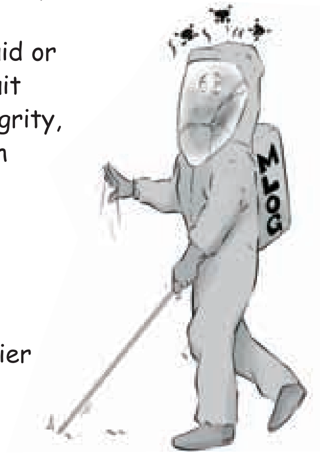
Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

Keeping you safe!

This column is intended to provide operational guidance to the hazmat/CBRNE community regarding the selection and performance of equipment and tactics. In this segment, we are focussing on topics related to chemical protective clothing (CPC).
Firstly, we will look at the way the international standards community uses a combination of factors to validate the broad-spectrum threat suitability of CPC. We will then consider the limitations in using permeation breakthrough tables as the primary selection criteria for CPC. This is timely as the new National Fire Protection Association (NFPA) 470 standard on hazardous materials/WMD response competencies and professional qualifications is set to be released in late 2021, and students following the NFPA process will be required to identify the limitations in using chemical compatibility charts alone to choose protective ensembles.

How do ensembles protect?

The protective capabilities of an ensemble are defined firstly by the integrity of the ensemble design and then the barrier properties of the material, seams and closures. After that, it's the other design/material attributes of the clothing that affect its durability, function and comfort. Chemicals take the path of least resistance, whether this be a gap at the interface of a sleeve and glove, an inadequate closure system, or poorly constructed seams.

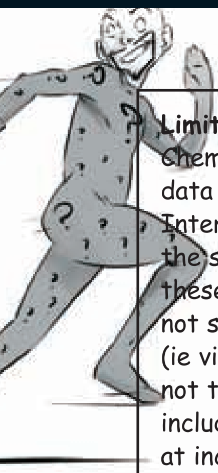


The interfaces between hoods and respirators frequently provide pathways for liquid or vapour penetration. This is far more likely than a liquid or vapour permeating the suit material. When selecting the appropriate CPC, one must consider the ensemble integrity, material/chemical compatibility, and other design/material attributes together with the operational factors of work location, type, duration and chemical concentration.

There is a common perception within the CBRN response community that lengthy chemical lists with permeation breakthrough data (commonly called chemical compatibility charts) are the best way to demonstrate the protective qualities of chemical clothing. Often, these lists only provide information on the principal barrier material which is usually the most protective part of the garment. The user rarely gets information on interface materials, seams, and visors used in the ensemble.

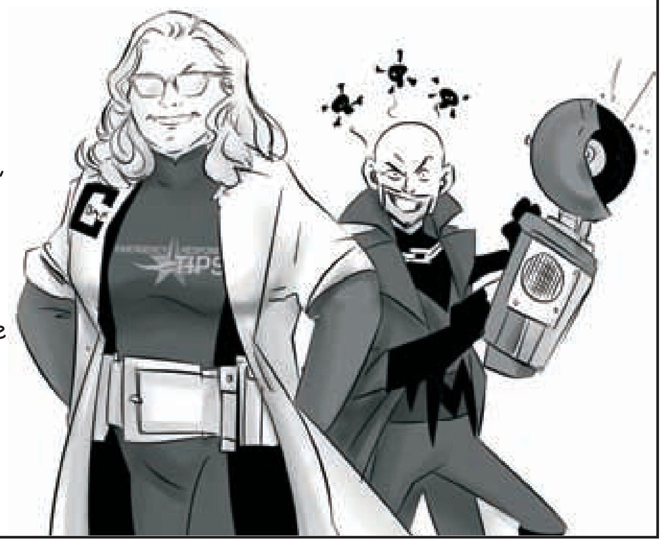
CBax: 25C & 40% humidity 👍 **MLog: 32C & 80% humidity 👎**

The importance of getting the complete picture is illustrated by an incident from California in 1983. Information was only available on the chemical compatibility of the suit material with dimethylamine (a toxic, corrosive and flammable material) and not the visor or suit seams. Contact with dimethylamine resulted in penetration of the suit seams and degradation of the visor which clouded over, cracked and began to melt. The responders incurred skin contact, but fortunately, the breathing apparatus protected their lungs. This incident prompted the development of NFPA performance specifications for chemical protective clothing.



Limitations of chemical compatibility charts

Chemical compatibility charts provide the user with data in accordance with the ASTM International or International Standards Organisation (ISO) tests for the suit materials under ideal conditions. Unfortunately, these tests are only applied to primary suit materials, not seams, interfaces, or other ensemble components (ie visors and gloves). The pristine fabric samples are not tested under actual use conditions, which would include abrasion and flexing of materials to simulate use at increased temperature and humidity levels as might well arise in practice. Finally, the data is often interpreted as minutes to chemical breakthrough when, actually, it should be interpreted as minutes to a normalised chemical permeation rate.

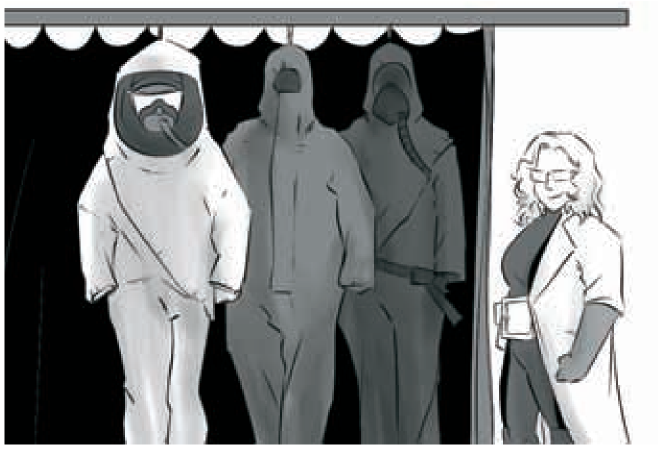


Standardised chemical batteries

It is impractical to measure every part of the protective ensemble for all potential chemical exposures - there are simply too many variables across chemicals, concentrations, mixtures, environmental conditions and different response operations. Therefore, a combination of worst case scenarios for dermal exposure, persistence, penetration and known degradation on polymers is applied. American, European, and international PPE standards all use standardised chemical batteries to represent the broad applicability of protective ensembles. Other chemicals are inferred, based on their structural and functional similarities. In general, the chosen chemicals are small molecules of each chemical class that's represented, as lower molecular weight chemicals permeate and/or penetrate many clothing materials more easily and thus serve as aggressive chemical challenges.

Each chemical protective clothing standard (NFPA, EU, ISO) uses a similar set of chemicals to represent the use-case for the ensemble. For example, the challenges for the two Level A (vapour tight) standards in the US (NFPA 1991 and NFPA 1994 Class 1) differ slightly. NFPA 1991 uses the entire list ,while NFPA 1994 Class 1 favours a subset of those that are likely to be encountered during emergency responses at high challenge levels. This is an important distinction, as the chemicals with high vapour pressures are removed since they will readily evaporate during the response thereby lowering the potential for first responder exposure. In a similar fashion, the NFPA 1992 suits (liquid tight) use the 10 low volatility chemicals in the battery, because these chemicals represent the types of threats that the suits have been designed for, ie liquid versus gas or vapour forming liquids.

Rest assured, regardless of what recognised standards your ensembles meet, the application of standardised chemical batteries provides the user community with confidence that the chemical protective ensembles provide protection against a broad spectrum range of chemical threats and operational utility.



NFPA 1991: entire list | **NFPA 1992: 10 lowest volatile chemicals** | **NFPA 1994: higher challenge level chemicals**

Images are courtesy of Phil Buckenham *https://philbuckenhamart.wixsite.com/philbuckenham*