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DOE STANDARD

THE DEPARTMENT OF ENERGY RESPIRATORY ACCEPTANCE PROGRAM FOR SUPPLIED-AIR SUITS

U.S. Department of Energy
Washington, D.C. 20585

AREA SAFT

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FOREWORD

This non-mandatory Technical Standard provides the Department of Energy (DOE) and contractor managers with a structured approach for assessing the safety and respiratory performance of supplied-air suits. It is approved for use by all DOE components and their contractors.

Supplied-air suits were developed in the 1960s to protect nuclear workers from respiratory and skin hazards, primarily plutonium and tritium. Originally developed to replace airline respirators used inside protective suits, the suits provided the worker with a more comfortable working environment and better visibility. The design features one or two-piece, full-body polyvinyl chloride (PVC) suits construction with air fed to the head and extremities. Over the years, DOE sites modified these suits for special operations, such as welding. In addition to providing workers with greater comfort and mobility, supplied-air suits provide very high protection factors as well as skin protection and

cooling. As a rule, they are used only once before disposal. Some suits contain components that are reused after laundering and inspection.

The National Institute for Occupational Safety and Health (NIOSH) regularly tests and certifies respiratory equipment for use by industrial workers. However, because use of the supplied-air suit was limited, NIOSH decided not to test them. As a result of this decision, the Los Alamos National Laboratory (LANL) began in 1973 a testing program on behalf of the DOE. LANL established testing criteria for accepting or sanctioning the tested suits for use in DOE workplaces. These guidelines included a review of standard operating procedures and training programs at the site submitting the suit and a site visit to evaluate how the suits were used. The DOE Office of Environment, Heath Safety and Security funded this effort.

Beginning with Fiscal Year 2002, user sites, such as the Savannah River Site (SRS), Idaho National Laboratory (INL) and the Miamisburg Environmental Management Program (MEMP or Mound), were required to fund and support the supplied-air suit testing they need. Concurrent with this transfer, a decision to formalize the acceptance test criteria was made.

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GLOSSARY

Acceptance – The determination that the tested supplied-air suit configuration can be used in the workplace without harm to the worker.

Aerosol – Particles, solid or liquid suspended in air (e.g. dust, fumes, mists or fibers).

Air – For the purpose of this technical standard, air that meets the requirements for Type I-Grade D breathing air as described in ANSI/CGA Commodity Specification for Air, G-7.1-2018.

Breakthrough Time – The time required for a detectable level of a chemical to traverse a membrane.

Configuration – A design described by its dimensions, components, method of assembly, and materials of construction. Supplied-air suit configurations are tested in a suit test facility.

Contaminant – a harmful, irritating or nuisance airborne material.

Department of Energy Respiratory Acceptance Program (ERAP) – A program set up, based primarily on respiratory protection performance, to accept or reject supplied-air suits that are used to protect DOE contractor and federal employees from exposure to harmful atmospheres and radioactive contamination.

Helmet – That portion of a supplied-air suit that surrounds the head and is intended to keep contaminants from entering a wearer's breathing zone.

Immediately Dangerous to Life or Health (IDLH) – Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual’s ability to escape unaided from a permit space.

Respiratory Advisory Committee (RAC) – The DOE Respirator Advisory Committee is composed of persons who are knowledgeable in the field of respiratory protective devices. This committee is composed principally of representatives from the field and headquarters elements, but may also include industry, academic or other government representatives. The Committee provides peer review of the test procedures and quality assurance.

Suit Tester – An individual who voluntarily agrees to put on a supplied-air suit and perform certain tests in this proposed supplied-air suit. These individuals must complete the physical and training qualifications as specified in the current OSHA respirator standard (29 CFR 1910.134)

Suit Test Facility (STF) – A testing facility capable of evaluating supplied air suits according to the guidance provided in this standard. Preferably, this facility is organizationally independent of the organization seeking the test.

Supplied-air suit – A supplied-air suit, as discussed herein, is considered ventilated protective clothing protecting the respiratory tract and skin of the wearer against harmful atmospheres and radioactive contamination. The air may be supplied only to the head portion but preferably is distributed to other parts of the suit. The supplied-air suit consists of the protective covering for the body of the wearer; the breathing air hose; and other attachments, accessories, and auxiliary items such as breathing tube, couplings, airflow-control valve, airflow meter, air-pressure gauge, communications equipment, gloves, boots, cooling devices, and shoe coverings. These supplied-air suits are never to be used in Immediately Dangerous to Life or Health (IDLH) or oxygen-deficient atmospheres.

Test Operator – The individual who directs the conduct of the tests specified in this standard.

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ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ACFM	Actual cubic feet per minute
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
ATSDR	Agency for Toxic Substances and Disease Registry
BNL	Brookhaven National Laboratory
CFM	Cubic feet per minute
CFR	Code of Federal Regulations
DEAR	Department of Energy Acquisition Regulation
DOE	Department of Energy
ERAP	Department of Energy Respiratory Acceptance Program
DOE-VPP	Department of Energy Voluntary Protection Program
AU-10	DOE Office of Health
EHSS	DOE Office of Environment, Safety and Health
EM	DOE Office of Environmental Management
EN	Européenne Norme
ES&H	Environment, Safety, and Health
HASP	Health and Safety Plan
HAZMAT	Hazardous Materials
HEPA	High Efficiency Particulate Air
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDLH	Immediately Dangerous to Life and Health
INL	Idaho National Laboratory
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ITF	Independent Testing Facility
LANL	Los Alamos National Laboratory
LOI	Lines of Inquiry

SO	Leading Program Secretarial Office
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute for Science and Technology
OE	Operating Experience
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PNNL	Pacific Northwest National Laboratory
RAC	Respiratory Advisory Committee
SDS	Safety Data Sheet
SME	Subject Matter Expert
SNL	Sandia National Laboratory
S/RIDs	Standards/Requirements Identification Documents
SRS	Savannah River Site
STF	Suit Testing Facility
TLV®	Threshold Limit Value
VPP	Voluntary Protection Program
WSS	Work Smart Standards

1.0 Purpose

The supplied-air suits that protect DOE contractor and federal employees from exposure to harmful atmospheres and radioactive contaminants are not included in the National Institute for Occupational Safety and Health (NIOSH) certification process for respiratory protective devices. Therefore, with the awareness and acknowledgement of NIOSH and the Occupational Safety and Health Administration (OSHA), the Department established a system for acceptance testing of supplied-air suits.

In addition, DOE O 440.1B Change 2 *Worker Protection Management for DOE Federal and Contractor Employees*, requires the "use of respiratory equipment tested under the DOE Respiratory Acceptance Policy (ERAP) when NIOSH approved respiratory protection does not exist for DOE tasks."

Accordingly, the purpose of this technical standard is to provide guidance for (a) establishing procedures for administering the ERAP, (b) prescribing test methods for evaluating the performance of supplied-air suits, and (c) specifying minimum performance standards for these suits. These supplied-air suits are not meant to protect against external exposure to ionizing radiation or Immediately Dangerous to Life and Health (IDLH) atmospheres.

While this test standard is focused on testing a supplied-air suit's ability to reduce solid particulate penetration and avoid cross-contamination of a worker during removal, it is recognized that supplied-air suits may also be used to provide protection from the permeation of liquids, gases, and vapors. The degree of protection is based on the polymers used and their manufacturing method, the polymer thickness, the method of suit assembly, the liquid, gas, or vapor in question, the length of exposure, and environmental conditions. If a liquid, gas, or vapor in the workplace can be expected to pose a hazard to workers, the supplied-air suit's resistance to permeation and breakthrough should be considered. Information on evaluating breakthrough times and permeation is provided in Appendix A.

2.0 Applicability

This technical standard applies to DOE headquarters, field organizations, and contractors, using supplied-air suits.

3.0 References

10 CFR 851. (2013) Worker Safety and Health Program

29 CFR 1910.134, *Respiratory Protection*, current OSHA Respirator Standard

ANSI/ASSE Z88.2 2015, American National Standard Practices for Respiratory Protection

ANSI Z88.6 2006, *American National Standard: Respirator Use-Physical Qualifications for Personnel*

ANSI Z88.10-2010, *American National Standard – Respirator Fit Testing Methods*

ASTM *American Society for Testing Materials Method F739 12 e 1*

Chemical Protective Clothing Volume 1 1990

Compressed Gas Association, *Commodity Specification for Air*, G-7.1-2018

DOE O 440.1B Change 2, *Worker Protection Management for DOE Federal and Contractor Employees*

BS EN ISO 13688, *Protective Clothing - General Requirements*

EN 1073-1 (2016), *Protective Clothing against Radioactive Contamination – Requirements and Test Methods for Ventilated Protective Clothing against Particulate Radioactive Contamination*

EN 1146 (2005), *Respiratory Protective Devices for Self-rescue - Self-contained Open-circuit Compressed Air Breathing Apparatus Incorporating a Hood (compressed air escape apparatus with hood) - Requirements, Testing, Marking*

Guidelines for the Selection of Chemical Protective Clothing – 3rd Edition February 1987

LA-10156-MS *Acceptance-Testing Procedures for Air-Line Supplied-Air Suits* (no longer publicly available), 1984

NFPA 701-2015, *Flame Resistant Textiles and Films*

NUREG/CR-0041, *Manual of Respiratory Protection against Airborne Radioactive Material*, 2001

4.0 ERAP Administration

4.1 Program Functions

The Associate Under Secretary for Environment, Health, Safety and Security.(currently designated AU-1) supports the ERAP through the Office of Health and Safety (currently designated AU-10). The following organizations and individuals also have support functions: The ERAP Reviewer, Lead Program Secretarial Officers (LPSOs), DOE field

organization managers, and managers of DOE and DOE contractor supplied-air suit and respiratory protection programs. The functions of each are described below:

4.2 The Associate Under Secretary for Environment, Health Safety and Security should:

- maintain historical records of supplied-air suit test results and program evaluations,
- establish and communicates any ERAP policy, and
- appoint the ERAP Reviewer.

4.3 The ERAP Reviewer should:

- develop policies, protocols, and guidelines necessary to maintain and improve the ERAP,
- review requests for interpretations of the provisions of this technical standard,
- issue technical notices to clarify various aspects of ERAP,
- coordinate a small group (5 or less persons) consisting principally of DOE field and HQ organization representatives to oversee program policy (called the Respiratory Advisory Committee),
- upon request, review the conclusions and recommendations of the Suit Test Facility (STF) concerning the adequacy of the performance of the supplied-air suit and accept or reject the conclusions and recommendations, and
- upon request, review site supplied-air suit procedures.

4.4 DOE Field Organization Managers and their designees should:

- ensure that DOE and DOE contractors under their administration are using supplied-air suits and supplied-air suit programs that have met the ERAP acceptance criteria,
- communicate information concerning the ERAP to appropriate sites and facilities,
- communicate changes in supplied-air suits used by DOE contractors to the LPSO and the ERAP reviewer, and
- review supplied-air suit procedures for DOE and DOE contractors under their administration.

4.5 Site Supplied-Air Suit Managers should:

- provide guidance to supplied-air suit user,
- ensure that only accepted supplied-air suit configurations and supplied-air suit programs are used,
- document the design and procedures dealing with the use of supplied-air suits,
- submit new or modified supplied-air suit configurations to a testing facility for testing and evaluation leading to ERAP acceptance, and

- notify the DOE field organization that a supplied-air suit configuration had been submitted to a suit testing facility (STF).

5.0 Acceptance Testing Process

5.1 Only supplied-air suit configurations and their programs that meet the specifications in this technical standard are considered to fulfill ERAP acceptance criteria. Failed programs will be counseled and are expected to pass another qualification process.

5.2 Supplied-air suit testing should be performed by an STF.

5.3 The appropriate DOE Operations/Field Office should review new or revised supplied-air suit procedures, which affect or potentially affect the accepted use of the suit. The review should address the intended uses of the supplied-air suit and determine the adequacy of the supplied-air suit program (see Appendix B).

5.4 The DOE site contractor requesting the testing and evaluation of a supplied-air suit configuration should:

- Arrange with a STF to (1) perform the necessary tests and compare the test results with performance criteria (see Appendix C), (2) formulate conclusions and recommendations relative to the adequacy of the respiratory performance of the supplied-air suit configuration and (3) write a report containing the test data and conclusions. The tests should be sufficient to evaluate the supplied-air suit configuration for the contaminants and operations for which protection is intended.
- Submit to the STF prior to scheduled testing, the supplied-air suit, including the breathing air hose and all attachments, accessories, and auxiliary items (such as couplings, airflow-control valve, airflow meter, air-pressure regulator, air-pressure gauge, communications equipment, cooling devices, gloves, boots, and shoe coverings), as well as training, donning, doffing, operating, maintenance and storage procedures. The maximum length of breathing air hose anticipated for operational use of the supplied-air suit should be provided.
- Submit to the DOE Operations/Field Office the procedures for donning, doffing, operating, maintaining, and storing the supplied-air suit and for the quality assurance program (manufacturer’s or contractor).
- If the supplied-air suit or a portion of it is reusable and is laundered, the contractor should also submit a laundered supplied-air suit to the STF, along with a description of the laundering procedures and conditions, and a statement of the number of times that the suit or its components has been laundered. The maximum number of washings should be used.
- Provide copies of the STF’s report to the DOE Operations/Field Office and to the ERAP Reviewer.

5.5 The DOE Operations/Field Office should review and evaluate the test results given in the STF report, and formulate conclusions and recommendations relative to the adequacy of the performance of the supplied-air suit configuration. At the same time, the supplied-air suit procedures should be evaluated.

- Upon request of the DOE Operations/Field Office, the ERAP reviewer will review and comment upon the STF's test results, conclusions, and recommendations concerning the adequacy of the performance of the supplied air suit configuration. Upon request of the DOE Operations/Field Office, the ERAP reviewer will evaluate the supplied-air suit procedures.
- The DOE Operations/Field Office should convey final acceptance or rejection of the supplied-air suit configuration to the contractor in writing within 60 days of receipt of the STF report. If final acceptance or rejection of the STF conclusions and recommendations are not received within sixty (60) days of receipt of the STF report, the Site supplied-air suit manager may elect to use the supplied-air suit, as proposed, pending final disposition of the STF report by the DOE Operations/Field Office.

6.0 Exceptions to the Acceptance Process

6.1 Exceptions to the acceptance process such as those listed below may be granted based on the review and approval of the cognizant Operations/Field Office.

6.2 A DOE or DOE contractor does not need to test and evaluate their supplied-air suit configuration, using all of the below tests, if for a given test the certified results of independent testing (using the European standards, etc.) meet the acceptance criteria for the ERAP for that test (see Appendix C)

6.3 A DOE or DOE contractor does not need to obtain acceptance of their supplied-air suit configuration and program, using the below procedures, if:

- The supplied-air suit and associated supplied-air suit program had been approved per the Acceptance Testing Procedures for Air-Line Supplied-Air Suits (LA10156-MS) prior to the issuance of this technical standard, and no modifications that degrade the level of protection have been made to the supplied-air suit configuration.
- The supplied-air suit configuration at one DOE site is identical to an accepted configuration used at another DOE site and the DOE Operations/Field Office accepts the revised supplied-air suit program from its own site.

7.0 Quality Assurance 7.1 Site Self-assessment

A site using supplied-air suits should conduct a self-evaluation of their supplied-air suit program along with their respirator program, preferably every year (or as recommended by

the ANSI Z88.2 standard). Such self-assessment reports should be made available during any independent assessment.

7.2 Independent Assessment

An on-site evaluation of supplied-air suit program implementation should be repeated every 4 years by an individual independent of the respirator program. Additional assessors may be used, if the contractor deems it necessary. This evaluation should cover at least the elements specified in Appendix B. This evaluation may be part of the Site evaluation performed in the Departmental Integrated Safety Management System reviews. The independent assessor should be knowledgeable in respiratory protection (e.g., Respiratory Protection Program Administrators (RPPA) group, supplied-air suit administrators from other sites).

7.3 Assessment of STF

The capability of the STF to perform the tests specified in this standard should be evaluated and documented by the DOE contractor requesting such tests.
If the STF is a contract operation, the authority to audit should be in the contract.

8.0 Record Keeping

8.1 Current Records

Records, including any test data, if available, for the past five (5) years should be maintained by the site and the STF and be made available to authorized assessors. Copies of the final STF reports and any DOE evaluations should also be sent to the ERAP.

8.2 Historical Records

For historical purposes, AU should maintain all final testing and evaluation reports for each supplied-air suit configuration accepted by DOE and reports from the independent assessments, in accordance with DOE record retention requirements.

9.0 General Supplied-Air Suit Design Requirements

9.1 A DOE contractor should not submit a supplied-air suit configuration for examination and testing unless the supplied-air suit has been designed on sound engineering and scientific principles, is constructed of suitable materials, and shows evidence of good workmanship.

- Components of the supplied-air suit that are exposed to the wearer’s skin should be composed of materials that do not normally irritate the skin of workers.

- Components of the supplied-air suit that must be disassembled or replaced during or after use of the suit should be composed of materials and constructed so that normal handling does not damage them.

- Reusable components of the supplied-air suit that are exposed to the wearer's skin or that must be cleaned after use should be composed of materials and constructed so that they will withstand repeated washing and sanitizing as prescribed by the instructions of the DOE contractor or the manufacturer of the suit.

9.2 The supplied-air suit may consist of one or several parts. The suit may be fitted with a respiratory protective device to enable the wearer to breathe in case of failure of the primary air supply.

10.0 Conduct of Examinations and Tests, Assistance, and Observers at an STF

All examinations and tests of the supplied-air suit by a DOE contractor should be under the sole direction and control of the STF. Only personnel of the STF, the DOE contractor or his designee, and such other persons as are requested by the STF may be present during any examination and test of the supplied-air suit submitted by a DOE contractor.

11.0 General Criteria for Testing by STF

Each supplied-air suit submitted for evaluation of its performance should be examined and tested in accordance with procedures set forth in this standard or equivalent procedure(s) in a recognized standard such as EN-1073-1 (The European standard for ventilated protective clothing).

11.1 Initial Testing Criteria

11.1.1 The STF should not initiate testing unless the suit has been designed to allow at least a 6.0 acfm flow of air to the helmet.

11.1.2 Written instructions covering donning, operation, maintenance, storage, and contaminant protection offered should be provided along with the supplied-air suit to the STF. The manufacturer's or the contractor's quality assurance program pertaining to the supplied-air suit submitted by the DOE contractor should be examined and studied by the STF staff. If these instructions or the assurance program are considered inaccurate, confusing, or incomplete, the supplied-air suit should not be considered acceptable for testing.

- The supplied-air system should be equipped with an airflow meter or a pressure gauge for measurement of the rate of flow of air to the supplied-air suit.
- The entire supplied-air suit, including the breathing air hose and including attachments, accessories, and auxiliary items (such as couplings, flow-control

valve, airflow meter, air-pressure regulator, air-pressure gauge, communications equipment, gloves, boots, and shoe covers), submitted by the DOE contractor should be used as appropriate during the testing process.

- The test operator should examine the supplied-air suit worn by the suit tester to observe if it contains any punctures, tears, seam separations, loose joints, and other defects. If any such defects are found, the suit should not be considered acceptable. This examination should also be carried out on a laundered or reusable supplied-air suit or component if applicable.

11.2 Reusable or Laundered Supplied-Air Suit Components

If a supplied-air suit or a supplied-air suit component that has been reused or laundered is submitted to the STF for testing, the maximum number of acceptable launderings or reuses of the supplied-air suit or portion should be recorded and listed in the report containing the results of tests on the suit. This requirement does not apply to certain reusable items such as coveralls, cloth hoods, cloth booties, rubber gloves, or rubber overshoes that are worn with supplied-air suits.

11.3 Use of Individuals to Test Supplied-Air Suits

11.3.1 Testing should use three volunteer suit testers to determine the performance of the supplied-air suit. Each of the three suit testers should be of a different size. One suit tester should be selected from each of the following range of heights: (a) 168 to 176 cm (5 ft. 6 in. to 5 ft. 9 in.); (b) 177 to 188 cm (5 ft. 10 in. to 6 ft. 2 in.); and (c) 191 to 198 cm (6 ft. 3 in. to 6 ft. 6 in.).

11.3.2 In the event that a supplied-air suit is designed for individuals meeting specific requirements, i.e., minimum or maximum height and girth (chest and/or stomach), the three suit testers should be selected to be representative of the minimum and maximum range.

11.3.3 The height and the maximum girth (chest and/or stomach) of each of the three suit testers should be determined and listed in the report containing the results of the tests on the supplied-air suit.

11.3.4 Each suit tester must have successfully passed a medical evaluation as required by the Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.134.

11.4 Donning and Wearing of Supplied-Air Suit by Suit Tester

11.4.1 Before permitting a suit tester to don the supplied-air suit submitted by a DOE contractor, a test operator should attach to the test subject a suitable device that contains the appropriate probes and sensing elements for measuring the performance characteristics of the supplied-air suit.

11.4.2 Before donning the supplied-air suit, the suit tester should don spectacles, hearing protectors, and any other items needed for comfort or considered

necessary. The suit tester should don and wear the supplied-air suit in accordance with instructions provided to the STF by the DOE contractor.

11.5 Determination of Airflow Indicator Accuracy

11.5.1 During a test of the airflow to the supplied-air suit, the rate of flow of air to the suit should be determined at the minimum and maximum airflow rate values specified by the DOE contractor for a particular length and inside diameter of the breathing air hose. The air pressure in the breathing zone of the suit tester wearing the suit should be measured at the minimum and maximum specified values for airflow specified by the DOE contractor for a particular length and inside diameter of breathing air hose.

11.5.2 The acceptable accuracy of the airflow and pressure indicators of the supplied-air suit should be plus or minus 10 percent for each airflow rate value and for the minimum and maximum lengths of breathing air hose.

These indicators should be calibrated according to National Institute of Science and Technology (NIST) specifications.

12.0 Test for Aerosol Penetration

12.1 Requirements and Test Equipment

12.1.1 In a test carried out to determine the level of respiratory protection provided by the supplied-air suit, a suit tester should wear the suit, which is connected to a source of air, in an atmosphere containing a non-toxic test agent. The penetration of the test agent into the helmet of the supplied-air suit should be measured as the suit tester carries out various exercises. In tests carried out to determine the level of respiratory protection of the supplied-air suit, each of the three test subjects should wear the supplied-air suit.

12.1.2 The test atmosphere to be used to determine the level of respiratory protection provided by the supplied-air suit should be a polydisperse aerosol. The aerosol particle size and concentration should be measured before and after each series of tests, by appropriate methods and recorded.

12.1.3 Appropriate monitoring equipment and accessories should be used to detect the aerosol particles in the test atmosphere and inside the helmet of the supplied-air suit. A suitable recorder should be used to record penetration measurements.

12.1.4 A chamber containing the test atmosphere should be used to carry out tests to determine the level of respiratory protection provided by the supplied-air suit. The chamber should be of suitable size to permit a suit tester wearing the supplied-air suit to carry out freely the various prescribed exercises.

12.1.5 A probe, located inside the chamber and connected by means of tubing to the aerosol detection equipment device, should be used to sample the test atmosphere. A probe located inside the helmet of the supplied-air suit should be used to sample the air from the suit tester’s breathing zone. The helmet probe may be inserted through the supplied-air suit’s helmet or be passed

through openings inherent to the supplied-air suit's design (i.e., two-piece supplied-air suit).

12.1.6 The rate of flow of sample air from the chamber and from inside the helmet of the supplied-air suit should be within the range specified by the penetrometer's manufacturer and ideally be selected to determine the maximum protection factor feasible.

12.1.7 The maximum length of breathing air hose, provided with the supplied-air suit, should be used in carrying out the tests to determine the level of protection provided by the supplied-air suit. A suit tester upon entering the test chamber should connect the breathing air hose to a fitting located inside the chamber that is connected to a source of air. An airflow control valve and a calibrated airflow-measuring instrument should be used to control the flow of air to the supplied-air suit worn by the test subject inside the chamber and to measure the rate of flow of this air.

12.2 Test Procedures

12.2.1 The suit tester, wearing the supplied-air suit, should enter the test chamber containing a nontoxic test agent and should attach the breathing air hose to the fitting inside the chamber that is connected to the source of air. The suit tester should connect the tubing leading from the probe inside the helmet of the supplied-air suit to a fitting located inside the chamber that is connected to the equipment utilized to detect aerosol concentration.

12.2.2 The suit tester should carry out the following series of exercises, and the test operator should ensure that the recorder attached to the aerosol-monitoring equipment records the penetration of aerosol into the helmet of the supplied air suit during each exercise. Each exercise should be carried out for at least 120 sec (2 min) or until no further increase in aerosol penetration is observed for at least 30 sec (0.5 min):

a. Standing still, arms hanging downward along the sides of body, normal breathing.

b. Bending forward and touching toes repeatedly.

c. Running in place (or use of a treadmill).

d. Raising arms above head and looking upward repeatedly.

e. Bending the knees by squatting repeatedly.

f. Crawling on hands and knees.

g. Standing with arms folded in front of chest and twisting torso from side to side.

h. Standing still, arms hanging downward along sides of body, normal breathing.

12.2.3 If one of the exercises listed in b, c, d, e, f, and g of 12.2.2 results in a penetration of aerosol (greater than 1 percent) into the helmet, the suit tester should stand still with his arms hanging downward along the sides of his body and breathe normally for 120 to 180 sec. (2 to 3 min.) or until penetration returns to that measured during exercise a., to purge the aerosol inside the helmet of the supplied-air suit.

12.2.4 If the penetration of the aerosol into the helmet of the supplied-air suit exceeds 10 percent, the test should be terminated to prevent undue exposure of the suit tester to the aerosol.

12.2.5 After the exercises described in 12.2.2 b, c, d, e, f, and g have been carried out by the suit tester, the test operator should stop the flow of air to the supplied-air suit, and the test subject should continue to stand still with his arms hanging downward along his sides and breathe normally. The test operator should observe the increase in penetration of the aerosol into the helmet of the supplied-air suit, and record the time between the termination of the air flow and the moment that the aerosol penetration reaches values of 0.05 percent, 0.1 percent, and 1 percent. The test operator then should restore the flow of air to the supplied-air suit, while the suit tester remains standing still with his arms hanging downward along his sides breathing normally until the aerosol penetration returns to the value occurring before the flow of air was terminated.

For supplied-air suits equipped with an escape feature, the supplied-air suit shall be tested with the flow of air stopped as the suit tester uses the escape feature while standing still with his arms hanging downward along his sides. The test operator should observe the increase in penetration of the aerosol into the helmet of the supplied-air suit, and record the time between the termination of airflow and the moment that the aerosol penetration reached the value of 0.05 percent, 0.1 percent and 1 percent or 3 minutes, whichever is first achieved. The test operator then should restore the flow of air to the supplied-air suit and the suit tester should remain standing still with his arms hanging downward along his sides and breathe normally until the aerosol penetration returns to the value occurring before the flow of air was terminated.

12.2.6 Determine the average of the peak aerosol penetration values that occurred during each of the exercises listed in 12.2.2, and record these average peak penetration values.

12.2.7 Using the values determined in 12.2.6, calculate the average peak penetration for all exercises carried out by each suit tester.

12.2.8 If required, repeat 12.2.2 through 12.2.7 for maximum and minimum rates of airflow and length of breathing air hose (if more than one length of hose is used to connect the supplied-air suit to the supply manifold) specified by the DOE contractor.

12.2.9 Repeat 12.2.1 through 12.2.8 for each of the suit testers.

12.2.10 If the supplied-air suit is reusable or a part of it is laundered; a reused or laundered supplied-air suit or part submitted by the DOE contractor should also be tested in accordance with 12.2.1 through 12.2.9.

12.2.11 The suit should be acceptable in regard to providing respiratory protection if the average peak aerosol penetration into the helmet of the supplied-air suit of each test subject does not exceed 0.02 percent for any individual exercise or does not exceed 0.01 percent for all exercises. This should be true for all values of the rate of airflow and hose length into the supplied-air suit ranging from the minimum value to the maximum value specified by the DOE contractor. For assigned protection factors in excess of 10,000, the values of 0.02 and 0.01 percent aerosol penetration shall be adjusted in proportion. For example, for a protection factor of 20,000, the value of peak penetration for any exercise should be 0.01% and for all exercises 0.005%.

13.0 Test for Crush Resistance of Breathing Air Hose

(*Does not apply to hoses that cannot be crushed during use, i.e., hoses within the envelope of the supplied-air suit*)

13.1 Test Equipment and Requirements

13.1.1 In a test carried out to determine the crush resistance of the breathing air hose, the reduction in the flow of air through the hose is measured when a crushing force is applied to the hose.

13.1.2 The breathing air hose should be connected to a source of air, and a calibrated airflow-measuring instrument should be used to monitor the rate of flow of air through the hose. The rate of flow of air through the breathing air hose should be adjusted to the minimum value specified by the DOE contractor.

13.1.3 The breathing air hose should rest on a horizontal surface. A crushing force of 250 lb should be applied to the hose along 3 in. of its length for 300 sec (5 min).

13.2 Test Procedure

13.2.1 The airflow rate through the breathing air hose during the application of the crushing force should be observed. The lowest value of the airflow rate through the hose should be recorded. The maximum decrease in the rate of airflow through the hose should be calculated and recorded.

13.2.2 After removal of the crushing force from the breathing air hose, the condition of the section of the hose where the crushing force had been applied should be examined, and record should be made of any permanent deformation of the hose.

13.2.3 The breathing air hose should be acceptable in regard to crush resistance if the lowest rate of airflow through the hose during the application of the crushing force is not less than 90 percent of the original rate of airflow through the hose and if permanent deformation of the hose does not occur because of the

application of the crushing force. In addition, after removal of the crush force, airflow must return to at least 95 percent of the original rate.

14.0 Test for Kink Resistance of Breathing Air Hose

(*Does not apply to hoses that cannot be kinked during use, i.e., hoses within the envelope of the supplied-air suit*)

14.1 Test Equipment and Requirements

14.1.1 In tests carried out to determine the resistance to kinking of the breathing air hose, the reduction in the flow of air through the hose should be measured and must not be less than 90 percent of the original airflow.

14.1.2 The breathing air hose should be connected to a source of air, and a calibrated airflow-measuring instrument should be used to monitor the rate of airflow through the hose.

14.1.3 The rate of airflow through the breathing air hose should be adjusted to the minimum value specified by the DOE contractor.

14.1.4 A 6-ft-diameter single-coil loop of the breathing air hose should be formed with the loop on a horizontal surface.

14.1.5 At a distance of 3 ft from the single-coil loop, one of the sections of the breathing air hose, which extends from the loop and which leads to the source of compressed air, should be securely fastened to the horizontal plane surface.

14.2 Test Procedure

14.2.1 The portion of the breathing air hose that extends from the single-coil loop, and which is not fastened to the horizontal plane surface, should be slowly pulled parallel to the horizontal plane surface. The hose should be held by the attached fittings and pulled until the loop unfolds and the hose straightens out.

14.2.2 The rate of airflow through the breathing air hose should be observed during the time that the single-coil loop of the hose is unfolded and the hose is straightened out. The lowest value of the rate of airflow through the hose during the hose-straightening process should be recorded. The maximum decrease in the rate of airflow through the hose as a percentage of the original flow rate should be calculated and recorded.

14.2.3 The way in which the single-coil loop of air hose unfolds should be observed, and a record should be made of any localized kinking of the hose.

14.2.4 The breathing air hose should be acceptable in regard to resistance to kinking if, during the process of unfolding the single-coil loop of hose, the lowest rate of flow of air through the hose is not less than 90 percent of the original rate of airflow through the hose and if localized kinking of the hose does not occur.

15.0 Test for Strength of Breathing Air Hose and Couplings

(*Does not apply to hoses that do not incur any significant pulling during use, i.e., hoses within the envelope of the supplied air suit*)

15.1 Test Equipment and Requirements

15.1.1 The strength of the breathing air hose and couplings of the supplied-air suit submitted by a DOE contractor should be determined by two tests. If more than one type of coupling is used in the suit, then a length of breathing air hose with each type of coupling should be tested.

15.1.2 The breathing air hose and coupling should be connected to a source of compressed air, and a calibrated airflow-measuring instrument should be used to monitor the rate of airflow through the hose and coupling. The rate of airflow through the breathing air hose and coupling should be adjusted to the minimum value specified by the DOE contractor. 15.2Test Procedure

15.2.1 A steady pull of 100 lb for 300 sec (5 min) should be made on the breathing air hose and coupling.

15.2.2 The breathing air hose and coupling should be observed during the steady pull. Any breaking of the hose, separation of the hose and coupling, and separation of components of the coupling should be recorded.

15.2.3 The rate of airflow through the breathing air hose and coupling during the steady pull should be observed. The lowest value of the rate of airflow through the hose and coupling should be recorded. The maximum decrease in the rate of airflow through the hose and coupling as a percentage of the original airflow rate should be calculated and recorded.

15.2.4 A rapid pull of 100 lb of 0.5-sec duration or less should be made on the breathing air hose and couplings. A total of three of these rapid pulls should be carried out.

15.2.5 The breathing air hose and coupling should be observed after each of the three rapid pulls. Any breaking of the hose, separation of the hose and coupling, and separation of components of the coupling should be recorded.

15.2.6 The rate of airflow through the breathing air hose and coupling during each of the three rapid pulls should be observed. The lowest value of the rate of airflow through the hose and coupling during each rapid pull should be recorded. The maximum decrease in the rate of airflow through the hose and coupling as a percentage of the original airflow rate should be calculated and recorded.

15.2.7 The procedures given in 15.2.1 through 15.2.6 should be carried out on the breathing air hose and each type of coupling used.

15.2.8 The strength of the breathing air hose and couplings of the supplied-air suit should be acceptable if, during the prescribed tests, breaking of the hose, separation of the hose and couplings, and separation of components of couplings do not occur and if the lowest rate of airflow through the hose and couplings is not less than 90 percent of the original rate of airflow through the hose and couplings.

16.0 Strength of Connection of Breathing Air Hose to Supplied-Air Suit 16.1 Test Equipment and Requirements

16.1.1 The strength of the connection of the breathing air hose to the supplied-air suit submitted by a DOE contractor should be determined by means of a test involving a measure of the fit factor provided by the suit when the connection of the breathing air hose to the helmet is subjected to a separating force. In the test, a suit tester should wear the breathing air suit, which is connected by means of the breathing air hose to a source of air, in an atmosphere containing a test agent.

16.1.2 A description of the aerosol, the instrumentation, and methods that should be used to measure the penetration of the aerosol into the breathing zone of the suit tester is given in 12.1.2 through 12.1.7.

16.1.3 A length of breathing air hose should be used, and all of the three suit testers should be tested. The length of the breathing air hose should be adequate to permit the carrying-out of the procedure described in 16.2.

16.1.4 The suit tester, wearing the supplied-air suit upon entering the test chamber, should connect the breathing air hose to a fitting located inside the chamber that is connected to a source of air. The suit tester, upon entering the test chamber, also should connect the tubing from the probe inside the helmet of the supplied-air suit to a fitting that is connected to the aerosol detection equipment.

16.1.5 The test operator should adjust the rate of flow of air going to the supplied-air suit worn by the suit tester to the minimum airflow rate value specified by the DOE contractor. The test operator should check the operation of the aerosol monitoring equipment and make any necessary adjustments.

16.2 Test Procedure

16.2.1 The suit tester should walk at a normal pace away from the point where the breathing air hose of the suit is connected to a fitting located inside the chamber. The suit tester should continue to walk until stopped by the limited length of the breathing air hose. The suit tester should stand still, while keeping a steady tension on the taut breathing air hose, for at least 120 sec (2 min) or until the penetration of aerosol into the supplied-air suit helmet shows no further increase.

16.2.2 The test operator should determine the average of the peak aerosol penetration values, which occurred while the suit tester kept a steady tension on the taut breathing air hose, and record this value.

16.2.3 The strength of the connection of the breathing air hose to the supplied-air suit should be acceptable if the average peak penetration of the aerosol into the helmet in the breathing zone of the suit tester, which occurred while the suit

tester maintained a steady tension on the taut breathing air hose, does not exceed 0.02 percent.

17.0 Noise Test 17.1 Test Equipment and Requirements

17.1.1 The level of noise generated by the flow of air into the helmet of a supplied air suit should be less than 80 dBA when measured within three inches of the test subject's ear while the supplied-air suit is worn following the DOE contractor's instructions, with the shortest length of breathing air hose permitted, and with minimum and maximum air volumes permitted.

17.1.2 Noise measurements should be conducted with Type I or Type II sound level meters equipped with omni-directional microphones using the A-weighted network and the slow-response setting. Sound level meters should be calibrated following the manufacturer's recommendations. Prior to and immediately after completing sound level testing, the accuracy of sound level meters should be verified following the manufacturer's recommendations using a source recommended by the manufacturer. Calibration and accuracy checks should be incorporated into the test report.

17.1.3 The sound level meter should have the microphone attached using a manufacturer's recommended extension cable to permit the microphone to be remote from the display unit.

17.1.4 A device to hold the remote microphone within three inches of either ear of the suit tester while not affecting the normal operation of the suit should be used. The device is only required for testing the supplied-air suit noise levels, and if desired, may be eliminated during other evaluations. The reading on the Sound Pressure Level Meter can be affected by the diaphragm of the microphone in the direct airflow path of the inlet air, or if it is incident to the airflow path. When directly in the path it could result in an artificially high reading and when at a 90-degree angle to the path (if the velocity is great enough) it can result in an artificially low reading. Therefore, the test operator should take care to assure that the microphone is placed near the suit tester's ear, but not in or incident to the airflow path.

17.1.5 Airflow measuring equipment should be capable of determining the volume of air entering the supplied-air suit with an accuracy of plus or minus 10 percent. Calibration information should be incorporated into the test report.

17.1.6 Prior to a suit tester donning the supplied-air suit the test operator should confirm that the noise level inside the helmet is less than 85 dBA and determine whether noise levels are uniformly distributed within the helmet. If the helmet noise levels equals or exceeds 85 dBA, testing should not continue without concurrence from the ERAP administrator. If the noise levels are not uniformly distributed, the in-helmet microphone should be positioned near the ear expected to experience the greatest noise. The test operator should attach the device containing the remote microphone to the suit tester, and

ensure that the microphone is located within three inches of the suit tester's right or left ear except as noted above. The suit tester should don the supplied-air suit in accordance with instructions provided by the DOE contractor.

17.2 Test Procedure

17.2.1 The test operator should measure the background noise in the helmet with no air flowing into the supplied-air suit. While determining the background noise, the suit tester should stand still with his arms hanging along his sides and he should hold his breath. The background noise level should be recorded. Tests to measure the level of noise generated by the flow of air through the helmet should not be carried out if the background noise level exceeds 74 dBA.

17.2.2 The test operator should connect the breathing air hose to a source of air. An airflow control valve and a calibrated airflow-measuring instrument should be used to control and measure the rate of flow of air to the helmet worn by the suit tester.

17.2.3 During tests conducted to determine the level of noise generated by the flow of air through the device, the suit tester, wearing the helmet, should stand still with arms hanging downward along his/her sides, and should breathe normally.

17.2.4 The test operator should adjust the flow of air going to the helmet being worn by the suit tester to the minimum airflow specified by the DOE contractor. The test operator should observe and record the measurement of the noise level. The test operator should then adjust the flow of the device to the maximum airflow specified by the DOE contractor. The test operator should observe and record the measurement of the noise level.

17.2.5 The test operator should compare the noise-level measurement recorded for the maximum airflow rate in 17.2.4 with the acceptable maximum of 80 dBA. Should this recorded noise-level measurement be greater than 80 dBA, the test operator should decrease the rate of flow of air going to the helmet in increments of 1.0 cfm from the maximum airflow rate specified by the DOE contractor. The test operator should observe and record the measurement of the noise level for each airflow rate, and should repeat this step until the maximum acceptable noise level of 80 dBA is reached.

18.0 Escape Test

(This test is not needed if the suit being tested is fitted with a respiratory protective device to enable the wearer to breathe in case of failure of the primary air supply.)

Supplied-air suit users should never experience an oxygen concentration of less than 16 percent or the carbon dioxide concentration of greater than 5 percent in an emergency. This

test permits the ERAP Reviewer to determine that contractor's supplied-air suit design and emergency procedures are adequate to mitigate this scenario.

18.1 Safety Considerations

18.1.1 Air must be restored to the supplied-air suit when the oxygen level drops to 16% or below or the carbon dioxide level rises to 5% or above.

18.1.2 Additional help shall be immediately available to assist the suit tester during the conduct of this test.

18.2 Test Equipment

18.2.1 Measurements of oxygen and carbon dioxide concentrations should be made using instruments that are capable of drawing a sample from within the breathing zone of the helmet of the supplied-air suit. The instruments should be calibrated following the manufacturers' recommendations. Prior to and immediately after completing measurements, the accuracy of the instruments should be verified following the manufacturers' recommendations using a gas source recommended by the manufacturer. Calibration and accuracy checks should be incorporated into the test report.

18.2.3 A device to hold the sampling tubes in the breathing zone of the supplied-air helmet, while not affecting the normal operation of the suit, should be used. The device is only required for testing oxygen and carbon dioxide concentrations, and if desired, may be eliminated during other evaluations.

18.3 Test Procedure

18.3.1 Test Subjects. This test should be run on each of the three suit testers. The suit testers' physical sizes should be as listed in Section 11.3.1.

18.3.2 The suit tester should don the supplied-air suit in accordance with the instructions provided by the DOE contractor. Taping or any relevant accessories, such as a hardhat or body harness, should be used, and the supplied-air suit should be supplied with the minimum airflow rate, as specified by the DOE contractor. The suit tester should stand with his arms by his sides. The test operator should stop the flow of air, and the suit tester should begin to remove the supplied-air suit as quickly as possible.

18.3.3 The test will be terminated when any of the following conditions occurs:

- The suit tester escapes from the suit. The suit tester should be considered to have "escaped" when his head is outside of the supplied-air suit. The test operator should record the time necessary to escape.
- The oxygen concentration reaches 16 percent.
- The carbon dioxide concentration reaches 5 percent.

18.3.4 The test operator should record the time at which the test was terminated.

19.0 Contaminated Supplied-Air Suit Removal Test 19.1 Test Equipment

19.1.1 The degree of contamination incurred when removing a supplied-air suit following the DOE contractors' normal removal procedures is evaluated using a fluorescing powder. A suit tester dons non-ultraviolet fluorescing protective clothing consisting of coveralls, cloth hood, cloth booties, and gloves. "Before" pictures are taken with ultraviolet (UV) lights to ensure that there is no UV fluorescing material at the start of the test. The suit tester then dons the supplied-air suit to be tested, in accordance with instructions provided by the DOE contractor. The suit tester enters a special test chamber wearing the supplied-air suit operated at the minimum airflow rate specified for the supplied-air suit under test. The test operator, reaching through glovebox sleeves in the side of the chamber, sprays a coating of dry, UV fluorescent powder over the entire exterior of the supplied-air suit. A blower should be started to clear the chamber of suspended powder. After the chamber has been cleared, the suit tester leaves the chamber and removes the supplied-air suit, following the DOE contractor's standard removal procedure for the supplied-air suit under test. After the supplied-air suit is removed, the degree of contamination is determined using UV lights.

19.1.2 The coveralls worn by the suit tester should be full-body, long-sleeved, non-ultraviolet fluorescing. Cloth hood, cloth booties, and gloves should be non-ultraviolet fluorescing. Because fingernails are UV fluorescent, the gloves must be opaque. The cloth hood, cloth booties, and gloves should be taped to the coveralls with 2-in. non-ultraviolet fluorescing tape. The cloth hood, cloth booties, and gloves are not removed during supplied-air suit removal since they represent the skin and hair of the test subject.

19.1.3 If the supplied-air suit wearer normally wears gloves inside the supplied-air suit, and, if these gloves are removed during supplied-air suit removal, they should be cotton gloves. The rubber gloves usually worn cannot be used because they are coated internally with talcum powder, which is UV fluorescent. If rubber gloves are worn over the initial pair of gloves, talcum powder could coat the initial pair of gloves and show up as contamination on the final photographs.

19.1.4 Tape used to attach the suit tester's clothing must be 2-in.-wide non-ultraviolet fluorescing tape.

19.1.5 Personal air sampler with AA Millipore filter should be installed.

19.1.6 Miscellaneous. All other articles of clothing or accessories should be supplied by the DOE contractor and should be used according to the contractor's standard operating procedures (SOPs).

19.1.7 Test Chamber. A special test chamber should be used that has a filtered intake and exhaust, a variable speed exhaust blower, "glove box" gloves installed in one wall, and a metered air supply. The gloves allow the test operator to spray the supplied-air suit with the UV fluorescent powder. The metered air

supply is needed in order to supply breathing air to the supplied air suit being tested.

19.1.8 Spray Gun. A spray gun or equal device should be used to spray the small sized UV fluorescent powder onto the exterior of the supplied-air suit. The spray gun should be used so that the operator has a directional spray and to obtain an even and complete coating. A spray gun with a large orifice should be used to avoid clogging while the UV fluorescent powder is being sprayed.

19.1.9 UV Detection Equipment. If desired, equipment capable of recording the presence of the fluorescent powder on the suit tester can be utilized. The equipment should be equal to a 4 by 5 inch speed graphic camera with a 121mm f/8 Schneider-Kreuznach Super Angular Lens to photograph the subject. The light source should consist of six Speedotron strobe flash units or their equivalent, synchronized with the camera shutter. Each lamp should be filtered through a Corning No. 5840 glass filter or equivalent, which transmits UV radiation at wavelengths between 300 and 400 nm. A Wratten No. 2A blocking filter or equivalent should be used over the lens of the camera. The 2A filter cuts off UV radiation below 405 nm. This filter allows only the visible fluorescent light to reach and record on the film. The exposures should be made in a darkened room at 1/25 s at f:8. Kodak Royal Pan film, ASA 400, or equivalent may be used as the prime recording film, and Polaroid type 52, ASA 400 or equivalent, may be used for quick test prints when necessary.

An alternate approach is to use a handheld ultraviolet lamp to scan the suit tester's clothing and face for the presence of the fluorescent powder. The location(s) degree of contamination should be recorded on a survey form and included in the test report.

19.1.10 Miscellaneous. Miscellaneous equipment should be used, such as craft paper to protect walking surfaces from becoming contaminated and a box used as a receptacle for the contaminated supplied-air suit after removal. Other items may be used as necessary.

19.2 Test Procedure

19.2.1 Dressing Procedure. The suit tester should don the coveralls, cloth hood, cloth booties, and the initial pair of gloves and tape the cloth hood, cloth booties, and gloves to the coveralls.

19.2.2 Preliminary photographs should be taken of the suit tester as follows: full front with backs of hands turned to camera, and full back with palms of hands turned to camera. Instant photographs also should be made of each pose to ensure that the subject is not wearing any UV fluorescent material or equivalent. If the alternate approach is used, the handheld ultraviolet lamp will be used and the results recorded on a survey form.

19.2.3 A personal air sampler with AA Millipore filters installed should be fitted to the suit tester with the sampling port as close to test subject's breathing zone as possible.

19.2.4 The suit tester then should don the supplied-air suit to be tested, exactly as given in the supplied-air suit user's SOP. The only exception is the use of cotton gloves instead of rubber gloves over the initial gloves. Taping of the supplied-air suit parts should be exactly as given in the DOE contractor's SOP.

19.2.5 Powder Spraying. The suit tester should enter the test chamber and connect the airline to the chamber fitting. The test operator should supply air to the supplied-air suit at the minimum airflow rate specified by the DOE contractor. The test operator should put his hands into the glove-box sleeves and, using the spray gun (or equal device), spray UV fluorescent powder or equivalent onto the supplied-air suit exterior. The test operator and test subject should work together to ensure that all surfaces of the supplied-air suit are coated with the powder. When the powder spraying is complete, the test operator should start the exhaust blower and adjust the blower speed to maintain a negative pressure within the chamber. When the test chamber air has been cleared, the test subject should leave the test chamber. The suit tester should stand just outside the chamber and remove the supplied-air suit exactly as instructed by the DOE contractor's SOP. The suit tester should then enter the photography or observation room.

19.2.6 Photographs should be made of the suit tester, with UV lights or equivalent, using the same poses used for preliminary photographs or observations will be made with a handheld ultraviolet light.

19.2.7 Any contamination transfer indicated by the UV powder visible in the photographs or by the analysis of the Millipore filters should constitute cause to re-examine and consider modification of the supplied-air suit removal procedures.

20.0 Material Flammability Test 20.1 Test Equipment and Requirements

20.1.1 This test method is a modification of the NFPA 701-2015 "Flame-Resistant Textiles and Films." Two modifications of the NFPA test are necessary for this application:

- Material that has been treated or conditioned to enhance non-flammability should be accepted for testing.
- The material is not considered self-extinguishing if the material melts, allowing the flame to drop away and accomplishing extinguishment.

20.1.2 Test Description: This test is performed by cutting supplied-air suit material into strips of appropriate length, and burning the material in a special shield.

20.1.3 A shield should be constructed from fire-resistant material, having interior dimensions of approximately 12 in. wide, 12 in. deep, and 30 in. high, and an opening at the top. The shield should be so constructed as to provide a ventilating opening 1 in. high around the bottom and should have a viewing window large enough to permit observation of the entire test specimen. A spring clamp should be attached rigidly to the shield so that when a specimen is attached, it will be centered within the shield.

20.1.4 Two strips of supplied-air suit material, 1 in. wide by 18 in. long, should be cut in both the machined and the transverse directions from each of the materials being tested. Gauge marks should be drawn across the specimens 3 in. from each end, defining a 12 in. gauge length over which the burning is to be measured.

20.2 Test Procedure

20.2.1 Attach a strip of supplied-air suit material to clamp.

20.2.2 Apply a 1-inch high Bunsen burner flame to the bottom end of the test strip until it is ignited, but not longer than 15 s. If the material does not ignite, it should be considered nonflammable.

20.2.3 If the specimen ignites, the test should begin when the charred edge reaches the lower gauge mark. If the flame is extinguished before reaching the upper gauge mark (12 inches) and if the extinguishment is not due to the specimen separating and causing the burning part to drop off, the material should be considered self-extinguishing. If the specimen burns the full 12 inches or if the flame is extinguished because the specimen separates allowing the flame to drop off, the material should not be acceptable.

20.3 Nonattached gloves and shoe covers, materials covered by self-extinguishing materials, breathing air hoses, and tape used to attach gloves to the supplied air suit do not require this test.

APPENDIX A

Breakthrough Times and Permeation

Information on breakthrough times and permeation is included in this standard in recognition that supplied-air suits are often used for protection against radiological gases and vapors, primarily tritium, as well as non-radiological gases and vapors. This information is not intended to require breakthrough and permeation testing for every chemical that a supplied-air suit may be exposed. Likewise, a specific assessment is not required for every chemical for which breakthrough and permeation data is not available. Testing or assessments should only be done when a credible exposure scenario and health concern exists. Information on this topic can be found in Guidelines for the Selection of Chemical Protective Clothing published by the American Conference of Governmental Industrial Hygienists (ACGIH) and Chemical Protective Clothing published by the American Industrial Hygiene Association (AIHA).

When evaluating the results of breakthrough and permeation data, the conditions under which the supplied-air suit is used should be taken into consideration. For example, a polymer with a short breakthrough time (several minutes) and significant permeation rate to a chemical would not likely be suitable for immersion in that chemical. However, this polymer might be adequate for protection from splashes of the same chemical if user instructions addressed adequately the scenario. A supplied-air suit should be considered to provide adequate resistance to permeation and breakthrough if workers do not receive a radiation dose or chemical exposure that exceeds established criteria intended to minimize potential health effects.

Where available, resistance to permeation and breakthrough can be evaluated using information available in reference texts or from manufacturers. While reference texts often provide sufficient information to make informed decisions, evaluators should be more cautious when using manufacturer's literature. Often, a manufacturer's literature is limited to general statements such as a particular polymer's resistance to permeation and breakthrough is excellent, very good, good, etc. While useful, one manufacturer's information may not be applicable to another manufacturer's polymer. Contacting the manufacturer can often yield more details, i.e., test method and test results, to provide additional confidence in the data.

Where exposure to the chemicals are not considered serious, i.e., the volume of chemicals involved is small and they are of low toxicity, a review of manufacturers information, recognized references, and qualitative estimates from immersion testing may be all that is necessary, in particular if operational experience supports this decision.

When reference texts or manufacturer's data do not provide sufficient information to evaluate a planned use for a supplied-air suit, it may be possible to develop qualitative estimates of a polymer's resistance to permeation and breakthrough by immersing a sample of the polymer in the chemical in question. Following immersion, an examination for visible degradation, swelling, or weight change can provide sufficient information. Quantitative testing as described in American Society for Testing Materials (ASTM) Method F739-12 e 1 can be performed if necessary.

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APPENDIX B

Program Evaluation Checklist

The following elements constitute a minimum set of elements found in acceptable supplied-air suit programs:

Description of the various supplied-air suit configurations accepted by the ERAP for use. Description of the supplied-air system(s) that includes air quality, air volume, pressures, egress air, maintenance, and inspection specifications of the supplied-air suit configuration. Supplied air for such suits shall meet the requirements of the Compressed Gas Association Specification CGA G-7.1-1997 for Grade D air. Procedures for verifying air quality.

Results of acceptance testing

Wearer instructions for routine and emergency conditions. Such instructions should include directions for donning, doffing, and instances when air supply fails.

Quality control plan and documentation - Site and manufacturer/supplier including materials of construction, method of assembly, method of testing, items tested, specifications for testing, references (i.e., NFPA, ASTM, MilSpec)

Control of document revisions (as in use and production)

Appropriate standard operating procedures and training programs. Such training other hazards such as heat stress, cold stress, planning for emergencies, and emergency procedures should be a part of the routine user-training program.

Inspection and testing including receipt, in-process, and final storage conditions

Shelf life of supplied-air suit components and complete supplied-air suit configurations.
Control of measurement & test equipment
site and source control of non-conforming products

Audits of site program, of supplied-air suit manufacturer, and of suit testing facility

Program for Corrective Actions

Record-keeping program

Training programs for assembly, use and maintenance of supplied-air suits

Method for determining supplied-air suit permeability and breakthrough times applicable to the gases for which the supplied-air suit is intended to provide protection. The supplied-air suit should be impervious to the material(s) against which it is intended to protect for a period greater than the required work time.

Similar training, medical surveillance, and other ancillary services to those provided for any approved respirator. These considerations are included because supplied-air suits act as continuous flow loose fitting hoods or helmets; therefore, current OSHA regulations for training and medical certification must be followed as well as the need to provide rescue support found in 29CFR1910.134 (g) (3). Consideration of human factors associated with the use of supplied-air suits. Such considerations include:

- Mobility limitations created by the suit as a result of its size and construction must be considered.
- A person using such a suit may take longer to complete a specific job than if another device were used.
- The employee must be given an adequate amount of time to adjust to the use of a supplied-air suit.
- Adequate personnel and emergency systems must exist in case of suit or system failure.

APPENDIX C

Acceptance Criteria for Supplied-Air Suits

1. Visual examination of suit (11.1)
   The test operator shall examine the supplied-air suit worn by the suit tester to observe if the suit contains any punctures, tears, seam separations, loose joints, and other defects. If any such defects are found, the suit shall not be considered acceptable to provide protection to workers against inhalation of harmful atmospheres. This examination shall also be carried out on a laundered suit if the DOE contractor has submitted such a suit.

2. Manufacturer instructions and quality assurance program review (11.1)
   The donning, operation, maintenance, storage, and the manufacturer or contractor's quality assurance program instructions pertaining to the supplied-air suit submitted by the DOE contractor shall be examined and studied. If these instructions are considered inaccurate, confusing, or incomplete, the suit shall not be considered acceptable for testing.

3. Aerosol penetration during exercise (12.0)
   The supplied air suit shall be acceptable in regard to providing respiratory protection if the average peak aerosol penetration into the helmet of the suit in the breathing zone of the suit tester does not exceed 0.02 percent for any individual exercise or does not exceed 0.01 percent for all exercises. This shall be true for all values of the rate of airflow into the suit ranging from the minimum value to the maximum value specified by the DOE contractor.

4. Crush resistance of air hose (13.0)
   The breathing air hose shall be acceptable in regard to crush resistance if the lowest rate of airflow through the hose during the application of the crushing force is not less than 90 percent of the original rate of airflow through the hose and if permanent deformation of the hose does not occur because of the application of the crushing force. In addition, after removal of the crush force, airflow must return to at least 95 percent of the original rate.

5. Kink resistance of air hose (14.0)
   The breathing air hose shall be acceptable in regard to kink resistance if, during the process of unfolding the single-coil loop of hose, the lowest rate of flow of air through the hose is not less than 90 percent of the original rate of airflow through the hose and if localized kinking of the hose does not occur.

6. Strength of air hose and couplings (15.0)
   The strength of the breathing air hose and couplings of the supplied-air suit shall be acceptable if, during the prescribed tests, breaking of the hose, separation of the hose and couplings, and separation of components of couplings do not occur and if the lowest rate of airflow through the hose and couplings is not less than 90 percent of the original rate of airflow through the hose and couplings.

7. Strength of connection of hose to suit (16.0)
   The strength of the connection of the breathing air hose to the helmet of the supplied-air suit shall be acceptable if the average peak penetration of the aerosol into the helmet in the breathing zone of the human test subject, which occurred while the subject maintained a steady tension on the taut breathing air hose, does not exceed 0.01 percent.

8. Noise (17.0)
   The level of noise generated by the flow of air through a supplied air suit shall be acceptable if the highest noise level measured does not exceed 80 dBA.

9. Escape test (18.0)
   The test operator shall stop the flow of respirable air, and the subject shall begin to remove the suit as quickly as possible. The subject shall be considered to have “escaped” when his head is outside of the suit. The test operator shall record the time necessary to escape.

10. Contaminated suit (19.0)
    Any contamination transfer to the individual wearing the suit indicated by the UV powder visible in the photographs or by the analysis of the Millipore filters shall constitute cause to re-examine and modify the suit removal procedures

11. Material flammability (20.0)
    If the specimen burns the full 12 in. or if the flame is extinguished by the specimen separating and allowing the flame to drop off, the material shall not be acceptable.