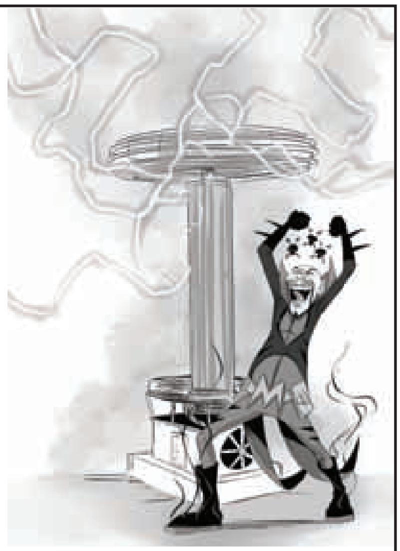
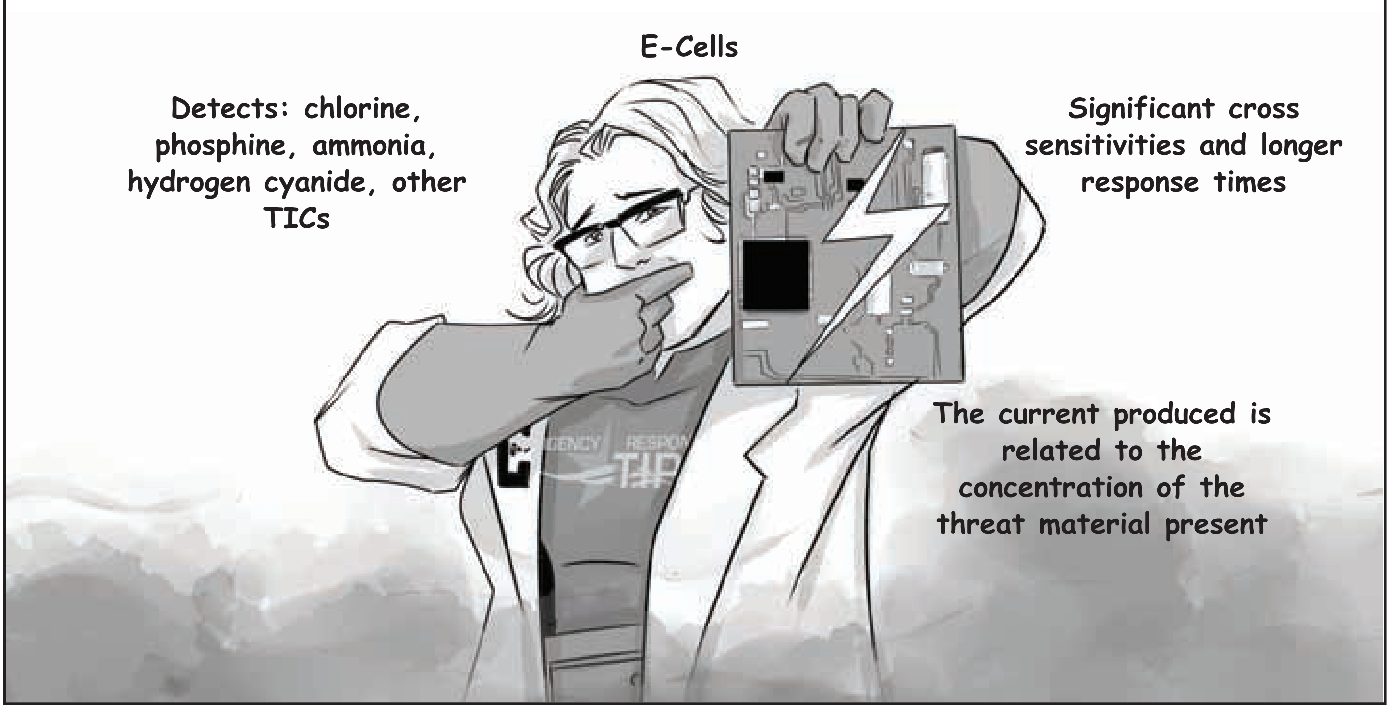
Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

Keeping you safe!



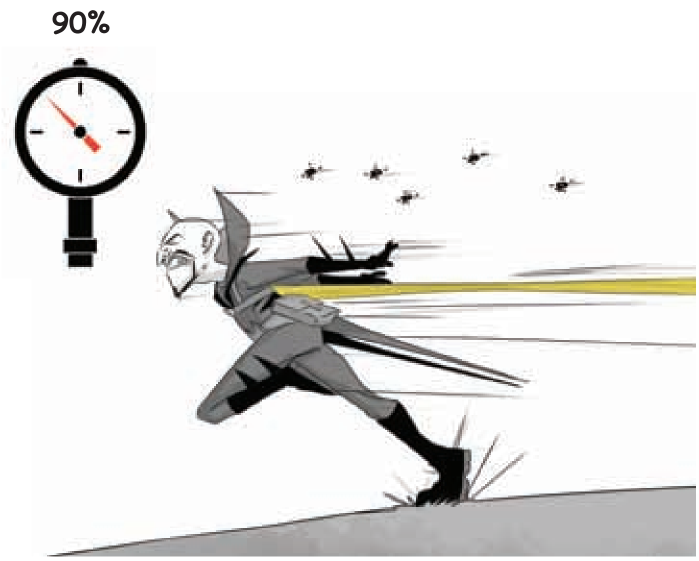
The column endeavours to provide operational guidance to the hazmat/CBRNE community on the selection and performance of equipment and tactics. In this issue, we focus on the use of electrochemical, or e-cell, sensors in hazmat/CBRNE response.

E-cells utilise many different operating principles but the one most commonly used in the hazmat/CBRNE arena is based on amperometry. These operate by measuring electrical current changes due to electrochemical reactions at an electrode surface. The current produced is related to the concentration of the threat material present. E-cell sensors mostly detect airborne contaminants such as chlorine, phosphine, ammonia, hydrogen cyanide and other common toxic gases. Unfortunately, these devices also tend to have significant cross sensitivities and longer response times (few to many seconds). In this product category there are many devices available today, therefore it is critical to understand instrument performance parameters to help in deciding which product best meets your operational needs.



Key performance specifications

Time profiles are an important indicator of system performance and operational utility. Startup time, especially from a cold start or from storage, is an important indicator for ensuring that a sensor can be operational in the required time frame. Response time (t90) is defined as the time in which a sensor reaches 90% of its final value while under a constant challenge. Faster response times are better when making operational decisions, especially those related to exposure control zones and suitability of PPE, such as respiratory protection.



A sensor's limit of detection (LOD) is the lowest concentration at which it can reproducibly detect the target material. The resolution of the measurement is the degree to which the instrument recognises a change in reading. The linear, or measuring, range represents the minimum and maximum value that the sensor is designed to measure. These parameters and others (accuracy, specificity, selectivity, etc) all inform the suitability of the e-cell for your operational setting. The sensor should measure the threat material at the concentration, or concentration range, of interest and respond quickly when it is present.

The two main types of interferences that must be fully characterized by sensor manufacturers are chemical cross sensitivities and interferences. Chemical cross sensitivities are the known positive or negative readings produced by individual, or classes of, gases/vapours other than the target chemical. In this case, the development of correction factors for the cross sensitive materials can be seen as an extra use case for the instrument. Interferences that are due to chemical or physical interactions must be identified as they reduce sensor performance, therefore the sensor should not be used in the presence of these materials.

It is critical that instruments are certified for use in the intended environments. In some cases this requires intrinsic safety certifications. Intrinsically safe instruments prevent sparks and keep temperatures low to ensure that the available energy is too low to cause ignition even in a flammable environment. In the US, the National Electric Code (NFPA 70) defines hazardous locations using the division system in NEC 500 and the zone system in NEC 505. Similar standards exist in Europe (ATEX Directive 2014/34/EU) and internationally (IECEx).

In addition to intrinsic safety, it is imperative that manufacturers provide guidance on the appropriate approach for decontaminating the instrument should it be contaminated with threat materials. Many instruments require dry decontamination, which can be suitable for many threats, but not all.

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Operational considerations

Besides instrument and sensor type considerations, there are other elements to think about such as construction, size, weight and power. These factors also extend to usability like ergonomics, screen size, and screen performance. Collectively, they inform how robust the instrument is and how user friendly it will be for operators.

We are at a time in emergency response where many disparate data sources are available. It is vitally important that we can access the information easily and are able to apply that information across multiple tool sets, including those providing a common operating picture. With that said, data must be accessible in standardised formats and preferably without the use of proprietary software. Instruments must be capable of onboard data logging as well as simple transfers to computer systems. If data could be used for evidentiary purposes, consideration should be given to its security.

Operational applications

Most e-cells are intended to identify specific threat agents, but their cross sensitivity can also be used to give a response advantage. When the identity of the contaminant is uncertain, consider utilising the cross sensitivities to your advantage. Otherwise, be careful that the result displayed only represents that contaminant specified. Use multiple detection techniques for reassurance.

E-cell performance tends to be focused on the concentration range that spans odour thresholds, occupational exposure limits (OELs), acute emergency guideline levels (AEGLs) and immediately dangerous to life or health (IDLH). These values can also be considered action levels for operators. Their low detection range and slower response time in comparison to instruments such as a PID means we need to be more selective about where we apply our instruments. Avoid using them immediately adjacent to an emission source, or where the airborne concentration exceeds the instrument's detection range.

This enables the operator to apply the instrument for:

- Problem identification - Characterise the leak extent, direction and or other issues like sick building syndrome.
- Identification of control zones - Hot zone identification often uses the IDLH as a threshold guide while the warm zone uses the OEL as a threshold guide.
- PPE selection - The selection of respiratory protection uses the odour threshold, OEL, and IDLH as key action levels while chemical protective clothing focuses on dermal notations.
- Decontamination efficacy - E-cells can be applied to demonstrate whether decontamination of people or materials is required and also to determine whether decontamination is a success. Measure immediately downwind from the object of interest and compare the results against action levels.
- Re-occupancy - For buildings that have been evacuated or are used for sheltering in place, community protective action levels (eg protective action criteria, AEGLs, etc) can be applied to reassure the affected community that the building or their local environment is safe to reoccupy.

The Emergency Response Decision Support System (ERDSS, aka Chemical Companion) includes correction factors for most common electrochemical cells within the detector tool and includes worker and civilian protective action levels for ease of implementation.

Stay safe!

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

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