



## National Fire Protection Association

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### MEMORANDUM

TO: NFPA Technical Correlating Committee on Fire and Emergency Services  
Protective Clothing and Equipment

FROM: Stacey Van Zandt

DATE: June 23, 2011

SUBJECT: NFPA 1991 ROC TCC Letter Ballot (F2011)

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In accordance with the NFPA Regulations Governing Committee Projects, attached is the Letter Ballot on the Report on Comments (ROC) for the 2012 Edition of NFPA 1991. Also attached is a report that contains the TC comments that were acted on by the TC, TCC notes generated at the last TCC meeting, and the TCC comment (Log #34) that was also generated at the last TCC meeting.

Please note the ballot has three parts:

Part 1 is a Letter Ballot on the Technical Correlating Committee Comment (Log #34). Reasons must accompany “Negative” and “Abstaining” votes.

Part 2 is a Letter Ballot on the Technical Correlating Committee Amendments to the ROC (TCC Notes), and not on the Comments themselves. Reasons must accompany “Negative” and “Abstaining” votes.

Part 3 is an Informational Letter Ballot Authorizing the Release of the ROC.

Negative votes are limited to subjects within the purview of the TCC. Opposition on a strictly technical basis is not sufficient grounds for substantiating a negative vote. If you have correlation issues please identify and describe your concerns in the area of the ballot form for identification of correlation issues.

Please complete and return your ballot as soon as possible but no later than July 7, 2011. As noted on the ballot form, please return the ballot to Stacey Van Zandt via e-mail to [svanzandt@nfpa.org](mailto:svanzandt@nfpa.org) or via fax to 617-984-7056. You may also mail your ballot to the attention of Stacey Van Zandt at NFPA, 1 Batterymarch Park, Quincy, MA 02169.

The return of ballots is required by the Regulations Governing Committee Projects. As usual, nonvoting members (for example, the nonvoting technical committee chairs) need not return ballots.

Attachments: Ballot Form  
NFPA 1991 ROC

1991-1 Log #31 FAE-HAZ

Final Action: Accept in Principle

(1.3.6, 4.3.18, 5.1.1.11, 5.2.4, 5.3.2.2, 8.4.4.1, 8.8.4.11, 8.8.4.12, and A.1.3.6)

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to add the section below to NFPA 1991 for correlation purposes with NFPA 1994, NFPA 1951 and NFPA 1971. The TCC agrees that the specific language developed by the CBRN Test Methods Task Group under its direction addresses the issue of determining the effect of the ensemble on the respirator at the current time. The proposed language provides the basis for the certification organization to make a decision whether further action is needed on its part or that of the manufacturer for investigation any compromise of the respirator certification and end user protection as affected by the integration of the ensemble.

6.1.11 The interface of and integration of the selected respirator with the protective ensemble shall not invalidate the NIOSH certification of the respective respirator.

A.6.1.11 Invalidation of the NIOSH certification may occur as the result of modifications to the respirator by the attachment of additional parts or interface components, or through modification of the respirator configuration in order for the respirator to be donned with the ensemble. This requirement is not intended to affect common industry practices for the integration of respirators with protective ensembles such as through the use of a soft, flexible gasket material on the hood of a protective ensemble that provides a circumferential seal around the respirator facepiece.

**Submitter:** Jeffrey O. Stull, International Personnel Protection, Inc.

**Comment on Proposal No:** 1991-8

**Recommendation:** Revise text to read as follows:

~~1.3.6\* Requirements of this standard shall not apply to the use of closed circuit SCBA.~~

~~A.1.3.6 The testing in this standard is currently limited to an NFPA 1981 compliant open circuit SCBA.~~

4.3.18 The manufacturer shall be permitted to specify one or more different types of specific self-contained breathing apparatus for use with the vapor-protective ensemble. Where the manufacturer submits a vapor-protective ensemble for certification with one or more specific self-contained breathing apparatus, the certification organization will require the manufacturer to list the acceptable self-contained breathing apparatus as part of the product label as specified in 5.1.1.11 and require overall ensemble function and integrity testing using each listed self-contained breathing apparatus as specified in Section 8.4.

5.1.1.11 Where specific self-contained breathing apparatus are specified by the manufacturer for the certification of the vapor-protective ensemble, the following additional statement shall be provided as part of the product label:

FOR COMPLIANCE WITH NFPA 1991, THE FOLLOWING SELF-CONTAINED BREATHING APPARATUS MUST BE USED IN CONJUNCTION WITH THIS VAPOR PROTECTIVE ENSEMBLE:

(List each self-contained breathing apparatus).

5.2.4(4)(d) Proper integration and wearing of ensemble with specified self-contained breathing apparatus, if applicable.

5.2.2(12) Type of or specific self-contained breathing apparatus to be worn with vapor-protective ensemble.

8.4.4.1(6) Unless otherwise specified, test subjects shall wear a self-contained breathing apparatus (SCBA) that is compliant with NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services.

(7) Where specific self-contained breathing apparatus are specified by the manufacturer for the certification of the vapor-protective ensemble, separate testing shall be performed with each type of self-contained breathing apparatus specified by the manufacturer.

8.8.4.11 For consistency in testing Unless otherwise specified, the SCBA used for all testing with the vapor-protective ensemble shall be certified as compliant with NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services, and shall be equipped with a fully charged 60-minute breathing air cylinder.

8.4.4.12 Where specific self-contained breathing apparatus are specified by the manufacturer for the certification of the vapor-protective ensemble, separate testing shall be performed with each type of self-contained breathing apparatus specified by the manufacturer.

**Substantiation:** This requirement is design restrictive and will prohibit use of alternative SCBA that have frequently been used as part of vapor-protective ensembles. It will also prevent the development of innovative designs involving the integration of SCBA with vapor-protective ensembles that could afford potential advantages for hazardous materials first responders in terms of reduced weight, profile, and stress as well as increasing ensemble service life, when needed. The NFPA Technical Committee on Respiratory Protective Equipment is working on a new standard for closed circuit self contained breathing apparatus that may become available sometime after the promulgation for the new

edition of the NFPA 1991 standard. Specific changes to the standard have been proposed that permit certification and testing with other types of SCBA, when specified by the manufacturer.

**Committee Meeting Action: Reject**

**Committee Statement:** The technical committee rejected the comment since specifying the respiratory protection to be worn with the suit is not necessary and creates additional testing that is not warranted. Non-NFPA 1981 compliant SCBA are not intended to be used with these ensembles. There remains unresolved technical concerns with the use of closed-circuit SCBA and NFPA 1991 ensembles. There was no substantiation provided by the submitter as to why this is design-restrictive.

**Number Eligible to Vote: 31**

**Ballot Results:** Affirmative: 27 Negative: 2

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

STORMENT, S.: The committee has falsely assumed that all NFPA 1991 vapor-protective suits must be encapsulating in nature. Anyone that is familiar with the history of this standard's development would know that this is not the case. The committee's attention is directed to paragraph A.3.3.47 that recognizes that different configurations of vapor-protective suits are possible and can be tested. The suggested change for the specification of respiratory equipment is entirely consistent with this provision and the current language in the standard is design-restrictive. At worst, the committee should have decided on an action of "hold for further study" for this comment as it should investigate ways for encouraging the improvement of vapor-protective suits designs. These designs have not changed for last 30 years showing the lack of imagination for many manufacturers. The greatest danger of these suits is not in the potential for chemical exposure, but in the heat stress and ergonomic limitations of the suits. It is precisely for this reason that the requirement of specifying only one type of respiratory equipment that the current requirement is design-restrictive.

STULL, J.: The committee has falsely assumed that all NFPA 1991 vapor-protective suits must be encapsulating in nature. Anyone that is familiar with the history of this standard's development would know that this is not the case. The committee's attention is directed to paragraph A.3.3.47 that recognizes that different configurations of vapor-protective suits are possible and can be tested. The suggested change for the specification of respiratory equipment is entirely consistent with this provision and the current language in the standard is design-restrictive. At worst, the committee should have decided on an action of "hold for further study" for this comment as it should investigate ways for encouraging the improvement of vapor-protective suits designs. These designs have not changed for last 30 years showing the lack of imagination for many manufacturers. The greatest danger of these suits is not in the potential for chemical exposure, but in the heat stress and ergonomic limitations of the suits. It is precisely for this reason that the requirement of specifying only one type of respiratory equipment that the current requirement is design-restrictive.

**Comment on Affirmative:**

BAXTER, C.: It is the intent of the current committee to limit certification to ensembles containing a certified NFPA 1981 open-circuit SCBA. Questions still remain regarding the used of closed-circuit SCBA with NFPA 1991 ensembles. Negative comments relating to history of the standard's development are not useful unless the history is also provided.

1991-1a Log #34 FAE-AAC  
(Various Sections)

Final Action: Accept

Submitter: Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment,  
Comment on Proposal No: N/A  
Recommendation: Comment 1  
*Revise Paragraph 8.1.6 as follows:*

**8.1.6 Flexural Fatigue Procedure for Footwear.** Sample footwear shall be subjected to 100,000 flexes in accordance with Appendix B of FIA Standard 1209, *Whole Shoe Flex* with the following modifications.:

(1) Water shall not be used.

(2) The flex speed shall be 60 +/- 2 cycles per minute.

(3) Alternative flexing equipment shall be permitted to be used when the flexing equipment meets the following parameters:

(a) The alternative flexing equipment shall be capable of providing the angle of flex as described in FIA 1209.

(b) The alternative flexing equipment shall be capable of a flex speed of 60 +/- 2 cycles per minute.

(c) The alternative flexing equipment shall be provide a means of securing the footwear during flexing.

#### Comment 2

*Change the edition date of the following referenced standard:*

#### 2.3.2 ASTM Publications.

ASTM F 1790, *Standard Test Methods for Measuring Cut Resistance of Materials Used in Protective Clothing*, ~~1997~~ 2005.

*Revise the performance criteria as follows:*

**7.4.3** Glove materials shall be tested for cut resistance as specified in Section 8.15, Cut Resistance Test, and shall have a blade travel distance of not less than ~~25 mm (1 in.)~~ 20 mm (0.8 in.).

**7.5.3** Footwear upper materials shall be tested for cut resistance as specified in Section 8.15, Cut Resistance Test, and have a blade travel distance of not less than ~~25 mm (1 in.)~~ 20 mm (0.8 in.).

*Revise the test method as follows:*

#### 8.15.7 Specific Requirements for Testing Glove Materials.

8.15.7.1 Specimens shall be taken from the back and palm of the glove and shall not include seams.

8.15.7.2 Cut resistance testing shall be performed under a load of ~~200 g (7 oz)~~ 150 g (5 ½ oz).

#### 8.15.8 Specific Requirements for Testing Footwear Upper

##### Materials.

8.15.8.1 Specimens shall be taken from the parts of the footwear upper that provide uniform thickness and shall not include seams.

8.15.8.2 Cut resistance testing shall be performed under a load of ~~400 g (14 oz)~~ 350 g (12 ½ oz).

#### Comment 3

*Change the date of the test method reference in Chapter 2 as follows:*

#### 2.3.2 ASTM Publications.

ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, ~~1996~~ 2005.

*Revise the test method paragraph as follows:*

**8.16.4 Procedure.** Specimens shall be tested in accordance with ASTM F 1342, *Standard Test Method for Resistance of Protective Clothing Materials to Puncture*, using Method A.

## Comment 4

Add the following reference to Chapter 2:

## 2.3.2 ASTM Publications.

ASTM F2413, Performance Requirements for Protective (Safety) Toe Cap Footwear, 2011.

Delete the following reference from Chapter 2:

## 2.3.1 ANSI Publications.

~~ANSI Z41, Standard for Personal Protection – Protective Footwear, 1999.~~

Add a new design requirement:

6.3.X Footwear shall meet the performance requirements as specified in ASTM F2413, Performance Requirements for Protective (Safety) toe cap Footwear, for Impact, Compression, and Puncture Resistant Footwear with the exception that Flex Resistance to Cracking shall not be evaluated.

Delete current performance requirements superseded by 6.3.X:

~~7.5.5 Footwear toes shall be tested for impact and compression resistance as specified in Section 8.21, Impact and Compression Test, and shall have an impact resistance of not less than 101.7 J (75 ft-lb), and shall have a compression resistance of not less than 11,121 N (2500 lbf).~~

~~7.5.6 Footwear soles and heels shall be tested for puncture resistance as specified in Section 8.19, Puncture Resistance Test Two, and shall have a puncture resistance of not less than 1210 N (272 lbf).~~

Delete the test methods in Section 8.19 and 8.21.

**Substantiation: Comment 1.** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to revise the text as indicated below for the purposes of correlation with other standards in the project. The proposed changes align the footwear flexing requirements with other standards in the project, which all currently employ the same requirement. These criteria are necessary because of the lack of current specifications for this test equipment.

**Comment 2.** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to revise the text as indicated below for the purposes of correlation with other standards in the project. The TCC notes that while the Technical Committee made changes to NFPA 1994 for cut resistance using the newer test method, these same changes were not incorporated in the proposed revisions of NFPA 1991. The proposed changes reference the most current test method and adjust the criteria for the new specified blade travel distance.

**Comment 3.** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to revise the text as indicated below for the purposes of correlation with other standards in the project.

**Comment 4.** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to revise the text as indicated below for the purposes of correlation with other standards in the project.

**Committee Meeting Action: Accept**

1991-2 Log #8 FAE-HAZ  
(2.3.2, 2.3.4, 8.18.4, 8.15.5, and 8.18.6)

Final Action: Accept

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to accept this comment for the purpose of correlation with other documents within the project, and provides the following amended text:

Add to 2.3.2: ASTM F 2700, *Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, 2008.*

~~2.3.4. ISO 17492, *Clothing for protection against heat and flame -- determination of heat transmission on exposure to both flame and radiant heat, 2003.*~~

**8.18.4 Apparatus.** The test apparatus specified in ~~ISO 17492, *Clothing for protection against heat and flame determination of heat and transmission on exposure to both flame and radiant heat.*~~ Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, shall be used.

**8.18.5 Procedure.** Radiant protective performance testing shall be performed in accordance with ~~ISO 17492, *Clothing for protection against heat and flame -- determination of heat transmission on exposure to both flame and radiant heat,*~~ Standard for Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, shall be used with the following modifications:

(1) ~~An exposure heat flux of 84 kW/m<sup>2</sup> (2.0 cal/cm<sup>2</sup>s) shall be used:~~

(2) ~~(1) The contact configuration optional spacer shall not be used for testing of all material specimens.~~

(3) ~~(2) The thermal threshold index analysis method heat transfer performance value shall be used with calculations made using the heat flux in calories per square centimeter per second and reported as the TPP rating.~~

(4) ~~T-150 quartz tubes shall be used:~~

**8.18.6 Report.** The individual test TPP rating of each specimen shall be recorded and reported. The average TPP rating shall be calculated, recorded, and reported.

Delete 8.18.6.1.

Delete 8.18.6.2

Delete 8.18.6.3

Submitter: Jeffrey O. Stull, International Personnel Protection, Inc.

Comment on Proposal No: 1991-1

Recommendation: Revise text to read as follows:

Add to 2.3.2: ASTM F 2700, Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, 2008.

Delete from 2.3.4: ~~ISO 17492, *Clothing for protection against heat and flame--determination of heat transmission on exposure to both flame and radiant heat, 2003.*~~

**8.18.4 Apparatus.** The test apparatus specified in ~~ISO 17492, *Clothing for protection against heat, and flame--determination of heat transmission on exposure to both flame and radiant heat,*~~ Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, shall be used.

**8.18.5 Procedure.** Radiant protective performance testing shall be performed in accordance with ~~ISO 17492, *Clothing for protection against heat and flame--determination of heat transmission on exposure to both flame and radiant heat,*~~ Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame Resistant Materials for Clothing with Continuous Heating, shall be used with the following modifications:

- ~~(1) An exposure heat flux of 84 kW/m<sup>2</sup> (2.0 cal/cm<sup>2</sup>s) shall be used.~~  
~~(2) (1) The contact configuration optional spacer shall not be used for testing of all material specimens.~~  
~~(3) (2) The thermal threshold index analysis method heat transfer performance value shall be used with calculations made using the heat flux in calories per square centimeter per second and reported as the TPP rating.~~  
~~(4) T-150 quartz tubes shall be used.~~

#### 8.18.6 Report.

~~8.18.6.1~~ The individual test TPP rating of each specimen shall be recorded and reported. The average TPP rating shall be calculated, recorded, and reported.

~~8.18.6.2~~ Where a TPP rating is greater than 60, then the TPP rating shall be reported as "<60."

**Substantiation:** The proposed reference test method for the conduct of thermal protective performance (TPP) has been updated and includes an improved calibration protocol. The new method permit reporting of TPP values greater than 60 cal/cm<sup>2</sup>.

**Committee Meeting Action:** Hold

**Committee Statement:** The technical committee decided to hold this comment for further study. No validation testing has been provided to the technical committee for its review.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 26 Negative: 2 Abstain: 1

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

STORMENT, S.: If it has been acceptable to other committees to adopt ASTM F2700, which are more reliant on TPP testing than is the case for NFPA 1991 (e.g., structural fire fighting for NFPA 1971), then why should the committee including persons knowledge with the other activities, choose to hold this comment? Given that this test method is used in the same manner for several different standards, each going through the revision process at the same time, this is a matter for consideration by the TCC for correlation purposes.

STULL, J.: If it has been acceptable to other committees to adopt ASTM F2700, which are more reliant on TPP testing than is the case for NFPA 1991 (e.g., structural fire fighting for NFPA 1971), then why should the committee including persons knowledge with the other activities, choose to hold this comment? Given that this test method is used in the same manner for several different standards, each going through the revision process at the same time, this is a matter for consideration by the TCC for correlation purposes.

**Explanation of Abstention:**

FITHIAN, W.: Recent information has been provided that brings into question which method provides the more accurate performance result. At this time, there is insufficient data or documentation to determine which method is better for this application.

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1991-3 Log #3 FAE-HAZ Final Action: Accept in Principle  
(3.3.2.5 Radiological Particulate Terrorism Agents and A.3.3.2.5 (New) )

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Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 1991-1

Recommendation: Revise text to read as follows:

**3.3.2.5\* Radiological Particulate Terrorism Agents.** Radioactive particulates, including alpha and beta particulates, that are generated from a source of radioactive material or nuclear event which are intentionally used to inflict lethal or incapacitating casualties, generally on a civilian population as a result of a terrorist attack. ~~The contaminated particles emit ionizing radiation.~~

A.3.3.2.5 The contaminated particles emit ionizing radiation.

**Substantiation:** The proposed definition conflicts with the Manual of Style as it has multiple sentences. The second sentence is not part of the definition but is information that can be placed into an annex or somewhere in the body of the standard.

**Committee Meeting Action:** Accept in Principle

Replace the current definition of Radiological Particulate Terrorism Agents in 3.3.2.5 with the following project definition, and add an Annex item as follows:

**3.3.2.5 Radiological Particulate Terrorism Agents.** Particles that emit ionizing radiation in excess of normal background levels used to inflict lethal or incapacitating casualties, generally on a civilian population, as the result of a terrorist attack.

**A.3.3.2.5** This standard only provides partial protection from certain radiation sources. By their nature these ensembles provide protection from alpha radiation, and the element materials and distance will significantly attenuate beta radiation. These ensembles do not provide any protection from ionizing radiation such as gamma- and X-rays other than to keep the actual radiological particulate from direct skin contact.

**Committee Statement:** The technical committee accepted the comment in principle, and is replacing the current definition of Radiological Particulate Terrorism Agents with the project definition.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-4 Log #1 FAE-HAZ Final Action: Accept  
(3.3.25 External Fittings)

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Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 1991-1

Recommendation: Revise text to read as follows:

**3.3.25 External Fittings.** Any component that allows the passage of gases, liquids, or electrical current from the outside to the inside of the element or item as well as any ~~any~~ fitting externally located on, and part of, the ensemble which is not part of the garment material, visor material, gloves, footwear, seams, or closure assembly.

**Substantiation:** The proposed definition conflicts with the Manual of Style as it has multiple sentences. The second sentence needs to be changed either by incorporating into a single sentence (as proposed) or by placing it elsewhere in the standard.

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-5 Log #2 FAE-HAZ  
(3.3.54 Respiratory Equipment)

Final Action: Accept in Principle

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Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 1991-1

Recommendation: Revise text to read as follows:

**3.3.54 Respiratory Equipment.** A positive pressure, self-contained breathing apparatus (SCBA) or combination SCBA/supplied-air breathing apparatus certified by the National Institute for Occupational Safety and Health (NIOSH) and certified as compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services*.

**4.9 Certification of respiratory equipment.** Respiratory equipment shall be certified by the National Institute for Occupational Safety and Health (NIOSH) and shall be certified as compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services*.

**Substantiation:** The proposed definition conflicts with the Manual of Style as it contains requirements. The proposed change will place the requirements where they belong, which is within the body of the standard.

**Committee Meeting Action:** Accept in Principle

Revise text in the 2005 edition to read as follows:

Delete the existing definition of respiratory equipment in 3.3.55.

Add the project definitions for "respirator" and "self-contained breathing apparatus" (and related Annex) to section 3.3 as follows:

**3.3.X Respirator.** A certified device that provides respiratory protection for the wearer within the limits of the certification.

**3.3.X Self-Contained Breathing Apparatus.** An atmosphere-supplying respirator that supplies a respirable air atmosphere to the user from a breathing air source that is independent of the ambient environment and designed to be carried by the user.

**A.3.3.X** For the purposes of this standard, where the term is used without a qualifier, it indicates only open-circuit self-contained breathing apparatus or combination SCBA/SARs. See also the definitions for: *Atmosphere-Supplying Respirator*, *Combination SCBA/SAR*, and *Supplied Air Respirator*.

**Committee Statement:** The technical committee decided to delete the definition for respiratory equipment.

The technical committee also added the project definition for respirator and the project definition of self-contained breathing apparatus.

Respiratory equipment is not a project definition, therefore it is being deleted and replaced with the project definitions as indicated in the meeting action.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-6 Log #17 FAE-HAZ  
(3.3.55 Sample)

Final Action: Accept in Principle

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Submitter: Daniel J. Gohlke, W. L. Gore and Associates

Comment on Proposal No: 1991-1

Recommendation: Rewrite 3.3.55 Sample. The ensemble, element, item, component, or composite that is conditional prior to testing. (see also specimen).

Substantiation: This is the definition of sample from NFPA 1951. It captures the important concept that samples are the subject of conditioning which is not captured in the current definition.

Committee Meeting Action: Accept in Principle

Replace current definition for "sample" with the project definition as follows:

3.3.55 Sample. The equipment, equipment component, ensemble, element, item, component, or composite that is conditioned for testing.

Committee Statement: The technical committee accepted the comment in principle, and decided to replace the current definition of "sample" with the project definition.

Number Eligible to Vote: 31

Ballot Results: Affirmative: 29

Ballot Not Returned: 2 Thompson, D., Wisner, Jr., J.

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1991-7 Log #26 FAE-HAZ  
(4.3.17)

Final Action: Accept in Principle

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Submitter: Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment,

Comment on Proposal No: 1991-17

Recommendation: **The TCC instructs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to consider adding the text "During each inspection" to the beginning of the new Section 4.3.18. The TCC recognizes that there will be a new Section 4.3.18 to follow the existing Section 4.3.17.**

Substantiation: This is a direction from the Technical Correlating Committee on Hazardous Materials Protective Clothing and Equipment in accordance with 3.4.2 and 3.4.3 of the Regulations Governing Committee Projects.

Committee Meeting Action: Accept in Principle

Add "During follow-up inspection...." to the beginning of paragraph 4.3.17.

Committee Statement: The technical committee accepted the comment in principle, and provided the clarification as shown in the meeting action.

Number Eligible to Vote: 31

Ballot Results: Affirmative: 29

Ballot Not Returned: 2 Thompson, D., Wisner, Jr., J.

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1991-8 Log #5 FAE-HAZ  
(4.3.17)

Final Action: Accept

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**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change its action from reject to accept in Comment 1991-8 (Log #5) as it believes the TC has not given due consideration to all evidence presented to it in connection with the preparation of its report, including all comments related to negative votes.

**Submitter:** Jeffrey O. Stull, International Personnel Protection, Inc.

**Comment on Proposal No:** 1991-17

**Recommendation:** Revise text to read as follows:

4.3.17 The certification organization shall ensure that the manufacturer tests each vapor protective suit element for gastight integrity as specified in Section 8.2, Gastight Integrity Test. Each suit element shall show an ending pressure of at least ~~1350 Pa (5.4 in.)~~ 125 mm (5 in.) water gauge pressure. The date of the test shall be placed on the product label as specified in Section 5.1.1.8(5). Additionally, the manufacturer shall provide the result with each suit.

**Substantiation:** I oppose the change for modifying the gas-tight integrity test specified in NFPA 1991 to the European approach for two primary reasons--(1) There are no data and no research has been conducted to justify that the proposed change in the test procedures will provide a higher degree of suit quality and integrity as used as the basis in accepting this modification, and (2) The idea that the committee should have a goal of harmonization with the International standards on chemical protective clothing is absolutely preposterous.

The basis for the current pressure test procedures can be found in the following reference:

Carroll, T. R., Resha, C. J., Vencill, C. T., and Langley, J. D., "Determining the Sensitivity of International Test Methods Designed to Assess the Gas-Tight Integrity of Fully Encapsulating Garments," Sixth Volume, Performance of Protective Clothing: ASTM STP 1273, Jeffrey O. Stull and Arther D. Schwoppe, Eds., American Society for Testing and Materials, 1997, pp. 3-15.

This research evaluated a range of pressure testing conditions, including those used in Europe and Internationally. Experiments were conducted to determine the relative sensitivity of the inflation pressure, dwell pressure, and dwell time in showing pressure drop from leaks introduced into sample garments from different diameter hypodermic needles. At the time of this research, a slightly lower inflation pressure (3 in.), dwell pressure (2 in.) and test duration (3 minutes) were specified in the procedures of ASTM Test Method F1052. These conditions, along with those established in EN 464 (the equivalent of ISO 17491, Procedure 2), and other intermediate pressures and test times, were evaluated for leak detection sensitivity. The study found that a 4 in. water gauge pressure, 4-minute pressure test provided the optimum pressure test conditions for identifying leaks. As a result of this research, the test conditions in ASTM F1052 were increased to those currently specified and now cited in the 2005 edition of NFPA 1991. This information was presented internationally and Europe chose to ignore it. The reason for the continued insistence on high pressures and longer dwell times in Europe is the accommodation of rubber-based technology combined with relatively insensitive permeation measurements.

As the original author of ISO 17491 and then head of the U.S. Delegation to ISO TC94, SC13 on Protective Clothing, I can attest that the reason that there are two pressure test methods in that standard is because of a refusal for European interests to compromise with North American practice. The terms "minimum procedure" assigned to the U.S.-based pressure test method and "rigorous procedure" representing the European approach were not acceptable to the United States for the designation of these test methods. In fact, it was the U.S. experience that some European interests preferred not to compromise on any technical testing issues related to evaluation of chemical protective clothing counter to an agreement that was reached in 1993 with Phil Turnbull. That is why there are two sets of pressure and shower tests in the ISO 17491 standard, which incidentally, Europe is trying to discontinue. Just as a simple example, it is instructive to point out that European standards define normalized breakthrough time for permeation using a permeation rate that is 10 times higher than that used in ASTM F739 and NFPA 1991. In all certainty, harmonization with European practice is not a safety-based goal for the development of U.S.-based standards.

**Committee Meeting Action:** Reject

**Committee Statement:** The ISO standard has a more stringent level, so the technical committee supported its previous decision to move in that direction.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 23 Negative: 6

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

BAXTER, C.: There is potential room for further discussions on this topic. However, the committee comment

provided does come directly from the referenced paper in the later negative comments received. The paper does state "EN464 appears to offer a more stringent protocol by which to conduct such testing and results in a higher level of sensitivity than ASTM F1052". Therefore, the committee statement provided is not "totally erroneous". However, there is enough data contained within the paper to suggest that "a 10 m-bar (4-in H<sub>2</sub>O), 4 min test offers the optimum level of sensitivity for both film-based and elastomeric fabrics".

This paper also brings up issues regarding the sensitivity of the test to temperature fluctuations. This topic should also be addressed. Studies should be performed to ensure that the evaluation of pressure using the current test methods is a valid practice at undefined temperatures.

These topics should be re-addressed with the ASTM F23 committee. If necessary, a TIA could be used to increase the pressures if it is determined to be necessary after proper evaluation.

KAVALESKY, P.: I agree with Jeff Stull's comments listed under PC 1991-8 (Log #5)

KELLY, B.: I see no evidence that increasing pressure and time assures better gas-tight integrity.

STORMENT, S.: I am completely and utterly amazed by this decision of the committee. Somehow, convincing arguments must have been made that higher test pressures will ensure better quality and improved integrity of suits. The committee has absolutely no evidence on which to base this supposition. The committee statement used to justify the rejection of the comment is totally erroneous. On the contrary, I have provided information (if anyone cared to look) of a peer-review article where research was done to demonstrate the basis for the current requirement and why any deviation from the current requirement should be rejected. I thought my substantiation in this area was quite clear particularly on the thinking that European requirement is more rigorous. As the author of ISO 17491 and having to fight a host of ridiculous arguments against a single harmonized pressure test for vapor-protective suits (a term not used in Europe anyway), the word "rigorous" was only inserted as a manner of placation for European, self-serving interests for the chemical suit industry. If end users believe that the quality of their suits will improve as a consequence of changing this requirement, then they are sadly mistaken. The quality of current suits in meeting the inflation test does not have anything to do with the inflation and test pressures being too low -- it is a manner of poor manufacturing or improper handling of the suits after they have been manufactured. This is why it is recommended that suits be inspected and tested on a regular basis including immediately after their receipt. If this issue is not reversed, I will consider putting this standard into suspense through a NITMAM.

STULL, J.: I am completely and utterly amazed by this decision of the committee. Somehow, convincing arguments must have been made that higher test pressures will ensure better quality and improved integrity of suits. The committee has absolutely no evidence on which to base this supposition. The committee statement used to justify the rejection of the comment is totally erroneous. On the contrary, I have provided information (if anyone cared to look) of a peer-review article where research was done to demonstrate the basis for the current requirement and why any deviation from the current requirement should be rejected. I thought my substantiation in this area was quite clear particularly on the thinking that European requirement is more rigorous. As the author of ISO 17491 and having to fight a host of ridiculous arguments against a single harmonized pressure test for vapor-protective suits (a term not used in Europe anyway), the word "rigorous" was only inserted as a manner of placation for European, self-serving interests for the chemical suit industry. If end users believe that the quality of their suits will improve as a consequence of changing this requirement, then they are sadly mistaken. The quality of current suits in meeting the inflation test does not have anything to do with the inflation and test pressures being too low -- it is a manner of poor manufacturing or improper handling of the suits after they have been manufactured. This is why it is recommended that suits be inspected and tested on a regular basis including immediately after their receipt. If this issue is not reversed, I will consider putting this standard into suspense through a NITMAM.

ZISKIN, M.: There is no benefit to increased test pressure. There is no data to support that such a change will benefit the user.

1991-9 Log #9 FAE-HAZ  
(4.3.18)

**Final Action: Reject**

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**Submitter:** William Alexander, Onguard Industries

**Comment on Proposal No:** 1991-17

**Recommendation:** Revise text to read as follows:

Clarification needed in reference to the gas tight fixture that would be utilized in testing footwear elements for gas tight integrity.

**Substantiation:** No substantiation provided.

**Committee Meeting Action:** Reject

**Committee Statement:** The technical committee believes that this requirement does not apply to footwear, only to suits.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

STORMENT, S.: The committee statement is in error. Testing according to 4.3.18 is for ensembles, which can include footwear that is attached to the suit forming the ensemble. In some cases, full footwear has been attached to compliant ensembles. The correct statement is that the requirement in 4.3.18 is not intended to apply to over boots, when the ensemble includes a bootie design.

STULL, J.: The committee statement is in error. Testing according to 4.3.18 is for ensembles, which can include footwear that is attached to the suit forming the ensemble. In some cases, full footwear has been attached to compliant ensembles. The correct statement is that the requirement in 4.3.18 is not intended to apply to over boots, when the ensemble includes a bootie design.

1991-10 Log #29 FAE-HAZ  
(4.5)

Final Action: Accept in Principle

Submitter: William A. Fithian, Safety Equipment Institute (SEI)

Comment on Proposal No: 1991-18

Recommendation: Revise text to read as follows:

~~4.5.2 The manufacturer shall be registered to ISO 9001, Quality management systems — requirements.~~

~~4.5.3 The operation of the quality assurance program shall evaluate and test compliant product production against this standard to assure production remains in compliance.~~

4.5.2 The operation of the quality assurance program shall evaluate and test compliant product production to the requirements of this standard to assure production remains in compliance.

4.5.3 The manufacturer shall be registered to ISO 9001, Quality management systems — requirements.

4.5.3.1 Registration to the requirements of ISO 9001, Quality management systems — requirements, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO Guide 62, General requirements for bodies operating assessment and certification/registration of quality systems. The registrar shall affix the accreditation mark on the ISO registration certificate.

4.5.3.2 The scope of the ISO registration shall include at least the design and manufacturing systems management for the type of personal protective equipment being certified.

4.5.4 Any entity that meets the definition of manufacturer specified in Section 3.3, General Definitions, and therefore is considered to be the “manufacturer” but does not manufacture or assemble the compliant product, shall meet the requirements specified in Section 4.5.

4.5.5 Where the manufacturer uses subcontractors in the construction or assembly of the compliant product, the locations and names of all subcontractor facilities shall be documented, and the documentation shall be provided to the manufacturer’s ISO registrar and the certification organization.

4.5.5.1 Component manufacturers shall be considered as subcontractors.

4.5.5.2 Subcontractors shall include but not be limited to a person or persons, or a company, firm, corporation, partnership, or other organization having an agreement with or under contract with the compliant product manufacturer to supply or assemble components of the compliant product, or to assemble portions of the compliant product.

4.5.5.3 The assembly portion of the manufacturing process shall include but not be limited to the sewing, gluing, laminating, tacking, or other means of attaching whereby materials or component parts are joined together to form a portion, a component, or a complete compliant product.

4.5.6 All subcontractors, where different from the manufacturer, shall also be registered to the requirements of ISO 9001, Quality management systems — requirements, for manufacturing.

Substantiation: The wording in Section 4.5 needs to be consistent between the NFPA 1991, NFPA 1992 and NFPA 1994 Standards. The proposed changes presented above will accomplish this goal.

Additionally, it was brought to SEI’s attention that some ISO Registrars will not allow a manufacturer to apply an ISO registration to a subcontractor. Based on this, the provisions in Sections 4.5.6.1 and 4.5.6.2 cannot be complied with and need to be removed from the 2011 edition.

This is not original material; its reference/source is as follows:

2007 Edition of the NFPA 1994 Standard.

Committee Meeting Action: Accept in Principle

Replace the current definition of “manufacturer” in 3.3.40 with the project definition as follows:

3.3.40 Manufacturer. The entity that directs and controls any of the following: compliant product design, compliant product manufacturing, or compliant product quality assurance; or the entity that assumes the liability for the compliant product or provides the warranty for the compliant product.

Replace existing text in Section 4.5 with the following, and add the associated Annex items:

**4.5 Manufacturers’ Quality Assurance Program.**

4.5.1 The manufacturer shall provide and operate a quality assurance program that meets the requirements of this section and that includes a product recall system as specified in 4.2.7.1, and Section 4.8, Manufacturers’ Safety Alert and Product Recall Systems.

4.5.2 The operation of the quality assurance program shall evaluate and test compliant product production to the requirements of this standard to assure production remains in compliance.

4.5.3 The manufacturer shall be registered to ISO 9001, *Quality management systems – requirements*.

4.5.3.1 Registration to the requirements of ISO 9001, *Quality management systems – requirements*, shall be conducted by a registrar that is accredited for personal protective equipment in accordance with ISO 17021, *Conformity*

*assessment – Requirements for bodies providing audit and certification of management systems.*

4.5.3.2 The scope of the ISO registration shall include at least the design and manufacturing systems management for the personal protective equipment being certified.

4.5.3.3 The registrar shall affix the accreditation mark on the ISO registration certificate.

4.5.4\* Any entity that meets the definition of manufacturer specified in Section 3.3, General Definitions, and therefore is considered to be the “manufacturer,” but does not manufacture or assemble the compliant product, shall meet the requirements specified in this Section 4.5.

4.5.5\* Where the manufacturer uses subcontractors in the construction or assembly of the compliant product, the locations and names of all subcontractor facilities shall be documented and the documentation shall be provided to the manufacturer’s ISO registrar and the certification organization.

A.4.5.4 For example, this situation exists when a product is wholly manufactured and assembled by another entity or entities for a separate entity that puts its name and label on the product (frequently called “private labeling”) and markets and sells the product as its own product.

A.4.5.5 Subcontractors include, but are not limited to, a person or persons, company, firm, corporation, partnership, or other organization having an agreement with or under contract with the compliant product manufacturer to supply or assemble the compliant product or portions of the compliant product.

**Committee Statement:** The technical committee accepted the comment in principle, and agrees that the language should be harmonized with the current boilerplate language on Manufacturers Quality Assurance Program. However, current language as shown in the Meeting Action is from NFPA 1952, section 4.5 and the associated Annex items.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

1991-11 Log #18 FAE-HAZ  
(5.1.1.8(5))

**Final Action: Reject**

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change its action from accept to reject in Comment 1991-11 (Log #18) as it believes the TC has not given due consideration to all evidence presented to it in connection with the preparation of its report, including all comment relating to negative votes. See also the TCC note to Comment 1991-8 (Log #5).

**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-1

**Recommendation:** Change reference from ASTM F 1052 to ISO 17491

**Substantiation:** I can find no where where the ensembles are required to be tested according to ASTM F 1052.

**Committee Meeting Action:** Accept

**Committee Statement:**

The full title of the ISO standard is as follows:

ISO 17491-1 Protective Clothing - Test methods for clothing providing protection against chemicals - Part 1: Determination of resistance to outward leakage of gases (internal pressure test). Method 2 "Rigorous procedure."

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 25 Negative: 4

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

KAVALESKY, P.: See my Explanation of Negative on Comment 1991-8 (Log #5).

STORMENT, S.: See my Explanation of Negative on Comment 1991-8 (Log #5).

STULL, J.: See my Explanation of Negative Vote on Comment 1991-8.

ZISKIN, M.: See my Explanation of Negative on Comment 1991-8 (Log #5).

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1991-12 Log #15 FAE-HAZ  
(6.1.3)

Final Action: Accept in Principle

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**Submitter:** Peter Kirk, Saint-Gobain Performance Plastics

**Comment on Proposal No:** 1991-20

**Recommendation:** Revise text to read as follows:

6.1.3\* Other than outer gloves and outer boots, vapor-protective ensembles shall be designed so that all separate components are securely attached and provided as a single and integrated unit. Secure attachment of separate components shall include the use of zippers, snaps, other hardware, hook and loop closure tape, belts, or other means that require the end user to physically separate the separate component from the vapor-protective ensemble.

**Substantiation:** Currently, some vapor-protective ensemble manufacturers provide over covers that are simply worn over top of the inner ensemble that provides the primary chemical protection of the wearer. The words "securely attached" must be better defined to ensure that the certification organization can properly assess the compliance of the manufacturer product with this requirement.

**Committee Meeting Action:** Accept in Principle

**Committee Statement:** See Comment 1991-35 (Log #16).

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-13 Log #14 FAE-HAZ  
(6.1.3(5))

Final Action: Hold

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**Submitter:** Peter Kirk, Saint-Gobain Performance Plastics

**Comment on Proposal No:** 1991-25

**Recommendation:** Revise text to read as follows:

(5) The specimen shall be abraded for 25 continuous cycles for 3 and 4(b), and ~~200~~ 2500 continuous cycles for 4(a).

**Substantiation:** The application of a larger number of abrasion cycles is appropriate for the abrasion testing of the exterior layer against the ensemble layer that is tested for permeation resistance. However, given the relative motion of the two layers against one another, a significantly larger number of abrasion cycles should be applied. The 25 cycles of the highly abrasive surface for the normal exterior layer was based on wear conditions correlating to actual use. A total of 2500 cycles is proposed to account for layer wear from movement that can range up to an hour for each use. One movement every second for a period of 45 minutes is 2,700.

**Committee Meeting Action:** Hold

**Committee Statement:** The technical committee decided to hold this comment for further study. The TC also notes that the incorrect print line is referenced, it should be 8.1.4.1 (4) in the 2005 edition. This constitutes new material, and there was insufficient data provided to support the change at this stage of the document's development.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

1991-14 Log #7 FAE-HAZ  
(7.1.2(1), 7.1.3, and 7.1.4)

Final Action: Accept

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change its action from reject to accept in Comment 1991-14 (Log #7) as it believes the TC has not given due consideration to all evidence presented to it in connection with the preparation of its report, including all comment relating to negative votes. See also the TCC note to Comment 1991-8 (Log #5).

**Submitter:** Jeffrey O. Stull, International Personnel Protection, Inc.

**Comment on Proposal No:** 1991-28

**Recommendation:** Revise the following text:

7.1.2(1) Ensembles shall have an ending pressure of at least ~~1350 Pa (5.4 in.)~~ 80 mm (3 5/32 in.) water gauge pressure upon completion of the functional test.

7.1.3 Ensembles shall be tested for airflow capacity as specified in Section 8.5, Maximum Suit Ventilation Rate Test, and shall exhibit no internal pressures greater than 100 mm (4 in.) water gauge pressure, and shall show an ending pressure of at least ~~1350 Pa (5.4 in.)~~ 80 mm (3 5/32 in.) water gauge pressure after subsequent testing for gastight integrity as specified in Section 8.2, Gastight Integrity Test.

7.1.4 Ensembles on which external fittings are installed that penetrate any primary materials shall be tested for gastight integrity as specified in Section 8.2 Gastight Integrity Test, and show an ending pressure of at least ~~1350 Pa (5.4 in.)~~ 80 mm (3 5/32 in.) water gauge pressure.

**Substantiation:** I oppose the change for modifying the gas-tight integrity test specified in NFPA 1991 to the European approach for two primary reasons--(1) There are no data and no research has been conducted to justify that the proposed change in the test procedures will provide a higher degree of suit quality and integrity as used as the basis in accepting this modification, and (2) The idea that the committee should have a goal of harmonization with the International standards on chemical protective clothing is absolutely preposterous.

The basis for the current pressure test procedures can be found in the following reference:

Carroll, T. R., Resha, C. J., Vencill, C. T., and Langley, J. D., "Determining the Sensitivity of International Test Methods Designed to Assess the Gas-Tight Integrity of Fully Encapsulating Garments," Sixth Volume, Performance of Protective Clothing: ASTM STP 1273, Jeffrey O. Stull and Arther D. Schwoppe, Eds., American Society for Testing and Materials, 1997, pp. 3-15.

This research evaluated a range of pressure testing conditions, including those used in Europe and Internationally. Experiments were conducted to determine the relative sensitivity of the inflation pressure, dwell pressure, and dwell time in showing pressure drop from leaks introduced into sample garments from different diameter hypodermic needles. At the time of this research, a slightly lower inflation pressure (3 in.), dwell pressure (2 in.) and test duration (3 minutes) were specified in the procedures of ASTM Test Method F1052. These conditions, along with those established in EN 464 (the equivalent of ISO 17491, Procedure 2), and other intermediate pressures and test times, were evaluated for leak detection sensitivity. The study found that a 4 in. water gauge pressure, 4-minute pressure test provided the optimum pressure test conditions for identifying leaks. As a result of this research, the test conditions in ASTM F1052 were increased to those currently specified and now cited in the 2005 edition of NFPA 1991. This information was presented internationally and Europe chose to ignore it. The reason for the continued insistence on high pressures and longer dwell times in Europe is the accommodation of rubber-based technology combined with relatively insensitive permeation measurements.

As the original author of ISO 17491 and then head of the U.S. Delegation to ISO TC94, SC13 on Protective Clothing, I can attest that the reason that there are two pressure test methods in that standard is because of a refusal for European interests to compromise with North American practice. The terms "minimum procedure" assigned to the U.S.-based pressure test method and "rigorous procedure" representing the European approach were not acceptable to the United States for the designation of these test methods. In fact, it was the U.S. experience that some European interests preferred not to compromise on any technical testing issues related to evaluation of chemical protective clothing counter to an agreement that was reached in 1993 with Phil Turnbull. That is why there are two sets of pressure and shower tests in the ISO 17491 standard, which incidentally, Europe is trying to discontinue. Just as a simple example, it is instructive to point out that European standards define normalized breakthrough time for permeation using a permeation rate that is 10 times higher than that used in ASTM F739 and NFPA 1991. In all certainty, harmonization with European practice is not a safety-based goal for the development of U.S.-based standards.

**Committee Meeting Action:** Reject

**Committee Statement:** The ISO standard has a more stringent level, so the technical committee supported its previous decision to move in that direction.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 24 Negative: 5

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

KAVALESKY, P.: See my Explanation of Negative on Comment 1991-8 (Log #5).

KELLY, B.: I see no evidence that increasing pressure and time assures better gas-tight integrity.

STORMENT, S.: See my Explanation of Negative on Comment 1991-8 (Log #5).

STULL, J.: See my Explanation of Negative Vote on Comment 1991-8.

ZISKIN, M.: See my Explanation of Negative on Comment 1991-8 (Log #5).

1991-15 Log #32 FAE-HAZ  
(7.2, 7.3, 7.4, 7.5, 7.7, and 8.6)

Final Action: Accept in Principle

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to do the following for the purposes of correlation with other standards in the project:

1. Correct the permeation language to test acrylonitrile and acrolein as liquid TICs in Chapter 7 and Chapter 8 as indicated in the text provided below.
2. Correct the permeation test method to reflect updates made by the CBRN task group for permeation of the CWAs and TICs as indicated in the text provided below.
3. Address the issues of ammonia and chlorine to be tested twice, once as an industrial chemical and once as a TIC.
4. Address the issue of how industrial chemicals, TICs and warfare agents endpoints are evaluated (cumulative permeation vs breakthrough times).

Note: Items 3 and 4 should be addressed by the TC with the objective of submitting a concurrent TIA at the time of publication of the 2012 edition of NFPA 1991.

With this direction, the TCC has harmonized the permeation resistance performance criteria and test method among each of the standards specifying CBRN requirements. In the case of NFPA 1991, this has been accomplished by establishing the criteria in separate paragraphs and using a separate second permeation test method to address chemical warfare agents and toxic industrial chemicals to reduce confusion as to which test methods apply to which chemicals. In addition, the error of requiring acrolein and acrylonitrile testing as 99% gases has been corrected by specifying that these chemicals be tested as neat liquids. The redundancy for testing ammonia and chlorine both as industrial chemicals and toxic industrial chemicals using both methods has been retained to create an incentive for the Technical Committee to resolve issues regarding those chemicals that should be tested for breakthrough time and those that chemicals that should be tested for cumulative permeation mass.

Note: The following changes override those made in the committee actions on Proposal 1991-29 (Log #1) with the exception that the change for 7.1.4 (repositioning of SF6 integrity test criteria) still applies. The changes are indicated relative to NFPA 1991-2005.

Revise referenced paragraphs as follows:

7.2.1 Suit materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.2.6 Suit seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.3.1 Visor materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.3.6 Visor materials seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.4.1 Glove materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.5.1 Footwear materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.7.2 Primary suit, glove, and footwear element materials shall be tested for liquefied gas permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not show signs of damage, and shall not exhibit a normalized breakthrough detection time of 15 minutes or less for the following list of gaseous industrial chemicals:

[retain current list of chemicals]

Add the following paragraphs to Chapter 7:

7.2.1.2 Suit materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

7.2.6.2 Suit seams shall be tested for permeation resistance as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

7.3.1.2 Visor materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

7.3.6.2 Visor material seams shall be tested for permeation resistance as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

**7.4.1.2** Glove materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

**7.5.1.2** Footwear materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

## 8.6 Chemical Permeation Resistance Test One.

### 8.6.1 Application.

8.6.1.1 This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to the elements' seams.

8.6.1.2 Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in 8.6.7.

8.6.1.3 Modifications to this test method for testing glove materials after flexing and abrading shall be as specified in 8.6.8.

8.6.1.4 Modifications to this test method for testing footwear materials after flexing and abrading shall be as specified in 8.6.9.

8.6.1.5 Modifications to this test method for testing seams shall be as specified in 8.6.10.

8.6.1.6 Modifications to this test for testing primary materials against liquefied gases shall be as specified in 8.6.11.

8.6.1.7 Modifications to this test for testing suit, visor, glove, and footwear materials following cold temperature embrittlement exposure shall be as specified in 8.6.12.

**8.6.2 Sample Preparation.**

8.6.2.1 Samples shall be either vapor-protective ensembles or suit materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

8.6.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

**8.6.3 Specimens.**

8.6.3.1 Specimens shall be the size specified in ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*.

8.6.3.2 At least three specimens shall be tested per chemical challenge.

8.6.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

**8.6.4 Procedures.****8.6.4.1 Industrial Chemicals:**

~~8.6.4.1.1~~ Permeation resistance shall be measured in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, at 27°C, ±2°C (81°F, ±3°F) for a test duration of at least 3 hours for the following chemicals:

- (1) Acetone
- (2) Acetonitrile
- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

~~8.6.4.1.2~~ **8.6.4.2** The minimum detectable permeation rate for the permeation test apparatus shall be measured for each chemical tested. The minimum detectable permeation rate shall be less than or equal to 0.10 ig/cm<sup>2</sup>/min for all permeation resistance tests. When using closed loop systems, the testing laboratory shall assume 1 hour accumulated permeation.

8.6.4.3 The supply of the gas or vapor challenge chemical shall be sufficient to maintain the gas or vapor challenge chemical concentration during the exposure period of 60 minutes + 1.0 / -0.0 minutes.

**8.6.4.2 Chemical Warfare Agents:**

~~8.6.4.2.1~~ Specimens shall be tested for permeation resistance for not less than 60 minutes in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, with the following modifications:

- (1) The test cells shall be designed to accommodate the introduction of liquid chemicals in a safe manner.
- (2) The liquid concentration density shall be 100 g/m<sup>2</sup>, +10/-0 g/m<sup>2</sup>, and the cell shall be assembled in closed top configuration.
- (3) The collection media shall be filtered air flowed through the bottom of the test cell at a rate of 1 L/min ±0.1 L/min.
- (4) Analytical methods used shall be sensitive to concentrations of at least one order of magnitude lower than the required end points.
- (5) Cumulative permeation shall be determined and reported.
- (6) Testing shall be performed at a temperature of 32°C, ±1°C (90°F, ±2°F).

~~8.6.4.2.2~~ The following chemicals shall be tested:

- (1) Cyanogen chloride (CK, 506-77-4)
- (2) Carbonyl chloride (CG, 75-44-5)

~~(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester, 77-78-1)~~

~~(4) Hydrogen cyanide (AC, HCN, CAS, 74-90-8)~~

~~8.6.4.2.3 The chemical warfare agent sarin (GB) shall be tested.~~

~~8.6.4.2.4 The minimum detectable cumulative permeation shall be determined for each chemical warfare agent tested.~~

8.6.5 Report.

8.6.5.1 The following information and results shall be recorded and reported for each chemical:

(1) Material type or name

(2) Chemical or chemical mixture (volume composition of mixture)

(3) Permeation normalized breakthrough detection time in minutes calculated at a system detectable permeation rate of 0.10 ig/cm<sup>2</sup>/min ~~for industrial chemicals~~

(4) Maximum permeation rate (ig/cm<sup>2</sup>/min) observed ~~for industrial chemicals~~

(5) Minimum detectable rate for test apparatus (ig/cm<sup>2</sup>/min) ~~for industrial chemicals~~

~~(6) Cumulative permeation mass (ig/cm<sup>2</sup>) for chemical warfare agents~~

~~(7) Minimum detectable cumulative permeation mass (ig/cm) for chemical warfare agents~~

~~(8) (6) Detection method~~

~~(9) (7) Date of test~~

~~(10) (8) Testing laboratory~~

8.6.5.2 The manufacturer shall report all three measured normalized breakthrough detection times or cumulative permeation masses in the technical data package.

8.6.5.3 The manufacturer shall report all three observed permeation rates in the technical data package for industrial chemicals.

8.6.6 Interpretation.

~~8.6.6.1 For industrial chemicals, The average normalized breakthrough detection time shall be used in determining compliance for the particular material/chemical combination.~~

~~8.6.6.2 For chemical warfare agents, the average cumulative permeation mass shall be used in determining compliance for the particular material/chemical combination.~~

8.6.7 Specific Requirements for Testing Suit Materials After Flexing and Abrading.

8.6.7.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.

8.6.7.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

8.6.7.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

8.6.7.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the flexed samples.

8.6.7.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.6.7.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.6.7.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.6.7.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.6.8 Specific Requirements for Testing Glove Materials After Flexing and Abrading.

8.6.8.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.6.8.2 Samples shall first be conditioned by flexing as specified in 8.1.5.

8.6.8.2.1 Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the gauntlet portion of the flexed sample.

8.6.8.2.2 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.6.8.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.6.8.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.6.8.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

8.6.9 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.

8.6.9.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie

constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.6.9.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.6.9.3 Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the footwear upper where the greatest flexing occurred, usually at the quarter or vamp of the flexed sample.

8.6.9.4 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.6.9.4.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.6.9.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### 8.6.10 Specific Requirements for Testing Seams.

8.6.10.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm(6 in.) of material on each side of the seam center.

8.6.10.2 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.6.10.3 Seam specimens shall be prepared representing each different seam or shall be taken from each different type of seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

8.6.10.4 Samples for conditioning shall be 600 mm (239/16 in.) lengths of prepared seam or cut from vapor-protective ensembles.

#### 8.6.11 Specific Requirements for Testing Primary Materials Against Liquefied Gases.

8.6.11.1 Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

8.6.11.2 Specimens shall be conditioned as specified in 8.1.8.

8.6.11.3 Visor materials that are rigid and cannot be bent in the test apparatus shall be excluded from this conditioning.

8.6.11.4 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

8.6.11.5 The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid at ambient pressure such that a 13 mm (1/2 in.) liquid layer is maintained at all times during the test.

#### 8.6.12 Specific Requirements for Testing Suit, Visor, Glove, and Footwear Materials Following Cold Temperature Embrittlement Exposure.

8.6.12.1 Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

8.6.12.2 Specimens shall be conditioned as specified in 8.1.8.

8.6.12.3 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning.

8.6.12.4 The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

Add New Test Method as follows:

### 8.28 Chemical Permeation Resistance Test Two.

#### 8.28.1 Application.

8.28.1.1 This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to the elements' seams.

8.28.1.2 Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in 8.6.10.

8.28.1.3 Modifications to this test method for testing glove materials after flexing and abrading shall be as specified in 8.6.11.

8.28.1.4 Modifications to this test method for testing footwear materials after flexing and abrading shall be as specified in 8.6.12.

8.28.1.5 Modifications to this test method for testing seams shall be as specified in 8.6.13.

#### 8.28.2 Samples.

8.28.2.1 Samples for conditioning shall be as specified according to the specific requirements in 8.28.10, 8.28.11, 8.28.12, and 8.28.13 as appropriate.

8.28.2.2 Samples shall be conditioned as specified according to the specific requirements in 8.28.10, 8.28.11, 8.28.12, and 8.28.13 as appropriate.

8.28.2.3 Samples shall then be cut to the specimen size.

8.28.2.4 All layers of the samples during conditioning shall be present and configured in the order and orientation as

worn.

### 8.28.3 Specimens.

8.28.3.1 Specimens shall be of the size required to fit the permeation test cell.

8.28.3.2 A minimum of three specimens shall be tested against each challenge chemical.

8.28.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

8.28.3.4 If the specimen is the outer most layer of the composite then it shall be tested without any additional layers on top.

8.28.3.5 Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

8.28.3.6 Specimens with non-uniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical in order to allow sealing of the test cell to a uniform surface of the specimen.

8.28.3.7 Following any sample preparation, the specimens shall be conditioned at a temperature of 32° C +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, for at least twenty-four hours prior to testing in accordance with 8.28.7.1.1

### 8.28.4 Apparatus.

8.28.4.1 A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within +/- 1.0° C (+/- 2.0° F) of the test temperature and +/- 5 percent of the test relative humidity. The controlled environment chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing, as well as holding the test cells horizontally during use while connected to the air delivery system with manifold and to the effluent sampling mechanism.

8.28.4.2\* The test cell shall be a two-chambered cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and for flowing a collection medium on the specimen's normal inside surface, consisting of parts shown in Figure 8.28.4.2(1) and individual part detail shown in Figures 8.28.4.2(2) through 8.28.4.2(6).

\*\*\*insert Figure 8.28.4.2(1) here\*\*\*

Figure 8.28.4.2(1) – Diffusion Test Cell Assembly

\*\*\*insert Figure 8.28.4.2(2) here\*\*\*

Figure 8.28.4.2(2) – Lower Body (Collection Side)

\*\*\*insert Figure 8.28.4.2(3) here\*\*\*

Figure 8.28.4.2(3) – Sample Support Plate

\*\*\*insert Figure 8.28.4.2(4) here\*\*\*

Figure 8.28.4.2(4) – Compression Plate

\*\*\*insert Figure 8.28.4.2(5) here\*\*\*

Figure 8.28.4.2(5) – Upper Body (Challenge Side)

\*\*\*insert Figure 8.28.4.2(6) here\*\*\*

Figure 8.28.4.2(6) – Top Cap

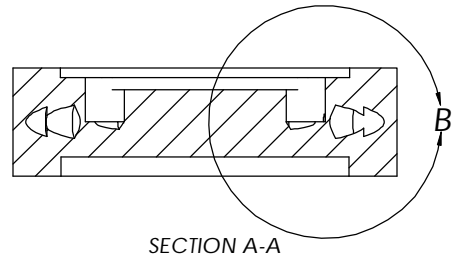
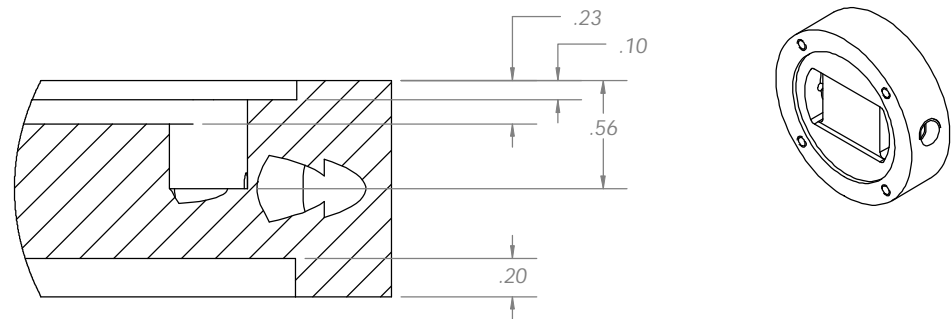
8.28.4.3\* An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cell/fixtures at a rate of 2 standard liters per minute (SLPM) per test cell/fixture with a temperature precision of +/- 0.2° C and a relative humidity precision of +/- 5 percent. The manifold is designed to deliver 0.3 L/min for the challenge side of the test cell and 1 L/min for the collection side of the test cell and maintain at the test temperature. All parts of the air delivery system and manifold must be chemically inert and non-absorptive to the challenge chemical.

8.28.4.4\* An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams from the collection side of the test cell and shall be selected to provide the ability to measure the challenge chemical at 0.1 µg/cm<sup>2</sup> over the test exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real time chemical analyzer. Effluent sampling shall be permitted to be taken discretely or cumulatively; however the selected analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.28.4.5 A vacuum pump capable of creating vacuum of at least 5 inches water column shall be used for testing the integrity of the assembled test cell.

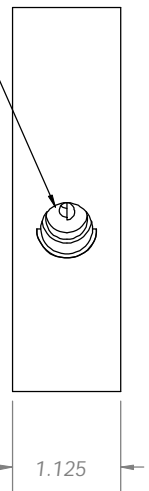
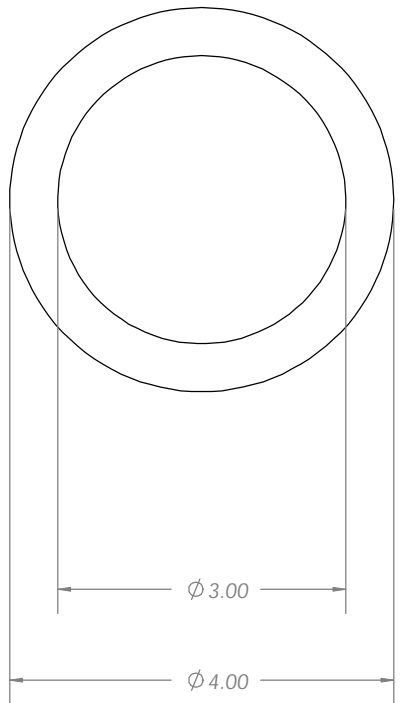


ZONE		REV.	REVISION HISTORY		DATE	APPROVED
			DESCRIPTION			

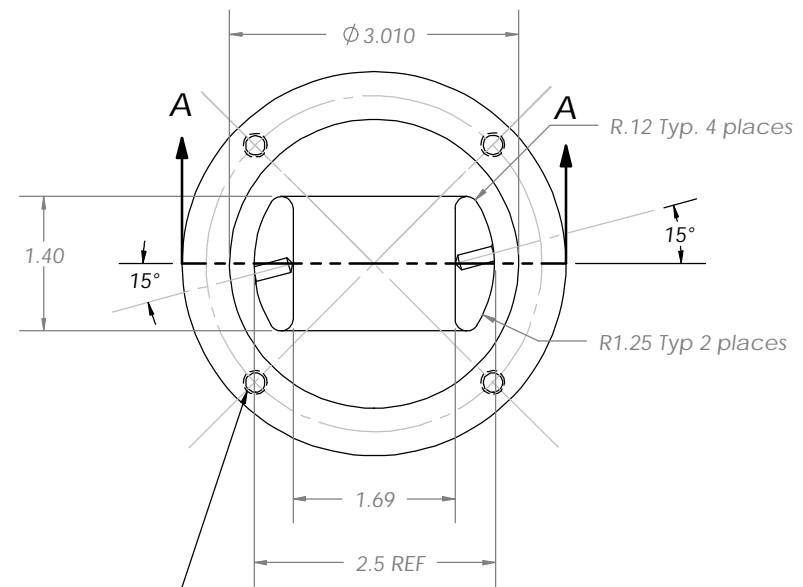


DETAIL B  
SCALE 1:1

5/32 X 1.10 DP DRILL,  
TAP 1/4 NPT, 0.5 DP  
2 PLCS.



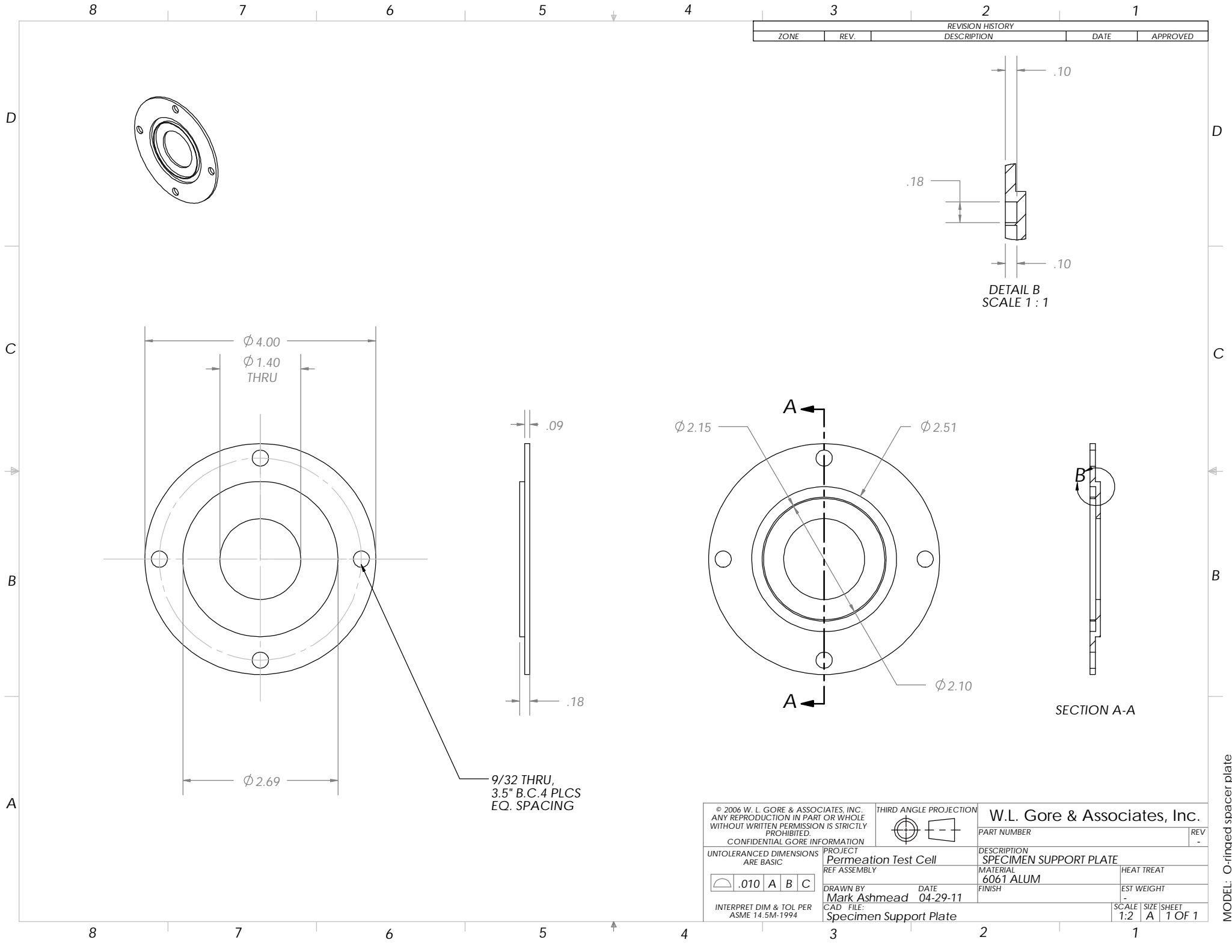
TAP 1/4-20 x 9/16 DP  
3.5" B.C., TYP. 4 PLC.,  
EQ. SPACED



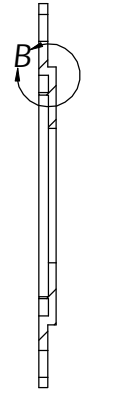
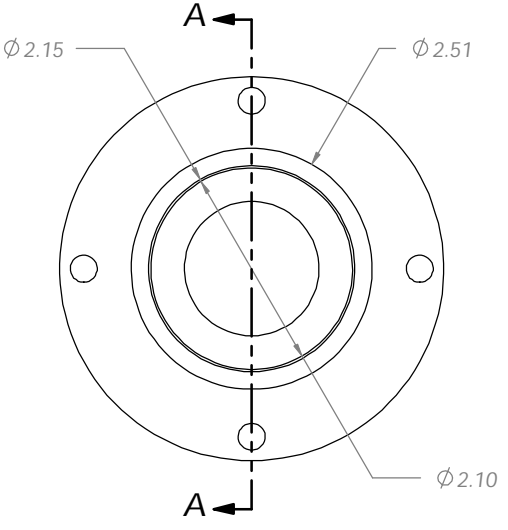
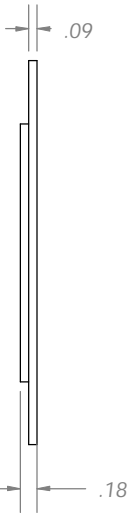
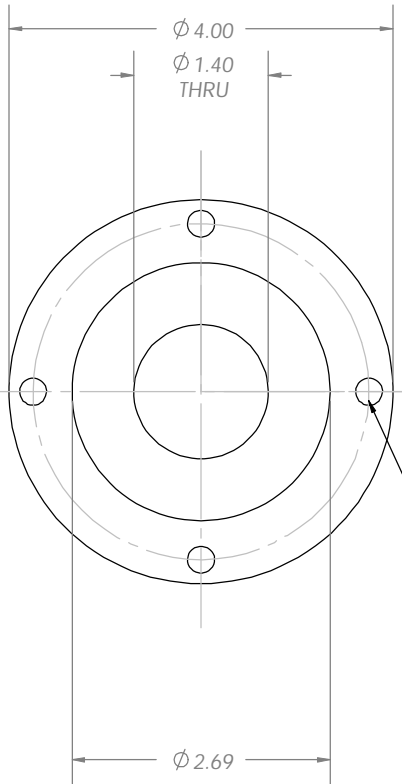
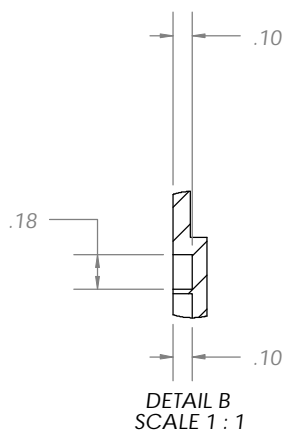
- NOTES**
- DIMENSIONS ARE IN INCHES.
  - BREAK ALL SHARP EDGES AND DEBUR.
  - STAMP OR ETCH WITH P/N USING .12" [3.0mm] HIGH CHARACTERS MINIMUM.

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CONFIDENTIAL GORE INFORMATION		PROJECT		PART NUMBER	
UNTOLERANCED DIMENSIONS ARE BASIC		Permeation Test Cell		LOWER BODY (COLLECTION SIDE)	
INTERPRET DIM & TOL PER ASME 14.5M-1994		DRAWN BY Mark Ashmead		MATERIAL 6061 Aluminum	
		DATE 05-03-11		HEAT TREAT	
		CAD FILE: Bottom Manifold		EST WEIGHT	
				SCALE SIZE SHEET	
				1:2 A 1 OF 1	

MODEL: Bottom manifold



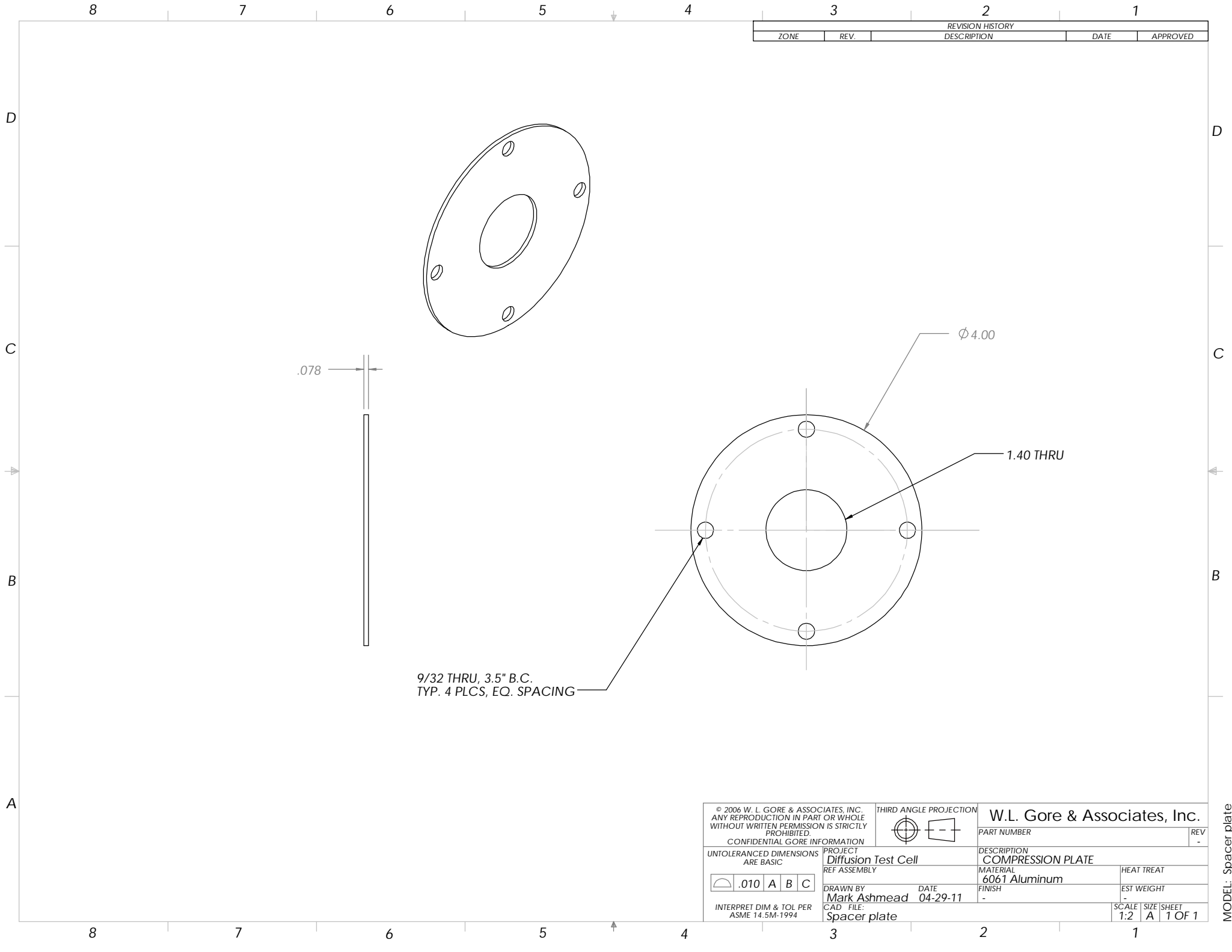
REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED



9/32 THRU,  
3.5" B.C. 4 PLCS  
EQ. SPACING

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CONFIDENTIAL GORE INFORMATION		PROJECT		PART NUMBER	
UNTOLERANCED DIMENSIONS ARE BASIC		Permeation Test Cell		SPECIMEN SUPPORT PLATE	
INTERPRET DIM & TOL PER ASME 14.5M-1994		DRAWN BY Mark Ashmead		MATERIAL 6061 ALUM	
.010 A B C		DATE 04-29-11		HEAT TREAT	
		CAD FILE: Specimen Support Plate		EST WEIGHT	
				FINISH	
				SCALE	
				SIZE	
				SHEET	
				1:2 A 1 OF 1	

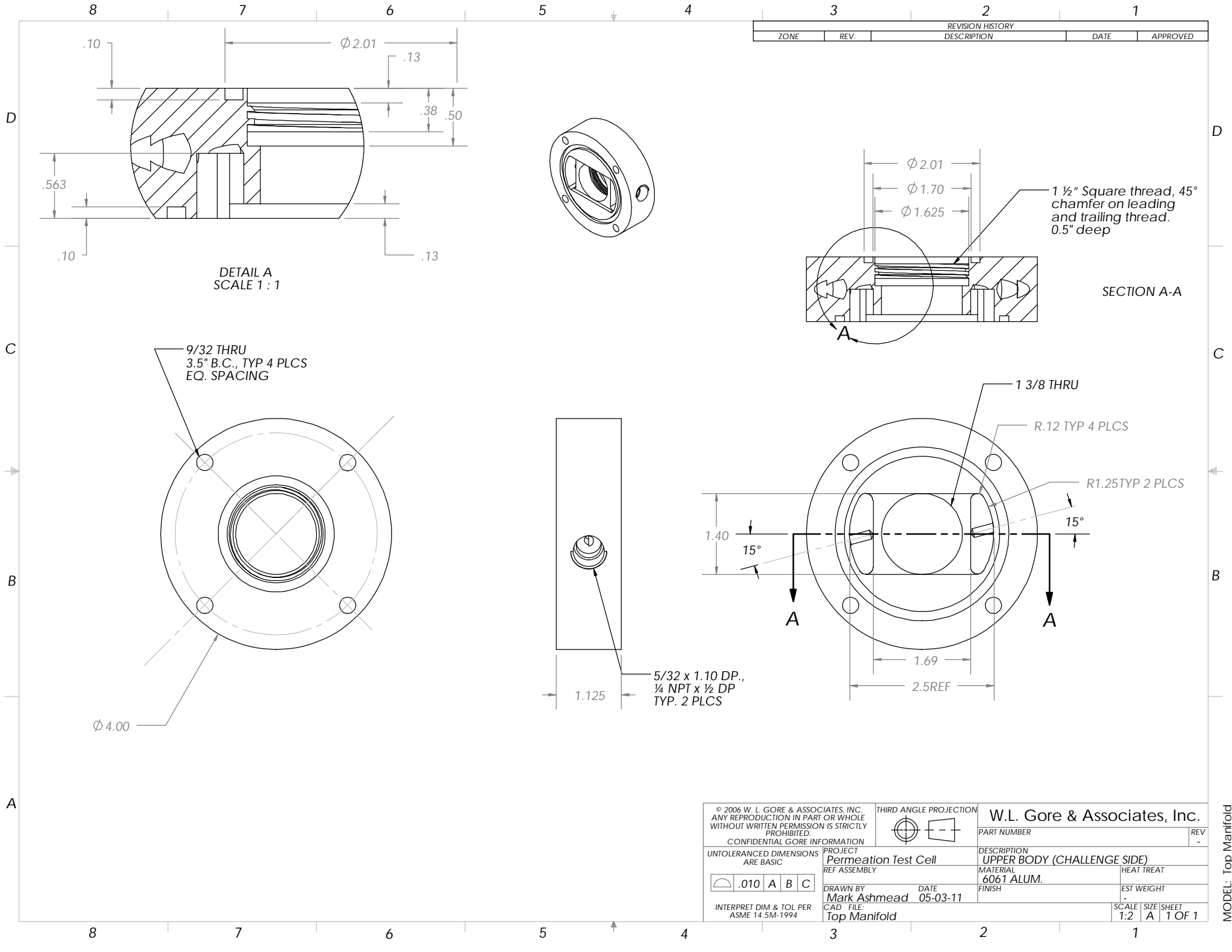
MODEL: O-ringed spacer plate



REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
3				
2				
1				

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UNTOLERANCED DIMENSIONS ARE BASIC			PROJECT <b>Diffusion Test Cell</b>		PART NUMBER -	
INTERPRET DIM & TOL PER ASME 14.5M-1994			REF ASSEMBLY <b>Spacer plate</b>		DESCRIPTION <b>COMPRESSION PLATE</b>	
DRAWN BY <b>Mark Ashmead</b>			DATE <b>04-29-11</b>		MATERIAL <b>6061 Aluminum</b>	
FINISH -			EST WEIGHT -		HEAT TREAT -	
SCALE <b>1:2</b>			SIZE <b>A</b>		SHEET <b>1 OF 1</b>	

MODEL: Spacer plate



REVISION HISTORY		DATE	APPROVED
ZONE	REV.	DESCRIPTION	

DETAIL A  
SCALE 1:1

SECTION A-A

9/32 THRU  
3.5" B.C., TYP 4 PLCS  
EQ. SPACING

Ø 4.00

5/32 x 1.10 DP,  
¼ NPT x ½ DP  
TYP. 2 PLCS

1 ½" Square thread, 45°  
chamfer on leading  
and trailing thread.  
0.5" deep

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UNTOLERANCED DIMENSIONS ARE BASIC		PROJECT <b>Permeation Test Cell</b>	DESCRIPTION <b>UPPER BODY (CHALLENGE SIDE)</b>
INTERPRET DIM & TOL PER ASME 14.5M-1994		REF ASSEMBLY DRAWN BY <b>Mark Ashmead</b>	MATERIAL <b>6061 ALUM.</b>
.010 A B C		DATE <b>05-03-11</b>	HEAT TREAT EST WEIGHT -
		CAD FILE: <b>Top Manifold</b>	SCALE <b>1:2</b>
			SIZE <b>A</b>
			SHEET <b>1 OF 1</b>

MODEL: Top Manifold

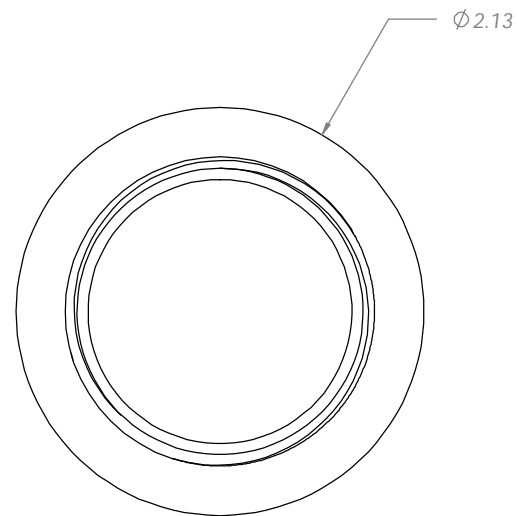
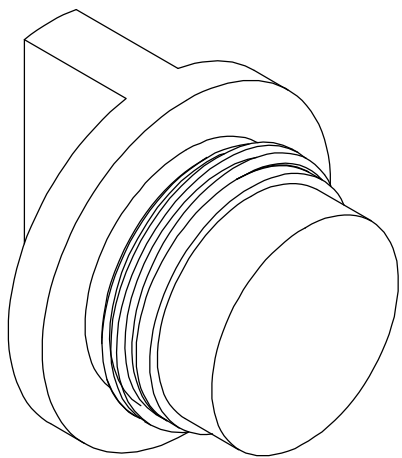
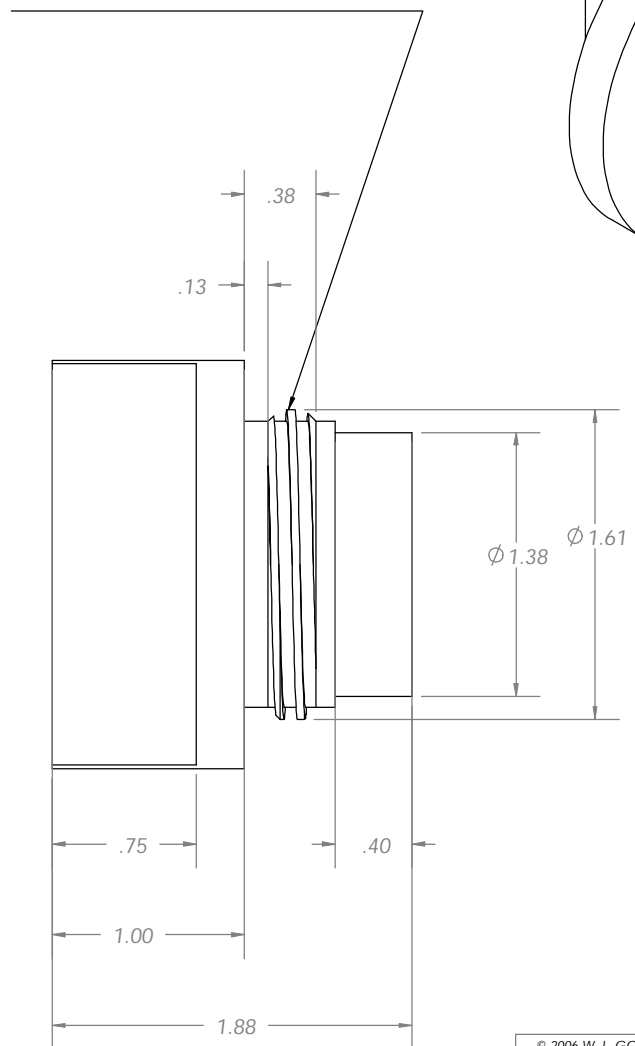
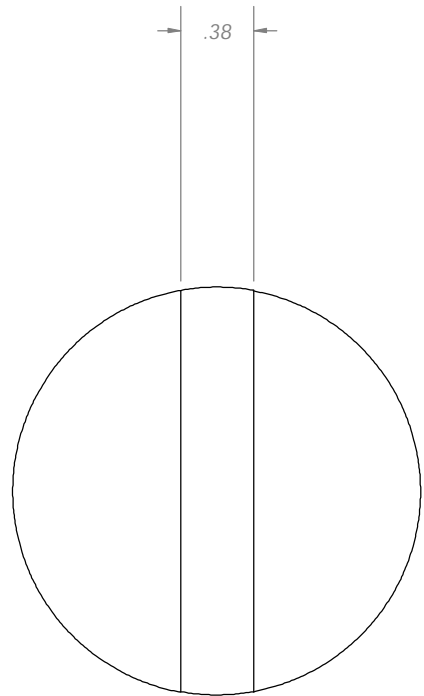
8 7 6 5 4 3 2 1

REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

D  
C  
B  
A

D  
C  
B

1 1/2" Square thread, 45° chamfer on leading and trailing thread.



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CONFIDENTIAL GORE INFORMATION		PROJECT		PART NUMBER	
UNTOLERANCED DIMENSIONS ARE BASIC		Diffusion Test Cell		CELL CAP	
INTERPRET DIM & TOL PER ASME 14.5M-1994		DRAWN BY Mark Ashmead		MATERIAL 6061 Aluminium	
.010 A B C		DATE 04-29-11		HEAT TREAT	
CAD FILE: Top cap		FINISH Anodize Black		EST WEIGHT 0.11	
SCALE 1:1		SIZE A		SHEET 1 OF 1	

8 7 6 5 4 3 2 1

MODEL: Top cap

8.28.4.6 A manometer or pressure gage capable of measuring pressures or vacuums to 10 inches water column, with an accuracy of 5 percent of scale, shall be used for testing the integrity of the assembled test cell.

#### **8.28.5 Supplies**

8.28.5.1 Syringe, capable of delivering challenge chemical, shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.28.5.2\* Replacement O-rings shall be available for use in the permeation test cell.

8.28.5.2.1\* If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

8.28.5.2.2 If an O-ring shows any signs of chemical degradation in the form of softening, hardening, swelling, deterioration, or loss of shape, or function, an O-ring of different material shall be used that does not show chemical degradation.

8.28.5.3\* An inert impermeable surrogate material shall be used as a negative control during validation tests.

#### **8.28.6 Chemicals**

8.28.6.1 The following challenge chemicals shall be tested as liquids:

(1) Liquid chemical warfare agents

(a) Sulfur mustard, distilled [HD, or bis (2- chloroethyl) sulfide, CAS 505-60-2]

(b) Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8]

(2) Liquid toxic industrial chemicals

(a) Acrolein (allyl aldehyde, CAS 107-02-8)

(b) Acrylonitrile (VCN, cyanoethylene, CAS 107-13-1)

(c) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)

8.28.6.2 The following challenge chemicals shall be tested as gases .

(1) Ammonia (NH<sub>3</sub>, CAS 7664-41-7)

(2) Chlorine (Cl<sub>2</sub>, CAS 7782-50-5)

#### **8.28.7 Procedures.**

##### **8.28.7.1 Preconditioning.**

8.28.7.1.1 The challenge chemicals, test specimen, test equipment, and test cell assembly shall be placed in the environmental chamber for a minimum of twenty-four hours at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, prior to testing.

##### **8.28.7.2 Test Cell Assembly.**

8.28.7.2.1 The test cell shall be assembled in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent.

8.28.7.2.2 O-Ring #1 shall be placed on the lower body (collection side) of the test cell.

8.28.7.2.3 The sample support plate shall be placed on the lower body (collection side) of the test cell.

8.28.7.2.4 O-ring #2 (outer) and O-ring #3 (inner) shall be placed in the respective grooves on the sample support plate.

8.28.7.2.5 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate.

8.28.7.2.6 With the upper body (challenge side) of the test cell upside down, O-ring #4 shall be placed in the upper body of the test cell on the specimen side and the compression plate shall be positioned over O-ring #4.

8.28.7.2.7 The upper body (challenge side) of the test cell with O-ring #4 and the compression plate, shall be inverted, aligned with the lug posts, and joined with the lower body (collection side) of the test cell.

8.28.7.2.8 Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm-kq (45 in-lbs) of torque shall be applied to each lug to ensure a proper cell seal.

8.28.7.2.9 O-ring #5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell and the cell top cap shall be screwed into place.

8.28.7.2.10 The integrity of the test cell assembly shall be verified using the procedure in 8.28.7.3.

8.28.7.2.11 Each test cell shall be labeled with the challenge chemical to be used in it.

##### **8.28.7.3 Verification of Test Cell Integrity.**

8.28.7.3.1 Test cell integrity shall be performed in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent.

8.28.7.3.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.28.7.3.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.28.7.3.4 Both inlet ports shall be connected to a vacuum and the test cell upper body and test cell lower body shall be depressurized to 75 mm (3 inch) water column pressure.

8.28.7.3.5 If the test cell pressure drops below 50 mm (2 inch) of water column within 2 minutes, the test cell shall be reassembled according to the steps in 8.28.7.2

8.28.7.3.6 Only test cells that have passed this integrity test shall be used for testing.

**8.28.7.4 Determination of Procedure for Applying Liquid Challenge Chemicals.**

The liquid chemical challenge concentration shall be 100 g/m<sup>2</sup>(+1.0 / -0.0 g/m<sup>2</sup>) to achieve a flooded surface on the specimen.

**8.28.7.5 Procedure for Liquid Chemical Challenge.**

8.28.7.5.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.28.7.5.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.28.7.5.2.1 If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

8.28.7.5.2.2 If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

8.28.7.5.3 The air delivery shall be flowing filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of the test cell at least 15 minutes prior to the application of the challenge chemical.

8.28.7.5.4 With the cell top cap removed, the liquid chemical shall be placed through the agent challenge port of the test cell on the specimen's outer surface within 20 seconds, according to the procedure determined in 8.28.7.4

8.28.7.5.5 After placing the liquid challenge chemical on the specimen in the test cell, the cell top cap shall be sealed within 5 seconds. The filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, shall be flowed only to the collection side of the test cell a rate of 1.0 LPM, +/- 0.1 LPM. No air shall be flowed across the challenge side of the test cell.

8.28.7.5.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / - 0 minutes.

8.28.7.5.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.28.7.5.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

8.28.7.5.9\* At least one test shall be conducted with an inert impermeable surrogate specimen as a negative control.

8.28.7.5.10 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

**8.28.7.6 Procedure for Gas Challenge Chemicals.**

8.28.7.6.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.28.7.6.2 The air delivery shall be connected and flowing 1 LPM of filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of test cell at least 15 minutes prior to the initiation of any gas challenge chemical.

8.28.7.6.3 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.28.7.6.4 The initiation of the test shall occur when the gas challenge chemical is introduced into the challenge side of the test cell.

8.28.7.6.4.1 The supply of the gas challenge chemical shall be sufficient to maintain the gas challenge chemical concentration during the exposure period of 60 minutes + 1.0 / -0.0 minutes.

8.28.7.6.4.2 The gas challenge chemical shall be at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F).

8.28.7.6.4.3 The concentration of the gas challenge chemical shall be 99% or greater.

8.28.7.6.4.4 For testing of Class 3 ensemble materials, the concentration of the gas challenge chemical shall be 40 ppm, +10 / -0 ppm.

8.28.7.6.5 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / -0 minutes.

8.28.7.6.6 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.28.7.6.7 At least one test shall be conducted with the specimen, but without the challenge chemical, as a negative control.

8.28.7.6.8\* At least one test shall be conducted with an inert surrogate specimen as a negative control.

8.28.7.6.9 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

**8.28.7.7 Test Conclusion, Cleaning of Test Cell, and Specimen Disposal.**

8.28.7.7.1 At the conclusion of the test, the test cell shall be purged and the air delivery and analytical system shall be shut down.

8.28.7.7.2 Each cell shall be disassembled one at a time.

8.28.7.7.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.28.7.7.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal or other applicable regulations.

8.28.7.7.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals.

8.28.7.7.6 The cell shall be allowed to air dry in a clean area for 24 hours before reuse.

#### **8.28.8 Report**

8.28.8.1 The cumulative permeation in one hour shall be calculated, recorded, and reported in  $\mu\text{g}/\text{cm}^2$  for each specimen for each challenge chemical.

8.28.8.1.1 If no challenge chemical is detected at the end of the 60 minute test period, then the cumulative permeation shall be recorded and reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

8.28.8.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

8.28.8.2.1 For the calculation of average cumulative permeation, if the results of one or more of the specimens tested is less than the minimum detectable cumulative permeation then use the minimum detectable cumulative permeation as the result for those specimens.

8.28.8.2.2 For the calculation of average cumulative permeation, if the results of all the specimens tested are less than the minimum detectable cumulative permeation then the average cumulative permeation is reported as the minimum detectable cumulative permeation.

8.28.8.3 Report any observations of degradation or other abnormalities at the conclusion of the testing of each specimen.

8.28.9 Interpretation. The average cumulative permeation for each challenge chemical shall be used to determine pass or fail performance.

#### **8.28.10 Specific Requirements for Testing Suit Materials After Flexing and Abrading.**

8.28.10.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.

8.28.10.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

8.28.10.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

8.28.10.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the flexed samples.

8.28.10.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.28.10.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.10.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.28.10.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### **8.28.11 Specific Requirements for Testing Glove Materials After Flexing and Abrading.**

8.28.11.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.28.11.2 Samples shall first be conditioned by flexing as specified in 8.1.5.

8.28.11.2.1 Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the gauntlet portion of the flexed sample.

8.28.11.2.2 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.28.11.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.11.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.28.11.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### **8.28.12 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.**

8.28.12.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie

constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.28.12.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.28.12.3 Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the footwear upper where the greatest flexing occurred, usually at the quarter or vamp of the flexed sample.

8.28.12.4 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.12.4.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.28.12.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### 8.28.13 Specific Requirements for Testing Seams.

8.28.13.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm(6 in.) of material on each side of the seam center.

8.28.13.2 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.28.13.3 Seam specimens shall be prepared representing each different seam or shall be taken from each different type of seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

8.28.13.4 Samples for conditioning shall be 600 mm (239/16 in.) lengths of prepared seam or cut from vapor-protective ensembles.

Add new Annex paragraphs as follows:

A.8.28.4.2 The specified test cell meets the test cell requirements for the Liquid Challenge/Vapor Penetration (L/V) Test Cell specified in TOP 8-2-501 with the following exceptions:

(1) The test cell is configured to separately permit flow across the challenge side and the collection side, and to allow the challenge side to be exposed for the placement of challenge chemical.

(2) The sample support plate shown in Figure 8.28.4.2 (3) has been modified to permit the O-rings to be closer to the exposed surface area of the specimen.

(3) The cell top cap shown in Figure 8.28.4.2 (5) has a smooth solid surface facing the test specimen, i.e. no opening ports for cell integrity testing.

(4) Ports for testing the integrity of the assembled test cell are mounted on the inlet fittings on both the upper body and lower body of the test cell.

A.8.28.4.5 It is essential that the air delivery system provide precise flow to each test cell and achieve the specified temperature and humidity conditions. This delivery is controlled by the conditioning of the incoming air to achieve the temperature and humidity conditions before reaching each test cell and is monitored by separate flow meters or controllers for each test cell.

A.8.28.4.6 The performance requirement is based on a cumulative measurement; however discrete measurements can be used to determine this. These discrete measurements must be able to account for the total amount of the challenge chemical permeating. This means that the frequency of the discrete sampling must be almost continuous, at least sampling once per minute, preferably sampling two to four times per minute, or more. The efficacy of the selected sampling and analysis approach should be validated for each challenge chemical through the use of procedures where a known amount of the challenge chemical, representative of a cumulative permeation close to the minimum requirement, is injected into the collection medium of a trial test. The selected sampling and analytical approach should be able to demonstrate a mass recovery of 95% or better at test conditions to be considered a valid part of the procedures.

A.8.28.5.2 Viton® O-rings have been found to be compatible with the challenge chemicals.

A.8.28.5.2.1 One procedure to determine the compatibility of O-ring material with the challenge chemicals would be to place the O-rings in contact with the challenge chemical for a period of 4 hours. Remove the O-ring from contact with the challenge chemical and observe for any physical changes or signs of degradation.

A.8.28.5.3 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.6.2.2 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.7.5.9 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.7.6.8 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

Submitter: Jeffrey O. Stull, International Personnel Protection, Inc.

Comment on Proposal No: 1991-29, 1991-30, 1991-31, 1991, 37

Recommendation:

\*\*\*\*Include-L1991\_L32\*\*\*\*

**Substantiation:** This comments provides several changes: (1) The chemical lists are provided in the test method not in each individual requirement; (2) Cumulative permeation masses are used instead of normalized breakthrough time for determining the permeation resistance of all chemicals; (3) The list of toxic industrial chemicals and chemical warfare agents has been harmonized with NFPA 1994; (4) Specific permeation procedures have been specified for the testing of chemical warfare agents that are consistent with industry testing approaches for these chemicals; (5) A number of corrections have been made to the permeation criteria and test method. For example, Section 8.6.12 was removed because the associated criteria were removed in an earlier revision of this standard.

1. The current criteria for permeation resistance are awkwardly written. The list of test chemicals is repeated for each element and should be part of the test method. The indication of flexing and abrasion of specimens should be part of the test method, not the performance criteria.

2. The use of cumulative permeation mass is a more appropriate measurement for assessing the chemical barrier resistance of chemical protective clothing material because it permits an evaluation of the relative amount of chemical presented to the skin and can be related to acceptable levels of dermal exposure in the same manner that protection factors are used for determining the suitability of respirators. In addition, cumulative permeation mass is a much more precisely measured permeation test result as compared to normalized breakthrough time, which is dependent on the laboratory's chosen sampling frequency and method of analytical detection. It is currently common practice to report cumulative permeation masses for both toxic industrial chemicals and chemical warfare agents in the other standards (NFPA 1994 and NIJ 0116-00-2010). The proposed changes still permit the reporting of actual and normalized breakthrough times; however, only cumulative permeation masses are used for the interpretation of the permeation test results. The appropriateness of cumulative permeation masses as an end point is documented in the Technical Support Working Group Contract No. W91CRB-07-C-0006 Project Final Report, *Risk-Based Protective Clothing Material Permeation Criteria*, dated 31 March 2010 on pages 75 to 82.

3. The committee statements for 1991-30 and 1991-31 were in error. The measurements of cumulative permeation mass does not require unique analytical test methods but uses the same analytical methods as required for the determination of normalized breakthrough time and permeation rate. Laboratories capable of measuring normalized breakthrough time and permeation rate are also able to use test methods for determining the cumulative permeation mass.

4. NFPA 1994 was revised in 2007 and included changes from the 2001 edition for both toxic industrial chemicals and chemical warfare agents. NFPA 1991 specifies testing with three different gases, which primarily represent a respiratory hazard and are not significant skin absorption hazards. The new NFPA 1994 toxic industrial chemicals have greater significance as dermal exposure chemicals. Similarly, Soman replaced Sarin because of the relative volatility of Sarin.

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1991-16 Log #19 FAE-HAZ  
(7.4.6 and 7.5.6)

**Final Action: Accept**

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**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-1

**Recommendation:** Change "25 mm (1 in)" to "20 mm (0.8 in)."

**Substantiation:** ASTM F 1790 was revised and this change is needed in order not to inadvertently increase the requirement.

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

*Where paragraphs have been removed, the respective section should be renumbered*

**7.2.1** Suit materials shall be tested for permeation resistance ~~after flexing and abrading~~ as specified in Section 8.6, Chemical Permeation Resistance Test, and shall ~~not exhibit a breakthrough detection time of 1 hour or less~~ have a cumulative permeation of 6.0  $\mu\text{g}/\text{cm}^2$  or greater for the following list of industrial chemicals: each chemical tested.

- (1) Acetone
- (2) Acetonitrile
- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

**7.2.2** ~~Primary~~ Suit materials shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit normalized breakthrough detection times of 60 minutes or less for the following list of industrial chemicals:

- (1) Cyanogen chloride (CK; 506-77-4)
- (2) Carbonyl chloride (CG; 75-44-5)
- (3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)
- (4) Hydrogen cyanide (AC, HCN, CAS; 74-90-8)

**7.2.3** ~~Primary~~ Suit materials shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 1.25  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sarin (GB, or isopropyl methyl phosphonofluoridate) soman (GD, o-pinacolyl methylphosphonofluoridate).

**7.2.4** ~~Primary~~ Suit materials shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 4  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sulfur mustard, distilled [HD, or bis(2-chloroethyl)sulfide].

**7.2.9** Suit seams shall be tested for permeation resistance ~~after flexing and abrading~~ as specified in Section 8.6, Chemical Permeation Resistance Test, and shall ~~not exhibit a breakthrough detection time of 1 hour or less~~ have a cumulative permeation of 6.0  $\mu\text{g}/\text{cm}^2$  or greater for the following list of industrial chemicals: each chemical tested.

- (1) ~~Acetone~~
- (2) ~~Acetonitrile~~
- (3) ~~Anhydrous ammonia (gas)~~
- (4) ~~1,3-Butadiene (gas)~~
- (5) ~~Carbon disulfide~~
- (6) ~~Chlorine (gas)~~
- (7) ~~Dichloromethane~~
- (8) ~~Diethyl amine~~
- (9) ~~Dimethyl formamide~~
- (10) ~~Ethyl acetate~~
- (11) ~~Ethylene oxide (gas)~~
- (12) ~~Hexane~~
- (13) ~~Hydrogen chloride (gas)~~
- (14) ~~Methanol~~
- (15) ~~Methyl chloride (gas)~~
- (16) ~~Nitrobenzene~~
- (17) ~~Sodium hydroxide~~
- (18) ~~Sulfuric acid~~
- (19) ~~Tetrachloroethylene~~
- (20) ~~Tetrahydrofuran~~
- (21) ~~Toluene~~

**7.2.10** ~~Primary suit material seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit normalized breakthrough detection times of 60 minutes or less for the following list of industrial chemicals:~~

- (1) ~~Cyanogen chloride (CK; 506-77-4)~~
- (2) ~~Carbonyl chloride (CG; 75-44-5)~~
- (3) ~~Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)~~
- (4) ~~Hydrogen cyanide (AC, HCN, CAS; 74-90-8)~~

**7.2.11** ~~Primary~~ Suit material seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 1.25  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent ~~sarin (GB, or isopropyl methyl phosphonofluoridate)~~ soman (GD, o-pinacolyl methylphosphonofluoridate).

**7.2.12** ~~Primary~~ Suit material seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 4  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sulfur mustard, distilled [HD, or bis(2-chloroethyl)sulfide].

**7.3.1** Visor materials shall be tested for permeation resistance ~~after flexing and abrading~~ as specified in Section 8.6, Chemical Permeation Resistance Test, and shall ~~not exhibit a~~

~~breakthrough detection time of 1 hour or less have a cumulative permeation of 6.0 µg/cm<sup>2</sup> or greater for the following list of industrial chemicals: each chemical tested.~~

- ~~(1) Acetone~~
- ~~(2) Acetonitrile~~
- ~~(3) Anhydrous ammonia (gas)~~
- ~~(4) 1,3-Butadiene (gas)~~
- ~~(5) Carbon disulfide~~
- ~~(6) Chlorine (gas)~~
- ~~(7) Dichloromethane~~
- ~~(8) Diethyl amine~~
- ~~(9) Dimethyl formamide~~
- ~~(10) Ethyl acetate~~
- ~~(11) Ethylene oxide (gas)~~
- ~~(12) Hexane~~
- ~~(13) Hydrogen chloride (gas)~~
- ~~(14) Methanol~~
- ~~(15) Methyl chloride (gas)~~
- ~~(16) Nitrobenzene~~
- ~~(17) Sodium hydroxide~~
- ~~(18) Sulfuric acid~~
- ~~(19) Tetrachloroethylene~~
- ~~(20) Tetrahydrofuran~~
- ~~(21) Toluene~~

~~7.3.2 Primary suit visor materials and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit normalized breakthrough detection times of 60 minutes or less for the following list of industrial chemicals:~~

- ~~(1) Cyanogen chloride (CK; 506-77-4)~~
- ~~(2) Carbonyl chloride (CG; 75-44-5)~~
- ~~(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)~~
- ~~(4) Hydrogen cyanide (AC, HCN, CAS; 74-90-8)~~

~~7.3.3 Primary suit Visor materials shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 1.25 µg/cm<sup>2</sup> for the chemical warfare agent sarin (GB, or isopropyl methyl phosphonofluoridate) soman (GD, o-pinacolyl methylphosphonofluoridate).~~

~~7.3.4 Primary suit Visor materials shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 4 µg/cm<sup>2</sup> for the chemical warfare agent sulfur mustard, distilled [HD, or bis(2-chloroethyl)sulfide].~~

~~7.4.1 Glove materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit a breakthrough detection time of 1 hour or less have a cumulative permeation of 6.0 µg/cm<sup>2</sup> or greater for the following list of industrial chemicals: each chemical tested.~~

- (1) Acetone
- (2) Acetonitrile
- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

~~7.4.2 Primary glove materials and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit normalized breakthrough detection times of 60 minutes or less for the following list of industrial chemicals:~~

- ~~(1) Cyanogen chloride (CK; 506-77-4)~~
- ~~(2) Carbonyl chloride (CG; 75-44-5)~~
- ~~(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)~~
- ~~(4) Hydrogen cyanide (AC, HCN, CAS; 74-90-8)~~

~~7.4.3 Primary Glove material and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 1.25  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sarin (GB, or isopropyl methyl phosphonofluoridate) soman (GD, o-pinacolyl methylphosphonofluoridate).~~

~~7.4.4 Primary Glove material and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 4  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sulfur mustard, distilled [HD, or bis(2-chloroethyl)sulfide].~~

~~7.5.1 Footwear material and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit a breakthrough detection time of 1 hour or less have a cumulative permeation of 6.0  $\mu\text{g}/\text{cm}^2$  or greater for the following list of industrial chemicals: each chemical tested.~~

- (1) Acetone
- (2) Acetonitrile

- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

~~7.5.2 Primary footwear materials and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exhibit normalized breakthrough detection times of 60 minutes or less for the following list of industrial chemicals:~~

- ~~(1) Cyanogen chloride (CK; 506-77-4)~~
- ~~(2) Carbonyl chloride (CG; 75-44-5)~~
- ~~(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)~~
- ~~(4) Hydrogen cyanide (AC, HCN, CAS; 74-90-8)~~

~~7.5.3 Primary Footwear material and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 1.25  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sarin (GB, or isopropyl methyl phosphonofluoridate) soman (GD, o-pinacolyl methylphosphonofluoridate).~~

~~7.5.4 Primary Footwear material and seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not exceed a cumulative permeation of 4  $\mu\text{g}/\text{cm}^2$  for the chemical warfare agent sulfur mustard, distilled [HD, or bis(2-chloroethyl)sulfide].~~

~~7.7.2 Primary suit, glove, and footwear element materials shall be tested for liquefied gas permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test, and shall not show signs of damage, and shall not exhibit a normalized breakthrough detection time of 15 minutes or less have a cumulative permeation of 6.0  $\mu\text{g}/\text{cm}^2$  or greater for the following list of gaseous industrial chemicals: each chemical tested.~~

- ~~(1) Ammonia~~
- ~~(2) Chlorine~~
- ~~(3) Ethylene oxide~~

## **8.6 Chemical Permeation Resistance Test.**

### **8.6.1 Application.**

**8.6.1.1** This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to the elements' seams.

**8.6.1.2** Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in ~~8.6.7~~ 8.6.8.

**8.6.1.3** Modifications to this test method for testing glove materials after flexing and abrading shall be as specified in ~~8.6.8~~ 8.6.9.

**8.6.1.4** Modifications to this test method for testing footwear materials after flexing and abrading shall be as specified in ~~8.6.9~~ 8.6.10.

**8.6.1.5** Modifications to this test method for testing seams shall be as specified in ~~8.6.10~~ 8.6.11.

**8.6.1.6** Modifications to this test for testing primary materials against liquefied gases shall be as specified in ~~8.6.11~~ 8.6.12.

**8.6.1.7** ~~Modifications to this test for testing suit, visor, glove, and footwear materials following cold temperature embrittlement exposure shall be as specified in 8.6.12.~~

### **8.6.2 Sample Preparation.**

**8.6.2.1** Samples shall be either vapor-protective ensembles or suit materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

**8.6.2.2** Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

### **8.6.3 Specimens.**

**8.6.3.1** Specimens shall be the size specified in ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*.

**8.6.3.2** At least three specimens shall be tested per chemical challenge.

**8.6.3.3** For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

#### **8.6.4 Apparatus.**

**8.6.4.1 Industrial Chemicals.** The test apparatus shall be as specified in ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, with the following modifications:

(1) Alternative permeation test cells shall be permitted if demonstrated to meet the expected variation of results that are established in ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, using the standard reference material for either the Neoprene or Butyl rubber reference materials.

(2) A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within  $\pm 1.0^{\circ}\text{C}$  of the test temperature and  $\pm 5\%$  of the test relative humidity. The controlled environmental chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing.

#### **8.6.4.2 Chemical Warfare Agents.**

**8.6.4.2.1** A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within  $\pm 1.0^{\circ}\text{C}$  of the test temperature and  $\pm 5\%$  of the test relative humidity. The controlled environmental chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing.

**8.6.4.2.2\*** The test cell shall be a two-chambered stainless steel cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and with a collection medium on the specimen's normal inside surface, which meets the test cell requirements for the Liquid Challenge/Vapor Penetration (L/V) Test Cell specified in TOP 8-501 and shown in Figure 8.6.4.2.2(2) and with the following additional specifications:

(1) The test cell is configured to separately permit flow across the challenge side and the collection side, and to allow the challenge side to be exposed for the placement of challenge chemical.

(2) The sample support plate and compression plate indicated in Figure 8.6.5.2.2 shall be modified as show in Figures 8.6.4.2.2(2)-1, 8.6.4.2.2(2)-2, and 8.6.4.2.2(2)-3, to permit the O-rings to be closer to the exposed surface area of the specimen.

(3) The cap of the test cell shall be modified to permit the attachment of a manometer or pressure gauge meeting the requirements of 8.6.4.2.7.

\*\*\*\*Insert Figure 8.6.4.2.2(2) Here\*\*\*\*

\*\*\*\*Insert Figure 8.6.4.2.2(2)-1 Here\*\*\*\*

\*\*\*\*Insert Figure 8.6.4.2.2(2)-2 Here\*\*\*\*

\*\*\*\*Insert Figure 8.6.4.2.2(2)-3 Here\*\*\*\*

**8.6.4.2.3** Equipment shall be placed within the controlled environmental chamber to position the test cells horizontally and permit connection with the air delivery system and manifold.

**8.6.4.2.4\*** An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cells/fixtures at a rate of 1 standard L/min (slpm) per test cell/fixture with a temperature precision of  $\pm 0.2^{\circ}\text{C}$  and relative humidity precision of  $\pm 5$  percent. The manifold

shall be designed to deliver 1 L/min for the collection side of the test cell and maintain the test temperature. All parts of the air delivery system and manifold shall be chemically inert and non-absorptive to the challenge chemical.

**8.6.4.2.5** An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams from the collection side of the test cell and shall be selected to provide the ability to measure the chemical at 0.1  $\mu\text{g}/\text{cm}^2$  over the test exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real time chemical analyzer. Samples shall be permitted to be taken continuous, discretely, or cumulatively; however, the selected analytical system shall capture all challenge chemical emitted in the effluent air stream.

**8.6.4.2.6** A vacuum pump capable of creating vacuum of at least 5 inches water column shall be used for testing the integrity of the assembled test cell.

**8.6.4.2.7** A manometer or pressure gauge capable of measuring pressures or vacuums to 10 inches water column, with an accuracy of 5% scale, shall be used for testing the integrity of the assembled test cell.

**8.7.4.3** The following chemical warfare agents shall be tested:

(1) Distilled sulfur mustard [HD; bis (2-chloroethyl) sulfide], 505-60-2

(2) Soman (GD; o-pinacolyl methylphosphonofluoridate), 96-64-0

#### **8.6.4 8.6.5 Procedures.**

##### **8.6.4.1 8.6.5.1 Industrial Chemicals.**

**8.6.4.1.1 8.6.5.1.1** Permeation resistance shall be measured in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, at 27°C,  $\pm 2^\circ\text{C}$  (81°F,  $\pm 3^\circ\text{F}$ ) for a test duration of at least 3 hours for the following chemicals and test conditions:

- (1) Acetone
- (2) Acetonitrile
- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

(1) Testing shall be performed for a minimum exposure period of 3 hours.

(2)\* Individual tests shall be conducted for all 21 chemicals of ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*, chemicals at 27°C, ±2°C (81°F, ±3°F).

(3) Individual tests shall be conducted for the additional following chemicals at 32°C ±1°C (90°F ±2°F):

(a) Acrolein (allyl aldehyde), 107-02-8

(b) Acrylonitrile (VCN, cyanoethylene), 107-13-1

(c) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester), 77-78-1

(4) Testing of liquids shall be performed with sufficient neat liquid at to fully cover the exposed specimen surface over the exposure period.

(5) Testing with gases shall performed with the concentration of the gas is 100%, +0,-0%.

**8.6.4.1.2** (6) The minimum detectable permeation rate for the permeation test apparatus shall be measured for each chemical tested. The minimum detectable permeation rate shall be less than or equal to 0.10 µg/cm<sup>2</sup>/min for all permeation resistance tests.

(7) When using closed loop systems, the testing laboratory shall assume 1 hour accumulated permeation for the purpose of reporting normalized breakthrough time.

(8) The cumulative permeation mass shall be measured at 60 minutes.

(9) It shall be permitted to measure the actual breakthrough detection time, normalized breakthrough detection time, and maximum or steady-state permeation rate for reporting purposes only.

#### **8.6.4.2 8.6.5.2 Chemical Warfare Agents.**

~~8.6.4.2.1 Specimens shall be tested for permeation resistance for not less than 60 minutes in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, with the following modifications:~~

~~(1) The test cells shall be designed to accommodate the introduction of liquid chemicals in a safe manner.~~

~~(2) The liquid concentration density shall be 100 g/m<sup>2</sup>, +10/-0 g/m<sup>2</sup>, and the cell shall be assembled in closed top configuration.~~

~~(3) The collection media shall be filtered air flowed through the bottom of the test cell at a rate of 1 L/min ±0.1 L/min.~~

~~(4) Analytical methods used shall be sensitive to concentrations of at least one order of magnitude lower than the required end points.~~

~~(5) Cumulative permeation shall be determined and reported.~~

~~(6) Testing shall be performed at a temperature of 32°C, ±1°C (90°F, ±2°F).~~

**8.6.4.2.2** The following chemicals shall be tested:

(1) Cyanogen chloride (CK; 506-77-4)

(2) Carbonyl chloride (CG; 75-44-5)

(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester; 77-78-1)

(4) Hydrogen cyanide (AC, HCN, CAS; 74-90-8)

**8.6.4.2.3** The chemical warfare agent sarin (GB) shall be tested.

~~8.6.4.2.4 The minimum detectable cumulative permeation shall be determined for each chemical warfare agent tested.~~

**8.6.5.2.1 Test Set Up.** The following steps shall be undertaken before conducting the test:

(1) The test cell holders and the air delivery system manifolds shall be installed in the environmental chamber and shall be prepared to receive the loaded test cells.

- (2) The analytical detection system shall be assembled and calibrated.
- (a) If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipetter or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.
- (b) If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.
- (3) Each test cell shall be labeled.
- (4) All liquid chemical containers shall be placed in the environmental chamber for a minimum of 24 hours prior to testing.
- (5) The air delivery system shall be turned on and shall be operated at  $32.2 \pm 1.67^{\circ}\text{C}$  ( $90 \pm 3^{\circ}\text{F}$ ) and  $80 \pm 5$  percent relative humidity for a minimum of 30 minutes to achieve environmental equilibrium before swatch loading.
- 8.6.5.2.2 Test Cell Assembly.** The test cell shall be assembled 24 hours before specimen conditioning in the environmental chamber as shown in Figure 8.7.5.2.2 and using the following steps:
- (1) An O-ring shall be placed on the lower body of test cell.

\*\*\*\*Insert Figure 8.7.5.2.2 Here\*\*\*\*

- (2) The sample support plate shall be placed on O-ring 1 and O-ring 2 shall be placed in the groove on the sample support plate.
- (3) The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed in the depression of the sample support plate with O-ring 3 placed over the specimen.
- (4) O-ring 4 shall be placed in the upper body of the test cell and the compression plate shall be positioned over O-ring 4.
- (5) O-ring 4 shall be inverted and the upper body shall be aligned with the lower body.
- (6) Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm-kg (45 in-lbs) of torque shall be applied to each lug to ensure a proper cell seal.
- (7) O-ring 5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell and the cell cap shall be screwed into place.
- 8.6.5.2.3 Verification of Test Cell Integrity (Impermeable Fabrics).** Verify the test cell seal using the following steps:
- (1) Before applying chemical challenge, each test cell shall be subjected to a vacuum of 75 mm (3 in.) water column pressure in the bottom chamber of the cell as measured by a manometer.
- (2) The pressure shall be maintained for 2 minutes.
- (3) The pressure drop shall be observed at 2 minutes.
- (4) Test cells shall be considered to have an adequate seal if the pressure drop is less than a 25 mm (1 in.) drop in water column pressure.
- (5) If a pressure drop of 25 mm (1 in.) drop in water column pressure or greater is observed, the procedures in 8.7.5.2 for assembling the cell shall be repeated to reseal the cell.
- (6) Only cells that have passed this test shall be used for testing.

**8.7.5.2.4 Test Start-Up.** The following steps shall be undertaken to conduct the exposure of the material specimens to the liquid chemical warfare agents.

- (1) The test cells shall be installed in test cell holder prior to chemical challenge and all connections shall be ensured to have been properly made.
- (2) The operation of any analytical system shall be initiated according to its instructions.
- (3) After placing the challenge chemical on the specimen surface in the test cell at a liquid concentration density of  $100 \text{ g/m}^2$ ,  $+10$ ,  $-0 \text{ g/m}^2$ , the cell cap shall be closed.
- (4) The air delivery system shall be immediately operated to provide filtered air at a temperature of  $32^\circ\text{C} \pm 3^\circ\text{C}$  ( $90^\circ\text{F} \pm 5^\circ\text{F}$ ) and a relative humidity of 80 percent  $\pm 5$  percent, flowed through the collection chamber of the test cell at a rate of  $1.0 \text{ Lpm} \pm 0.1 \text{ Lpm}$ .
- (5) Challenge chemical in the effluent air streams shall be collected, measured, and analyzed either by using appropriate discrete sample methods or continuously.
- (6) If bubblers or sorbent tubes are used for collecting challenge chemical, bubblers or sorbent tubes shall be replaced at a prescribed frequency.
- (7) The collection media for challenge chemical shall be analyzed using an appropriate analytical procedure.
- (8) The exposure to challenge chemical shall be conducted for 60 minutes,  $-0$ ,  $+1$  minute.
- (9) A minimum of three specimens shall be tested with challenge chemical.
- (10) At least one test shall be conducted with the specimen but without challenge chemical.

**8.7.5.2.5 Test Conclusion, Test Cell Clean Up and Specimen Disposal.** The following steps shall be undertaken at the conclusion of the test:

- (1) At the conclusion of the test, the air delivery and analytical systems shall be shut down.
- (2) The test cells shall be removed from the test cell holders after completion of each trial.
- (3) Each cell shall be disassembled one at a time.
- (4) The test specimen shall be removed and inspected for any degradation or obvious abnormalities; these observations shall be recorded with test results.
- (5) Each specimen shall be extracted using appropriate extraction procedures for challenge chemical.
- (6) The extracted protective clothing material specimens and test cell O-rings shall be disposed of according to local, stated, Federal or other applicable regulations.
- (7) Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals.
- (8) The cells shall be allowed to air-dry in a clean area for 24 hours before reuse.

#### **8.6.5 8.6.6 Report.**

**8.6.5.1 8.6.6.1** The following information and results shall be recorded and reported:

- (1) Material type or name
- (2) Chemical or chemical mixture (volume composition of mixture)
- (3) Individual test cell and average cumulative permeation mass ( $\mu\text{g}/\text{cm}^2$ )
- (4) Minimum detectable cumulative permeation mass ( $\mu\text{g}/\text{cm}^2$ )
- ~~(3) Permeation~~ (5) Actual and normalized breakthrough detection time in minutes calculated at a system detectable permeation rate of  $0.10 \mu\text{g}/\text{cm}^2/\text{min}$  for industrial chemicals
- ~~(4) (6)~~ Maximum or steady-state permeation rate ( $\mu\text{g}/\text{cm}^2/\text{min}$ ) observed for industrial chemicals, whichever is greater
- ~~(5) (7)~~ Minimum detectable rate for test apparatus ( $\mu\text{g}/\text{cm}^2/\text{min}$ ) for industrial chemicals
- ~~(6) Cumulative permeation mass ( $\mu\text{g}/\text{cm}^2$ ) for chemical warfare agents~~

(7) ~~Minimum detectable cumulative permeation mass ( $\mu\text{g}/\text{cm}$ ) for chemical warfare agents~~

(8) Detection method

(9) Date of test

(10) Testing laboratory

~~8.6.5.2~~ **8.6.6.2** The manufacturer shall report all three ~~measured normalized breakthrough detection times or~~ cumulative permeation masses in the technical data package for each chemical.

~~8.6.5.3~~ **8.6.6.3** The manufacturer shall report all three measured normalized breakthrough detection times and the observed permeation rates in the technical data package for industrial chemicals.

### **8.6.6** **8.6.7 Interpretation.**

~~8.6.6.1~~ For industrial chemicals, the average normalized breakthrough detection time shall be used in determining compliance for the particular material/chemical combination.

~~8.6.6.2~~ For chemical warfare agents, The average cumulative permeation mass shall be used in determining compliance for the particular each material/chemical combination.

### ~~8.6.7~~ **8.6.8 Specific Requirements for Testing Suit Materials After Flexing and Abrading.**

~~8.6.7.1~~ **8.6.8.1** Samples for conditioning shall be 200 mm  $\times$  280 mm (8 in.  $\times$  11 in.) rectangles and shall consist of all layers as configured in the suit.

~~8.6.7.2~~ **8.6.8.2** Two samples shall first be conditioned by flexing as specified in 8.1.3.

~~8.6.7.2.1~~ **8.6.8.2.1** One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

~~8.6.7.2.2~~ **8.6.8.2.2** Following flexing, two samples for abrasion conditioning, each measuring 45 mm  $\times$  230 mm (1 $\frac{3}{4}$  in.  $\times$  9 in.), shall be cut from the center of the flexed samples.

~~8.6.7.2.3~~ **8.6.8.2.3** At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

~~8.6.7.3~~ **8.6.8.3** These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

~~8.6.7.3.1~~ **8.6.8.3.1** Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

~~8.6.7.3.2~~ **8.6.8.3.3** The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

### ~~8.6.8~~ **8.6.9 Specific Requirements for Testing Glove Materials After Flexing and Abrading.**

~~8.6.8.1~~ **8.6.9.1** Samples for conditioning shall be whole glove components or whole glove individual elements.

~~8.6.8.2~~ **8.6.9.2** Samples shall first be conditioned by flexing as specified in 8.1.5.

~~8.6.8.2.1~~ **8.6.9.2.1** Following flexing, three samples for abrasion conditioning, each measuring 45 mm  $\times$  230 mm (1 $\frac{3}{4}$  in.  $\times$  9 in.), shall be cut from the center of the gauntlet portion of the flexed sample.

**8.6.8.2.2 8.6.9.2.2** At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

**8.6.8.3 8.6.9.3** These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

**8.6.8.3.1 8.6.9.3.1** Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

**8.6.8.3.2 8.6.9.3.2** The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

### **8.6.9 8.6.10 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.**

**8.6.9.1 8.6.10.1** This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

**8.6.9.2 8.6.10.2** Samples for conditioning shall be whole footwear components or whole footwear individual elements.

**8.6.9.3 8.6.10.3** Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (1¾ in. × 9 in.), shall be cut from the center of the footwear upper where the greatest flexing occurred, usually at the quarter or vamp of the flexed sample.

**8.6.9.4 8.6.10.4** These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

**8.6.9.4.1 8.6.10.4.1** Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

**8.6.9.4.2 8.6.10.4.2** The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

### **8.6.10 8.6.11 Specific Requirements for Testing Seams.**

**8.6.10.1 8.6.10.1** Seam specimens shall be prepared from seam samples that have a minimum of 150 mm (6 in.) of material on each side of the seam center.

**8.6.10.2 8.6.10.2** Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

**8.6.10.3 8.6.10.3** Seam specimens shall be prepared representing each different seam or shall be taken from each different type of seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

**8.6.10.4 8.6.10.4** Samples for conditioning shall be 600 mm (23 9/16 in.) lengths of prepared seam or cut from vapor-protective ensembles.

### **8.6.11 8.6.12 Specific Requirements for Testing Primary Materials Against Liquefied Gases.**

**8.6.11.1 8.6.12.1** Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

**8.6.11.2 8.6.12.2** Specimens shall be conditioned as specified in 8.1.8.

~~8.6.11.3~~ **8.6.12.3** Visor materials that are rigid and cannot be bent in the test apparatus shall be excluded from this conditioning.

~~8.6.11.4~~ **8.6.12.4** Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

~~8.6.11.5~~ **8.6.12.5** The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid at ambient pressure such that a 13 mm ( $\frac{1}{2}$  in.) liquid layer is maintained at all times during the test.

**8.6.12.6** Testing shall be performed against the following chemicals:

- (1) Ammonia
- (2) Chlorine
- (3) Ethylene oxide

### **8.6.12 Specific Requirements for Testing Suit, Visor, Glove, and Footwear Materials Following Cold Temperature Embrittlement Exposure.**

~~8.6.12.1~~ Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

~~8.6.12.2~~ Specimens shall be conditioned as specified in 8.1.8.

~~8.6.12.3~~ Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning.

~~8.6.12.4~~ The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

A.8.6.4.2.2 A test cell meeting these requirements is available from Aerospace Tooling & Machining, 2190 West 1700 South, Salt Lake City, UT 84104.

A.8.6.4.2.4 It is essential that the air delivery system provide precise flow to each test cell and achieve the specified temperature and humidity conditions. This delivery is controlled by the conditioning of the incoming air to achieve the temperature and humidity conditions before reaching each test cell and is monitored by separate flow meters or controllers for each test cell.

A.8.6.5.1.1 The referenced edition of ASTM F1001, *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials*, includes the following chemicals:

Liquids:

- (1) Acetone (2-propanone), [67-64-1]
- (2) Acetonitrile (cyanomethane), [75-05-8]
- (3) Carbon Disulfide, [75-15-0]
- (4) Dichloromethane (methylene chloride), [75-09-2]
- (5) Diethylamine, [109-89-7]
- (6) Dimethylformamide (DMF), [68-12-2]
- (7) Ethyl Acetate, [141-78-6]
- (8) n-Hexane, [110-54-3]
- (9) Methanol (methyl alcohol, carbinol), [67-56-1]
- (10) Nitrobenzene, [98-95-3]
- (11) Sodium Hydroxide (50 % w/w), [1310-73-2]

(12) Sulfuric Acid (93.1 % sp gr 1.84, 66° Be8), [7664-93-9]

(13) Tetrachloroethylene (perchloroethylene), [127-18-4]

(14) Tetrahydrofuran (THF, 1,4-epoxybutane), [109-99-9]

(15) Toluene (toluol), [108-88-3]

Gases:

(1) Ammonia, anhydrous, (99.99 %), [7664-41-7]

(2) 1,3-Butadiene, inhibited, (99.0 %) (bivinyll, vinylethylene, biethylene), [106-99-0]

(3) Chlorine, 99.5 %, [7782-50-5]

(4) Ethylene Oxide, (99.7 %), (oxirane, 1,2-epoxyethane), [75-21-8]

(5) Hydrogen Chloride, (99.0 %), (hydrochloric acid), [7647-01-0]

(6) Methyl Chloride, (99.5 %), (chloromethane), [74-87-3]

1991-17 Log #12 FAE-HAZ  
(7.5.9)

**Final Action: Accept in Principle**

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change the pass/fail value from 0.30 or greater to 0.40 or greater based on test data provided for hazmat boot performance levels as requested by the TC at the ROC meeting.

Revise text as follows:

7.5.9 Footwear ~~soles~~ shall be tested for slip resistance as specified in Section 8.23, Slip Resistance Test, and shall have a ~~static~~ coefficient of ~~0.75~~ 0.40 or greater.

**Submitter:** William Alexander, Onguard Industries

**Comment on Proposal No:** 1991-58a

**Recommendation:** Revise text to read as follows:

Does the proposed minimum 0.2 static coefficient of friction apply to both wet and dry conditions?

**Substantiation:** No substantiation provided.

**Committee Meeting Action:** **Accept in Principle**

Revise paragraph 7.5.9 as follows:

7.5.9 Footwear ~~soles~~ shall be tested for slip resistance as specified in Section 8.23, Slip Resistance Test, and shall have a ~~static~~ coefficient of ~~0.75~~ 0.30 or greater.

**Committee Statement:** The technical committee accepted the comment in principle, and revised the text in 7.5.9 as shown in the meeting action.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

FITHIAN, W.: A study is underway and test data is being collected on currently certified HazMat footwear in order to establish an accurate performance criteria for this test. Data will be available prior to the TCC meeting, and the final performance requirement for the Slip Resistance Test should be based on the test data generated. The proposed value of 0.30 is too low, since this value is essentially the standing slip resistance value for footwear tested by this method.

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1991-18 Log #25 FAE-HAZ  
(7.5.9)

Final Action: Accept in Principle

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**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change the pass/fail value from 0.30 or greater to 0.40 or greater based on test data provided for hazmat boot performance levels as requested by the TC at the ROC meeting.

Revise paragraph 7.5.9 as follows:

7.5.9 Footwear ~~soles~~ shall be tested for slip resistance as specified in Section 8.23, Slip Resistance Test, and shall have a ~~static~~ coefficient of ~~0.75~~ 0.40 or greater.

**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-36

**Recommendation:** Change requirement and method to be based on DIN EN ISO 13287

**Substantiation:** The current slip resistant test is not very discerning. Revise requirement and method as proposed by NFPA 1951.

**Committee Meeting Action:** Accept in Principle

**Committee Statement:** See Comment 1991-17 (Log #12).

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

STORMENT, S.: The introduction of a new slip resistance requirement should be harmonized among all standards where it is being implemented and is a matter of correlation by the Technical Correlating Committee.

STULL, J.: The introduction of a new slip resistance requirement should be harmonized among all standards where it is being implemented and is a matter of correlation by the Technical Correlating Committee.

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1991-19 Log #20 FAE-HAZ  
(7.6)

Final Action: Accept

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**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-29

**Recommendation:** Reinstate 7.6 Optional Liquefied Gas Protection Performance Requirements for Vapor-Protective Ensembles and Ensemble Elements.

**Substantiation:** It appears when 7.6 was deleted by Log #1, the new section 7.6 (original section 7.7) was also deleted in the preprint.

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-20 Log #28 FAE-HAZ  
(7.6.1, 7.6.2, 7.6.3, and 8.6.4.2)

Final Action: Accept in Principle

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**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to do the following for the purposes of correlation with other standards in the project:

1. Correct the permeation language to test acrylonitrile and acrolein as liquid TICs in Chapter 7 and Chapter 8 as indicated in the text provided below.
2. Correct the permeation test method to reflect updates made by the CBRN task group for permeation of the CWAs and TICs as indicated in the text provided below.
3. Address the issues of ammonia and chlorine to be tested twice, once as an industrial chemical and once as a TIC.
4. Address the issue of how industrial chemicals, TICs and warfare agents endpoints are evaluated (cumulative permeation vs breakthrough times).

Note: Items 3 and 4 should be addressed by the TC with the objective of submitting a concurrent TIA at the time of publication of the 2012 edition of NFPA 1991.

With this direction, the TCC has harmonized the permeation resistance performance criteria and test method among each of the standards specifying CBRN requirements. In the case of NFPA 1991, this has been accomplished by establishing the criteria in separate paragraphs and using a separate second permeation test method to address chemical warfare agents and toxic industrial chemicals to reduce confusion as to which test methods apply to which chemicals. In addition, the error of requiring acrolein and acrylonitrile testing as 99% gases has been corrected by specifying that these chemicals be tested as neat liquids. The redundancy for testing ammonia and chlorine both as industrial chemicals and toxic industrial chemicals using both methods has been retained to create an incentive for the Technical Committee to resolve issues regarding those chemicals that should be tested for breakthrough time and those that chemicals that should be tested for cumulative permeation mass.

Note: The following changes override those made in the committee actions on Proposal 1991-29 (Log #1) with the exception that the change for 7.1.4 (repositioning of SF6 integrity test criteria) still applies. The changes are indicated relative to NFPA 1991-2005.

Revise referenced paragraphs as follows:

7.2.1 Suit materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.2.6 Suit seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.3.1 Visor materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.3.6 Visor materials seams shall be tested for permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.4.1 Glove materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.5.1 Footwear materials and seams shall be tested for permeation resistance after flexing and abrading as specified in

Section 8.6, Chemical Permeation Resistance Test One, and shall not exhibit a breakthrough detection time of 1 hour or less for the following list of industrial chemicals:

[retain current list of chemicals]

7.7.2 Primary suit, glove, and footwear element materials shall be tested for liquefied gas permeation resistance as specified in Section 8.6, Chemical Permeation Resistance Test One, and shall not show signs of damage, and shall not exhibit a normalized breakthrough detection time of 15 minutes or less for the following list of gaseous industrial chemicals:

[retain current list of chemicals]

Add the following paragraphs to Chapter 7:

7.2.1.2 Suit materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

7.2.6.2 Suit seams shall be tested for permeation resistance as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

7.3.1.2 Visor materials shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed 4.0  $\mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed 1.25  $\mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed 6.0  $\mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average

cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

7.3.6.2 Visor material seams shall be tested for permeation resistance as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

7.4.1.2 Glove materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

7.5.1.2 Footwear materials and seams shall be tested for permeation resistance after flexing and abrading as specified in Section 8.28, Chemical Permeation Resistance Test Two, and shall meet the following performance criteria:

(1) For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2-chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g}/\text{cm}^2$ .

(2) For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g}/\text{cm}^2$ .

(3) For permeation testing of the liquid toxic industrial chemical acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(4) For permeation testing of the liquid toxic industrial chemical acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(5) For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(6) For permeation testing of the gaseous toxic industrial chemical ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

(7) For permeation testing of the gaseous toxic industrial chemical chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g}/\text{cm}^2$ .

## **8.6 Chemical Permeation Resistance Test One.**

### **8.6.1 Application.**

8.6.1.1 This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to the elements' seams.

8.6.1.2 Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in 8.6.7.

8.6.1.3 Modifications to this test method for testing glove materials after flexing and abrading shall be as specified in

8.6.8.

8.6.1.4 Modifications to this test method for testing footwear materials after flexing and abrading shall be as specified in 8.6.9.

8.6.1.5 Modifications to this test method for testing seams shall be as specified in 8.6.10.

8.6.1.6 Modifications to this test for testing primary materials against liquefied gases shall be as specified in 8.6.11.

8.6.1.7 Modifications to this test for testing suit, visor, glove, and footwear materials following cold temperature embrittlement exposure shall be as specified in 8.6.12.

#### 8.6.2 Sample Preparation.

8.6.2.1 Samples shall be either vapor-protective ensembles or suit materials, visor materials, gloves, and footwear of the sizes specified in the modifications.

8.6.2.2 Samples shall be conditioned as specified in 8.1.2 after the conditioning specified in the modifications.

#### 8.6.3 Specimens.

8.6.3.1 Specimens shall be the size specified in ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*.

8.6.3.2 At least three specimens shall be tested per chemical challenge.

8.6.3.3 For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

#### 8.6.4 Procedures.

##### 8.6.4.1 ~~Industrial Chemicals:~~

~~8.6.4.1.1~~ Permeation resistance shall be measured in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, at 27°C, ±2°C (81°F, ±3°F) for a test duration of at least 3 hours for the following chemicals:

- (1) Acetone
- (2) Acetonitrile
- (3) Anhydrous ammonia (gas)
- (4) 1,3-Butadiene (gas)
- (5) Carbon disulfide
- (6) Chlorine (gas)
- (7) Dichloromethane
- (8) Diethyl amine
- (9) Dimethyl formamide
- (10) Ethyl acetate
- (11) Ethylene oxide (gas)
- (12) Hexane
- (13) Hydrogen chloride (gas)
- (14) Methanol
- (15) Methyl chloride (gas)
- (16) Nitrobenzene
- (17) Sodium hydroxide
- (18) Sulfuric acid
- (19) Tetrachloroethylene
- (20) Tetrahydrofuran
- (21) Toluene

~~8.6.4.1.2~~ **8.6.4.2** The minimum detectable permeation rate for the permeation test apparatus shall be measured for each chemical tested. The minimum detectable permeation rate shall be less than or equal to 0.10 ug/cm<sup>2</sup>/min for all permeation resistance tests. When using closed loop systems, the testing laboratory shall assume 1 hour accumulated permeation.

8.6.4.3 The supply of the gas or vapor challenge chemical shall be sufficient to maintain the gas or vapor challenge chemical concentration during the exposure period of 60 minutes + 1.0 / -0.0 minutes.

##### ~~8.6.4.2 Chemical Warfare Agents:~~

~~8.6.4.2.1~~ Specimens shall be tested for permeation resistance for not less than 60 minutes in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact*, with the following modifications:

(1) The test cells shall be designed to accommodate the introduction of liquid chemicals in a safe manner.

(2) The liquid concentration density shall be 100 g/m<sup>3</sup>, +10/-0 g/m<sup>3</sup>, and the cell shall be assembled in closed top configuration.

(3) The collection media shall be filtered air flowed through the bottom of the test cell at a rate of 1 L/min ±0.1 L/min.

~~(4) Analytical methods used shall be sensitive to concentrations of at least one order of magnitude lower than the required end points.~~

~~(5) Cumulative permeation shall be determined and reported.~~

~~(6) Testing shall be performed at a temperature of 32°C, ±1°C (90°F, ±2°F).~~

~~8.6.4.2.2 The following chemicals shall be tested:~~

~~(1) Cyanogen chloride (CK, 506-77-4)~~

~~(2) Carbonyl chloride (CG, 75-44-5)~~

~~(3) Dimethyl sulfate (DMA, sulfuric acid dimethyl ester, 77-78-1)~~

~~(4) Hydrogen cyanide (AC, HCN, CAS, 74-90-8)~~

~~8.6.4.2.3 The chemical warfare agent sarin (GB) shall be tested.~~

~~8.6.4.2.4 The minimum detectable cumulative permeation shall be determined for each chemical warfare agent tested.~~

~~8.6.5 Report.~~

~~8.6.5.1 The following information and results shall be recorded and reported for each chemical:~~

~~(1) Material type or name~~

~~(2) Chemical or chemical mixture (volume composition of mixture)~~

~~(3) Permeation normalized breakthrough detection time in minutes calculated at a system detectable permeation rate of 0.10 ig/cm<sup>2</sup>/min for industrial chemicals~~

~~(4) Maximum permeation rate (ig/cm<sup>2</sup>/min) observed for industrial chemicals~~

~~(5) Minimum detectable rate for test apparatus (ig/cm<sup>2</sup>/min) for industrial chemicals~~

~~(6) Cumulative permeation mass (ig/cm<sup>2</sup>) for chemical warfare agents~~

~~(7) Minimum detectable cumulative permeation mass (ig/cm) for chemical warfare agents~~

~~(8) (6) Detection method~~

~~(9) (7) Date of test~~

~~(10) (8) Testing laboratory~~

~~8.6.5.2 The manufacturer shall report all three measured normalized breakthrough detection times or cumulative permeation masses in the technical data package.~~

~~8.6.5.3 The manufacturer shall report all three observed permeation rates in the technical data package for industrial chemicals.~~

~~8.6.6 Interpretation.~~

~~8.6.6.1 For industrial chemicals, The average normalized breakthrough detection time shall be used in determining compliance for the particular material/chemical combination.~~

~~8.6.6.2 For chemical warfare agents, the average cumulative permeation mass shall be used in determining compliance for the particular material/chemical combination.~~

~~8.6.7 Specific Requirements for Testing Suit Materials After Flexing and Abrading.~~

~~8.6.7.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.~~

~~8.6.7.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.~~

~~8.6.7.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.~~

~~8.6.7.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 3/4 in. × 9 in.), shall be cut from the center of the flexed samples.~~

~~8.6.7.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.~~

~~8.6.7.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.~~

~~8.6.7.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.~~

~~8.6.7.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.~~

~~8.6.8 Specific Requirements for Testing Glove Materials After Flexing and Abrading.~~

~~8.6.8.1 Samples for conditioning shall be whole glove components or whole glove individual elements.~~

~~8.6.8.2 Samples shall first be conditioned by flexing as specified in 8.1.5.~~

~~8.6.8.2.1 Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (1 3/4 in. × 9 in.), shall be cut from the center of the gauntlet portion of the flexed sample.~~

~~8.6.8.2.2 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.~~

8.6.8.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.6.8.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.6.8.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### **8.6.9 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.**

8.6.9.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.6.9.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.6.9.3 Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the footwear upper where the greatest flexing occurred, usually at the quarter or vamp of the flexed sample.

8.6.9.4 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.6.9.4.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.6.9.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### **8.6.10 Specific Requirements for Testing Seams.**

8.6.10.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm (6 in.) of material on each side of the seam center.

8.6.10.2 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.6.10.3 Seam specimens shall be prepared representing each different seam or shall be taken from each different type of seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

8.6.10.4 Samples for conditioning shall be 600 mm (239/16 in.) lengths of prepared seam or cut from vapor-protective ensembles.

#### **8.6.11 Specific Requirements for Testing Primary Materials Against Liquefied Gases.**

8.6.11.1 Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

8.6.11.2 Specimens shall be conditioned as specified in 8.1.8.

8.6.11.3 Visor materials that are rigid and cannot be bent in the test apparatus shall be excluded from this conditioning.

8.6.11.4 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning. The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

8.6.11.5 The test cell and test chemical shall be maintained at a temperature sufficient to keep the test chemical as a liquid at ambient pressure such that a 13 mm (1/2 in.) liquid layer is maintained at all times during the test.

#### **8.6.12 Specific Requirements for Testing Suit, Visor, Glove, and Footwear Materials Following Cold Temperature Embrittlement Exposure.**

8.6.12.1 Samples for conditioning shall be suit material, visor material, glove material from the glove gauntlet, and footwear material from the footwear upper.

8.6.12.2 Specimens shall be conditioned as specified in 8.1.8.

8.6.12.3 Only one specimen for permeation resistance testing shall be taken from each sample subjected to embrittlement conditioning.

8.6.12.4 The permeation test specimen shall be taken from the exact center of the folded sample so that the center of the permeation test and the center of the folded sample coincide.

Add New Test Method as follows:

### **8.28 Chemical Permeation Resistance Test Two.**

#### **8.28.1 Application.**

8.28.1.1 This test method shall apply to suit, visor, glove, and footwear element materials, and shall apply to the elements' seams.

8.28.1.2 Modifications to this test method for testing suit materials after flexing and abrading shall be as specified in 8.6.10.

8.28.1.3 Modifications to this test method for testing glove materials after flexing and abrading shall be as specified in 8.6.11.

8.28.1.4 Modifications to this test method for testing footwear materials after flexing and abrading shall be as specified in 8.6.12.

8.28.1.5 Modifications to this test method for testing seams shall be as specified in 8.6.13.

**8.28.2 Samples.**

**8.28.2.1** Samples for conditioning shall be as specified according to the specific requirements in 8.28.10, 8.28.11, 8.28.12, and 8.28.13 as appropriate.

**8.28.2.2** Samples shall be conditioned as specified according to the specific requirements in 8.28.10, 8.28.11, 8.28.12, and 8.28.13 as appropriate.

**8.28.2.3** Samples shall then be cut to the specimen size.

**8.28.2.4** All layers of the samples during conditioning shall be present and configured in the order and orientation as worn.

**8.28.3 Specimens.**

**8.28.3.1** Specimens shall be of the size required to fit the permeation test cell.

**8.28.3.2** A minimum of three specimens shall be tested against each challenge chemical.

**8.28.3.3** For composite materials, only the chemical protection layer shall be the sample for testing for chemical permeation resistance.

**8.28.3.4** If the specimen is the outer most layer of the composite then it shall be tested without any additional layers on top.

**8.28.3.5** Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

**8.28.3.6** Specimens with non-uniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical in order to allow sealing of the test cell to a uniform surface of the specimen.

**8.28.3.7** Following any sample preparation, the specimens shall be conditioned at a temperature of 32° C +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, for at least twenty-four hours prior to testing in accordance with 8.28.7.1.1

**8.28.4 Apparatus.**

**8.28.4.1** A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within +/- 1.0° C (+/- 2.0° F) of the test temperature and +/- 5 percent of the test relative humidity. The controlled environment chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing, as well as holding the test cells horizontally during use while connected to the air delivery system with manifold and to the effluent sampling mechanism.

**8.28.4.2\*** The test cell shall be a two-chambered cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and for flowing a collection medium on the specimen's normal inside surface, consisting of parts shown in Figure 8.28.4.2(1) and individual part detail shown in Figures 8.28.4.2(2) through 8.28.4.2(6).

\*\*\*insert Figure 8.28.4.2(1) here\*\*\*

**Figure 8.28.4.2(1) – Diffusion Test Cell Assembly**

\*\*\*insert Figure 8.28.4.2(2) here\*\*\*

**Figure 8.28.4.2(2) – Lower Body (Collection Side)**

\*\*\*insert Figure 8.28.4.2(3) here\*\*\*

**Figure 8.28.4.2(3) – Sample Support Plate**

\*\*\*insert Figure 8.28.4.2(4) here\*\*\*

**Figure 8.28.4.2(4) – Compression Plate**

\*\*\*insert Figure 8.28.4.2(5) here\*\*\*

**Figure 8.28.4.2(5) – Upper Body (Challenge Side)**

\*\*\*insert Figure 8.28.4.2(6) here\*\*\*

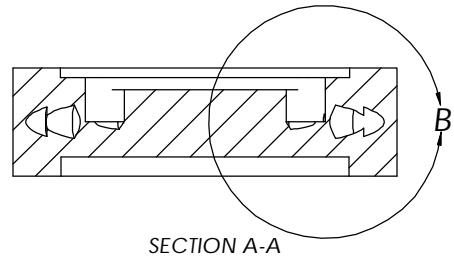
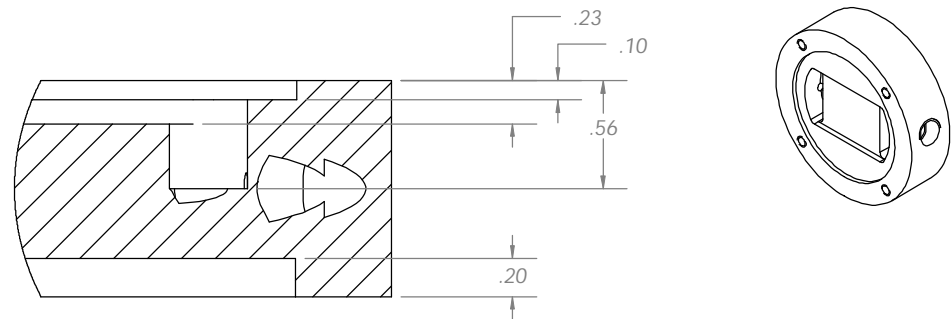
**Figure 8.28.4.2(6) – Top Cap**

**8.28.4.3\*** An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cell/fixtures at a rate of 2 standard liters per minute (SLPM) per test cell/fixture with a temperature precision of +/- 0.2° C and a relative humidity precision of +/- 5 percent. The manifold is designed to deliver 0.3 L/min for the challenge side of the test cell and 1 L/min for the collection side of the test cell and maintain at the test temperature. All parts of the air delivery system and manifold must be chemically inert and non-absorptive to the challenge chemical.

**8.28.4.4\*** An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams.

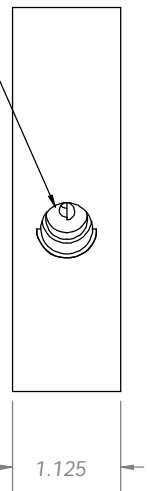
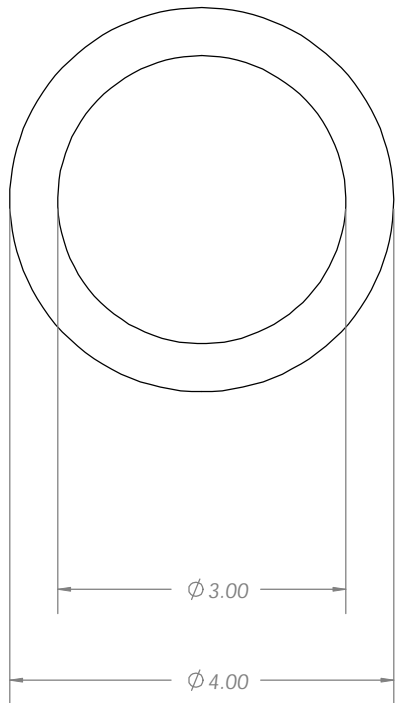


ZONE		REV.	REVISION HISTORY		DATE	APPROVED
			DESCRIPTION			

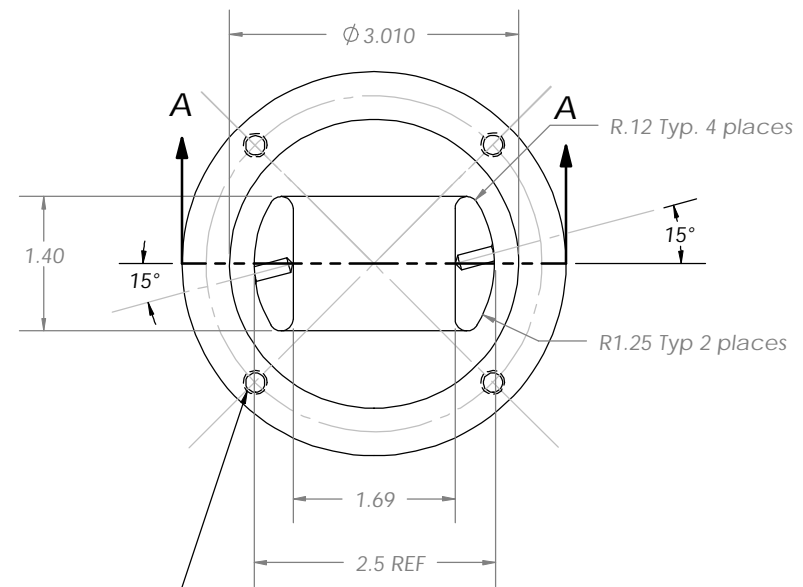


DETAIL B  
SCALE 1:1

5/32 X 1.10 DP DRILL,  
TAP 1/4 NPT, 0.5 DP  
2 PLCS.



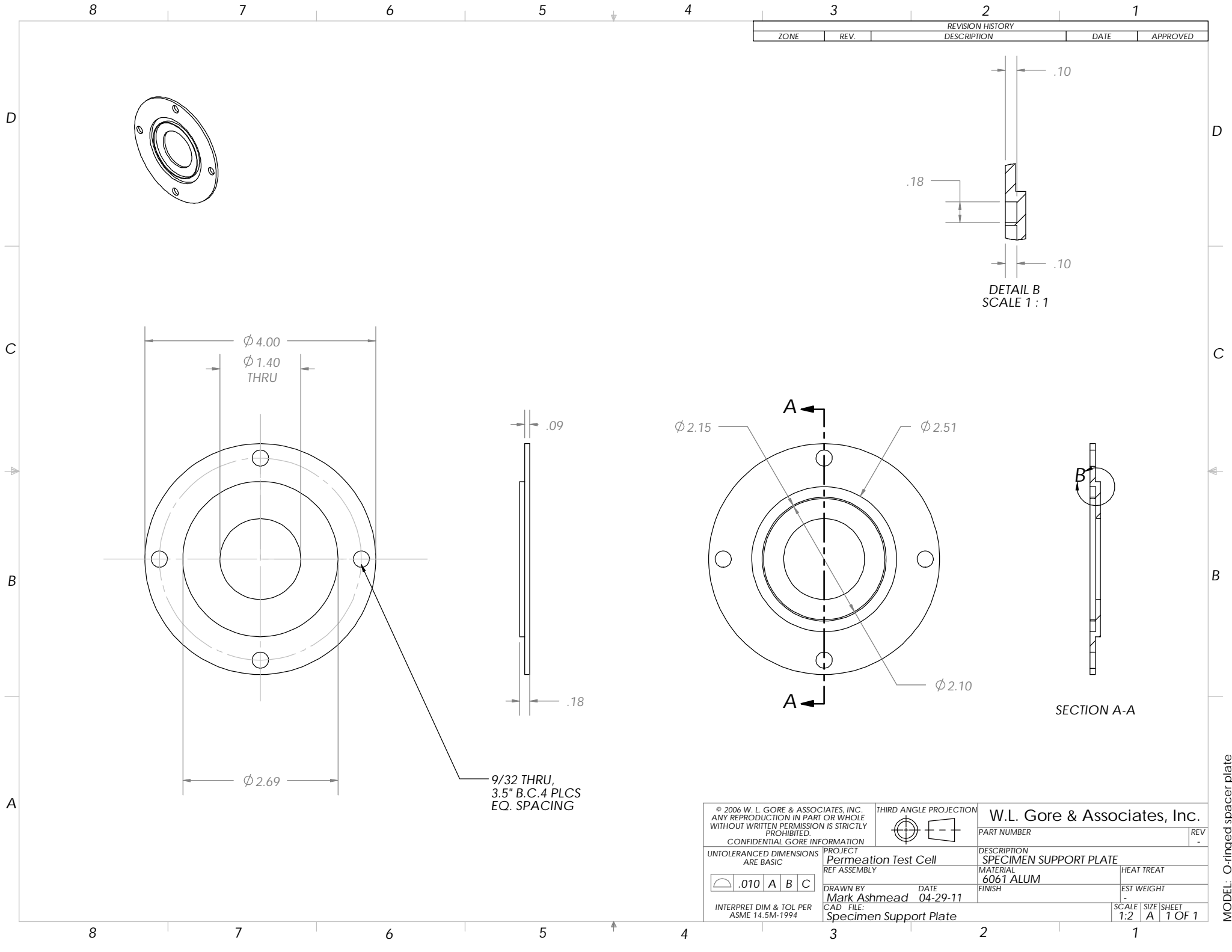
TAP 1/4-20 x 9/16 DP  
3.5" B.C., TYP. 4 PLC.,  
EQ. SPACED



- NOTES**
1. DIMENSIONS ARE IN INCHES.
  2. BREAK ALL SHARP EDGES AND DEBUR.
  3. STAMP OR ETCH WITH P/N USING .12" [3.0mm] HIGH CHARACTERS MINIMUM.

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CONFIDENTIAL GORE INFORMATION		PROJECT		PART NUMBER	
UNTOLERANCED DIMENSIONS ARE BASIC		Permeation Test Cell		LOWER BODY (COLLECTION SIDE)	
INTERPRET DIM & TOL PER ASME 14.5M-1994		DRAWN BY Mark Ashmead		MATERIAL 6061 Aluminum	
		DATE 05-03-11		HEAT TREAT	
		CAD FILE: Bottom Manifold		EST WEIGHT	
				SCALE SIZE SHEET	
				1:2 A 1 OF 1	

MODEL: Bottom manifold



REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

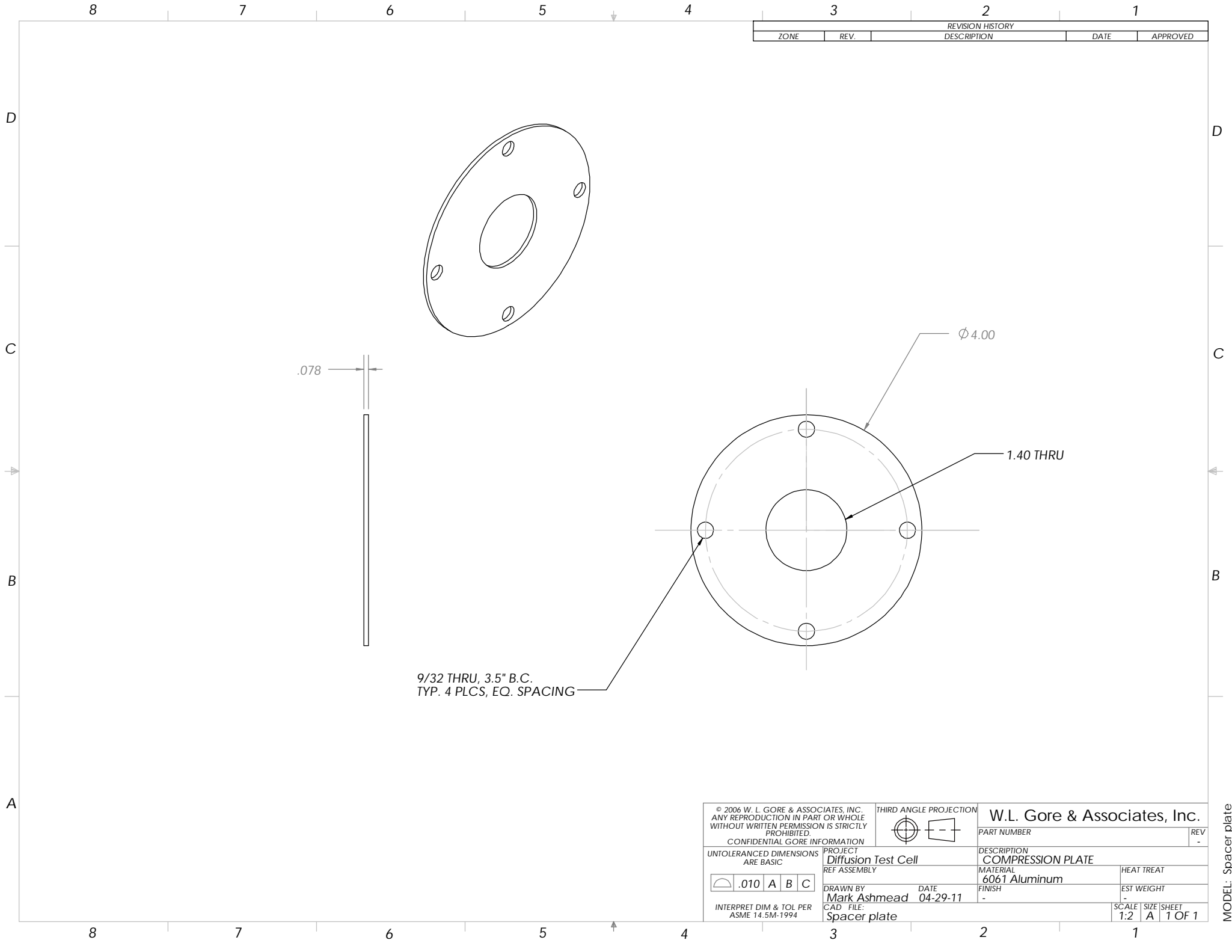
DETAIL B  
SCALE 1 : 1

SECTION A-A

9/32 THRU,  
3.5" B.C. 4 PLCS  
EQ. SPACING

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UNTOLERANCED DIMENSIONS ARE BASIC		PROJECT Permeation Test Cell	PART NUMBER -	
INTERPRET DIM & TOL PER ASME 14.5M-1994		REF ASSEMBLY Specimen Support Plate	DESCRIPTION SPECIMEN SUPPORT PLATE	
DRAWN BY Mark Ashmead		DATE 04-29-11	MATERIAL 6061 ALUM	
.010 A B C		CAD FILE Specimen Support Plate	HEAT TREAT EST WEIGHT -	
SCALE 1:2		SIZE A	SHEET 1 OF 1	

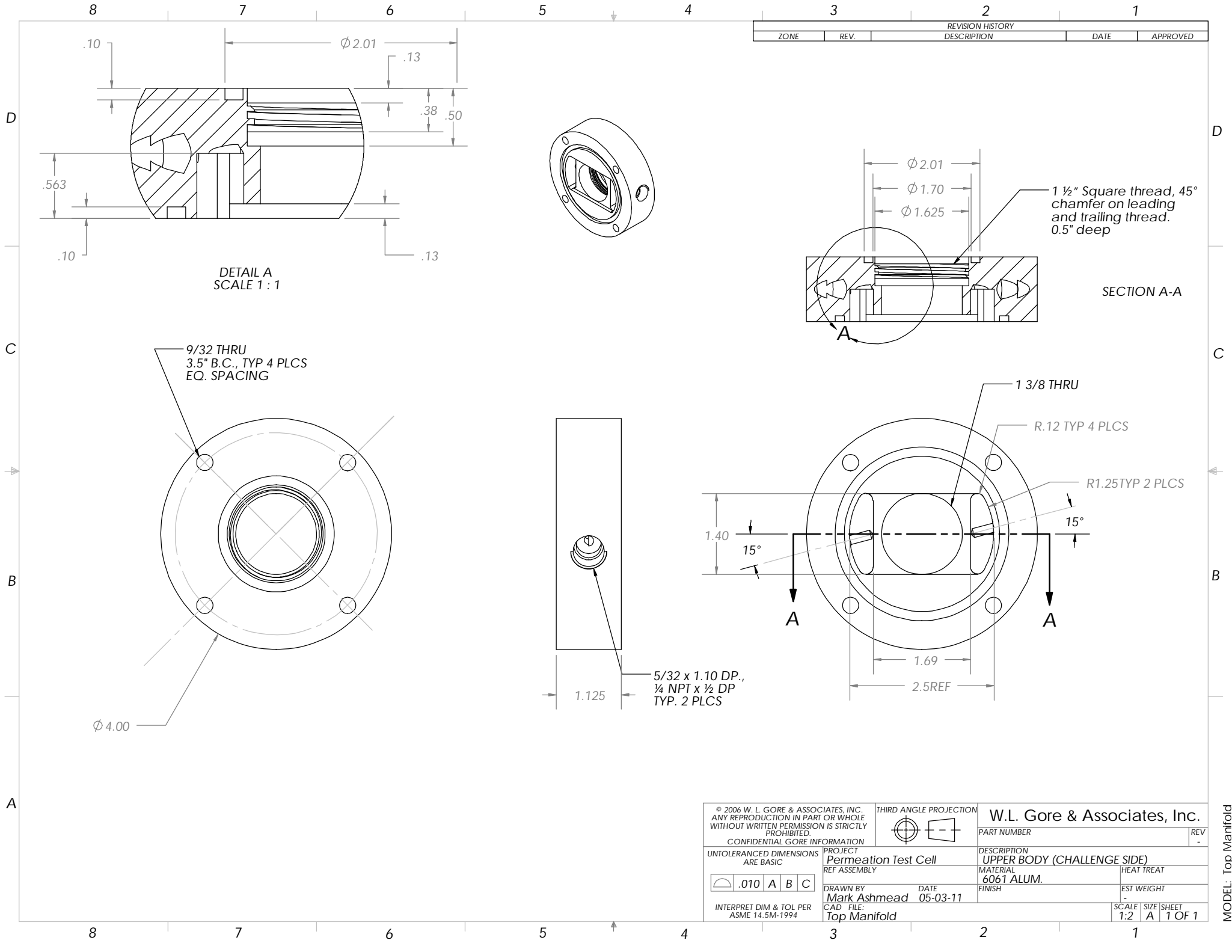
MODEL: O-ringed spacer plate



REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
3				
2				
1				

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UNTOLERANCED DIMENSIONS ARE BASIC			PROJECT Diffusion Test Cell		PART NUMBER -	
INTERPRET DIM & TOL PER ASME 14.5M-1994			REF ASSEMBLY Spacer plate		DESCRIPTION COMPRESSION PLATE	
DRAWN BY Mark Ashmead			DATE 04-29-11		MATERIAL 6061 Aluminum	
FINISH -			EST WEIGHT -		HEAT TREAT -	
SCALE 1:2			SIZE A		SHEET 1 OF 1	

MODEL: Spacer plate



REVISION HISTORY		DATE	APPROVED
ZONE	REV.	DESCRIPTION	

DETAIL A  
SCALE 1:1

SECTION A-A

9/32 THRU  
3.5" B.C., TYP 4 PLCS  
EQ. SPACING

Ø4.00

1 1/2" Square thread, 45°  
chamfer on leading  
and trailing thread.  
0.5" deep

5/32 x 1.10 DP.,  
1/4 NPT x 1/2 DP.  
TYP. 2 PLCS

1 3/8 THRU  
R.12 TYP 4 PLCS  
R1.25 TYP 2 PLCS

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UNTOLERANCED DIMENSIONS ARE BASIC		PROJECT Permeation Test Cell	PART NUMBER	REV -
DRAWN BY Mark Ashmead		DATE 05-03-11	DESCRIPTION UPPER BODY (CHALLENGE SIDE)	
INTERPRET DIM & TOL PER ASME 14.5M-1994		CAD FILE Top Manifold	MATERIAL 6061 ALUM.	HEAT TREAT
.010 A B C		SCALE 1:2	FINISH	EST WEIGHT
		SCALE 1:2	SIZE A	SHEET 1 OF 1

MODEL: Top Manifold

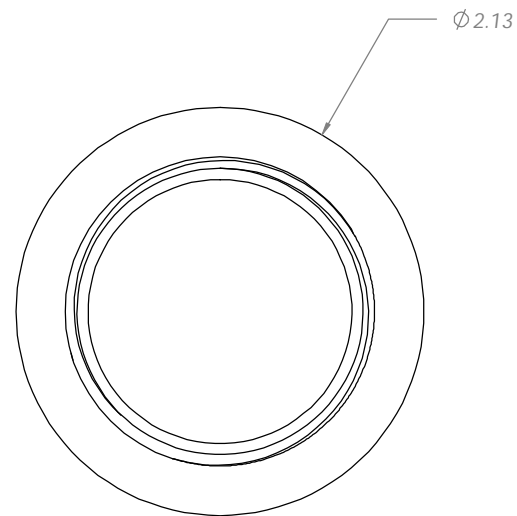
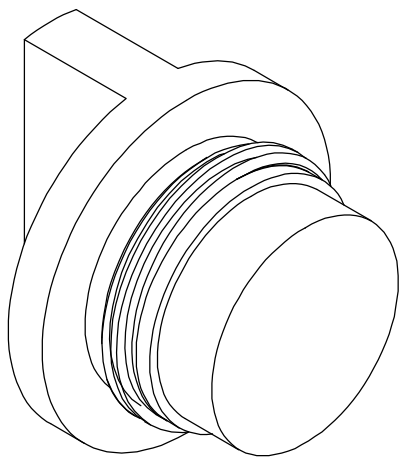
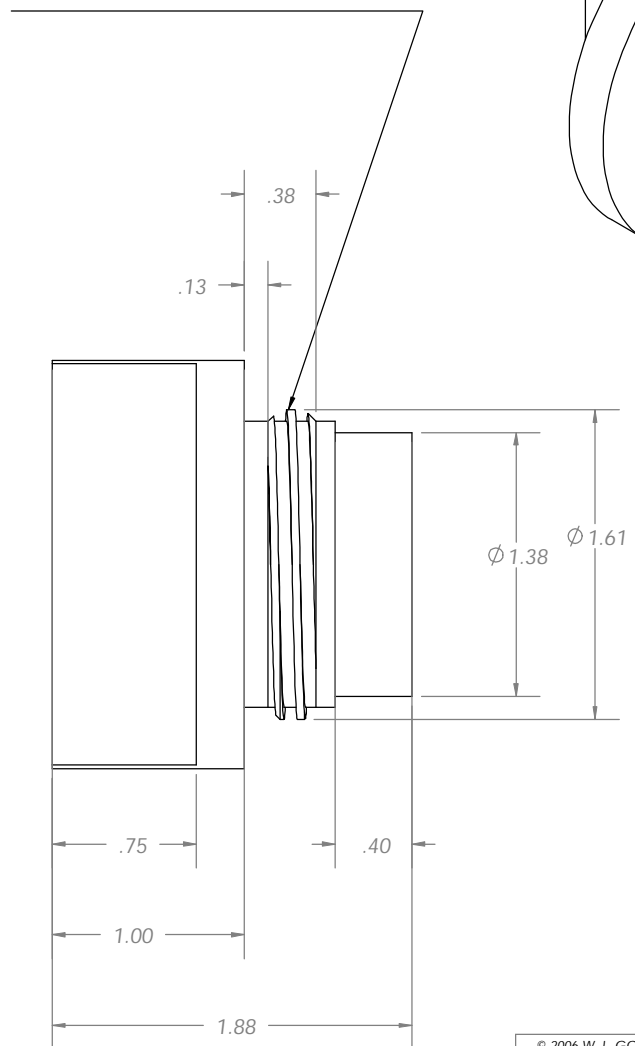
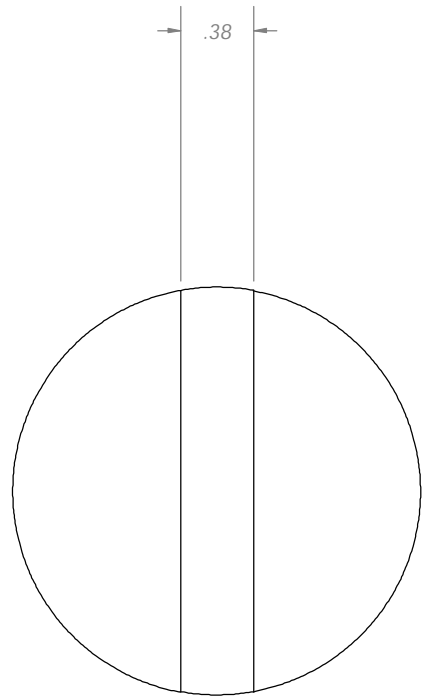
8 7 6 5 4 3 2 1

REVISION HISTORY				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

D  
C  
B  
A

D  
C  
B

1 1/2" Square thread, 45° chamfer on leading and trailing thread.



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CONFIDENTIAL GORE INFORMATION		PROJECT Diffusion Test Cell		PART NUMBER						
UNTOLERANCED DIMENSIONS ARE BASIC		REF ASSEMBLY		DESCRIPTION CELL CAP						
<table border="1"> <tr> <td></td> <td>.010</td> <td>A</td> <td>B</td> <td>C</td> </tr> </table>			.010	A	B	C	DRAWN BY Mark Ashmead		DATE 04-29-11	
	.010	A	B	C						
INTERPRET DIM & TOL PER ASME 14.5M-1994		CAD FILE Top cap		MATERIAL 6061 Aluminium						
				HEAT TREAT						
				EST WEIGHT 0.11						
				FINISH Anodize Black						
				SCALE SIZE SHEET 1:1 A 1 OF 1						

8 7 6 5 4 3 2 1

MODEL: Top cap

from the collection side of the test cell and shall be selected to provide the ability to measure the challenge chemical at 0.1 µg/cm<sup>2</sup> over the test exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real time chemical analyzer. Effluent sampling shall be permitted to be taken discretely or cumulatively; however the selected analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.28.4.5 A vacuum pump capable of creating vacuum of at least 5 inches water column shall be used for testing the integrity of the assembled test cell.

8.28.4.6 A manometer or pressure gage capable of measuring pressures or vacuums to 10 inches water column, with an accuracy of 5 percent of scale, shall be used for testing the integrity of the assembled test cell.

#### 8.28.5 Supplies

8.28.5.1 Syringe, capable of delivering challenge chemical, shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.28.5.2\* Replacement O-rings shall be available for use in the permeation test cell.

8.28.5.2.1\* If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

8.28.5.2.2 If an O-ring shows any signs of chemical degradation in the form of softening, hardening, swelling, deterioration, or loss of shape, or function, an O-ring of different material shall be used that does not show chemical degradation.

8.28.5.3\* An inert impermeable surrogate material shall be used as a negative control during validation tests.

#### 8.28.6 Chemicals

8.28.6.1 The following challenge chemicals shall be tested as liquids:

(1) Liquid chemical warfare agents

(a) Sulfur mustard, distilled [HD, or bis (2- chloroethyl) sulfide, CAS 505-60-2]

(b) Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8]

(2) Liquid toxic industrial chemicals

(a) Acrolein (allyl aldehyde, CAS 107-02-8)

(b) Acrylonitrile (VCN, cyanoethylene, CAS 107-13-1)

(c) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)

8.28.6.2 The following challenge chemicals shall be tested as gases .

(1) Ammonia (NH<sub>3</sub>, CAS 7664-41-7)

(2) Chlorine (Cl<sub>2</sub>, CAS 7782-50-5)

#### 8.28.7 Procedures.

##### 8.28.7.1 Preconditioning.

8.28.7.1.1 The challenge chemicals, test specimen, test equipment, and test cell assembly shall be placed in the environmental chamber for a minimum of twenty-four hours at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, prior to testing.

##### 8.28.7.2 Test Cell Assembly.

8.28.7.2.1 The test cell shall be assembled in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent.

8.28.7.2.2 O-Ring #1 shall be placed on the lower body (collection side) of the test cell.

8.28.7.2.3 The sample support plate shall be placed on the lower body (collection side) of the test cell.

8.28.7.2.4 O-ring #2 (outer) and O-ring #3 (inner) shall be placed in the respective grooves on the sample support plate.

8.28.7.2.5 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate.

8.28.7.2.6 With the upper body (challenge side) of the test cell upside down, O-ring #4 shall be placed in the upper body of the test cell on the specimen side and the compression plate shall be positioned over O-ring #4.

8.28.7.2.7 The upper body (challenge side) of the test cell with O-ring #4 and the compression plate, shall be inverted, aligned with the lug posts, and joined with the lower body (collection side) of the test cell.

8.28.7.2.8 Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm-kq (45 in-lbs) of torque shall be applied to each lug to ensure a proper cell seal.

8.28.7.2.9 O-ring #5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell and the cell top cap shall be screwed into place.

8.28.7.2.10 The integrity of the test cell assembly shall be verified using the procedure in 8.28.7.3.

8.28.7.2.11 Each test cell shall be labeled with the challenge chemical to be used in it.

##### 8.28.7.3 Verification of Test Cell Integrity.

8.28.7.3.1 Test cell integrity shall be performed in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent.

8.28.7.3.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.28.7.3.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.28.7.3.4 Both inlet ports shall be connected to a vacuum and the test cell upper body and test cell lower body shall be depressurized to 75 mm (3 inch) water column pressure.

8.28.7.3.5 If the test cell pressure drops below 50 mm (2 inch) of water column within 2 minutes, the test cell shall be reassembled according to the steps in 8.28.7.2

8.28.7.3.6 Only test cells that have passed this integrity test shall be used for testing.

8.28.7.4 Determination of Procedure for Applying Liquid Challenge Chemicals.

The liquid chemical challenge concentration shall be at least 100 g/m<sup>2</sup> to achieve a flooded surface on the specimen over the duration of the test period..

8.28.7.5 Procedure for Liquid Chemical Challenge.

8.28.7.5.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.28.7.5.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.28.7.5.2.1 If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

8.28.7.5.2.2 If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

8.28.7.5.3 The air delivery shall be flowing filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of the test cell at least 15 minutes prior to the application of the challenge chemical.

8.28.7.5.4 With the cell top cap removed, the liquid chemical shall be placed through the agent challenge port of the test cell on the specimen's outer surface within 20 seconds, according to the procedure determined in 8.28.7.4

8.28.7.5.5 After placing the liquid challenge chemical on the specimen in the test cell, the cell top cap shall be sealed within 5 seconds. The filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, shall be flowed only to the collection side of the test cell a rate of 1.0 LPM, +/- 0.1 LPM. No air shall be flowed across the challenge side of the test cell.

8.28.7.5.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / - 0 minutes.

8.28.7.5.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.28.7.5.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

8.28.7.5.9\* At least one test shall be conducted with an inert impermeable surrogate specimen as a negative control.

8.28.7.5.10 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

8.28.7.6 Procedure for Gas Challenge Chemicals.

8.28.7.6.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.28.7.6.2 The air delivery shall be connected and flowing 1 LPM of filtered air at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of test cell at least 15 minutes prior to the initiation of any gas challenge chemical.

8.28.7.6.3 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.28.7.6.4 The initiation of the test shall occur when the gas challenge chemical is introduced into the challenge side of the test cell.

8.28.7.6.4.1 The supply of the gas challenge chemical shall be sufficient to maintain the gas challenge chemical concentration during the exposure period of 60 minutes + 1.0 / -0.0 minutes.

8.28.7.6.4.2 The gas challenge chemical shall be at a temperature of 32° C, +/- 1° C (90° F, +/- 2° F).

8.28.7.6.4.3 The concentration of the gas challenge chemical shall be 99% or greater.

8.28.7.6.5 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / -0 minutes.

8.28.7.6.6 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.28.7.6.7 At least one test shall be conducted with the specimen, but without the challenge chemical, as a negative control.

8.28.7.6.8\* At least one test shall be conducted with an inert surrogate specimen as a negative control.

8.28.7.6.9 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

**8.28.7.7 Test Conclusion, Cleaning of Test Cell, and Specimen Disposal.**

8.28.7.7.1 At the conclusion of the test, the test cell shall be purged and the air delivery and analytical system shall be shut down.

8.28.7.7.2 Each cell shall be disassembled one at a time.

8.28.7.7.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.28.7.7.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal or other applicable regulations.

8.28.7.7.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals.

8.28.7.7.6 The cell shall be allowed to air dry in a clean area for 24 hours before reuse.

**8.28.8 Report**

8.28.8.1 The cumulative permeation in one hour shall be calculated, recorded, and reported in  $\mu\text{g}/\text{cm}^2$  for each specimen for each challenge chemical.

8.28.8.1.1 If no challenge chemical is detected at the end of the 60 minute test period, then the cumulative permeation shall be recorded and reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

8.28.8.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

8.28.8.2.1 For the calculation of average cumulative permeation, if the results of one or more of the specimens tested is less than the minimum detectable cumulative permeation then use the minimum detectable cumulative permeation as the result for those specimens.

8.28.8.2.2 For the calculation of average cumulative permeation, if the results of all the specimens tested are less than the minimum detectable cumulative permeation then the average cumulative permeation is reported as the minimum detectable cumulative permeation.

8.28.8.3 Report any observations of degradation or other abnormalities at the conclusion of the testing of each specimen.

8.28.9 Interpretation. The average cumulative permeation for each challenge chemical shall be used to determine pass or fail performance.

**8.28.10 Specific Requirements for Testing Suit Materials After Flexing and Abrading.**

8.28.10.1 Samples for conditioning shall be 200 mm × 280 mm (8 in. × 11 in.) rectangles and shall consist of all layers as configured in the suit.

8.28.10.2 Two samples shall first be conditioned by flexing as specified in 8.1.3.

8.28.10.2.1 One sample shall be flexed with the longitudinal axis parallel to the machine direction of the material, and the second sample shall be flexed with the longitudinal axis parallel to the cross-machine direction of the material.

8.28.10.2.2 Following flexing, two samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the flexed samples.

8.28.10.2.3 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.28.10.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.10.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.28.10.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

**8.28.11 Specific Requirements for Testing Glove Materials After Flexing and Abrading.**

8.28.11.1 Samples for conditioning shall be whole glove components or whole glove individual elements.

8.28.11.2 Samples shall first be conditioned by flexing as specified in 8.1.5.

8.28.11.2.1 Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the gauntlet portion of the flexed sample.

8.28.11.2.2 At least one specimen for abrasion conditioning shall be taken from a sample flexed in the machine direction, and at least one specimen for abrasion conditioning shall be taken from a sample flexed in the cross-machine direction for each chemical tested.

8.28.11.3 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.11.3.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample.

subjected to abrasion.

8.28.11.3.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### 8.28.12 Specific Requirements for Testing Footwear Materials After Flexing and Abrading.

8.28.12.1 This test shall apply to all types of footwear configurations. Where the footwear incorporates a bootie constructed of suit material, the suit material flex fatigue resistance test shall be permitted to be substituted for this test.

8.28.12.2 Samples for conditioning shall be whole footwear components or whole footwear individual elements.

8.28.12.3 Samples shall first be conditioned by flexing as specified in 8.1.6. Following flexing, three samples for abrasion conditioning, each measuring 45 mm × 230 mm (13/4 in. × 9 in.), shall be cut from the center of the footwear upper where the greatest flexing occurred, usually at the quarter or vamp of the flexed sample.

8.28.12.4 These new samples for abrasion conditioning shall then be conditioned by abrading as specified in 8.1.4.

8.28.12.4.1 Following abrasion, only one specimen for permeation resistance testing shall be taken from each sample subjected to abrasion.

8.28.12.4.2 The permeation test specimen shall be taken from the exact center of the abraded sample so that the center of the permeation test and the center of the abraded sample coincide.

#### 8.28.13 Specific Requirements for Testing Seams.

8.28.13.1 Seam specimens shall be prepared from seam samples that have a minimum of 150 mm(6 in.) of material on each side of the seam center.

8.28.13.2 Permeation test specimens shall be cut such that the exact seam center divides the specimen in half.

8.28.13.3 Seam specimens shall be prepared representing each different seam or shall be taken from each different type of seam found in the vapor-protective suit, including as a minimum the suit-to-suit material seams and the suit-to-visor material seams.

8.28.13.4 Samples for conditioning shall be 600 mm (239/16 in.) lengths of prepared seam or cut from vapor-protective ensembles.

Add new Annex paragraphs as follows:

A.8.28.4.2 The specified test cell meets the test cell requirements for the Liquid Challenge/Vapor Penetration (L/V) Test Cell specified in TOP 8-2-501 with the following exceptions:

(1) The test cell is configured to separately permit flow across the challenge side and the collection side, and to allow the challenge side to be exposed for the placement of challenge chemical.

(2) The sample support plate shown in Figure 8.28.4.2 (3) has been modified to permit the O-rings to be closer to the exposed surface area of the specimen.

(3) The cell top cap shown in Figure 8.28.4.2 (5) has a smooth solid surface facing the test specimen, i.e. no opening ports for cell integrity testing.

(4) Ports for testing the integrity of the assembled test cell are mounted on the inlet fittings on both the upper body and lower body of the test cell.

A.8.28.4.5 It is essential that the air delivery system provide precise flow to each test cell and achieve the specified temperature and humidity conditions. This delivery is controlled by the conditioning of the incoming air to achieve the temperature and humidity conditions before reaching each test cell and is monitored by separate flow meters or controllers for each test cell.

A.8.28.4.6 The performance requirement is based on a cumulative measurement; however discrete measurements can be used to determine this. These discrete measurements must be able to account for the total amount of the challenge chemical permeating. This means that the frequency of the discrete sampling must be almost continuous, at least sampling once per minute, preferably sampling two to four times per minute, or more. The efficacy of the selected sampling and analysis approach should be validated for each challenge chemical through the use of procedures where a known amount of the challenge chemical, representative of a cumulative permeation close to the minimum requirement, is injected into the collection medium of a trial test. The selected sampling and analytical approach should be able to demonstrate a mass recovery of 95% or better at test conditions to be considered a valid part of the procedures.

A.8.28.5.2 Viton® O-rings have been found to be compatible with the challenge chemicals.

A.8.28.5.2.1 One procedure to determine the compatibility of O-ring material with the challenge chemicals would be to place the O-rings in contact with the challenge chemical for a period of 4 hours. Remove the O-ring from contact with the challenge chemical and observe for any physical changes or signs of degradation.

A.8.28.5.3 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.6.2.2 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.7.5.9 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

A.8.28.7.6.8 Aluminum foil with a thickness of 1/32<sup>nd</sup> of an inch has been found to be acceptable.

Submitter: Paul Dacey, W L Gore & Associates

Comment on Proposal No: 1991-29

Recommendation: Revise text to read as follows:

\*\*\*Insert 1991\_L28\_Include\_F2011\_R\*\*\*

**Substantiation:** This revised requirement and test method will, if adopted, harmonize the permeation resistance performance requirements for CWAs and TICs in NFPA 1951, NFPA 1971, NFPA 1991, and NFPA 1994. Currently, they all try to do the same thing with slightly different words and format. This comment updates the procedures to conform with current best practices, corrects many editorial mistakes, and aligns the formatting in all four documents.

For NFPA 1991, this comment will also change the CWA challenge sarin to soman. Soman is both more lethal and more persistent than sarin, making it of more interest to the user and less difficult to test for the laboratory. This comment will also change the TICs from the current 3 to acrolein and acrylonitrile.

**This is not original material; its reference/source is as follows:**

**Risk-Based Protective Clothing Material Permeation Criteria: Final Report prepared by International Personnel Protection Inc. dated Feb 19, 2010.**

**Committee Meeting Action: Accept in Principle**

Revise text as indicated below:

7.2.2 Primary suit materials shall be tested for permeation resistance as specified in Section 8.6.4.2 and shall meet the following performance criteria:

1. For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2- chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g} / \text{cm}^2$ .
2. For permeation testing of the liquid chemical warfare agent Sarin [GB, or isopropyl methyl phosphonofluoridate, CAS 107-44-8] the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g} / \text{cm}^2$ .
3. For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .
4. For permeation testing of the chemical gas acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .
5. For permeation testing of the chemical gas acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

In NFPA 1971, replace para 7.20.1.3 with the following:

· In NFPA 1994 Replace para 7.1.2.1, 7.1.2.8.1, 7.1.3.2, 7.1.4.2 and create new para 7.1.1.6 with the following:

· In NFPA 1994, replace para , 7.2.2.1, 7.2.2.9.1, 7.2.3.2 & 7.2.4.2 and create new para 7.2.1.6 with the following:

· In NFPA 1951, replace para 7.3.1.3 with the following:

· In NFPA 1991, replace Para 7.2.2, 7.2.3, 7.2.4, 7.2.10, 7.2.11, 7.2.12, 7.3.2, 7.3.3, 7.3.4, 7.3.7, 7.3.8, 7.3.9, 7.4.2, 7.4.3, 7.4.4, 7.5.2, 7.5.3, 7.5.4 with the following new para 7.1.10:

The following numbering is correct for NFPA 1951 document only

7.3.1.3 Each ensemble element's CBRN barrier layer and the CBRN barrier layer's seams shall be tested for permeation resistance as specified in Section 8.45 and shall meet the following performance criteria:

1. For permeation testing of the liquid chemical warfare agent sulfur mustard, distilled [HD, or bis (2- chloroethyl) sulfide, CAS 505-60-2], the average cumulative permeation in one hour shall not exceed  $4.0 \mu\text{g} / \text{cm}^2$ .

2. For permeation testing of the liquid chemical warfare agent Soman [GD, or O- Pinacolyl methylphosphonofluoridate, CAS 96-64-0], the average cumulative permeation in one hour shall not exceed  $1.25 \mu\text{g} / \text{cm}^2$ .

3. For permeation testing of the liquid toxic industrial chemical dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

4. For permeation testing of the chemical gas acrolein (allyl aldehyde, CAS 107-02-8), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

5. For permeation testing of the chemical gas acrylonitrile (VCN, cyanoethylene, CAS 107-13-1), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

6. For permeation testing of the chemical gas ammonia ( $\text{NH}_3$ , CAS 7664-41-7), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

7. For permeation testing of the chemical gas chlorine ( $\text{Cl}_2$ , CAS 7782-50-5), the average cumulative permeation in one hour shall not exceed  $6.0 \mu\text{g} / \text{cm}^2$ .

In the NFPA 1971 Standard, replace Section 8.67 with the following:

In the NFPA 1994 Standard, replace Section 8.7 with the following:

In the NFPA 1951 Standard, replace Section 8.45 with the following:

In the NFPA 1991 Standard, replace Section 8.6.4.2 with the following new method:

The following numbering is correct for NFPA 1951 document only }

## **8.45 Chemical Permeation Resistance Test**

### **8.45.1 Application**

8.45.1.1 This method shall apply to the CBRN barrier layer and the CBRN barrier layer's seams used in ensembles and ensemble elements for CBRN terrorism agent protection.

8.45.1.2 Specific requirements for testing the CBRN barrier layer of garments, hoods, and booties shall be as specified in 8.45.10

8.45.1.3 Specific requirements for testing the CBRN barrier layer of visors shall be as specified in 8.45.11

8.45.1.4 Specific requirements for testing the CBRN barrier layer of gloves shall be as specified in 8.45.12

8.45.1.5 Specific requirements for testing the CBRN barrier layer of footwear shall be as specified in 8.45.13

8.45.1.6 Specific requirements for testing the CBRN barrier layer's seams of garments, hoods, booties, visors, and gloves shall be as specified in 8.45.14

#### **8.45.2 Samples**

8.45.2.1 Samples for conditioning shall be as specified according to the specific requirements in 8.45.10, 8.45.11, 8.45.12, 8.45.13, and 8.45.14 as appropriate.

8.45.2.2 Samples shall be conditioned as specified according to the specific requirements in 8.45.10, 8.45.11, 8.45.12, 8.45.13, and 8.45.14 as appropriate.

8.45.2.3 Samples shall then be cut to the specimen size.

8.45.2.4 All layers of the samples during conditioning shall be present and configured in the order and orientation as worn.

#### **8.45.3 Specimens**

8.45.3.1 Specimens shall be the CBRN barrier layer or the CBRN barrier layer's seam of the size required to fit the permeation test cell.

8.45.3.2 A minimum of three specimens shall be tested against each challenge chemical.

8.45.3.3 Any outer shell or other composite layers normally worn over the specimen shall be permitted to be included on top of the specimen in the test. Place the outer shell or other composite layers on the test specimen through the cell cap port after the test cell has been assembled.

8.45.3.4 If the specimen is the outer most layer of the composite then it shall be tested without any additional layers on top.

8.45.3.5 Any separable layers normally worn underneath the specimen shall not be permitted to be included in the test.

8.45.3.6 Specimens with non-uniform surfaces shall be permitted to be treated with an impermeable nonreactive sealant outside the area of the specimen exposed to the challenge chemical in order to allow sealing of the test cell to a uniform surface of the specimen.

8.45.3.7 Following any sample preparation, the specimens shall be conditioned at a temperature of 32°C +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, for at least twenty-four hours prior to testing in accordance with paragraph 8.45.7.1.1

#### **8.45.4 Apparatus**

8.45.4.1 A thickness gauge suitable for measuring thicknesses to the nearest 0.02 mm (or the nearest 0.001 in.), as specified in ASTM D1777, shall be used to determine the thickness of each test specimen.

8.45.4.2 An analytical balance readable and reproducible to +/- 0.5 mg, as specified in ASTM D3776 shall be used to determine the weight per unit area of each test specimen.

8.45.4.3 A controlled environmental chamber shall be used to maintain the test cell, air flow control system, and reagent chemicals within +/- 1.0°C (+/- 2.0°F) of the test temperature and +/- 5 percent of the test relative humidity. The controlled environment chamber shall be sized so that it can be used for conditioning test materials, test cells when not in use, challenge chemicals, and other test apparatus prior to testing, as well as holding the test cells horizontally during use while connected to the air delivery system with manifold and to the effluent sampling mechanism.

8.45.4.4 The test cell shall be a two-chambered aluminum alloy cell for contacting the specimen with the challenge chemical on the specimen's normal outside surface and for flowing a collection medium on the specimen's normal inside surface, conforming to diffusion test cell part # TOP 8-2-501 from Aero-Space Tooling & Machining, 2190 West 1700 South, Salt Lake City, UT 84104, with the following modifications:

(a) The cell cap shall have a smooth solid surface facing the test specimen, i.e. no opening ports for cell integrity testing.

(b) Ports for testing the integrity of the assembled test cell shall be mounted on the inlet fittings on both the upper body and lower body of the test cell.

8.45.4.5\* An air delivery system and manifold shall be used to provide oil-free, conditioned air to the test cell/fixtures at a rate of 2 standard liters per minute (SLPM) per test cell/fixture with a temperature precision of +/- 0.2°C and a relative humidity precision of +/- 5 percent. The manifold is designed to deliver 0.3 L/min for the challenge side of the test cell and 1 L/min for the collection side of the test cell and maintain at the test temperature. All parts of the air delivery system and manifold must be chemically inert and non-absorptive to the challenge chemical.

8.45.4.6\* An analytical system shall be used to evaluate the amount of challenge chemical in the effluent air streams from the collection side of the test cell and shall be selected to provide the ability to measure the challenge chemical at 0.1 µg/cm<sup>2</sup> over the test exposure period. The analytical system shall be permitted to include a bubbler tube, solid sorbent, or real time chemical analyzer. Effluent sampling shall be permitted to be taken discretely or cumulatively; however the selected analytical system shall be able to determine all of the challenge chemical permeating through the specimen in 60 minutes.

8.45.4.7 A vacuum pump capable of creating vacuum of at least 5 inches water column shall be used for testing the integrity of the assembled test cell.

8.45.4.8 A manometer or pressure gage capable of measuring pressures or vacuums to 10 inches water column, with an accuracy of 5 percent of scale, shall be used for testing the integrity of the assembled test cell.

#### **8.45.5 Supplies**

8.45.5.1 Syringe needles, capable of delivering one-microliter droplets, +/- 1%, of the challenge chemical, shall be used for dispensing liquid challenge chemical onto the surface of the specimen in the test cell.

8.45.5.2\* Replacement O-rings shall be available for use in the permeation test cell.

8.45.5.2.1\* If unknown, the compatibility of the O-ring material with the challenge chemical shall be verified before use.

8.45.5.2.2 If an O-ring shows any signs of chemical degradation in the form of softening, hardening, swelling, deterioration, or loss of shape, or function, an O-ring of different material shall be used that does not show chemical degradation.

8.45.5.3\* An inert impermeable surrogate material shall be used as a negative control during validation tests.

#### **8.45.6 Chemicals**

8.45.6.1 The following challenge chemicals shall be tested as liquids:

(1) Liquid chemical warfare agents

(a) Sulfur mustard, distilled [HD, or bis (2- chloroethyl) sulfide, CAS 505-60-2]

(b) Soman [GD, or O-Pinacolyl methylphosphonofluoridate, CAS 96-64-0]

(2) Liquid toxic industrial chemical

(a) Dimethyl sulfate (DMS, sulfuric acid dimethyl ester, CAS 77-78-1)

8.45.6.2 Process for Determining the Mass of Liquid Chemical Challenge Applied

8.45.6.2.1 Prior to assembling the test cell and conducting the test, the mass of the applied challenge chemical shall be determined using the following procedure.

8.45.6.2.2\* The challenge chemical shall be applied to an inert impermeable surrogate specimen in the pattern described in 8.45.7.4

8.45.6.2.3 After application, the inert impermeable surrogate specimen shall be visually inspected to verify that the liquid chemical challenge was correctly applied.

8.45.6.2.4 The inert impermeable surrogate specimen with the applied liquid chemical challenge shall be placed in a closed large vial containing a known volume of solvent compatible with the following analysis procedure.

8.45.6.2.5 The large vial with solvent and impermeable surrogate specimen with the applied liquid challenge chemical shall be agitated for at least 1 hour to ensure complete extraction of the challenge chemical.

8.45.6.2.6 After agitation the solvent vial shall be removed and submitted for analysis of the liquid challenge chemical using a procedure capable of detecting 1.0 µg of the liquid challenge chemical.

8.45.6.2.7 Using the mass of the liquid challenge chemical detected in the extraction procedure and the exposed area of the test specimen defined by the test cell, the exposure concentration shall be 10 g/m<sup>2</sup> (+1.0 / - 0.0 g/m<sup>2</sup>).

8.45.6.2.8 The number of one-microliter liquid droplets shall be adjusted to conform to the 10 g/m<sup>2</sup> (+1.0 / - 0.0 g/m<sup>2</sup>) concentration requirement.

8.45.6.3\* The following challenge chemicals shall be tested as gases or vapors in dry air or nitrogen.

(1) Ammonia (NH<sub>3</sub>, CAS 7664-41-7)

(2) Chlorine (Cl<sub>2</sub>, CAS 7782-50-5)

(3) Acrolein (allyl aldehyde, CAS 107-02-8)

(4) Acrylonitrile (VCN, cyanoethylene, CAS 107-13-1)

#### **8.45.7 Procedures**

8.45.7.1 Preconditioning

8.45.7.1.1 The challenge chemicals, test specimen, test equipment, and test cell assembly shall be placed in the environmental chamber for a minimum of twenty-four hours at 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, prior to testing.

8.45.7.2 Test Cell Assembly

INSERT FIGURE: Use figure 8.7.5.2.1 Permeation Cell Assembly from Risk-Based Protective Clothing Material Permeation Criteria: Final Report prepared by International Personnel Protection, Inc. dated February 19, 2010.

8.45.7.2.1 The test cell shall be assembled in the environmental chamber at 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent.

8.45.7.2.2 An O-ring shall be placed on the lower body of the test cell.

8.45.7.2.3 The sample support plate shall be placed on O-ring #1 and O-ring #2 shall be placed in the groove on the sample support plate.

8.45.7.2.4 The specimen shall be removed from the conditioning location in the environmental chamber and shall be placed on top of the sample support plate with O-ring #3 placed over the specimen.

8.45.7.2.5 With the upper body of the test cell upside down, O-ring #4 shall be placed in the upper body of the test cell and the compression plate shall be positioned over O-ring #4.

8.45.7.2.6 The upper body of the test cell with O-ring #4 and the compression plate, shall be inverted, aligned with the lug posts, and joined with the lower body of the test cell.

8.45.7.2.7 Using the four cell sealing lugs, the cell halves shall be clamped together and 51.8 cm-kg (45 in-lbs) of torque shall be applied to each lug to ensure a proper cell seal.

8.45.7.2.8 O-ring #5 shall be inserted into the groove around the agent challenge port in the upper body of the test cell and the cell cap shall be screwed into place.

8.45.7.2.9 The integrity of the test cell assembly shall be verified using the procedure in 8.45.7.3.

8.45.7.2.10 Each test cell shall be labeled with the challenge chemical to be used in it.

### **8.45.7.3 Verification of Test Cell Integrity**

8.45.7.3.1 Test cell integrity shall be performed in the environmental chamber at 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent.

8.45.7.3.2 Valves on the outlet ports of the upper and lower body of the test cell shall be closed.

8.45.7.3.3 Both the upper and lower body inlet ports of the test cell shall be connected to a manometer.

8.45.7.3.4 Both inlet ports shall be connected to a vacuum and the test cell upper body and test cell lower body shall be depressurized to 75 mm (3 inch) water column pressure.

8.45.7.3.5 If the test cell pressure drops below 50 mm (2 inch) of water column within 2 minutes, the test cell shall be reassembled according to the steps in 8.45.7.2

8.45.7.3.6 Only test cells that have passed this integrity test shall be used for testing.

### **8.45.7.4 Determination of Procedure for Applying Liquid Challenge Chemicals**

8.45.7.4.1 The liquid chemical challenge concentration shall be 10 g/m<sup>2</sup> (+1.0 / -0.0 g/m<sup>2</sup>).

8.45.7.4.1.2 The number of one-microliter droplets shall be permitted to vary depending on the density of the liquid chemical challenge. Eight droplets shall be applied evenly spaced around the perimeter. The remaining droplets shall be placed in the center, if more than one droplet is required in the center, then the droplets shall be spaced 8.1 mm (1/3 in) apart. For seams, the droplets in the center shall be spaced along the seam juncture.

8.45.7.4.1.3 A mechanical or automated device shall be permitted for uniformly dispensing the droplets onto the surface of the specimen.

8.45.7.4.1.4 Prior to testing any liquid chemical, a quality control trial shall be conducted to verify that the application process delivers 10 g/m<sup>2</sup> (+1.0 / - 0.0 g/m<sup>2</sup>) using the procedures in 8.45.6.2

### **8.45.7.5 Procedure for Liquid Chemical Challenge**

8.45.7.5.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32° C, +/- 1° C (90° F, +/- 2° F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.45.7.5.2 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.45.7.5.2.1 If bubblers are used, each bubbler shall be filled with the proper collection solvent using a calibrated pipette or equivalent device; the collection solvent shall

incorporate an internal standard so adjustments can be made for solvent evaporation/water condensation during sampling.

8.45.7.5.2.2 If solid sorbent tubes are to be used, each sorbent tube shall be cleaned by heating and purging; the absence of any residual chemical shall be verified by the appropriate analysis technique.

8.45.7.5.3 The air delivery shall be flowing filtered air at a temperature of 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of the test cell at least 15 minutes prior to the application of the challenge chemical.

8.45.7.5.4 With the cell cap removed, one-microliter droplets shall be placed through the agent challenge port of the test cell on the specimen's outer surface within 20 seconds, according to the procedure determined in 8.45.7.4

8.45.7.5.5 After placing the liquid challenge chemical on the specimen in the test cell, the cell cap shall be sealed within 5 seconds.

8.45.7.5.5.1 For testing of Class 2 ensemble materials, **(this paragraph should be used in NFPA 1971 and 1994 and 1991)** the filtered air at a temperature of 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, shall be flowed only to the collection side of the test cell a rate of 1.0 LPM, +/- 0.1 LPM. No air shall be flowed across the challenge side of the test cell.

8.45.7.5.5.2 For testing of Class 3 ensemble materials, **(this paragraph should be used in NFPA 1951 and 1994)** the filtered air at a temperature of 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, shall be flowed to the challenge side of the test cell at a rate of 0.3 LPM, +/- 0.03 LPM, and to the collection sides of the test cell at a rate of 1.0 LPM, +/- 0.1 LPM.

8.45.7.5.6 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / - 0 minutes.

8.45.7.5.7 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.45.7.5.8 At least one test shall be conducted with a specimen, but without the challenge chemical, as a negative control.

8.45.7.5.9\* At least one test shall be conducted with an inert impermeable surrogate specimen as a negative control.

8.45.7.5.10 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

#### **8.45.7.6 Procedure for Gas or Vapor Challenge Chemicals**

8.45.7.6.1 The test cell shall be mounted horizontally and connected to the air delivery system in the environmental chamber at 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent. All connections shall be secured.

8.45.7.6.2 The air delivery shall be connected and flowing 1 LPM of filtered air at a temperature of 32°C, +/- 1°C (90°F, +/- 2°F) and at a relative humidity of 80 percent, +/- 5 percent, to the collection side of test cell at least 15 minutes prior to the initiation of any gas or vapor challenge chemical.

8.45.7.6.3 The calibrated analytical detection system shall be assembled and initiated according to its instructions.

8.45.7.6.4 The initiation of the test shall occur when the gas or vapor challenge chemical is introduced into the challenge side of the test cell.

8.45.7.6.4.1 The supply of the gas or vapor challenge chemical shall be sufficient to maintain the gas or vapor challenge chemical concentration during the exposure period of 60 minutes + 1.0 / -0.0 minutes.

8.45.7.6.4.2 The gas or vapor challenge chemical shall be at a temperature of 32°C, +/- 1°C (90°F, +/- 2°F).

8.45.7.6.4.3 For testing of Class 2 ensemble materials, **(this paragraph should be used in NFPA 1971 and 1994 and 1991)** the concentration of the gas or vapor challenge chemical shall be 350 ppm, + 35 / -0 ppm.

8.45.7.6.4.4 For testing of Class 3 ensemble materials, **(this paragraph should be used in NFPA 1951 and 1994)** the concentration of the gas or vapor challenge chemical shall be 40 ppm, +10 / -0 ppm.

8.45.7.6.5 The challenge chemical in the effluent air stream shall be collected, measured, and analyzed using either discrete or cumulative methods for 60 minutes, +1.0 / -0 minutes.

8.45.7.6.6 The collection media for the challenge chemical shall be analyzed using an appropriate analytical procedure.

8.45.7.6.7 At least one test shall be conducted with the specimen, but without the challenge chemical, as a negative control.

8.45.7.6.8\* At least one test shall be conducted with an inert surrogate specimen as a negative control.

8.45.7.6.9 The results from tests accompanied by unsuccessful negative controls shall not be used and the test shall be repeated.

#### **8.45.7.7 Test conclusion, test cell cleaned, and specimen disposal**

8.45.7.7.1 At the conclusion of the test, the test cell shall be purged and the air delivery and analytical system shall be shut down.

8.45.7.7.2 Each cell shall be disassembled one at a time.

8.45.7.7.3 The tested specimen shall be inspected for degradation or other obvious abnormalities; these observations shall be recorded with the test results.

8.45.7.7.4 Disposal of tested specimens and other supplies shall be handled according to local, state, federal or other applicable regulations.

8.45.7.7.5 Each component of the test cell shall be rinsed with acetone or other appropriate solvent to remove residual chemicals.

8.45.7.7.6 The cell shall be allowed to air dry in a clean area for 24 hours before reuse.

#### **8.45.8 Report**

8.45.8.1 The cumulative permeation in one hour shall be calculated, recorded, and reported in  $\mu\text{g}/\text{cm}^2$  for each specimen for each challenge chemical.

8.45.8.1.1 If no challenge chemical is detected at the end of the 60 minute test period, then the cumulative permeation shall be recorded and reported as less than the minimum detectable mass per unit area for the specific chemical being tested.

8.45.8.2 The average cumulative permeation shall be calculated and reported by averaging the results from all specimens for each challenge chemical.

8.45.8.2.1 For the calculation of average cumulative permeation, if the results of one or more of the specimens tested is less than the minimum detectable cumulative permeation then use the minimum detectable cumulative permeation as the result for those specimens.

8.45.8.2.2 For the calculation of average cumulative permeation, if the results of all the specimens tested are less than the minimum detectable cumulative permeation then the average cumulative permeation is reported as the minimum detectable cumulative permeation.

8.45.8.3 Report the thickness and weight per unit area of each specimen.

8.45.8.4 Report any observations of degradation or other abnormalities at the conclusion of the testing of each specimen.

#### **8.45.9 Interpretation**

8.45.9.1 The average cumulative permeation for each challenge chemical shall be used to determine pass or fail performance.

#### **8.45.10 Specific Requirements for the CBRN Barrier layer of Garments, Hoods, and Booties.**

For NFPA 1951 see the existing text in section 8.45.7 of the 2007-edition Standard

For NFPA 1971 see the existing text in section 8.67.7 of the 2007-edition Standard

For NFPA 1991 see the existing text in section 8.6.7 of the 2005-edition Standard

For NFPA 1994 see the existing text in section 8.7.7 of the 2007-edition Standard

#### **8.45.11 Specific Requirements for Testing the CBRN Barrier Layer of Visors**

There is no specific text given for visors in NFPA 1951, 1971, or 1991

For NFPA 1994 see the existing text in section 8.7.8 of the 2007-edition Standard

#### **8.45.12 Specific Requirements for Testing the CBRN Barrier Layer of Gloves**

For NFPA 1951 see the existing text in section 8.45.9 of the 2007-edition Standard

For NFPA 1971 see the existing text in section 8.67.9 of the 2007-edition Standard

For NFPA 1991 see the existing text in section 8.6.8 of the 2005-edition Standard

For NFPA 1994 see the existing text in section 8.7.9 of the 2007-edition Standard

#### **8.45.13 Specific Requirements for Testing the CBRN Barrier Layer of Footwear**

For NFPA 1951 see the existing text in section 8.45.10 of the 2007-edition Standard

For NFPA 1971 see the existing text in section 8.67.10 of the 2007-edition Standard

For NFPA 1991 see the existing text in section 8.6.9 of the 2005-edition Standard

For NFPA 1994 see the existing text in section 8.7.10 of the 2007-edition Standard

#### **8.45.14 Specific Requirements for Testing the CBRN Barrier Layer's seams of Garments, Hoods, Booties, Visors, and Gloves**

For NFPA 1951 see the existing text in section 8.45.8 of the 2007-edition Standard

For NFPA 1971 see the existing text in section 8.67.8 of the 2007-edition Standard

For NFPA 1991 see the existing text in section 8.6.10 of the 2005-edition Standard

For NFPA 1994 see the existing text in section 8.7.11 of the 2007-edition Standard

Annex:

A.8.45.4.5 It is essential that the air delivery system provide precise flow to each test cell and achieve the specified temperature and humidity conditions. This delivery is controlled by the conditioning of the incoming air to achieve the temperature and humidity conditions before reaching each test cell and is monitored by separate flow meters or controllers for each test cell.

A.8.45.4.6 The performance requirement is based on a cumulative measurement; however discrete measurements can be used to determine this. These discrete measurements must be able to account for all of the permeating challenge chemical. This

means that the frequency of the discrete sampling must be almost continuous, at least sampling once per minute, preferably sampling two to four times per minute, or more.

The efficacy of the selected sampling and analysis approach should be validated for each challenge chemical through the use of procedures where a known amount of the challenge chemical, representative of a cumulative permeation close to the minimum requirement, is injected into the collection medium of a trial test. The selected sampling and analytical approach should be able to demonstrate a mass recovery of 95% or better to be considered a valid part of the procedures.

A.8.45.5.2 Viton<sup>®</sup> O-rings have been found to be compatible with the challenge chemicals.

A.8.45.5.2.1 One procedure to determine the compatibility of O-ring material with the challenge chemicals would be to place the O-rings in contact with the challenge chemical for a period of 4 hours. Remove the O-ring from contact with the challenge chemical and observe for any physical changes or signs of degradation.

A.8.45.5.3 Aluminum foil with a thickness of  $1/32^{\text{nd}}$  of an inch has been found to be acceptable.

A.8.45.6.2.2 Aluminum foil with a thickness of  $1/32^{\text{nd}}$  of an inch has been found to be acceptable.

A.8.45.6.3 It is recommended that the concentrations for the gases be achieved by ordering prepared gas mixtures at the prescribed concentration.

A.8.45.7.5.9 Aluminum foil with a thickness of  $1/32^{\text{nd}}$  of an inch has been found to be acceptable.

A.8.45.7.6.8 Aluminum foil with a thickness of  $1/32^{\text{nd}}$  of an inch has been found to be acceptable.

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1991-21 Log #13 FAE-HAZ  
(7.8.5 and 8.28)

Final Action: Accept

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**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change the action from reject to accept in Comment 1991-21 (Log #13) for correlation purposes for the optional flash fire requirements. Introduction of a new method was not considered in NFPA 1992. Adding this method to NFPA 1991 would result in a lack of correlation. The TCC also believes that there was a lack of technical input to support the change. The TC should also consider this method for future revisions to the standard if the application is validated.

**Submitter:** Peter Kirk, Saint-Gobain Performance Plastics

**Comment on Proposal No:** 1991-39

**Recommendation:** Delete the requirement for an additional overall ensemble flash fire test and test method found in paragraph 7.8.5 and section 8.28, respectively.

**Substantiation:** An overall flash fire test requirement and procedure is already provided in NFPA 1991-2005. The adoption of this comment adds a second test and is redundant. It is also inappropriate and problematic for several reasons:

1. ASTM F1930 was never intended for evaluating non-form fitting garments and instead is mainly applied to relatively tight-fitting uniforms and clothing (e.g., NFPA 2112). The test is not appropriate for encapsulating suit ensembles, which generally remain inflated and off of the wearer's body because of the exhalation air from the SCBA resulting in little contact of the suit materials with the wearer's skin. Heat transfer will only be measured if the suit material happens to contact the manikin in the specific area of a manikin sensor. As a result, test values will be highly dependent on the fit of the encapsulating ensemble on the manikin and will be highly variable.

2. With the lack of physical contact of the ensemble with the manikin, the test will fail to address the important issues of continued suit integrity and functional performance, if the ASTM F1930 test is accepted over the current flash test procedures. The current criteria were created to ensure that suit does not ignite and continue to burn, that the suit maintains its gas-tight integrity at some minimum level, and that the suit visor remains clear for continuing the protection of the individual and allowing their escape from the emergency scene. The proposed implementation of ASTM F1930 does not address any of these issues.

3. The proposed flash fire exposure of 3 seconds is much shorter than the 7 +/- 1 second exposure used in the current flash fire test. The current flash fire test (8.27) is a more realistic exposure of the ensemble to a flash fire caused by the ignition and burning of a chemical.

4. The incorporation of the ASTM F1930 imposes certain impracticalities for conducting the test. First, most thermal manikins do not have sensors in the hands, an area where burn injury could be expected to occur. Some of these manikins also do not have sensors in the head or feet. The design and fit of the vapor-protective ensembles is partly dependent of being worn over an individual wearing a self-contained breathing apparatus. No provision is provided in the proposed procedures to address this issue. Further, the configuration of thermal manikins requires the pass through of cables to provide signals from the sensors to recording software. Different thermal manikins have different locations for these cables, which in any case would require cutting a large hole in the suit for the purpose of creating a pass through.

5. NFPA 1991 already incorporates a separate requirement for the measurement of material thermal insulation using the thermal protective performance (TPP) test. This test requires that ensemble materials be exposed to a 2.0 cal/cm<sup>2</sup>sec exposure and have a TPP rating of 12, which is equivalent to 6 seconds of protection. The 2.0 cal/cm<sup>2</sup>sec is the same as the specified exposure level in the proposed ASTM F1930 test. The requirement for 6 seconds of protection is well in excess of the 3 second only manikin exposure provided in the new NFPA 1991 procedure. Moreover, the TPP represents a more rigorous method for evaluating thermal insulation against flash fire given the fact that the material system is in direct contact with the sensor.

6. The flash fire test for NFPA 1992-2005 employs the same flash fire test method as NFPA 1991-2005. No changes to the method have been proposed for NFPA 1992. Both standards should remain consistent in the evaluation of ensembles against flash fire.

7. For the reasons provided above, this test is redundant with current criteria and procedures. Access to thermal manikins is limited and the equipment is much more difficult to maintain. The proposed test adds unnecessary cost for no additional value for understanding chemical protective ensemble performance in flash fires.

**Committee Meeting Action:** Reject

**Committee Statement:** The technical committee rejected this comment because it believes it is important to maintain this performance and test requirement as it helps predict potential burn injury in addition to the ensemble integrity in the ensemble integrity test in 8.27.

**Number Eligible to Vote: 31**

**Ballot Results:** Affirmative: 22 Negative: 7

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

FITHIAN, W.: There are a number of testing parameters that require modification, including compromising the ensemble to fit the test fixture and changes to the test method to accommodate a fully encapsulating ensemble. These modifications will likely lead to inconsistencies in the result obtained and further validation on encapsulating ensembles should be conducted to verify this method.

GOHLKE, D.: I do not believe that including this requirement and method as written with a 3 sec exposure will provide any discriminating information about burn injury with these products. I agree with many of the other arguments made against the inclusion of this requirement and method made by Saint Gobain.

KAVALESKY, P.: I believe that the comments presented by Peter Kirk are correct and the addition of the ASTM F 1930 is not necessary.

KELLY, B.: This test is a redundant. I question a suit that has to be cut open to allow test cables to enter suit to conduct the test, then show gas-tight integrity without being repaired first.

STORMENT, S.: The committee is making a serious mistake in adding a second flash fire test. The utility of a 3-second flash fire exposure using the manikin-based test is questionable given the fact that there is likely little contact of the suit on the manikin sensors and the test would require putting a hole in the suit for providing sensor output. Moreover, if the suit was compromised by severe shrinkage, this damage would prevent the suit from meeting the post-exposure pressure test for the current flash test. Since the committee forgot to make this same change for NFPA 1992, this topic has now become a matter of consideration by the Technical Correlating Committee for correlation purposes.

STULL, J.: The committee is making a serious mistake in adding a second flash fire test. The utility of a 3-second flash fire exposure using the manikin-based test is questionable given the fact that there is likely little contact of the suit on the manikin sensors and the test would require putting a hole in the suit for providing sensor output. Moreover, if the suit was compromised by severe shrinkage, this damage would prevent the suit from meeting the post-exposure pressure test for the current flash test. Since the committee forgot to make this same change for NFPA 1992, this topic has now become a matter of consideration by the Technical Correlating Committee for correlation purposes.

ZISKIN, M.: The existing test is adequate enough and no data exists that would support that an additional test will provide increased benefits to the user.

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1991-22 Log #21 FAE-HAZ  
(8.1.1.1 and 8.1.1.2)

**Final Action: Accept**

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**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-44

**Recommendation:** Delete "preparation" from the expression "sample preparation section"

**Substantiation:** The "sample preparation" section has been reheaded "samples"

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

1991-23 Log #22 FAE-HAZ  
(8.1.2.1)

Final Action: Accept

Submitter: Daniel J. Gohlke, W. L. Gore and Associates  
 Comment on Proposal No: 1991-44  
 Recommendation: Delete "or specimens"  
 Substantiation: Samples are the subject of conditioning.  
 Committee Meeting Action: Accept  
 Number Eligible to Vote: 31  
 Ballot Results: Affirmative: 29  
 Ballot Not Returned: 2 Thompson, D., Wisner, Jr., J.

1991-24 Log #33 FAE-HAZ  
(8.1.9, 8.26.2.2, and 8.26.4.1)

Final Action: Accept

Submitter: Jeffrey O. Stull, International Personnel Protection, Inc.  
 Comment on Proposal No: 1991-43  
 Recommendation: Revise text to read as follows:

8.1.8 Elevated Humidity Conditioning Procedure for Exhaust Valves. Specimens for elevated humidity shall be conditioned at 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 80 percent ± 5 percent until equilibrium is reached, as specified in ASTM D 1776, Standard Practice for Conditioning and Testing Textiles, or for at least 24 hours, whichever is shortest.

8.26.2.2 Samples shall be conditioned as specified in ~~8.1.2~~ 8.1.8.

8.26.4.1 (5) The testing shall be carried out in an environment controlled to 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 80 percent ± 5 percent

**Substantiation:** Exhaust valves should be preconditioned and tested under wet, hot conditions consistent with the other material conditioning performed in the standard and to better replicate the environment where they will be operating (e.g., permeation resistance testing and man-in-simulant testing, taking into account the internal suit environment).

**Committee Meeting Action: Accept**

The technical committee notes that the new paragraph to be added should be 8.1.9, and the revised paragraph should be 8.26.4 (5), not 8.26.4.1 (5).

**Number Eligible to Vote: 31**

**Ballot Results: Affirmative: 29**

**Ballot Not Returned: 2 Thompson, D., Wisner, Jr., J.**

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1991-25 Log #4 FAE-HAZ  
(8.2.4)

Final Action: Accept

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**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change its action from reject to accept in Comment 1991-25 (Log #4) as it believes the TC has not given due consideration to all evidence presented to it in connection with the preparation of its report, including all comment relating to negative votes. See also the TCC note to Comment 1991-8 (Log #5).

**Submitter:** Peter Kirk, Saint-Gobain Performance Plastics

**Comment on Proposal No:** 1991-45

**Recommendation:** Revert to the original language in 8.2.4 as found in the 2005 edition. Do not include the new reference to ISO 17491.

**Substantiation:** 1. The testing of ensembles at higher pressures does not provide any additional value in the evaluation of ensemble integrity (the specified test pressures are well above any pressures that would be experienced inside the ensemble).

2. There is an increased cost associated with the longer required test time (16 minutes versus 5 minutes).

3. Most of the current equipment in place for evaluating ensembles is based on ASTM F1052. The adoption of this requirement would make this equipment obsolete and would require end users to replace the equipment.

4. The adoption of a new pressure testing method will create industry confusion, requiring different equipment and procedures for 2005-compliant ensembles compared to new ensembles certified to the 2011 edition.

5. No research has been conducted to determine the effects of the increased pressure of unused suits over time. Although the EN-943 standard utilizes these higher pressure values from ISO 17491, there is an absence of annual testing requirements forcing repeated inflations over time when suits are unused. NFPA 1991 specifies annual testing.

**Committee Meeting Action:** Reject

**Committee Statement:** The ISO 17491 standard has a more stringent level, so the technical committee supported its previous decision to move in that direction.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 23 Negative: 6

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

BAXTER, C.: See my Explanation of Negative on Comment 1991-8 (Log #5).

KAVALESKY, P.: See my Explanation of Negative on Comment 1991-8 (Log #5).

KELLY, B.: I see no evidence that increasing pressure and time assures better gas-tight integrity.

STORMENT, S.: See my Explanation of Negative on Comment 1991-8 (Log #5).

STULL, J.: See my Explanation of Negative Vote on Comment 1991-8.

ZISKIN, M.: See my Explanation of Negative on Comment 1991-8 (Log #5).

1991-26 Log #6 FAE-HAZ  
(8.2.4.1 and 8.2.4.2)

Final Action: Accept

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change its action from reject to accept in Comment 1991-26 (Log #6) as it believes the TC has not given due consideration to all evidence presented to it in connection with the preparation of its report, including all comment relating to negative votes. See also the TCC note to Comment 1991-8 (Log #5).

**Submitter:** Jeffrey O. Stull, International Personnel Protection, Inc.

**Comment on Proposal No:** 1991-45

**Recommendation:** Revise text to read as follows:

8.2.4.1 Specimens shall be tested in accordance with ~~ISO 17491, Method 2 (Rigorous Procedure)~~ ASTM F 1052, Standard Test Method for Pressure Testing of Vapor-Protective Ensembles.

8.2.4.2 The following pressures shall be used during testing:

(1) Pre-test expansion pressure of ~~1750 ±50 Pa (7.0 in.)~~ 125 mm (5 in.) water gauge

(2) Test pressure of ~~1650 ±25 Pa (6.6 in.)~~ 100 mm (4 in.) water gauge

**Substantiation:** I oppose the change for modifying the gas-tight integrity test specified in NFPA 1991 to the European approach for two primary reasons--(1) There are no data and no research has been conducted to justify that the proposed change in the test procedures will provide a higher degree of suit quality and integrity as used as the basis in accepting this modification, and (2) The idea that the committee should have a goal of harmonization with the International standards on chemical protective clothing is absolutely preposterous.

The basis for the current pressure test procedures can be found in the following reference:

Carroll, T. R., Resha, C. J., Vencill, C. T., and Langley, J. D., "Determining the Sensitivity of International Test Methods Designed to Assess the Gas-Tight Integrity of Fully Encapsulating Garments," Sixth Volume, Performance of Protective Clothing: ASTM STP 1273, Jeffrey O. Stull and Arther D. Schwoppe, Eds., American Society for Testing and Materials, 1997, pp. 3-15.

This research evaluated a range of pressure testing conditions, including those used in Europe and Internationally. Experiments were conducted to determine the relative sensitivity of the inflation pressure, dwell pressure, and dwell time in showing pressure drop from leaks introduced into sample garments from different diameter hypodermic needles. At the time of this research, a slightly lower inflation pressure (3 in.), dwell pressure (2 in.) and test duration (3 minutes) were specified in the procedures of ASTM Test Method F1052. These conditions, along with those established in EN 464 (the equivalent of ISO 17491, Procedure 2), and other intermediate pressures and test times, were evaluated for leak detection sensitivity. The study found that a 4 in. water gauge pressure, 4-minute pressure test provided the optimum pressure test conditions for identifying leaks. As a result of this research, the test conditions in ASTM F1052 were increased to those currently specified and now cited in the 2005 edition of NFPA 1991. This information was presented internationally and Europe chose to ignore it. The reason for the continued insistence on high pressures and longer dwell times in Europe is the accommodation of rubber-based technology combined with relatively insensitive permeation measurements.

As the original author of ISO 17491 and then head of the U.S. Delegation to ISO TC94, SC13 on Protective Clothing, I can attest that the reason that there are two pressure test methods in that standard is because of a refusal for European interests to compromise with North American practice. The terms "minimum procedure" assigned to the U.S.-based pressure test method and "rigorous procedure" representing the European approach were not acceptable to the United States for the designation of these test methods. In fact, it was the U.S. experience that some European interests preferred not to compromise on any technical testing issues related to evaluation of chemical protective clothing counter to an agreement that was reached in 1993 with Phil Turnbull. That is why there are two sets of pressure and shower tests in the ISO 17491 standard, which incidentally, Europe is trying to discontinue. Just as a simple example, it is instructive to point out that European standards define normalized breakthrough time for permeation using a permeation rate that is 10 times higher than that used in ASTM F739 and NFPA 1991. In all certainty, harmonization with European practice is not a safety-based goal for the development of U.S.-based standards.

**Committee Meeting Action:** Reject

**Committee Statement:** The ISO standard has a more stringent level, so the technical committee supported its previous decision to move in that direction.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 23 Negative: 6

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Explanation of Negative:**

BAXTER, C.: See my Explanation of Negative on Comment 1991-8 (Log #5).  
KAVALESKY, P.: See my Explanation of Negative on Comment 1991-8 (Log #5).  
KELLY, B.: I see no evidence that increasing pressure and time assures better gas-tight integrity.  
STORMENT, S.: See my Explanation of Negative on Comment 1991-8 (Log #5).  
STULL, J.: See my Explanation of Negative Vote on Comment 1991-8.  
ZISKIN, M.: See my Explanation of Negative on Comment 1991-8 (Log #5).

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1991-27 Log #23 FAE-HAZ **Final Action: Accept**  
(8.6.3.3)

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**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates  
**Comment on Proposal No:** 1991-49  
**Recommendation:** Change "sample" to "specimen"  
**Substantiation:** Specimens are the subject of testing.  
**Committee Meeting Action:** **Accept**  
**Number Eligible to Vote:** 31  
**Ballot Results:** Affirmative: 29  
**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-28 Log #CC1 FAE-HAZ **Final Action: Accept**  
(8.6.11.5.1 (New) )

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**Submitter:** Technical Committee on Hazardous Materials Protective Clothing and Equipment,  
**Comment on Proposal No:** 1991-32  
**Recommendation:** Add a new Section 8.6.11.5.1 as follows:  
8.6.11.5.1 The test cell for liquified gases shall be swept with nitrogen or dry air.  
**Substantiation:** The technical committee believes the use of conditioned air will create plugging in the test cell, so dry air or nitrogen is required.  
**Committee Meeting Action:** **Accept**  
**Number Eligible to Vote:** 31  
**Ballot Results:** Affirmative: 29  
**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.  
**Comment on Affirmative:**  
STORMENT, S.: While I agree with the change, it bothers me that the the committee statement indicates that "it believes" the test cell will be clogged by frozen moisture in the air. Surely with the laboratory experience by the certification organizations, there would either be or not be any history for this type of problem sufficient to warrant the change.  
STULL, J.: While I agree with the change, it bothers me that the the committee statement indicates that "it believes" the test cell will be clogged by frozen moisture in the air. Surely with the laboratory experience by the certification organizations, there would either be or not be any history for this type of problem sufficient to warrant the change.

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1991-29 Log #10 FAE-HAZ  
(8.23.3.1)

Final Action: **Accept in Principle**

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**Submitter:** William Alexander, Onguard Industries

**Comment on Proposal No:** 1991-58a

**Recommendation:** Revise text to read as follows:

Recommendation: Revise test to include the footwear size:

8.23.3.1 A minimum of three complete size 9 footwear items shall be tested in both the flat and heel position.

**Substantiation:** The surface contact area of different sizes of footwear will affect the static coefficient of friction. The size 9 is the typical median size.

**Committee Meeting Action:** **Accept in Principle**

**Committee Statement:** See Comment 1991-31 (Log #11).

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

1991-30 Log #27 FAE-HAZ  
(8.23.3.1, 8.23.4, 8.23.5)

Final Action: Accept in Principle

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change the pass/fail value from 0.30 or greater to 0.40 or greater based on test data provided for hazmat boot performance levels as requested by the TC at the ROC meeting, and provides the amended text shown below. The TCC has proposed these changes to the performance criteria and test method to align the procedures with other standards in the project.

Add a reference to Chapter 2, revise section 8.23 as follows, and add associated Annex items:

#### 2.3.4 ISO Publications.

ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*, 2006.

8.23.1 Application. This test method shall apply to vapor protective footwear ~~element soles~~.

8.23.2.1 Samples shall be complete footwear in men's size 9D, medium width.

8.23.2.2 Samples shall be conditioned as specified in ~~8.1.2~~ ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*.

8.23.3.1 Specimens shall be whole footwear heels and ball of soles items in men's size 9D, medium width.

8.23.3.2 At least three specimens ~~of footwear heels and at least three specimens of ball of soles~~ shall be tested.

8.23.4 Procedure. Slip resistance shall be performed in accordance with ~~ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*~~, for a dry condition ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*, in the following configurations. References to any other flooring and/or contaminate within EN 13287 shall not apply.

a.) Footwear shall be tested both in the forepart and heel positions.

b.) Footwear shall be tested in the wet condition. The wet condition shall be achieved using distilled or de-ionized water. The water shall be applied to thoroughly wet the testing surface and make a pool at least as wide and long as the test portion of the footwear in the area of initial contact.

c.) Footwear shall be tested on a quarry tile surface that meets the following specifications:

i.) Flat unglazed clay quarry tile that is wider than the test specimen and long enough to allow a sliding distance of at least 75mm without crossing a joint.

ii.) is sufficiently flat to allow it to be secured on the mounting table such that no movement occurs between the tile and mounting table during the test.

iii.) has a ribbed profile or directional marking on the underside to identify the direction in which the tile should be aligned (with the ribs parallel to the sliding direction).

iv.) conforms to the values specified in Table 8.23.4 when calibrated by the Slider 96 method.

v.)\* Calibration of the tiles shall be checked after every 10 tests or prior to each day of testing whichever is the less frequent, to ensure that they are not being worn smooth or otherwise damaged.

\*\*\*\*Insert Table 8.23.4, Calibration Values for Quarry Tiles Here\*\*\*\*

8.23.5 Report. ~~The static coefficient of friction average of four readings obtained from each heel and each ball of sole shall be recorded and reported as the average of a total footwear sole under both dry and wet conditions of each specimen shall be recorded and reported:~~

8.23.5.1 The coefficient of friction of each specimen shall be recorded and reported.

8.23.5.2 The average coefficient of friction of all specimens for each configuration shall be calculated, recorded, and reported.

8.23.6 Interpretation. ~~One or more footwear specimens failing this test~~ The average coefficient of friction for each configuration shall constitute failing ~~be used to determine pass/fail performance.~~

Add the following Annex items:

A.8.23.4(c)(v) However, if experience shows that the friction properties of the test floor are not strongly influenced by

**Table 8.23.4 Calibration Values for Quarry Tiles**

	Dry CoF	Wet CoF
Minimum	0.57	0.43
Maximum	0.63	0.49

repeated testing then calibration intervals may be extended.

**Submitter:** Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment,  
**Comment on Proposal No:** 1991-58a

**Recommendation:** The TCC instructs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to consider adding text as provided in the ROP ballot Affirmative with Comments by Corrado, Fithian and Kavelesky.

**Substantiation:** This is a direction from the Technical Correlating Committee on Hazardous Materials Protective Clothing and Equipment in accordance with 3.4.2 and 3.4.3 of the Regulations Governing Committee Projects.

**Committee Meeting Action:** **Accept in Principle**

**Committee Statement:** See Comment 1991-31 (Log #11).

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

STORMENT, S.: See my Comment on Affirmative on Comment 1991-18 (Log #25).

STULL, J.: See response to 1991-18.

1991-30 Log #27 FAE-HAZ  
(8.23.3.1, 8.23.4, 8.23.5)

Final Action: Accept in Principle

**TCC Action:** The TCC directs the Technical Committee on Hazardous Materials Protective Clothing and Equipment to change the pass/fail value from 0.30 or greater to 0.40 or greater based on test data provided for hazmat boot performance levels as requested by the TC at the ROC meeting, and provides the amended text shown below. The TCC has proposed these changes to the performance criteria and test method to align the procedures with other standards in the project.

Add a reference to Chapter 2, revise section 8.23 as follows, and add associated Annex items:

#### 2.3.4 ISO Publications.

ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*, 2006.

8.23.1 Application. This test method shall apply to vapor protective footwear ~~element soles~~.

8.23.2.1 Samples shall be complete footwear in men's size 9D, medium width.

8.23.2.2 Samples shall be conditioned as specified in ~~8.1.2~~ ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*.

8.23.3.1 Specimens shall be whole footwear heels and ball of soles items in men's size 9D, medium width.

8.23.3.2 At least three specimens ~~of footwear heels and at least three specimens of ball of soles~~ shall be tested.

8.23.4 Procedure. Slip resistance shall be performed in accordance with ~~ASTM F 489, *Standard Test Method for Static Coefficient of Friction of Shoe Sole and Heel Materials as Measured by the James Machine*~~, for a dry condition ISO 13287, *Personal Protective Equipment – Footwear – Test Method for Slip Resistance*, in the following configurations. References to any other flooring and/or contaminate within EN 13287 shall not apply.

a.) Footwear shall be tested both in the forepart and heel positions.

b.) Footwear shall be tested in the wet condition. The wet condition shall be achieved using distilled or de-ionized water. The water shall be applied to thoroughly wet the testing surface and make a pool at least as wide and long as the test portion of the footwear in the area of initial contact.

c.) Footwear shall be tested on a quarry tile surface that meets the following specifications:

i.) Flat unglazed clay quarry tile that is wider than the test specimen and long enough to allow a sliding distance of at least 75mm without crossing a joint.

ii.) is sufficiently flat to allow it to be secured on the mounting table such that no movement occurs between the tile and mounting table during the test.

iii.) has a ribbed profile or directional marking on the underside to identify the direction in which the tile should be aligned (with the ribs parallel to the sliding direction).

iv.) conforms to the values specified in Table 8.23.4 when calibrated by the Slider 96 method.

v.)\* Calibration of the tiles shall be checked after every 10 tests or prior to each day of testing whichever is the less frequent, to ensure that they are not being worn smooth or otherwise damaged.

\*\*\*\*Insert Table 8.23.4, Calibration Values for Quarry Tiles Here\*\*\*\*

8.23.5 Report. ~~The static coefficient of friction average of four readings obtained from each heel and each ball of sole shall be recorded and reported as the average of a total footwear sole under both dry and wet conditions of each specimen shall be recorded and reported:~~

8.23.5.1 The coefficient of friction of each specimen shall be recorded and reported.

8.23.5.2 The average coefficient of friction of all specimens for each configuration shall be calculated, recorded, and reported.

8.23.6 Interpretation. ~~One or more footwear specimens failing this test~~ The average coefficient of friction for each configuration shall constitute failing ~~be used to determine pass/fail performance.~~

Add the following Annex items:

A.8.23.4(c)(v) However, if experience shows that the friction properties of the test floor are not strongly influenced by

**Table 8.23.4 Calibration values for Quarry Tiles**

	<u>Dry CoF</u>	<u>Wet CoF</u>
<u>Minimum</u>	<u>0.57</u>	<u>0.36</u>
<u>Maximum</u>	<u>0.63</u>	<u>0.42</u>

The surfactant condition was changed to a plain water condition so that the basic conditions of the footwear slip industry would be recorded. The sole position was changed to the forepart condition because the forepart condition is more critical and more accurately reflects shoe position for actual slipping. The test method was changed from SATRA to DIN EN ISO for consistency with other standards in the project. Requirement is being changed based on information learned about minimum slip requirements necessary for standing and testing performed.

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

FITHIAN, W.: The new Slip Resistance Test shall be conducted under wet conditions only. Therefore, Table 8.18.4 needs to be corrected, eliminating the dry condition requirements. Additionally, the following section requires editing as follows:

8.18.4 b.) Footwear shall be tested ~~in both the dry and~~ under wet conditions. The wet condition shall be achieved using distilled or de-ionized water. The water shall be applied to thoroughly wet the testing surface and make a pool at least as wide and long as the test portion of the footwear in the area of initial contact.

STORMENT, S.: See my Comment on Affirmative on Comment 1991-18 (Log #25).

STULL, J.: See response to 1991-18

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1991-32 Log #24 FAE-HAZ  
(8.27.5.1)

**Final Action: Accept**

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**Submitter:** Daniel J. Gohlke, W. L. Gore and Associates

**Comment on Proposal No:** 1991-17

**Recommendation:** Change reference from ASTM F 1052 to Section 8.2 Gastight Integrity Test.

**Substantiation:** This will harmonize with 8.27.5.8.

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-33 Log #CC2 FAE-HAZ  
(8.28.4.3 (New) )

**Final Action: Accept**

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**Submitter:** Technical Committee on Hazardous Materials Protective Clothing and Equipment,

**Comment on Proposal No:** 1991-39

**Recommendation:** Add a new section as follows:

8.28.4.3 The manikin shall be fitted with a self-contained breathing apparatus (SCBA) that is compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services*.

(1) The air tank shall be empty.

(2) The manikin shall be fitted with the SCBA facepiece.

**Substantiation:** The technical committee submitted this comment to test the ensemble in the minimum configuration as specified in the standard.

**Committee Meeting Action:** Accept

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

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1991-34 Log #30 FAE-HAZ  
(A.1.1.7)

**Final Action: Reject**

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**Submitter:** Jeffrey O. Stull, International Personnel Protection, Inc.

**Comment on Proposal No:** 1991-6

**Recommendation:** Revise text to read as follows:

A.1.1.7 The ~~appropriate~~ primary recommended type of respiratory protection for this ensemble is a self-contained breathing apparatus that is certified to NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services, and certified to NIOSH requirements for CBRN SCBA. Other types of self-contained breathing apparatus may be specified by the manufacturer or authority having jurisdiction as long as the type of self-contained breathing apparatus is subject is certified by NIOSH per 42 CFR Part 84 and by additional organization as appropriate for use by emergency responders.

**Substantiation:** Other types of self-contained breathing apparatus can be appropriate. For example, the NFPA Technical Committee on Respiratory Protective Equipment is working on a new standard for closed circuit self contained breathing apparatus that may become available sometime after the promulgation for the new edition of the NFPA 1991 standard.

**Committee Meeting Action:** Reject

**Committee Statement:** See Comment 1991-1 (Log #31).

**Number Eligible to Vote:** 31

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.

**Comment on Affirmative:**

STORMENT, S.: See my Explanation of Negative on Comment 1991-1 (Log #31).

STULL, J.: See response to 1991-1.

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1991-35 Log #16 FAE-HAZ  
(A.6.1.3 (New) )

Final Action: Accept in Principle

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Submitter: Peter Kirk, Saint-Gobain Performance Plastics

Comment on Proposal No: 1991-20

Recommendation: Add new text to read as follows:

A.6.1.3 The simple placement of an outer cover over top of the chemical protective ensemble is an unacceptable practice for meeting this requirement. This requirement is intended to have the ensemble include a specific means for attaching the outer cover to the inner ensemble by means of zippers, snaps, other hardware, hook and loop closure tape, or belts that enable the secure integration of the outer cover with the ensemble.

**Substantiation:** This comment provides supplemental information in the form of an appendix item for another public comment. Currently, some vapor-protective ensemble manufacturers provide over covers that are simply worn over top of the inner ensemble that provides the primary chemical protection of the wearer. The words "securely attached" must be better defined to ensure that the certification organization can properly assess the compliance of the manufacturer product with this requirement.

**Committee Meeting Action: Accept in Principle**

Revise text to read as follows:

6.1.3\* Other than outer gloves and outer boots, vapor-protective ensembles shall be designed so that all separate components are securely attached and provided as a single and integrated unit.

A.6.1.3 The simple placement of an outer cover over top of the chemical protective ensemble is an unacceptable practice for meeting this requirement. This requirement is intended to have the ensemble include a specific means for attaching the outer cover to the inner ensemble which could include but is not limited to the use of zippers, snaps, other hardware, hook and loop closure tape, belts, or other means that require the end user to physically remove the separate component from the vapor-protective ensemble.

**Committee Statement:** The technical committee accepted the comment in principle, and provided alternate wording as shown in the meeting action.

**Number Eligible to Vote: 31**

**Ballot Results:** Affirmative: 29

**Ballot Not Returned:** 2 Thompson, D., Wisner, Jr., J.