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# GENERAL CONCEPTS OF CHEMICAL WARFARE

In the first of a series of technical bulletins on Chemical Warfare Defense, *Introduction to Chemical Warfare* (TB-11-25), it was noted that, although the use of incendiary materials predated the Christian era, the massive use of toxic chemicals against man was not possible until the development of the chemical industry about the turn of the century. It was also pointed out that, although the United States has always advocated the outlawing of gas warfare, it recognizes the potential threat of chemical warfare in the hands of an aggressor nation. A brief outline of the development of war gases from 1915 through the second World War was presented.

It was stressed that a new war gas should not only be more toxic than previous ones but that, if possible, it should bypass existing protective equipment and attack a different vital organic system. Starting in the first World War with lung irritants and blister gases, the Germans developed in World War II a series of compounds known as the "G series" that attacked the central nervous system by their anticholesterase action.

Before discussing certain war gases that might be used against our civilian population, and protective measures against them, it will be necessary to understand the following terms commonly used in chemical warfare.

## DEFINITIONS

*Chemical Warfare Agent.*—A solid, liquid, or gas which, through its chemical properties, produces lethal, injurious, or irritant effects or an incendiary action; a screening or signaling smoke. Although war gases, incendiaries, and smokes are generally considered as chemical warfare agents, this technical bulletin is concerned primarily with war gases and the following definitions will be confined to them.

*War Gas.*—A toxic or irritant chemical agent, irrespective of its physical state, which meets certain requisites and desirable features.

*Concentration.*—The amount of a war gas present in a unit volume of air. It is usually expressed in milligrams per cubic meter ($mg/m^3$) but formerly it was expressed in ounces per 1,000 cubic feet ($oz/1{,}000\ ft^3$). (One ounce per 1,000 cubic feet is equal to 1,000 milligrams per cubic meter.)

*Contamination.*—The presence of, or act of applying, a war gas in dangerous amounts or concentration, on a person, object, or area.

*Decontamination.*—The process of making any object or area safe for unprotected personnel by absorbing, destroying, neutralizing, or otherwise making harmless the war gases clinging to or around it.

*Decontamination Materials.*—Any substance used to absorb, make harmless, remove, or destroy a war gas.

*Dosage.*—The concentration of war gas to which a man or animal is subjected, multiplied by the length of exposure. Dosage is expressed as Ct., i.e. the product of the concentration of a war gas (C), in $mg/m^3$, multiplied by the time of exposure (t), in minutes. (Exposed subjects may be men, animals, or materials unprotected or protected, according to conditions.) Thus, the Ct. product expresses in a single figure the relationship of concentration and the duration of the exposure of war gases that exert their effects in vapor or aerosol form. These two factors, concentration and time, determine the potential effectiveness of a gas cloud. Since Ct. is a combination of two factors, for most war gases the same physiological effect can be obtained by an exposure to a high concentration for a short time or to a lower concentration for a longer time. For example, exposure to a certain war gas in a concentration of 100 $mg/m^3$ for 10 minutes would produce the same effect as 50 $mg/m^3$ for 20 minutes.

Actually, a person may receive an amount of war gas that is less or more than expected for a given dosage, depending on some of the following variables.

(a) How long the breath is held during short exposure.

(b) Whether the war gas was also absorbed through the skin.

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(c) Whether the war gas stimulated rate of breathing.

(d) Amount of physical exertion at the time of exposure.

(e) Rate and depth of breathing at the time of exposure.

(f) Rate of detoxification, especially if exposure was long.

For the purpose of tabulation, such variables are ignored and the Ct. values are assumed to measure the amount of war gas received by an individual breathing at a normal rate in a temperate climate with average humidity. These values provide a basis for comparison of war gases.

*Lethal Dosage (LCt.).*—The dosage of a war gas that will kill man. The numerical value of the concentration decreases as the time of exposure increases. This value is often expressed as the concentration that is lethal for a 1-minute exposure.

*Gas Casualty.*—From a civil defense point of view, a gas casualty is a person killed or needing immediate medical care in order to survive or carry out important civil defense duties.

*Persistency.*—Length of time a war gas normally remains effective (capable of producing casualties among unprotected personnel) in the open at the area of dispersion.

## REQUISITES AND DESIRABLE FEATURES OF WAR GASES

Requisites of a war gas include the following:

(a) It must be very toxic or irritating.

(b) It must be stable or capable of being stabilized during the period of time between its production and use.

(c) It must be procurable from available raw materials in the quantities required for effective military use.

(d) It must be capable of being disseminated from a device practicable for field use in sufficient concentration on the target to produce the effect desired.

(e) From a civil defense point of view, it must provide a potential enemy with a strategic weapon that will help him obtain his objectives; or give a saboteur an instrument for eliminating key personnel or immobilizing important facilities and installations.

Additional desirable features include the following:

(a) It should be capable of being handled and transported, provided proper precautions are observed.

(b) It should be capable of being produced quickly in existing commercial plants without extensive alterations of existing equipment.

(c) It should have little or no corrosive action on the munition during storage. (Corrosive action of a disseminated war gas, however, is an additional advantage.)

(d) It should possess such inherent properties that complete protection from it is difficult for civilian population. If possible, the war gas should be capable of overcoming our protective equipment.

(e) It should be difficult to detect by ordinary methods prior to the time it initiates physiological effects. (Colorless, tasteless, and odorless chemical agents are desirable.)

(f) The mechanism of action, protective measures, and method of treatment for the war gas should be difficult to determine.

These requisites and the additional desirable features greatly limit the number of potential war gases, and this is very fortunate from a civil defense point of view. Many highly toxic compounds would be useless as war gases due to lack of raw materials in the quantities required for effective military use. These limitations also provide another advantage; most war gases are relatively simple chemical compounds and, therefore, may be readily identified by analytical procedures.

## CLASSIFICATION OF WAR GASES

War gases are classified in four ways—by physical state, tactical use, physiological action, and persistency.

*Physical State.*—Under ordinary conditions of temperature and pressure, war gases may exist as solids, liquids, or gases. The state in which a war gas normally exists determines to a certain extent its tactical use, persistency, physiological action, and the type of munition used for its dispersion.

*Tactical Use.*—From a military point of view, war gases may be classified as casualty gases and harrassing gases; but from a civil defense point of view, casualty gases—those capable of producing serious injury or death in field concentrations—are the most important.

*Physiological Action.*—Although war gases are grouped into choking gases, blood gases, vomiting gases, tear gases, blister gases, and nerve gases, only the last two constitute sufficient civil defense threat to be considered in this technical bulletin.

(*a*) *Blister Gases.*—Those readily absorbed by both exterior and interior parts of the body. Blister gases cause inflammation, blisters, and general destruction of tissue. The vapors attack the respiratory tract; the effects are usually more severe in the upper tract. Eyes are very susceptible to blister gases.

(*b*) *Nerve Gases.*—These are of extreme importance to civil defense; and are those which, when absorbed into the body by breathing, by ingestion, or through the skin, affect the various functions by their primary action on the nervous system of the body.

*Persistency.*—The war gases are classified as follows, according to persistence.

(*a*) *Persistent.*—Those that are effective in

either liquid or solid form at the area of release for more than 10 minutes under field conditions. Persistent gases can be further divided into moderately persistent (effective at the point of release for 10 minutes to 12 hours) and highly persistent (effective at the point of release for more than 12 hours.)

(*b*) *Non-Persistent.*—Those that are effective in vapor or aerosol form at the point of release for less than 10 minutes under field conditions. Since non-persistent war gases offer serious logistical problems to an aggressor, civil defense is concerned mainly with persistent gases.

## PHYSIOLOGICAL EFFECTS

War gases have many physiological effects upon the human body. Some of these effects are harmful and some are harmless. War gases' toxic effects on the human body produce a harmful physiological reaction when applied to the body externally, when breathed in, or when taken internally. Most war gases cause disorganization of the metabolic functioning of the body.

*Odor.*—Some war gases can be identified easily by a distinguishing odor, while others cannot. Unfortunately, persons vary widely in their ability to detect odors and to differentiate between them. Most of the nerve gases are practically odorless; and certainly, under disaster conditions, could not be detected in this manner.

*Median Lethal Dosage* ($LCt_{50}$).—Median lethal dosage is that dosage of a war gas that will kill 50 percent of an exposed group of subjects. It is expressed as $LCt_{50}$ and usually refers to unprotected man. The lethal dosage of a war gas is usually expressed in terms of median lethal dosage. The unit used to express $LCt_{50}$ is milligram minutes per cubic meter. Thus the median lethal dosage of mustard is 1500 mg-min/$m^3$, the exposure time being one minute.

*Rate of Detoxification.*—The rate of detoxification is the rate at which the human body is able to change a poisonous substance into a harmless one. It is an important factor in determining the hazard of repeated exposure to low concentrations of toxic war gases. Some war gases are not detoxified at any detectable rate by the human body. Such war gases are cumulative in their effects. For example, an exposure of one hour to mustard followed within a few hours by another exposure of one hour has approximately the same effect as a single exposure of two hours. Within reasonable limits the disabling or lethal dosage in the case of such war gases is proportional to a time factor.

*Skin and Eye Toxicity.*—Some war gases are highly toxic by absorption through the skin or eyes while others are nontoxic. The blister gases affect all the internal and external body surfaces indiscriminately and are able to exert their full effect through these surfaces. War gases of the "G series" in liquid state exert their full toxic effect through the skin and eyes as well as in vapor state through the lungs.

*Rate of Action.*—There is a wide variation in the rate of reaction to toxic war gases, even to those of similar tactical or physiological classification. For example, mustard causes no immediate sensation on the skin and causes no effect for several hours or even, in a few cases, for 10 to 12 days. On the other hand, lewisite produces an immedate burning sensation on the skin upon contact and blistering in about half an hour. None of the other blister gases are as delayed as mustard in their effects. The nerve gases are characterized by the very great rapidity with which they act. First aid measures, such as administering antidotes, must be carried out within two minutes after a lethal dose of this gas has been absorbed if death is to be averted.

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