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Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials[1]

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INTRODUCTION

Workers involved in the production, use, and transportation of chemicals can be exposed to numerous compounds capable of causing harm upon contact with the human body. The deleterious effects of these chemicals can range from acute trauma, such as dermatitis or burns, to chronic degenerative disease, such as cancer or pulmonary fibrosis. Because engineering controls may not eliminate all possible exposures, attention is often given to reducing the potential for direct skin contact through the use of protective clothing that resists degradation, penetration, and permeation.

Standard test methods are being established to measure degradation, penetration, and permeation chemical resistance of protective clothing materials. Chemical resistance information for a number of chemicals often accompanies many protective clothing articles. However, because there are so many possible protective clothing and chemical combinations, the number and type of chemicals appearing in chemical resistance tables vary extensively.

This guide establishes a standardized list of chemicals to be used in evaluating protective clothing materials. The list of chemicals includes a broad range of representative chemical classes and properties. This guide is intended to provide a minimum set of chemicals in generating test results for protective clothing users and to aid in screening new materials.

1. Scope

1.1 The purpose of this guide is to provide a recommended list of both liquid and gaseous chemicals for evaluating protective clothing materials in testing programs.

1.2 Results derived from testing programs using these lists of test chemicals are not intended for the definitive characterization of protective clothing materials.

1.3 This list of test chemicals is not inclusive of all chemical challenges; the chemicals were chosen to represent broad ranges of liquid and gaseous chemical classes and properties. Not all chemical classes are represented. Other chemicals, especially those of interest to the manufacturer or user, should be tested in addition to those recommended in this guide.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* A specific hazards statement is given in Section 7.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F739 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact

F903 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids

F1052 Test Method for Pressure Testing Vapor Protective Suits

F1494 Terminology Relating to Protective Clothing

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

F2588 Test Method for Man-In-Simulant Test (MIST) for Protective Ensembles

2.2 *OSHA Standards:*[3]

29 CFR 1910.1047 Ethylene Oxide

29 CFR 1910.1051 1,3-Butadiene

29 CFR 1910.1052 Dichloromethane

2.3 *Other Standards:*

Compressed Gas Association Publication P-1 Safe Handling of Compressed Gases in Containers[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *degradation, n*—the deleterious change in one or more properties of a material.

3.1.2 *penetration, n*—for chemical protective clothing, the movement of substances through voids in protective clothing materials or items on a non-molecular level.

3.1.2.1 *Discussion*—Voids include gaps, pores, holes, and imperfections in closures, seams, interfaces, and protective clothing materials. Penetration does not require a change of state; solid chemicals move through voids in materials as solids, liquids as liquids, and gases as gases. Penetration is a distinctly different mechanism from permeation.

3.1.3 *permeation, n*—for chemical protective clothing, the movements of chemicals as molecules through protective clothing materials by the processes of (*1*) absorption of the chemical into the contact surface of the materials, (*2*) diffusion of the absorbed molecules throughout the material, and (*3*) desorption of the chemical from the opposite surface of the material.

3.1.3.1 *Discussion*—Permeation is a distinctly different mechanism from penetration.

3.1.4 *protective clothing material, n*—any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from a potential hazard.

3.1.5 *test chemical, n*—the solid, liquid, gas, or mixture thereof, used to evaluate the performance of a protective clothing material.

3.1.6 *totally encapsulating chemical protective suit, n*—a full-body garment that is constructed of protective clothing materials; covers the wearer's torso, head, arms, and legs; may cover the wearer's hands and feet with permanently or tightly attached gloves and boots; completely encloses the wearer by itself or in combination with the wearer's respiratory equipment, gloves, and boots.

3.1.7 For definitions of protective clothing terms used in this guide, refer to Terminology F1494.

4. Summary of Guide

4.1 In this guide, two lists of test chemicals are recommended to be used in testing programs to evaluate chemical/protective clothing material interactions or compatibility. One list includes 15 liquid chemicals while the other list includes six gaseous chemicals. Users of this guide may evaluate protective clothing materials against either list or both lists in combination.

4.2 Types of testing programs are not specified. However, when a protective clothing material is tested in accordance with this guide and any appropriate test method, all results and documentation required by the test method should be reported for *each* chemical tested.

5. Significance and Use

5.1 This guide establishes a recommended list of challenge chemicals to encourage those who evaluate chemical protective clothing to test a minimum number of chemicals in common. This list will simplify the comparison of data from different sources.

5.2 This guide may also serve material developers or evaluators in screening candidate protective clothing materials.

5.3 Test methods applicable to the use of this guide include, but are not limited to, Test Methods F903 and F739.

5.3.1 The battery of chemical gases shall not be used for testing material penetration resistance because Test Method F903 has been designed for measuring liquid penetration only.

5.3.2 Evaluation of materials against the gaseous chemical battery is primarily intended for those materials used in the construction of totally encapsulating protective suits or other clothing items that are designed to prevent exposure to chemical vapors or gases. Only vapor-protective clothing that has been evaluated for and has demonstrated appropriate levels of inward leakage against gases and vapor is appropriate for protection against vapors and gases. Protective clothing that only covers part of the body or that does not have vapor-resistant closures, closures, or interfaces to other ensemble components does not provide protection against hazardous chemical vapors and gases.

NOTE 1—Methods to evaluate the vapor-protective performance of protective clothing ensembles include, but are not limited to, Test Method F1052 and Test Method F2588.

5.4 The presence of any chemical in this battery does not connote any special significance of the chemical for protecting workers from chemical hazards. This battery of chemicals is intended to represent a range of chemical classes, hazards, physical characteristics, and other factors. Not of all of the chemicals in this battery have any significance from a skin toxicity or irritation perspective.

5.5 Chemical resistance of a protective clothing material against a specific chemical or list of chemicals does not infer the chemical resistance of that protective material against other chemicals.

6. Reagents

6.1 *Purity of Reagents*—Reagent-grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where

[3] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210.

[4] Available from Compressed Gas Association (CGA), 1725 Jefferson Davis Hwy., Suite 1004, Arlington, VA 22202-4102.

such specifications are available.[5] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *List of Recommended Liquid Test Chemicals*—Reagents are listed by common name, synonym, and Chemical Abstract Registry Service (CAS) number:

6.2.1 *Acetone* (2-propanone),[6] [67-64-1],

6.2.2 *Acetonitrile* (cyanomethane), [75-05-8],

6.2.3 *Carbon Disulfide,* [75-15-0],

6.2.4 *Dichloromethane* (methylene chloride), [75-09-2],

6.2.5 *Diethylamine,* [109-89-7],

6.2.6 *Dimethylformamide* (DMF), [68-12-2],

6.2.7 *Ethyl Acetate,* [141-78-6],

6.2.8 *n-Hexane,* [110-54-3],

6.2.9 *Methanol* (methyl alcohol, carbinol), [67-56-1],

6.2.10 *Nitrobenzene,* [98-95-3],

6.2.11 *Sodium Hydroxide* (50 % w/w), [1310-73-2],

6.2.12 *Sulfuric Acid* (93.1 % sp gr 1.84, 66° Be'), [7664-93-9],

6.2.13 *Tetrachloroethylene* (perchloroethylene), [127-18-4],

6.2.14 *Tetrahydrofuran* (THF, 1,4-epoxybutane), [109-99-9], and

6.2.15 *Toluene* (toluol), [108-88-3].

6.3 *List of Recommended Gaseous Test Chemicals*—Reagents are listed by common name, minimum purity, synonyms, and Chemical Abstracts Service (CAS) number.

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

6.3.2 *1,3-Butadiene,* inhibited, (99.0 %—(bivinyl, vinylethylene, biethylene), [106-99-0]

6.3.3 *Chlorine,* 99.5 %, [7782-50-5]

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

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

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

7. Safety Hazards

7.1 Before carrying out any test, safety precautions and disposal procedures for chemicals and contaminated protective clothing material should be identified and reviewed to provide full protection to all personnel. Consult chemical Material Safety Data Sheets on each chemical to determine all properties and hazards related to their use, storage, and disposal.

7.2 Ethylene oxide, 1,3-Butadiene, and Dichloromethane are listed by OSHA as carcinogens and require special handling. Refer to 29 CFR 1910.1047, 29 CFR 1910.1051, and 29 CFR 1910.1052, respectively. Dimethylformamide, nitrobenzene, and tetrachloroethylene are listed as possibly carcinogenic by IARC.[7]

7.3 The appropriate gas connectors, regulators, and compatible materials should be used with gaseous chemicals as recommended by the Compressed Gas Association. Refer to CGA Publication P-1.

7.4 Adequate ventilation should be provided at all times during testing. Ventilation is particularly important when testing any gases.

8. Procedure

8.1 For the proper implementation of this guide, manufacturers or others reporting results of testing programs involving the list of recommended test chemicals should report test results for all chemicals on the list. If a chemical or chemicals are not tested, the reason should be provided in place of the test results.

8.2 Care should be exercised in the interpretation of test results from testing programs using the list of test chemicals. Users of this guide should exercise particular caution in making inferences of protective clothing material behavior for chemicals or protective clothing materials that may seem similar.

8.3 When using this guide for comparison between different testing programs involving the same test method, the user should check the details and test parameters used in each test to ascertain whether a sufficient basis exists for comparing testing program results. For example, the detector sensitivity, length of test, and permeation rate should be considered when using this guide in conjunction with Test Method F739.

9. Keywords

9.1 chemicals; chemical testing; gaseous chemicals; liquid chemicals; protective clothing

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[5] *Reagent Chemicals, American Chemical Society Specifications,* American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals,* BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary,* U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

[6] Chemical Abstracts Service, Division of American Chemical Society, 2540 Olentangy River Road, Box 3012, Columbus, OH 43210.

[7] International Agency for Research on Cancer (IARC), 150 Cours Albert Thomas, 69372 Lyon CEDEX 08, France; http://www.iarc.fr.

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 *Selection of Chemicals*—Chemicals were selected to provide representation for a wide range of chemical classes and properties. Other criteria included how common the chemical was in industrial operations and transportation, the ease of handling the chemical, the hazards of the chemical, and if the chemical was known to permeate some protective clothing materials easily. Not all chemical classes or categories are represented in this list.

X1.2 *Acetone (ketone)*—Used in interlaboratory testing of Test Method F739; common industrial/non-industrial solvent.

X1.3 *Acetonitrile*—Nitrile compound.

X1.4 *Ammonia*—Basic gas; high volume chemical commodity.

X1.5 *1,3 Butadiene*—Unsaturated hydrocarbon gas.

X1.6 *Carbon Disulfide*—Sulfur-containing organic compound.

X1.7 *Chlorine*—Acid gas; high volume chemical commodity.

X1.8 *Dichloromethane*—Chlorinated paraffin.

X1.9 *Diethylamine*—Amine.

X1.10 *Dimethylformamide*—Amide.

X1.11 *Ethyl Acetate*—Ester.

X1.12 *Ethylene Oxide*—Heterocyclic ether gas.

X1.13 *n-Hexane*—Saturated hydrocarbon.

X1.14 *Hydrogen Chloride*—Inorganic acid gas.

X1.15 *Methanol*—Primary alcohol.

X1.16 *Methyl Chloride*—Chlorinated hydrocarbon gas.

X1.17 *Nitrobenzene*—Nitro-compound.

X1.18 *Sodium Hydroxide*—Inorganic base; largest production volume for base; concentration (50 %) chosen as common for transport and industrial applications.

X1.19 *Sulfuric Acid*—Inorganic mineral acid; largest chemical production volume in the United States; concentration (93.1 %, 66° Be′) was chosen as common for transport and in several industrial applications.

X1.20 *Tetrachloroethylene*—Chlorinated olefin.

X1.21 *Tetrahydrofuran*—Both heterocyclic and ether compound.

X1.22 *Toluene*—Aromatic hydrocarbon.