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Opinion
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Specific Approaches to Evaluation of Protection of Protective Devices in Accordance to Concerning Norms

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Introduction

There are a lot ways how to evaluate protection abilities of protective garments which are used in both military and civilian operations. Some of them have more practical importance and some, on the other hand, are more usable for operational commanders for quick determination of time during that soldiers are completely protected against the affection of high toxic compounds especially against them that are classified as chemical warfare agents and toxic industrial chemicals. The basic question is: Is it enough to assess a particular protective garment from the point of related norms or in accordance to very simple method based on determination of so breakthrough time or not?

Middle Paragraphs

In history all specialists used the breakthrough time (BT) for consideration of protective capabilities of protective garments. In accordance to test practice we can introduce some possibilities of definition of the breakthrough time. The first one could be that BT is (in the context of chemical exposure) the time which refers to the time between when a harmful chemical liquid substance touches the outside of a glove or other personal protective equipment and when it breaks the surface to reach the skin in a particular concentration. This definition points to the relatively huge problem that there must be information concerning the particular concentration which is named as a threshold dose in Armies. This information, however, is not commonly available not only for all chemical warfare agents but also for a minimal number of toxic industrial chemicals. This limitation is very important for telling that the result of either chemical reaction or the response of any sensor is related to the time which is close to real value of specific concentration.

Relatively more universal definition of BT is that it can be the period between exposure to any harmful substance and the appearance of its effects. This definition is applicable for both chemical and electro-physical methods. In relation to chemical methods the term of "appearance" would be understood as a color change of special chemical substance which is kept on a specific sorption chemical. As far as electro-physical methods are concerned, this term would be a growth of representative value which could be for example growth of frequency, growth of conductivity and so on. The last definition I mention in relation to BT is very simple and its employment can be very discussable. This one says that it is the time that elapses between the time the challenge chemical first contacts the test specimen. This definition tells nothing about the determination of any outputs which can be expected on the side of protective garment where the toxic chemical compound can occur in any way.

From the text above it is clear that determination of the exact definition of breakthrough time could be very difficult. Some of them are more suitable for chemical methods and some of them are more comfortable for electro-physical methods. For methods which have no analytical outputs is applicable only the last one. This one, however, is quite beyond any application because it is very short and the end of it is missing. It is just clear, that BT is reported in rough bands which reflect the variation of testing results within measuring permeation. The resistance of a protective isolative garment to permeation by a potentially hazardous chemical is determined by measuring the BT and the permeation rate of the chemical through the fabric. For determination of BT is a lot of permeation Test methods in use today. A particular method depends on a number of factors including the country of use for the protective clothing, and the type of chemical (i.e. gas or liquid).

For practical laboratories is better to combine definitions mentioned above with methods come out from specific norms, especially from EN 374-3, ASTM F739 and finally for example EN ISO 6529. In this norm, however not in all of them, the BT is defined as normalized breakthrough time. This application allows comparison of gained test data from different laboratories. This approach can be applied for both categories of laboratories it means for stationary and field ones. Oppl [1] mentions that: "Permeation rate is not used in Europe because it is said that no criteria exist for which amount of a chemical agent on skin is acceptable and which is not". On accordance to our own experiences it is truth.

In many cases, the permeation behavior of mixtures cannot be predicted from test data of the ingredient when these were tested as single substances. The permeation must be understood as the process by which a chemical moves through a protective clothing fabric on a molecular level.

Results we gain in stationary laboratories are recorded as permeation rate. This is the rate at which the hazardous chemical permeates through the test material and is expressed as a mass of hazardous chemical flowing through a fabric area per unit of time i.e. 1,0 $\mu g.cm^{-2}.min^{-1}$ or 1.0 millionth of a gram per square centimeter per minute. The second possibility is evaluation with the help of actual breakthrough time. This time expresses the average time elapsed between initial contact of the chemical with the outside surface of the test material and the detection of the chemical at the inside surface of the analytical device. For specific chemical from the category of chemical warfare agent an actual BT of >480 minutes and a permeation rate of "nd" (not detected) does not mean breakthrough has not occurred. It means that permeation was not detected after an observation time of eight hours. Permeation

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may have occurred, but at a rate less than the minimum detectable permeation rate or minimum detectable permeation rate. This one can vary depending on the chemical or the analytical device or test method. In norm there is also term of normalized BT – this is the average time between initial contact of the chemical with the outside surface of the test material and the time at which the chemical is detected at the inside surface of the test chemical at the permeation rate specified by the appropriate standard.

The key test methods and the normalized permeation rates required are listed in:

- EN374-3 specifies a normalized permeation rate of 1,0 $\mu g.cm^{-2}.min^{-1}$;
- ISO 6529: 2001 allows results to be reported at the normalized permeation rate of 1,0 $\mu g.cm^{-2}.min^{-1}$ or 0,1 $\mu g.cm^{-2}.min^{-1}$;
- ASTM F739 specifies results to be recorded as BT at 0,1 $\mu g.cm^{-2}.min^{-1}$;

In Europe (as specified in EN 14325:2004) either EN374-3 or EN ISO 6529: 2001 can be used for permeation testing, providing the normalized BT is recorded at the permeation rate of 1,0 $\mu g.cm^{-2}.min^{-1}$;

Conclusion

All chemical tests and BTs given relate to laboratory tests on fabrics only. Seams and closures may have lower BTs, particularly when worn or damaged. It is the user's responsibility to select an appropriate garment, gloves, boots and other equipment for the particular use. The operational commander and also the user shall be responsible for determining how long the protective garment can be worn for the particular use and whether it can be suitably cleaned with the help of decontamination for re-use. It is crucial to know that BT alone is not sufficient to determine how long a garment may be worn once the garment has been contaminated. Safe wear time may be longer or shorter than the breakthrough time depending on the permeation behavior of the substance, the toxicity of the substance and the exposure conditions.

References

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