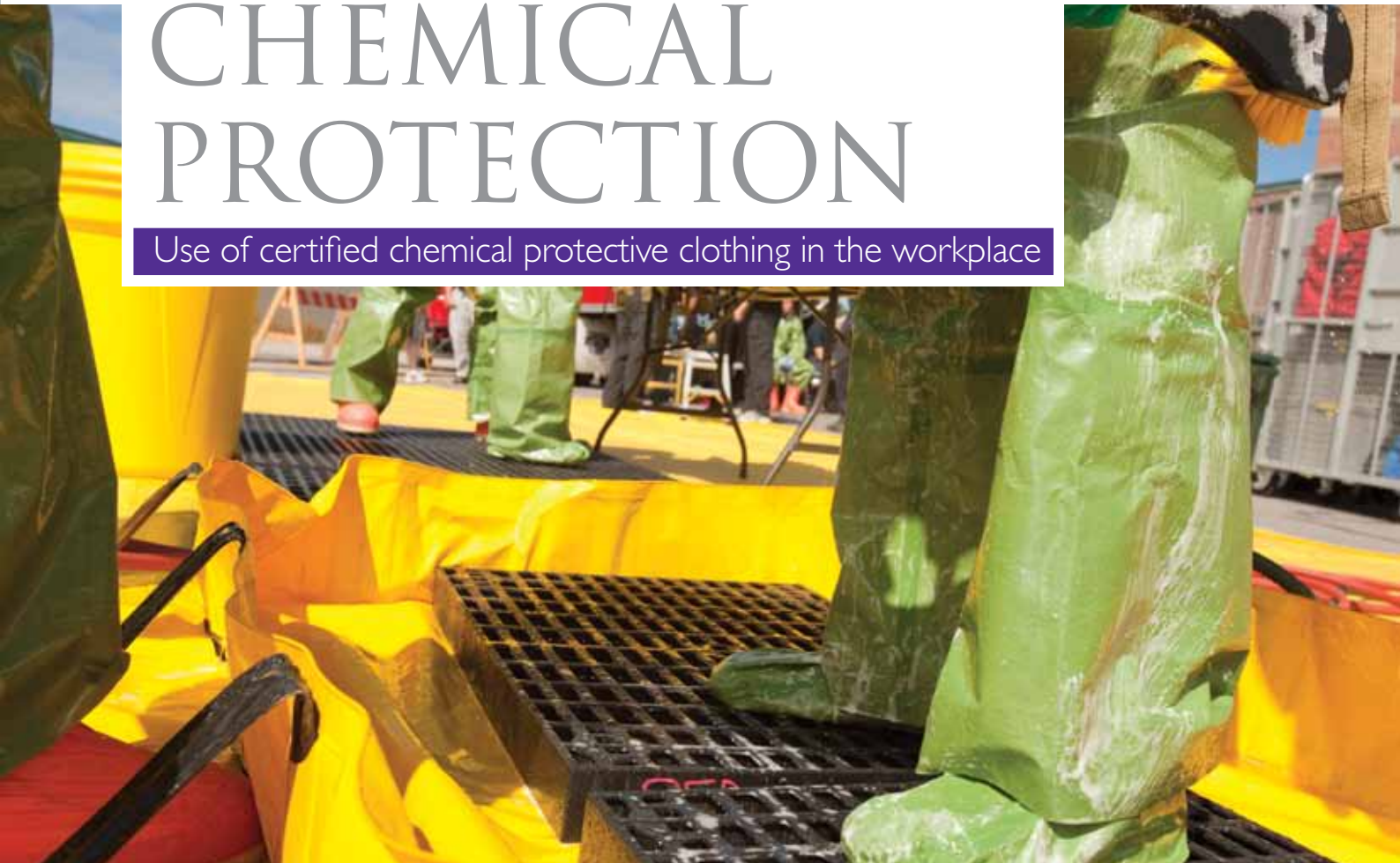


CHEMICAL PROTECTION

Use of certified chemical protective clothing in the workplace



Safety and health professionals are concerned, naturally, with the quality of their protective gear as they face potential hazards. The highest priority is given to employee safety. What type of personal protective equipment (PPE) should be used, and how can quality be screened? Issues such as safety, comfort, expense, ergonomics, practicality, and risk factors must all be considered and evaluated.

The very nature of businesses such as oil and gas production, refining, chemical, power, pulp and paper, and marine industry, dictate the need for strong safety and health practises. Also, as a result of heightened security concerns in these industries, safety and health professionals are now incorporating greater protection of physical property as well as protection of personnel into their responsibilities. PPE, training and response efforts to shield against possible outside intrusion require a different approach than what many safety and health professionals have been responsible for in the past.

Safety preparation Chemical standards

Companies should always ensure that their employees are adequately protected to do their job safely and effectively by conducting a detailed and thorough hazard assessment. Key elements include taking the time to implement the appropriate engineering controls in the workplace, as well as providing safety and protective equipment that is of high quality and has been independently certified.

Following the hazard/risk assessment, PPE manufacturers with excellent reputations should be sought. These companies should be known for providing high quality products that are designed to protect against specific hazards, and the products should be certified to appropriate industry standards. Independently certified safety and protective products should always be sought to ensure the quality of the product. Employers should also confirm that the certification has been issued by an accredited certification organisation.

Chemical protective clothing standards published by the National Fire Protection Association (NFPA) provide critical information to assist professionals in selecting the appropriate level of protection for their employees. Two standards of particular relevance in the United States are NFPA 1991 (2005 Edition), *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies* and NFPA 1992 (2012 edition), *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies*. Widely adopted internationally, these standards are referenced by government agencies, fire departments and corporations' reference in their purchasing specifications.

NFPA 1991 and 1992 were first written in the late 1980s in response to the growing number of hazardous material responders who were using chemical protective clothing from a variety ▶

of sources without consistent protection. In 1985, the US National Transportation Safety Board recommended that government agencies support the development of protective standards for chemical protection after several first responders were exposed to a hazardous chemical from a leaking railcar, even though the manufacturer recommended the use of their suits for the chemical involved. As a result, NFPA 1991 and NFPA 1992 were published and generally correspond to the US Environmental Protection Agency's Level A and B configurations that are common in the hazardous chemical response and remediation industries.

These NFPA standards have positively impacted on the chemical protective clothing offered by manufacturers to the industry. Before these standards, there were virtually no ensembles that provided protection against a broad range of chemicals and addressed the performance for all parts of the ensemble – suit, visor, gloves, footwear and seams.

Initially the idea of chemical protective clothing having some form of limited flame resistance was thought to be unattainable. Once published, the NFPA 1991 and NFPA 1992 standards prompted manufacturers to develop new material technologies and product designs, establishing fully qualified ensembles that improved the level and consistency of protection needed in the industry.

The table, right, shows how the two standards were positioned to provide performance based, instead of configuration based definitions of chemical protective clothing through the association of vapour protection, with US EPA Level A totally encapsulating chemical protective suits and liquid splash protection with US EPA Level B (and C) chemical splash suits. The NFPA standards incorporated specific tests for qualifying vapour and liquid protection for whole suits and suit materials.

NFPA 1991

NFPA 1991 was developed to establish a level of protection against adverse vapour, liquid splash, and particulate environments during hazardous materials incidents, and from specified chemical and biological terrorism agents in vapour, liquid splash, and particulate environments during chemical and biological terrorism incidents. The emphasis in NFPA 1991 is on protection from vapours, but the garments are

directly tested for total body liquid protection, and, on the basis of gas inward leakage, whole body particle protection.

The scope of NFPA 1991 addresses requirements for the design, performance, testing, documentation, and certification of vapour protective ensembles and ensemble elements used by personnel during hazardous materials incidents and chemical, biological, or radiological terrorism incidents.

The NFPA 1991 standard includes performance requirements established to reflect simulated use conditions. Some of the tests include a suit pressurisation test which is used to check the airtight integrity of each protective ensemble. An overall liquid tight integrity test is used to ensure the ensemble provides full body protection against liquid splashes, and an overall ensemble function and integrity test with a test subject is performed. A maximum suit ventilation rate test and gas tight integrity test are also included.

Suit materials must resist permeation and meet penetration requirements for each chemical in the NFPA battery of test chemicals. The test programme also includes exhaust valve mounting strength test, testing for external fittings and an exhaust valve inward leakage test. These tests allow for determination of adequate suit component performance in hazardous chemical environments.

Material testing for burst strength, tear strength, abrasion resistance, flammability resistance, cold temperature performance, and flexural fatigue are required so that materials used for vapour protective suits will afford adequate protection in the environment where they will be used.

As requirements for protection from chemical and biological terrorism agents are also included in the base requirements for all vapour protective ensembles, protective ensembles certified to NFPA 1991 offer the highest level of protection. Two optional criteria, chemical flash fire protection for escape only and liquefied gas protection, can be specified in purchase specifications. Additional criteria are provided for each of the certification options. Product labels must clearly indicate which options apply to the specific ensemble. The primary purpose of NFPA 1991 is to define requirements that isolate the wearer from a surrounding hazardous chemical environment.

NFPA 1991 defines an ensemble consisting of a suit with attached gloves that totally encapsulates the wearer and his or her breathing apparatus. Ensembles are frequently configured with an over-cover, outer gloves, and outer boots in order to meet the requirements of the standard, although some ensembles meet these requirements without extra layers.

“THESE NFPA STANDARDS HAVE POSITIVELY IMPACTED ON THE CHEMICAL PROTECTIVE CLOTHING OFFERED BY MANUFACTURERS TO THE INDUSTRY”

Definitions of Protective Ensemble Types by Performance Tests in NFPA Standards

Type of Ensemble	Corresponds to	Material Performance*	Overall Ensemble Performance
Vapour-protective (NFPA 1991)	EPA Level A	Permeation resistance	Integrity against gases and vapours
Liquid-splash protective (NFPA 1992)	EPA Level B	Penetration resistance	Integrity against liquids

* Permeation resistance testing measures the passage of chemicals (liquids or gases) through a material at a molecular level and requires sensitive analytical equipment to detect chemical breakthrough; penetration resistance testing evaluates if liquids physically penetrate materials, seams, or closures using visual observation for detection



Performance

NFPA 1991 also establishes some design requirements. Ensembles must be provided in a minimum of four sizes and must have protective, inverted pockets over exhaust valves. Gloves and footwear are subject to minimum length and height requirements, respectively.

Performance requirements include:

- *Inflation of ensembles to determine integrity against gas penetration and a shower-like test for demonstrating integrity of clothing against liquid penetration*
- *Permeation testing of suit, visor, glove, and footwear materials and their seams against a 21 chemical battery to demonstrate resistance against a broad range of industrial chemicals – the chemical battery contains gases and liquids representing different classes of chemicals*
- *Burst strength, puncture/tear resistance, low temperature performance, abrasion resistance, and flex fatigue testing of suit, glove, and footwear materials*
- *Breaking strength testing for seams and closures*
- *Leakage and mounting strength testing of exhaust valves*
- *Tests for evaluating the functional use of the ensemble and dexterity of gloves*

NFPA 1992

NFPA 1992 includes requirements for the design, performance, testing, documentation, and certification of liquid splash protective ensembles, ensemble

elements, and protective clothing used during hazardous materials incidents. It also specifies optional criteria for liquid splash protective ensembles for escape protection only from chemical flash fires encountered during hazardous materials incidents.

NFPA 1992 allows ensembles completely covering the body, or clothing which protects the torso, arms, and legs and optionally the arms, feet, and head. Both NFPA 1991 and NFPA 1992 standards can be used to certify ensembles for protection against additional chemicals and mixtures, but NFPA 1992 is limited to chemicals that have a vapour pressure greater than 5mm Hg at 25° C (77° F), are not of known or suspected human carcinogenicity as indicated by either Sax's Dangerous Properties of Industrial Chemicals document or the NIOSH Pocket Guide to Chemical Hazards documents, and do not have a skin notation as indicated by the American Conference of Governmental Industrial Hygienists' Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.

The primary purpose of NFPA 1992 is to establish requirements for clothing that keep liquids from contacting the wearer's skin. The standard addresses liquid splash protective ensembles and clothing designed to protect against exposure to specified chemicals in liquid splash environments during hazardous materials emergencies. Chemical penetration resistance documentation of garment material against an NFPA battery of test chemicals, and any additional chemicals or specific chemical

mixtures for which the manufacturer is certifying the suit is required. The NFPA chemicals were selected from ASTM F 1001, Standard Guide for Chemicals to Evaluate Protective Clothing Materials.

The standard includes performance requirements that were established to reflect simulated use conditions. An overall suit water penetration test is included to ensure the suit provides full body splash protection. Testing of materials includes burst strength, tear resistance, flammability resistance testing, abrasion resistance, cold temperature performance, thermal heat loss and flexural fatigue testing. These tests are required so that garment materials will provide adequate protection against adverse liquid splash environments during hazardous materials scenarios.

NFPA 1992 addresses the second tier of hazardous materials protection. This standard establishes the requirements for chemical liquid splash protection where the chemical vapours that exist are not a hazard. The liquid splash protective ensembles are intended for situations where the primary form of chemical exposure is short term, intermittent contact with liquid chemicals, which do not produce skin-toxic or carcinogenic vapours. NFPA 1992 further permits the individual certification of garments, gloves, and footwear, which may not be part of an overall ensemble.

NFPA 1992 contains some design requirements and the performance characteristics are similar to those specified in NFPA 1991 with the following differences: ▶

- NFPA 1992 garments, gloves, and footwear are only tested for liquid integrity and may not offer integrity against gases
- Penetration testing is used instead of permeation testing
- A smaller chemical battery is used for chemical resistance testing; gases, or liquid chemicals with known skin-toxicity or carcinogenic properties are not included
- Exhaust valves are neither required nor evaluated
- Physical strength and hazard resistance performance criteria are lower for NFPA 1992 items
- Only one option is provided – for flash fire escape protection

Manufacturers are required to provide a technical data package that consists of detailed descriptions of all ensemble parts and components and includes the performance data that demonstrates compliance of the ensemble with the respective standard.

Certification requirements

The NFPA 1991 and NFPA 1992 standards include extensive requirements for the certification of products to these standards. An entire chapter is devoted to the requirements for the certification organisations and their laboratories performing testing to the standards.

Certification organisations audit the manufacturer's quality assurance programme to ensure that it provides continued compliance for the certified product. If a manufacturer wishes to make a change to the product, the change must be presented to the certification organisation to determine what testing is required to ensure it does not affect the compliance of the product.

In this certification chapter there are also requirements for annual verification of product compliance, the manufacturer's quality assurance programmes, hazards involving compliant product, manufacturers' investigation of complaints and returns and safety alert and product recall procedures.

Third party certification is an important means of ensuring the quality of products. To ensure consistency among certification organisations and the integrity of products used to provide



**“CERTIFICATION ORGANISATIONS
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workers appropriate protection, the NFPA standards require the certification organisation to be accredited for personal protective equipment in accordance with ISO Guide 65, *General requirements for bodies, operating product certification systems*.

Those certification organisations which are accredited to ISO Guide 65, must comply with at least ten ISO guides that cover all areas of certification, from laboratory management and inspection requirements to how a certification organisation protects its certification mark. Within these documents are a variety of requirements that third party certification bodies must meet in order to operate as a fully accredited service provider. Among these requirements are their need to:

- *Be impartial*
- *Have a defined management structure – committee, group or person – for a variety of responsibilities*
- *Ensure that each decision on certification is taken by a person(s) different from those who carried out the evaluation*
- *Have adequate arrangements to cover liabilities arising from its operations*
- *Employ a sufficient number of personnel with necessary education, training, technical knowledge and experience*
- *Have a quality system in place giving confidence in its ability to operate*
- *Be free from any commercial, financial or other pressures that might influence the results of the process*
- *Ensure confidentiality and objectivity*
- *Have policies and procedures to resolve complaints, appeals and disputes*

Certification bodies must also undergo internal audits and management reviews to ensure quality requirements are being adhered to.

Such accreditation means another set of eyes, apart from an internal staff person verifies a certification organisation is operating in compliance with ISO Guide 65 as well as its own procedures. Accreditation of a certification organisation provides a high level of confidence to manufacturers and the end users of the products.

Additionally, the certification organisation's testing laboratory should be accredited to ISO 17025, *General requirements for the competence of testing and calibration laboratories*. Accreditation is the evaluation of a laboratory, conducted by a third party organisation that performs a technical assessment of the lab and its personnel in order to determine technical competence. Additionally, the lab's quality management system is evaluated for compliance to the standard. To achieve accreditation, the lab must be found to be competent and compliant with the standard to which they are testing, as well as any additional requirements that are imposed by the third party.

Chemical protective clothing that has been certified to the NFPA 1991 and NFPA 1992 standards must be made publicly available according to the requirements in these standards, as well as requirements in ISO Guide 65. ■

Author



Patricia Gleason currently serves as President of the Safety Equipment Institute (SEI), a third party certification organisation. She brings more than

25 years of management experience serving non profit, safety related organisations, and her area of expertise is in conformity assessment in the field of personal protective equipment and safety products.

In this position, Ms Gleason serves as a member of the American National Standards Institute (ANSI) Board of Directors, the ANSI Accreditation Committee, and is the Chairman of the ANSI Conformity Assessment Policy Committee. She also served on the US delegation for ISO Working Group 29, which was charged with the revision of ISO 17065, the standard governing the accreditation of third party certification organisations.

Ms Gleason also serves on technical committees for the American Society for Testing and Materials (ASTM), the National Fire Protection Association and the National Institute of Justice (NIJ) to provide expertise on certification and conformity assessment issues.

About SEI

SEI is a non profit organisation whose sole purpose is to test and certify a broad range of safety and protective equipment. SEI's certification programme assists government agencies in ensuring employers have confidence in the safety products they provide their workers for protection from potential workplace hazards.

For the past 32 years, SEI has operated certification programmes for safety and protective equipment used by industrial, fire service, and construction workers.

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