Chemical Protective Clothing Performance in Chemical Emergency Response

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Chemical Protective Clothing Performance in Chemical Emergency Response

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Foreword

The International Symposium on Protective Clothing: Chemical Protective Clothing Performance in Chemical Emergency Response was held 16–17 January 1989 in San Diego, California. The sponsor of the event was ASTM Committee F-23 on Protective Clothing. The symposium co-chairmen were Jimmy L. Perkins, University of Alabama at Birmingham, and Jeffrey O. Stull, Texas Research Institute, who have also served as editors of this publication.

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OVERVIEW

Chemical protective clothing is used in a variety of applications. These applications range from protecting workers against chemical exposure in industrial processes to hazardous waste site cleanup. Each application has its own special demands and requirements for the protective clothing used dictating different designs and levels of performance. Chemical emergency response represents one application of protective clothing where a large number of complex issues must be considered in both selecting and using the appropriate protection. Unlike many applications, chemical emergency response involves widely ranging conditions and a great deal of uncertainty. Any number, concentrations, and type of chemicals may be encountered. Emergency situations may include train derailments, marine vessel spills, or accidental industrial releases of chemicals. Generally, most sites are uncharacterized initially and require individual onsite evaluations of protective clothing needs. Differences in the performance offered by the various types of chemical protective clothing can make the difference between adequate protection and hazardous acute or chronic exposure.

This Special Technical Publication has been published as a result of the 1989 international symposium on protective clothing and focuses on chemical protective clothing performance in chemical emergency response. This was the third international symposium organized by ASTM's F23 Committee on Protective Clothing. Unlike prior symposia which were open to all protective clothing applications, this symposium was held to provide a state-of-the-art review of the problems, new technologies, and uses of protective clothing related specifically to chemical emergency response. This publication includes the majority of papers presented at the third international symposium and as such serves as a consolidated source of information on protective clothing testing, selection, and use for those organizations engaged in chemical emergency response.

Twenty-one papers are presented in this publication. In the first section, three overviews on chemical protective clothing are provided. The first paper provides an overview of the activities within the ASTM F23 Committee involving the preparation of new standard methods, guides, and practices for chemical emergency response. The second paper in this section gives background information on protective clothing material resistance testing and the interpretation of chemical resistance or permeation data. This information is paramount to understanding a number of the studies described in other papers found in the Special Technical Publication. A third paper presents a discussion of physical property tests that can discriminate the performance of protective materials against a variety of physical hazards. The relative merits and current "state-of-the-art" for these tests are discussed.

In the second section, four papers are offered on protocols used to evaluate entire protective suits, in addition to a paper dealing with specific tests of a suit-related problem - decontamination. Two of the papers deal principally with heat stress: one providing a comparison of four chemical protective suits under a variety of laboratory conditions, the other presenting a field study which shows the relative performance of four protective ensembles at different work sites involving varying climatic conditions. Each paper provides a basis for comparing the effect of suits and the likelihood for heat stress to occur. A third paper provides an overview and comparison of different test methods which can be used to assess the overall integrity i.e., presence of leaks, of protective garments. A fourth paper covers clothing decontamination techniques with specific reference to rocket propellants. However, the techniques and outcomes have general application. A final paper proposes a series of tests to measure protective clothing material resistance to thermal hazards principally flammability and heat degradation.

Several papers are presented covering different aspects of protective clothing material chemical resistance testing or chemical permeation research. Some of these papers examine the effect of different variables in the permeation resistance of protective clothing materials. Of these, two papers investigate the effect of solvent type and concentration on pesticide permeation; a third evaluates the effects of increasing temperature showing reduced breakthrough times and elevated permeation rates. The fourth paper of this series looks at how mixture permeation compares to permeation of single chemicals through protective clothing materials and attempts to explain and predict the outcomes using solubility parameters.

The fourth section of this publication concentrates on specialized applications within chemical emergency response. One paper discusses the role and problems associated with spill response within the semiconductor industry and the special considerations required to select protective clothing. Two papers look at the unique environmental conditions associated with diving in contaminated water and relate many of the requirements for conventional protective garments to diving scenarios. These papers also examine the development of a program for designing a protective dive suit and gloves which can meet the rigors of contaminated water environments. A final paper examines the degradation of suits used by propellant handlers in emergency response. Again, this is a specific application but general application of the results and methods is possible.

Four papers are included in a section on standards, policies, and procedures for protective clothing with direct and indirect application to emergency response. Two papers in this section relate to various considerations relevant to clothing design including a way of evaluating suit design based on failure modes analysis and its implications to fabrication technologies. The last two papers relate to clothing standards. One paper recommends a specific parameter for quantifying and comparing

chemical resistance or permeation test data in order to avoid problems with breakthrough time. A detailed analysis is provided to justify both the determination of this parameter (the minimum detectable permeation rate) and its use in publishing chemical resistance results. The other paper provides an overview of three draft National Fire Protective Association standards which apply performance criteria to the manufacture of various protective suits. This paper also describes a number of specific test methods developed or selected for use in these standards.

The papers described above should provide the reader with much of the latest information on protective clothing which can be related to the practices of its testing selection and use within the application of chemical emergency response. This comprehensive collection of papers should advance a number of new concepts and considerations that will help emergency responders and other parties in understanding the limitations and performance offered by protective clothing. The symposium co-chairmen gratefully acknowledge the efforts of the authors and ASTM personnel that have made this publication possible.

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Overviews

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AN OVERVIEW OF ASTM COMMITTEE F-23 ON PROTECTIVE CLOTHING

REFERENCE: Henry III, N.W., "An Overview of ASTM Committee F-23 On Protective Clothing," Chemical Protective Clothing Performance in Chemical Emergency Responses: ASTM STP 1037, J.L. Perkins and J.O. Stull Eds., American Society for Testing and Materials, Philadelphia, 1989.

ABSTRACT: ASTM Committee F-23 on Protective Clothing has tripled its membership, quadrupled the number of standards and now is holding its third international symposium on protective clothing. While focusing on developing standard test methods, terminology, classifications and performance specifications for clothing used to protect against occupational hazards, this committee has been instrumental in causing renewed development and research in improving protective clothing. This renewed interest has resulted in the expansion of F-23 into several new subcommittees addressing such issues as protective clothing programs, human factors and specific test methods for particulates and pesticides. The future growth and activities of Committee F-23 are unlimited when one considers the number of new occupations and technological advances being made today. This presentation will give an overview of ASTM Committee F-23, its past accomplishments, its present organization and future plans toward continued growth.

KEYWORDS: Committee F-23, protective clothing, standard methods, occupational hazards, developments, future plans

It is a distinct privilege to give an overview of ASTM Committee F23 on Protective Clothing at this Third International Symposium on Protective Clothing. Committee F23 has a number of proud accomplishments. For those of you who may not be familiar with committee F23's activities it is the intention of this paper to acquaint you with ASTM and F23's role in standards development for protective clothing.

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As you might imagine protective clothing is a broad subject for standards development, however, committee F23 has focused its attention on clothing that is used to protect against occupational hazards. These hazards may be physical, chemical or even biological in nature. F23's function is to develop voluntary standard test methods, terminology, classifications and performance specifications for protective clothing used against these hazards in the workplace.

Originally, the committee was organized in 1977 by a group of concerned individuals representing both producers and users of protective clothing. They were motivated by occupational safety and health concerns, since it was becoming increasingly apparent that protective clothing was not an impermeable barrier to all hazards in the workplace. With emphasis being placed on reducing and controlling occupational exposure, standard methods for evaluating the performance of protective clothing were needed. Therefore, the task of F23 was to develop voluntary standard test methods for evaluating performance of various types of protective clothing.

As one of 140 technical ASTM committees, F23's initial efforts were directed toward evaluating glove and suit performance to permeation and penetration of hazardous chemicals. Physical property test methods were also being considered for evaluating cut, tear, puncture and abrasion resistance. Resistance to the thermal properties of molten metals was the next area where performance standards were developed for protective clothing. After numerous round robin tests and balloting processes three standard methods evolved from committee F23. They were F739-81, for measuring permeation resistance, F903-84, for measuring penetration resistance, and F955-85 for measuring thermal resistance of protective clothing to molten metals. The last two digits represent the year in which the standard was published.

By this time the committee was gaining recognition and additional members were becoming involved in its activities. Regulatory agencies were sending participants to meetings and there was a need to expand the committee to address concerns about fully encapsulated suits, human factors, such as heat stress, dexterity and sizing. Specific test methods were needed to assess the performance of protective clothing to particulates and pesticides as well. The most recent subcommittee formed currently is addresssing the problem of protective clothing programs on care, maintenance and even labelling of protective clothing. All these efforts have resulted in reorganization of F23 into seven technical and five administrative subcommittees. Together these subcommittees have been responsible for nine standard test methods on protective clothing (Figure 1), two successful international symposiums, two standard technical publications (STP 900 & STP 989) and numerous publications in professional journals.

These achievements are the result of voluntary contributions from our committee members which now number 180. Composed of individuals from varied backgrounds, education, training and

experience committee F23 has made significant contributions toward improving the protection of our fellow workers in the workplace. By developing standard methods, guides and practices for protective clothing there has been a revitalized interest in improving protective clothing design and structure. Additional research in developing new and more resistant protective clothing materials has been initiated. Investigations into combining different fabric composites and laminates has resulted in new protective clothing products.

As we look toward the future of F23, there are unlimited possibilities for the development of protective clothing standards. Earlier biological hazards were mentioned as one possible area where standards were needed for protective clothing. In today's working environment where much of our attention is focused on biotechnology there is a real concern about occupational exposure to microorganisms such as bacteria and viruses. Obviously, the health care profession and emergency response personnel are in need of performance standards for protective clothing too. Hopefully the data generated by our chemical and physical test methods provide adequate information to those emergency response personnel who must enter and respond to hazardous waste clean up operations and/or industrial spills, leaks, fires and explosions.

We have purposely limited the scope of this third symposium to the performance of protective clothing in emergency response in hope of providing you with the best up to date information available in protective clothing research and development in this area. Perhaps the next symposium will focus on another area of protective clothing research, but whatever the decision, F23, will continue to provide the necessary mechanism for voluntary standards development for assessing the performance of protective clothing against occupational hazards. So as occupations change with the rapidly changing technologies of the future, so will protective clothing.

There are many opportunities and challenges ahead for committee F23. In particular, we can not over emphasize the need for training, education and communication of standards. To address these concerns the committee has formed an education subcommittee as well as given added attention and support to a publicity committee. Both of these subcommittees will play a vital role in acceptance and recognition of standards world wide. We mention world wide, because these standards not only impact upon protective clothing in the U.S.A., but also in other countries too. After all, we are concerned about the safety, health and welfare of all international friends. Finally, we would like to remind you that many of the accomplishments of man would not be possible without protective clothing, therefore take heed of the accomplishments of F23. The vision for the future is to help man accomplish his goals with appropriate protective clothing that meets fair and necessary standards. Indeed, if protective clothing is the last line of defense, F23's standards should be developed to give the best protection. You are encouraged to participate in committee activities, to meet the members and become part of committee F23 on Protective Clothing.

Figure 1

F23 Standards

F739-85 Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases.

F903-87 Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids.

F955-85 Standard Test Method for Evaluating Heat Transfer Through Materials for Protective Clothing Upon contact with Molten Substances.

F1001-86 Standard Guide for the Selection of Chemicals to Evaluate Protective Clothing.

F1002-86 New Standard Performance Specifications for Protective Clothing for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards.

F1052-87 New Standard Practice for Pressure Testing of Gas Tight Totally- Encapsulating Chemical Protective Suits (TECP).

F1060-87 New Standard Test Method for Thermal Protective Performance of Materials for Protective Clothing for Hot Surface Contact.

F1154-88 New Standard Practice for Quantitatively Evaluating the Comfort Fit Function and Integrity of Chemical Protective Clothing Suit Ensembles.

F1186-88 Classification System for Chemicals According to Functional Groups.

Ruth A. Jamke[1]

UNDERSTANDING AND USING CHEMICAL PERMEATION DATA IN THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING

REFERENCE: Jamke, Ruth A., "Understanding and Using Chemical Permeation Data in the Selection of Chemical Protective Clothing," Chemical Protective Clothing Performance in Chemical Emergency Response, ASTM STP 1037, Jimmy L. Perkins and Jeffrey O. Stull, Eds., American Society for Testing and Materials, Philadelphia, 1989.

ABSTRACT: Despite the high level of effort that ASTM F23.30 Subcommittee on Chemical Resistance of Protective Clothing has put into bringing order into the process of evaluating and selecting chemical protective clothing (CPC), much confusion and many misconceptions still exist in the minds of those using or selecting CPC. Inadvertent misuse or misunderstanding of manufacturers' or distributors' data or failure to seek out the proper chemical resistance information may lead to incorrect and potentially dangerous garment selection. Through a review of existing and proposed ASTM standards and related literature, this paper calls attention to critical issues in evaluating and comparing chemical protective clothing materials.

KEYWORDS: chemical protective clothing, chemical permeation, permeation data, protective clothing selection

In today's world of high technology, people are more familiar than ever before with the potential hazards in their environment. The various right-to-know laws have been responsible for greater worker and community sensitivity to the impact of industrial operations on human health and well-being. Although the level of technical sophistication of the general population is higher today than in the past, we still must remember the truth in the old saying that a little knowledge is a dangerous thing. The same is generally true for those who are faced with the task of selecting chemical protective clothing.

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