

4 Classifications

4.1 The valve shall be tested at one or more of the combined selected standard test temperatures and leak rate categories listed in table 1. All testing shall be done at the pressure rating. Each test, except test(s) made for valves classified for ambient temperature, shall include at least one thermal cycle.

4.2 Record the highest number of mechanical cycles achieved before any of the following conditions apply that would be cause to terminate the test:

a) The measured leakage exceeds the leak rate category and no stem seal adjustments are desired.

b) The measured leakage exceeds the leak rate category and stem seal adjustments do not bring and/or maintain the measured leakage to below the leak rate category.

c) The body seal leakage exceeds the leak rate category.

d) The number of mechanical cycles achieved is appropriate for the valve being tested.

Table 1 — Standard temperature and leak rate category

Standard test temperature			
-50°F (-46°C)	Ambient	350°F (177°C)	750°F (399°C)

Leak rate category		
50 ppm	100 ppm	500 ppm

4.3 The classification of a valve tested to the requirements of this Standard shall contain the following information presented in a format consistent with table 2:

a) Standard test temperature

b) Pressure rating

c) Leak rate category

d) Mechanical cycles

e) Thermal cycles

f) Stem seal adjustments

Table 2 — Valve classification

Standard test temperature (1)	Pressure rating (2)	Leak rate category (3)	Mechanical cycles (4)	Thermal cycles (5)	Number of stem seal adjustments (6)

NOTE 1 — Standard test temperature selected (from table 1).

NOTE 2 — Pressure rating selected.

NOTE 3 — Leak rate category selected (from table 1).

NOTE 4 — Report the number of mechanical cycles achieved when test is terminated.

NOTE 5 — Report the number of thermal cycles during the test.

NOTE 6 — Report the number of stem seal adjustments during the test.

4.4 The following are examples of valve classifications and should not be considered as requirements:

4.4.1 An ASME Class 150 valve tested at 350°F (177°C) up to a leak rate category of 100 ppm for 3000 mechanical cycles and three thermal cycles with no stem seal adjustments would be classified as follows:

Standard test temperature	Pressure rating	Leak rate category	Mechanical cycles	Thermal cycles	Number of stem seal adjustments
350°F (177°C)	ASME Class 150	100	3000	3	0

4.4.2 An ASME Class 600 valve tested at 350°F (177°C) up to a leak rate category of 50 ppm for 5000 mechanical cycles and three thermal cycles with two stem seal adjustments would be classified as follows:

Standard test temperature	Pressure rating	Leak rate category	Mechanical cycles	Thermal cycles	Number of stem seal adjustments
350°F (177°C)	ASME Class 600	50	5000	3	2

4.5 It is permissible to begin testing for a certain classification, and at the successful completion of the test, maintaining the same test parameters without any modifications and/or adjustments, continue mechanical and/or thermal cycling until another classification is achieved.

5 Special classifications

5.1 Upon successful completion of testing based on one of the standard test temperatures described in clause 4, the manufacturer may choose to test an additional valve at a non-standard test temperature.

5.2 The valve shall be tested at one of the leak rate categories listed in table 1. All testing shall be done at the pressure rating. Each test, except test(s) made for valves classified for ambient temperature, shall include at least one thermal cycle.

5.3 Record the highest number of mechanical cycles achieved before any of the following conditions apply that would be cause to terminate the test:

a) The measured leakage exceeds the leak rate category and no stem seal adjustments are desired.

b) The measured leakage exceeds the leak rate category and stem seal adjustments do not bring and/or maintain the measured leakage to below the leak rate category.

c) The body seal leakage exceeds the leak rate category.

d) The number of mechanical cycles achieved is appropriate for the valve being tested.

5.4 The classification of a valve tested to the requirements of clause 4 and to the special classification requirements of this clause shall contain the following information for each of the classification tests in a format consistent with table 3:

a) Standard test temperature

b) Pressure rating

c) Leak rate category

d) Mechanical cycles

e) Thermal cycles

f) Stem seal adjustments

g) Non-standard test temperature

Table 3 — Special valve classification

Standard test temperature (1)	Pressure rating (2)	Leak rate category (3)	Mechanical cycles (4)	Thermal cycles (5)	Number of stem seal adjustments (6)
Non-standard test temperature (7)	**Pressure rating (2)**	**Leak rate category (3)**	**Mechanical cycles (4)**	**Thermal cycles (5)**	**Number of stem seal adjustments (6)**

NOTE 1 — Standard test temperature selected (from table 1).

NOTE 2 — Pressure rating selected.

NOTE 3 — Leak rate category selected (from table 1).

NOTE 4 — Report the number of mechanical cycles achieved when test is terminated.

NOTE 5 — Report the number of thermal cycles during the test.

NOTE 6 — Report the number of stem seal adjustments during the test.

NOTE 7 — Non-standard test temperature selected (special).

5.5 The following is an example of special valve classification and should not be considered as a requirement:

5.5.1 An ASME Class 300 valve is tested at 350°F (177°C) up to a leak rate category of 100 ppm for 3000 mechanical cycles and three thermal cycles with no stem seal adjustments. The manufacturer chooses to do a non-standard test on an additional valve at a test temperature of 450°F (232°C) at leak rate category of 100 ppm for 3000 mechanical cycles and three thermal cycles with one stem seal adjustment. The valve would be classified as follows:

Standard test temperature	Pressure rating	Leak rate category	Mechanical cycles	Thermal cycles	Number of stem seal adjustments
350°F (177°C)	ASME Class 300	100	3000	3	0
Non-standard test temperature	**Pressure rating**	**Leak rate category**	**Mechanical cycles**	**Thermal cycles**	**Number of stem seal adjustments**
450°F (232°C)	ASME Class 300	100	3000	3	1

5.6 As is the case in standard classification, it is permissible to begin testing for a certain classification, and at the successful completion of the test, maintaining the same test parameters without any modifications and/or adjustments, continue mechanical and/or thermal cycling until another classification is achieved.

6 Testing

Successfully completing the test described herein shall constitute Proof of Design of the valve, including body and stem seals, and permit the classification of the product per the criteria achieved herein.

6.1 General

6.1.1 Valve assemblies shall be used for testing. An automated version of a manual valve of the same design may be used in lieu of the manual valve, and vice-versa providing the load on the stem is not changed. The use of gear boxes or other mechanical operating devices does not require a separate qualification. The use of test fixtures in lieu of valve assemblies is not permitted.

6.1.2 The test valve(s) shall be a standard production valve selected at random. Special preparation of the components or the assembly is prohibited.

6.1.3 The test valve body seal(s) shall not be disturbed or adjusted throughout the test.

6.1.4 Air, nitrogen, helium, or methane may be used as the medium to maintain pressure in the valve during mechanical and thermal cycling. The gas shall be oil and water free. Test gas used shall be at least 97% pure.

6.1.5 The leakage of a test gas other than methane that is used for leak detection shall have the results correlated to an equivalent methane leakage in ppm. The manufacturer shall document the validity of the correlation method used to convert to methane leakage in ppm. (See annex C for non-mandatory correlation formulas.)

6.2 Leakage and temperature measurement

6.2.1 The leakage from all sources shall be measured and the highest value reported. A bagging technique or a leak detection probe may be used. If a probe for leakage measurement is used, the areas probed shall be in still air, isolated from wind, fans, or drafts. Use of the measuring instrument shall be per the manufacturer's instructions.

6.2.2 Leakage measurements shall be made while valve is at rest, in the partially open position.

6.2.3 The leakage shall be measured at the end of each temperature extreme during a thermal cycle and at the end of the test.

6.2.4 Standard test temperature measurements shall be made by attaching a thermocouple or other contact type measurement device to the test valve along the flow line of the body. Stem and body seal temperature measurements shall be made by attaching a thermocouple or other contact type measurement device to the test valve adjacent to the seal. If the valve wall thickness in these regions is greater than ½ in., a hole shall be drilled into the valve such that a thermocouple may be inserted and is no more than ½ in. from the flow line of the body, stem, or body seal.

6.3 Test procedure (see figure 1 for Sample test profile)

6.3.1 The manufacturer's specified valve installation or any pre-installation maintenance instructions shall be carried out prior to testing.

6.3.2 The valve(s) shall be tested with the stem in the horizontal position.

6.3.3 During cycling, the valve closure element shall be fully engaged with the valve seat, and normal seating loads shall be applied during each mechanical cycle.

6.3.4 The valve operating speed throughout the test shall not be slower than normal for that valve.

6.3.5 Each test, except test(s) made for valves classified for ambient temperature, shall include at least one thermal cycle to the standard test temperature. A minimum of three thermal cycles are required for valves classified for more than 900 mechanical cycles. Valves tested for more than 300 mechanical cycles shall include one thermal cycle for each 300 mechanical cycles, up to 900 total cycles, preceded by one or more mechanical cycles.

6.3.5.1 The valve shall be at equilibrium at ambient temperature before initiating the thermal cycle. Then, the valve shall be heated or cooled to the standard test temperature before returning the valve to ambient temperature.

6.3.5.2 If thermal cycles are employed in the testing, the valve may have a limited amount of the total mechanical cycles during the temperature transitions. At least 50% of the total mechanical cycles must occur at temperatures within 10% of standard or special test temperatures of 350°F (177°C) and higher, or within 20°F (11°C) of standard or special test temperatures below 350°F (177°C). At least 5% of the total mechanical cycles must occur at ambient temperature.

6.3.6 Select the standard test temperature and leak rate category criteria from table 1 or select additional combinations of special test temperatures and standard leak rate categories as specified in clause 5. The results shall be recorded in table 2 or table 3, as applicable, for the duration of the test.

6.3.7 Bring the valve from ambient temperature and zero pressure to the selected test temperature and the pressure rating and begin mechanical cycling. Cycle the valve at least 10 cycles prior to the first leak test.

6.3.8 The valve classification is based upon the mechanical and thermal cycles achieved before the test is terminated per 4.2 (and 5.3.) Although not mandatory, frequent or continuous leakage measurements are suggested.

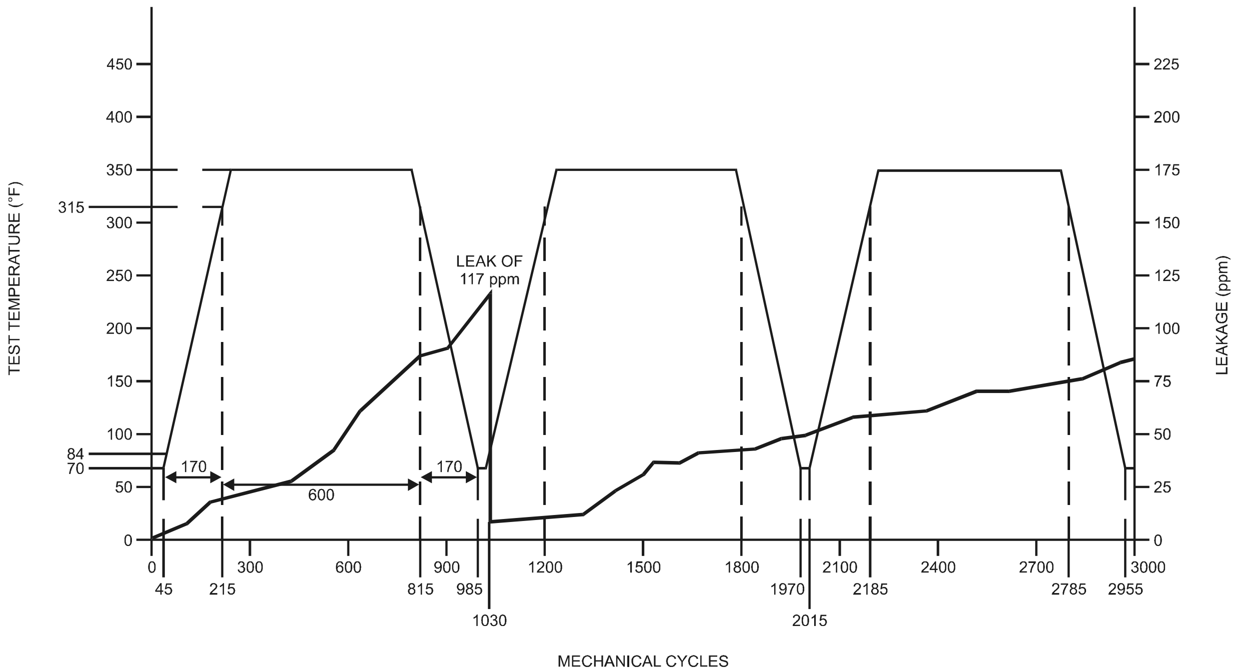


Figure 1 - Sample test profile

The above chart illustrates an example of a test that was performed at 350°F (177°C) for 3000 mechanical cycles with three thermal cycles. A total of 180 mechanical cycles (6%) were completed at ambient temperature. A total of 1800 mechanical cycles (60%) were performed at temperatures within 10% of the maximum test temperature of 350°F (177°C). The leak rate category selected was 100 ppm. Test leakage readings were taken at frequent intervals and plotted on the same chart. A packing adjustment was required at 1030 cycles due to leakage in excess of 100 ppm.

7 Test report requirements

7.1 For valves tested per this Standard, a test report shall be prepared and made available to the customer upon request. (See annex B for Sample test report form.)

7.2 The report shall include, as a minimum, the following information:

a) The manufacturer's standard general arrangement drawing and component list for the test valve, including design and data relative to the actuator utilized (if qualifying an automated valve)

b) Cross-sectional drawings, including the following data:

   1) Stem diameter at the seal

   2) Stem seal cross-section

   3) Stem seal height

   4) Body seal thickness or height

5) Body seal inside diameter

6) Body seal cross-section

7) Test pressure range

8) Pressure rating of the valve

c) The stem travel, linear or rotary, of the test valve to the stem travel, cycles per minute, and stem motion of the test valve

d) Make and model of the instrument and the method used to measure leakage and the correlation calculation if the test gas is other than methane

e) The number of mechanical cycles achieved when each adjustment was required to conform with the leak rate category, if applicable

f) The test temperature measured along the flow path and, for information, the body seal and stem seal temperatures (Any other pertinent measurements or observations should also be recorded.)

g) The classification(s) achieved (table 2 or 3 as applicable)

h) The additional valves to which this classification applies (per 1.4)

i) Additionally, the report will include the company name, and the name and signature of the principal testing individual.

This page intentionally left blank.

Annex A — References

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.34 Valves - Flanged, Threaded, and Welding End

Available from: **ASME**
Three Park Avenue
New York, NY 10016-5990
Tel: (800) 843-2763

Annex B — Sample test report form

Company name: Date of test:

Valve model:
Stem motion: linear ☐ rotary multi ☐ rotary quarter ☐
other ☐ specify:
Stem travel:

Actuator model: Cycles per minute:

Classification achieved

Standard test temperature	Pressure rating	Leak rate category	Mechanical cycles	Thermal cycles	Number of stem seal adjustments

List additional valve models this classification applies to:

Leak test media: Cycling test media:

Instrument make and model:

Method: probe ☐ bag ☐ other ☐

Correlation used: (if test media is other than methane)

Results

Date	Time	Mechanical Cycles	Pressure (state units)	Temperature (state units)			Leakage (ppm)	Adjustments
				Flow line	Body seal	Stem seal		

Technician:
Date:

Company official:
Date:

Annex C — Non-mandatory correlation formulas

C.1 Introduction

When considering the leakage correlation of a gas measured in ppm to methane leakage in ppm, it is important to recognize the factors that influence gaseous flow through leaks. These include

a) the molecular weight of the gas;

b) the viscosity of the gas;

c) the pressure differential causing the flow;

d) the absolute pressure in the system;

e) the length and cross section of the leak path; and

f) the temperature of the gas.

For the purposes of this Standard, the last four factors are considered constants between the measured gas and methane. The primary modes of leakage that can result from these factors are molecular, transitional, and viscous (both laminar and turbulent).

C.2 Molecular leakage

Molecular leakage results when the mean free path of both gases being correlated is greater than the cross-sectional dimension of the leak orifice. The mean free path is defined as the distance a molecule travels between successive collisions with other molecules in the vapor state. When this type of leakage is encountered, the measured leakage (concentration in ppm) of any gas can be correlated to methane leakage per the following formula:

$$M_L = (L_T)\,(MW_T)^{1/2} / (MW_M)^{1/2}$$

M_L = Methane equivalent leakage, ppm
L_T = Measured leakage of test gas, ppm
MW_T = Molecular weight of the test gas, atomic mass units
MW_M = Molecular weight of methane, atomic mass units

NOTE — Molecular leakage typically occurs when the flow is extremely low such as is encountered in vacuum systems.

C.3 Transitional leakage

Transitional leakage results when the mean free path of both gases being correlated is approximately equal to the cross sectional dimension of the leak orifice. When this type of leakage is encountered, the measured leakage (concentration in ppm) of any gas can be correlated to methane leakage per the following formula:

$$\text{Methane equivalent leakage, ppm} = \frac{(\text{Measured leakage of test gas, ppm}) \times [(\text{Molecular weight of test gas, atomic mass units}) \times (\text{Absolute temperature, Kelvin})]^{1/2}}{[(\text{Molecular weight of methane, atomic mass units}) \times (\text{Absolute temperature, Kelvin})]^{1/2}}$$

NOTE — Transitional leakage occurs under conditions intermediate between molecular and viscous (laminar) flow. This transition between molecular and laminar leakage is gradual.

C.4 Viscous leakage

Viscous leakage, both laminar and turbulent, results when the mean free path of both gases being correlated is smaller than the cross sectional dimension of the leak orifice. As the velocity of the gas flow increases, the leakage will go from laminar to turbulent. In laminar flow, particles follow a nearly straight path, while in turbulent flow, the path is more erratic. Provided the flow of both gases being correlated is either laminar or turbulent, the measured leakage (concentration in ppm) of any gas can be correlated to methane leakage per the following formula:

$$\text{Methane equivalent leakage, ppm} = \frac{(\text{Measured leakage of test gas, ppm}) \times (\text{Viscosity of test gas})}{(\text{Viscosity of methane})}$$

NOTE — Viscous leakage occurs in high pressure systems and is the most common mode encountered in probing type leakage tests.

C.5 Concluding remarks

It is important to note that the relationships defined by the above equations are most applicable when comparing gases of similar molecular size and viscosity. This is not to say that they cannot be used to correlate gases of significantly different molecular size and viscosity; however, the range of equation applicability must be established experimentally since it is possible for one of the gases being correlated to be governed by one leakage mode while the other gas is governed by another leakage mode.

Developing and promulgating technically sound consensus standards, recommended practices, and technical reports is one of ISA's primary goals. To achieve this goal, the Standards and Practices Department relies on the technical expertise and efforts of volunteer committee members, chairmen, and reviewers.

ISA is an American National Standards Institute (ANSI) accredited organization. ISA administers United States Technical Advisory Groups (USTAGs) and provides secretariat support for International Electrotechnical Commission (IEC) and International Organization for Standardization (ISO) committees that develop process measurement and control standards. To obtain additional information on the Society's standards program, please write:

ISA
Attn: Standards Department
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, NC 27709

ISBN 1-55617-712-7