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## Standard Practice for Chemical Protective Clothing Program<sup>1</sup>

This standard is issued under the fixed designation F1461; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice is intended to promote the proper selection, use, maintenance, and understanding of the limitations of chemical protective clothing (CPC) by users, employers, employees, and other persons involved in programs requiring CPC, thereby limiting potentially harmful and unnecessary skin exposures.

1.2 *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, safety, health, and health environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *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:<sup>2</sup>

[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](#)

[F1001 Guide for Selection of Chemicals to Evaluate Protective Clothing Materials](#)

[F1052 Test Method for Pressure Testing Vapor Protective Suits](#)

[F1154 Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Durability of Protective Ensembles and Ensemble Components](#)

[F1194 Guide for Documenting the Results of Chemical Permeation Testing of Materials Used in Protective Clothing](#)

[F1383 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Intermittent Contact](#)

[F1494 Terminology Relating to Protective Clothing](#)

[F2588 Test Method for Man-In-Simulant Test \(MIST\) for Protective Ensembles](#)

#### 2.2 NFPA Standards:<sup>3</sup>

[NFPA 1991 Vapor-Protective Ensembles for Hazardous Materials Emergencies](#)

[NFPA 1992 Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies](#)

[NFPA 1994 Protective Ensembles for First Responders to CBRN Terrorism Incidents](#)

#### 2.3 ISO Standard:<sup>4</sup>

[ISO 16602 Protective Clothing for Protection Against Chemicals—Classification, Labeling, and Performance Requirements](#)

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *analytical detection limit, n*—a number, expressed in units of concentration (or amount), that describes the lowest concentration level (or amount) that an analyst can determine to be different from an analytical blank (background level).

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

<sup>3</sup> Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

<sup>4</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

3.1.2 *biological monitoring, n*—the chemical analysis of chemicals or metabolites, or both, from a worker’s blood, urine, fingernails, sweat, breath, and so forth.

3.1.3 *buddy system, n*—a means of organizing employee work groups whereby each participant is matched with another so that prompt assistance can be rendered in the case of any emergency.

3.1.4 *chemical protective clothing (CPC), n*—an item of clothing that is specifically designed and constructed for the intended purpose of isolating all or part of the body from a chemical hazard.

3.1.5 *decontamination, n*—the reduction, removal, or neutralization of contaminant or contaminants from protective clothing to safely permit the protective clothing to be doffed (taken off), or reused, or discarded.

3.1.6 *elastomer, n*—an elastic polymer that has properties similar to rubber.

3.1.7 *fabric, n*—a planar structure consisting of yarns or fibers.

3.1.7.1 *Discussion*—

Unlike a polymer sheet, a fabric is normally subject to penetration by gases and liquids.

3.1.8 *Fick’s laws of diffusion, n*—mathematical descriptions of the movement of one type of molecule through another.

3.1.8.1 *Discussion*—

Diffusion is not due to holes or pores in chemical protective clothing materials.

3.1.9 *hazard assessment, n*—an examination of the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE)

3.1.10 *industrial hygienist, n*—a person who, by experience and academic training, is qualified to recognize, evaluate, and control chemical, physical, and biological agents in the workplace, or a person certified by the American Board of Industrial Hygiene.

3.1.11 *occlusion, n*—the physical process of covering a chemical that has been applied to or spilled on the skin, thereby disallowing its evaporation and generally increasing its absorption through the skin.

3.1.12 *physical-chemical parameters, n*—values for physical or chemical properties of a test chemical or polymer, or both, such as solubility parameters, molecular weight, vapor pressure, and so forth.

3.1.13 *plastic, n*—a material that contains, as an essential ingredient, one or more organic polymeric substances of large molecular weight, is solid in its finished state, and, at some stage in its manufacture or processing into finished articles, can be shaped by flow.

3.1.14 *polymer, n*—a substance consisting of molecules characterized by repetition (neglecting ends, branches, junctions, and other minor irregularities) of one or more chemically bonded types of monomeric units.

3.1.15 *polymer sheet, n*—a continuous polymeric planar structure.

3.1.15.1 *Discussion*—

It is not normally subject to penetration by gases or liquids.

3.1.16 *program, n*—a documented policy with procedures for selection and use of CPC.

3.1.17 *program administrator, n*—a person responsible for the formulation and implementation of a CPC program.

3.1.18 *program authority, n*—a person responsible for enforcing the requirements of a CPC program.

3.1.19 *toxicity, n*—the propensity of a substance to produce adverse biochemical or physiological effects.

3.1.19.1 *Discussion*—

Such effects are termed toxic effects, as used in this practice.

3.2 For definitions of other protective clothing-related terms used in this practice, refer to Terminology **F1494**.

#### 4. Significance and Use

4.1 This practice presents those elements that constitute a chemical protective clothing (CPC) program and conditions to be used in establishing a program for the selection and use of CPC. Adherence to this practice requires that a written program be developed for any use of CPC.

4.2 Although much remains to be determined regarding the toxicity of vapor and liquid exposure to the skin, this practice outlines the essential information necessary and suggested methods for hazard risk assessment prior to the selection of CPC (see Practice Practices F1154).

4.3 This practice does not address the various methods for testing CPC or obtaining the data upon which CPC assessments are made. These test methods are listed in Section 2 of this practice.

4.4 This practice does not include recommendations that may apply to personal protection from nuclear radiation, radioactive contamination, or microbiological organisms, or to clothing that is worn to protect a particular environment from the entry of chemicals, particles, or living matter that may arise from the wearer.

4.5 CPC should be used when other means of control are not available. Its major uses should be limited to the following:

- 4.5.1 Maintenance operations;
- 4.5.2 Upset or emergency conditions;
- 4.5.3 Use in lieu of engineering controls when they are not feasible or are being installed;
- 4.5.4 Supplementing feasible engineering controls when they fail to control the hazard completely; and
- 4.5.5 Use in the event that engineering controls fail.

4.6 Engineering controls and substitution of materials should be stressed as the first line of defense in all control situations since effective use of CPC depends on worker compliance, proper selection, quality control, and other variables that may prove to be weak links in an overall control process.

## 5. Minimum Program Requirements and Objectives

5.1 The primary objective shall be to minimize employee exposures. This objective should be accomplished to the extent feasible by accepted engineering control measures. These include enclosure or confinement of the operation, isolation of the worker from the operation, substitution of less toxic materials, and modification of work practices. When these controls are not feasible, or while they are being implemented or evaluated, appropriate CPC shall be used pursuant to the requirements in this practice and regulatory requirements, where applicable.

### 5.2 *Program Administration and Responsibility:*

5.2.1 Responsibility and authority for implementing the CPC program shall be assigned to a single person. This person will normally be a plant manager, supervisor, or other person with line supervisory authority. This person is called the program authority.

5.2.2 Normally, a second person shall have responsibility for preparing the written program. This person is called the program administrator. His duties also include maintaining and updating standard procedures and the CPC written program, based on changes in CPC technology and knowledge; maintaining records; auditing and evaluating the program; directing, interacting with, or supervising those who dispense CPC at the worksite and those who train workers in the use of CPC; and establishing procedures for the purchase of CPC. The program administrator will usually have staff responsibilities. The program administrator shall have knowledge of CPC sufficient to supervise the CPC program properly. (Where possible, the administrator of a CPC program should also be the administrator of the respiratory protection program, if one exists, in order to improve coordination.)

5.3 *Written Programs*—The CPC program shall be established and detailed in a written document.

5.4 *CPC Selection*—The selection of the CPC article shall be based on consideration of the following:

- 5.4.1 Exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact);
- 5.4.2 Toxicity and amount of the chemical(s) (that is, best knowledge or the estimate of ability to permeate the skin and of systemic toxicity);
- 5.4.3 Physical properties of the contaminant chemicals (for example, vapor pressure, molecular weight, and polarity);
- 5.4.4 Functional requirements of the task (for example, dexterity, thermal protection, fire protection, and mechanical durability requirements); and

5.4.5 Properties of the CPC that are relevant to the physical and chemical hazards and functional requirements of the task. These properties are determined through appropriate testing techniques and include permeation resistance, degradation resistance, penetration resistance, dexterity, resistance to tear, and so forth, as applicable. (See Test Method Methods F739 and F903, Guide F1001, and Practice-Test Method F1052.)

5.4.6 Selection of the CPC should consider the materials from which the garment, gloves, visor, hoods, and boots are constructed, the seam construction and the design of the garments.

5.4.7 Selection of the CPC should also consider the likelihood of coming in contact with the hazardous materials, the duration of the contact, the amount of contact and the direction of liquid contact.

5.5 The selection procedure shall be documented. Minimally, the selection process should consider degradation, penetration, and permeation resistance of the CPC. Degradation could result in an adverse loss of integrity and chemical resistance properties. Penetration could result in direct skin contact by an agent from bulk flow through seams, pinholes, and so forth. Permeation can result in skin contact by an agent without any outward signs of either penetration or degradation since molecular flow of the contaminant through the protective article is occurring.

5.6 *Training*—Each CPC user shall be given training that shall include the following:

5.6.1 A description of the hazards for which the CPC is being selected;

5.6.2 An explanation and discussion of the toxicity of the contaminants for which CPC is being used including symptoms that indicate an overexposure has occurred;

5.6.3 Limitations of CPC use;

5.6.4 Training *how to use CPC*, including donning, decontamination in order to safely doff the garment, doffing, proper storage, maintenance, inspection, and decontamination for safe reuse where applicable; and disposal of CPC.

5.6.5 Each CPC user should be tested after training and periodically thereafter, to verify that they understand and can follow the CPC training, retrained if necessary or restricted from using CPC if they can not understand or follow the training.

5.7 *CPC Use*—The employer shall not use CPC in violation of the written program or the manufacturer’s instructions. When using CPC, the employer shall consider special emergency-use precautions. The buddy system shall be used in conjunction with emergency-use CPC.

5.8 *Maintenance and Storage*—Maintenance and inspection shall be conducted on a schedule that ensures that each piece of CPC delivers the protection for which it was selected. Minimally, each piece of CPC shall be inspected by the wearer prior to its use to ensure its integrity. CPC should be stored in accordance with manufacturer’s instructions.

5.9 *Decontamination*—Procedures for decontamination and reuse shall be documented. CPC should not be used after it is contaminated unless it can be demonstrated that the decontaminated CPC is safe to wear.

5.10 *Field Evaluation and Biological Monitoring*—The use of methods to estimate actual exposures in the field or estimate doses from biological samples are appropriate when the choice of CPC has uncertainty or when estimates of total doses to employees are necessary. The latter is particularly important for low vapor pressure organic chemicals that are absorbed through the skin readily.

5.11 *Purchasing*—The purchase of CPC shall be coordinated carefully with the selection and use of CPC. Failure to monitor and control the purchase of CPC could result in improper CPC use, leading to worker exposure. The purchaser’s action shall be dependent on the requirements from the program administrator. Without clear CPC specification, the lowest price usually dictates purchase.

5.12 *Considerations of Medical and Human Factors*—The possible physiological and psychological effects caused by wearing CPC shall be considered. These effects, which include heat stress and claustrophobic reactions, may be particularly evident when TECP—totally encapsulating chemical protective (TECP) suits are worn. CPC selection is a balance between protection from chemical hazards and performance, physiological, and psychological burdens. Chemical protection should not be compromised, nor should the worker be unnecessarily burdened.

5.12.1 In most cases, use of CPC entails a risk of heat stress. There should be a written heat stress management plan in place to anticipate heat stress, monitor heat stress among CPC users, mitigate the risk by use of engineering controls, work practices of additional PPE and rehabilitate CPC users with elevated core body temperatures.

5.13 *Auditing*—CPC programs shall be audited periodically in order to ensure that all components are functioning as described in the written program. Methods for auditing the program shall be well described, including the ways and means for correcting defects in the program.

## 6. Program Administration and Responsibilities

6.1 *Employer Responsibility*—Employer responsibility is vested in the program authority. The employer shall be responsible for providing CPC to employees when it is necessary and enforcing its proper use. All CPC shall be selected by the employer using the latest information available to him. The employer shall establish and maintain a CPC program that shall include the minimum requirements of this practice as outlined in Section 5 and supported, where appropriate, by Sections 6 through 16 and the Appendixes:Appendices.

6.2 *Employee Responsibility*—Employees have the responsibility and duty to use all CPC that is provided to them in accordance with the instructions and the training that they have received. All CPC shall be treated with respect and inspected and maintained in accordance with the employer’s program requirements. Should an employee sense any change in the performance of his CPC or exhibit any symptoms of overexposure, he shall report this to the employer immediately.

6.3 *Program Administrator*—An individual, preferably from the company’s industrial hygiene or safety engineering function, should be assigned responsibility for administering the CPC program. For companies without these functions, the CPC program should be administered by a qualified person responsible to the program authority, and consultation from an industrial hygienist should be sought in establishing the program. The individual should be trained in control techniques that involve chemical protective clothing. Responsibilities of the individual include the following:

6.3.1 Performance of hazard assessments with respect to the exposure of employee’s skin to hazardous solids, liquids, or vapors.

6.3.2 Selection of the appropriate CPC configuration and materials of construction that will provide adequate protection for each exposure, either present or anticipated.



6.3.3 Maintenance of records and written procedures in a manner that documents the CPC program and allows for the evaluation of the program's effectiveness.

6.3.4 *Evaluation of the CPC Program's Effectiveness*—This includes frequent comparison of the program with current regulations and standards, and comparison of the program as it is implemented with the written procedures. At least annually, the program should be audited by a team from the plant or worksite.

6.3.5 The use or implementation of biological monitoring and medical surveillance, where necessary, to determine and document whether CPC use is controlling exposures effectively or CPC use is causing undue stress on the worker, or both.

## 7. Written Program

7.1 Minimally, all written programs shall address Section 5. This section should be supplemented with Sections 6 through 16 of this practice, where appropriate. The written program shall be available to employees at a place to which they have reasonable access. Employees shall receive training (Section 9), and it should address all sections of the written program.

7.2 Minimally, written procedures should address those operations for which routine uses of CPC are anticipated and contrast those with written procedures for the emergency use of CPC. Employees should have a thorough understanding of the limitations of CPC for routine use as compared to those situations in which emergency use of CPC is necessary. This should be stated clearly in the written program.

## 8. Selection of CPC

8.1 Selection of CPC requires determination of the nature and extent of the hazard, including the toxicity of the chemical and the manner in which it is used. The selection is then based on this hazard determination and the interpretation of appropriate physical and chemical resistance tests of the CPC. Ideally, these tests should be performed as part of the selection process. In emergency situations or in the interim before tests are performed, professional judgment involving analogous situations, available literature, or estimates of permeation based on physical-chemical factors may be relied on.

### 8.2 Hazard Assessment:

8.2.1 Determine what contaminants may be present and pose a significant threat of exposure to the worker's skin. Evaluate the likelihood or risk of contact with the worker's skin and the length of time for which exposure is expected. Consider the information given in [Appendix X1](#).

8.2.2 From analogy with other chemicals, previous experience, biological monitoring studies, or other available information, determine whether the skin is a significant route of uptake for the chemical in question, and the subsequent effect of uptake or primary contact, or both. Very little is known concerning the absorption rates of individual chemicals through the skin, the extent to which metabolic conversion of chemicals may occur within the skin, the differences in absorption of liquid or vapor forms of the same chemical, and the vapor exposure levels under CPC to which the skin may be exposed after CPC contact with a chemical. Hence, hazard assessment is qualitative, at best.

### 8.3 Selection Information:

8.3.1 Determine the configuration of CPC necessary (for example, apron, gloves, and TECP suit), based on the knowledge of the task to be performed and the hazards to which the worker is exposed. Consider 8.2 and the factors given in [Appendix X2](#).

8.3.2 *Selection Based on Penetration*—Determine penetration properties for those materials with seams, zippers, noticeable differences in thickness, or voids (paper, cotton, woven, or nonwoven fabrics). Proper selection based on a penetration test provides the user with a CPC garment that will not allow the bulk flow of liquid through seams, zippers, or imperfections in the CPC garment for a specified period of time at a specified pressure. Specifically for splash ~~protection~~ protection and when vapor exposure to the skin is not hazardous, negative penetration test results can be used to select a garment. See [Test Method F903](#).

8.3.3 *Selection or Disqualification Based on Degradation*—If the contaminants in question have low potential for skin absorption and are of low, low but significant, significant toxicity, degradation properties of the candidate CPC materials may be sufficient to determine acceptable CPC. Selection based on degradation alone provides the user with chemical protective clothing that should not degrade upon exposure. Hence, in the purest sense, degradation tests provide a mechanism for disqualifying certain CPC since those that pass must be evaluated for penetration or permeation, or both. CPC that fails degradation testing need not be subjected to penetration or permeation test.

8.3.4 *Selection Based on Permeation Resistance*—Where CPC must provide vapor protection or resistance to permeation of liquid chemicals, or both, permeation resistance data (see [Test Method Methods F739](#), [Test Method F1383](#), [Test Method F2588](#), [Practice and F1052](#), and [Guides F1001](#) and [F1194](#)) must be reviewed. These data must be interpreted and compared. In addition, factors affecting permeation such as material thickness, exposure to mixtures, and temperature may be important. See [Appendix X3](#) for more guidance in these areas.

8.3.5 *Physical Hazards and Functional Requirements of Task*—Where appropriate, determine other properties, other than chemical resistance, of the CPC and compare them to the functional requirements of the task and physical hazards associated with the task. Consider the need for cut and tear resistance, heat and cold resistance, puncture resistance, abrasion resistance, dexterity, and tactility. Additionally, consider flame, flash, and thermal protection needs. Consider potential human factors requirements such as heat stress, increased work rate, restricted movement, and so forth. Very few data are available for these parameters on most

CPC products. Where tests are available for these parameters, few are specific to CPC. Adaptation is possible, however, acceptance criteria often must be determined individually, since the criteria may vary with the job.

8.3.6 *Size*—Determine size options for the CPC candidate materials. Selection of CPC must take into consideration fit of the CPC to the wearer. Improper fit can cause a loss of coordination, dexterity, or tactility, thereby hindering the worker in the performance of his job, decreasing productivity, and possibly causing an increased hazard to the worker. In addition, certain CPC garments, such as TECP suits, may be so large for the individual that they cause increased work effort in performing the job and, consequently, increased stress to the worker. Garments that are too small may become stretched, torn, or separated at the seams and closures during use, thereby compromising protection.

8.4 *Selection Logic*—Based on all of the above factors, select from among the qualifying CPC candidates. The following alternative situations and selection outcomes are based on hazard, that is, the toxicity of the chemical (including propensity for skin absorption) and the nature of the job.

8.4.1 *Low Toxicity*—If toxicity and skin absorption are low, select that CPC demonstrating no observable penetration. The CPC should not degrade for the entire length of the task.

8.4.2 *A Moderate-to-High Toxicity*—For liquid contact or intermittent liquid contact, or both, with contaminants having toxicities and skin absorption properties that are ~~moderate-to-high~~, moderate to high, select the CPC garment with the longest time to normalized breakthrough or the lowest steady-state permeation rate, or the lowest amount of cumulative permeation. CPC garments not having the best permeation properties (that is, shortest normalized breakthrough times, highest steady-state permeation rates, or high amounts of cumulative permeation) may be selected provided that biological monitoring of the worker, field evaluations of the CPC, or a written risk assessment is performed. CPC should not degrade for the entire length of the task.

8.4.3 *Splash or Spill Only*—Where the only possibility for exposure is limited to splash, spill, or incidental contact, and egress from the workplace is easily achieved, select that CPC garment that demonstrates no observable ~~degradation~~, degradation, penetration, or penetration/permeation over a period of time for which egress would be required. Workers must be instructed to leave the work area and change CPC garments when splashed if garments are selected only for the purpose of resisting splash.

8.4.4 *Gas or Vapor Concentrations Only*—Where potential exposure to high vapor concentration is the only source of exposure, choose CPC in accordance with the toxicity and concentration of the chemical. A buddy system should be used.

8.4.5 *Combinations of Exposure Situations*—Where exposure situations are combinations of the above, select for the ~~worst-case~~ worst-case scenario.

8.4.6 *Quantitative Selection Criteria*—At present, decisions based on more quantitative selection criteria than described in 8.4 are not possible due to the lack of definitive information on skin absorption and subsequent toxic effects. Therefore, descriptions such as “significant skin absorption,” “low toxicity,” and “poorly absorbed through the skin” must be used. Individual experience and biological monitoring will indicate whether proper categorization of skin toxins has been made by individuals performing CPC selection.

8.5 *Selection ~~when~~When Permeation, Penetration, and Degradation Data are ~~not~~Not Available*—See [Appendix X1](#).

## 9. CPC Use

9.1 CPC should always be used in accordance with the manufacturer’s instructions. Where doubts concerning the intended uses of CPC exist, the manufacturer should be contacted.

9.2 The intended uses of CPC should be conveyed to employees during training.

9.3 It is the employee’s duty to use CPC in the manner prescribed in the employee’s training.

9.4 Emergency-use CPC should be differentiated clearly from routine-use CPC. Only persons who have received appropriate training should use emergency-use CPC. A buddy system shall be used with emergency-use CPC.

9.5 For CPC selected for splash protection only, the employee should be aware of the limited use of such CPC. When splashed, the employee should immediately leave the area and remove the CPC.

9.6 Where a ~~material~~ safety data sheet (~~MSDS~~)(SDS) recommends the use of specific CPC, instructions should be followed, unless reliable data contradicts the ~~MSDS~~SDS or conditions of use permit alternative CPC. If CPC is generally recommended in a ~~MSDS~~,SDS, use Section 8 to select ~~the CPC~~; assist with the selection of CPC within the context of a hazard assessment.

## 10. Training

10.1 Supervisors, persons issuing CPC, and CPC users shall be given adequate training by a qualified person to ensure the proper use of CPC. Written records should be kept of the names of persons trained and the dates on which training occurred. A qualified person is the program administrator, a person trained by the program administrator, or a person who has received equivalent training to the program administrator.

10.2 Minimum training for supervisors, issuers, and users of CPC should include the following:

10.2.1 The nature, extent, and health effects (including dermal) of chemical hazards posed by the job.

10.2.2 The proper use, limitations, and purpose of the assigned CPC.

10.2.3 Where appropriate, symptoms and effects of heat stress, including first aid and preventive measures.