CHAPTER 1

INTRODUCTION

101. Definition.

The NATO definition of a chemical agent is: A chemical substance which is intended for use in military operations to kill, seriously injure or incapacitate people because of its physiological effects. Excluded from this definition are riot control agents, herbicides, smoke and flame. Structural formulae and physical properties of some of the more important compounds are shown in figures and tables in the appropriate chapters. Brief consideration of riot control agents, herbicides and smoke and flame materials are also included in this text. It must be remembered that possible new agents are constantly being discovered, and also, that some chemical agents may be used together as a mixture. Toxins are discussed in AMedP-6(B), Part II. From the medical standpoint, toxins could pose similar problems to those produced by chemical agents. By constant vigilance on the part of all medical personnel in looking for new or unexpected syndromes, and by prompt reporting of any suspicious event, the use of new or mixed agents can be discovered.

102. Historical.

a. Chemical agents in the modem sense were first used in World War I, when chlorine gas was released, from large cylinders, in a favorable wind. This surprise operation caused massive casualties, demoralisation of the forces attacked and demonstrated the need for protection from this kind of warfare. The first improvised mask was a cotton pad soaked in sodium thiosulphate, glycerine and sodium carbonate. Subsequently in World War I, a great variety of chemical agents were used by both sides, the most damaging being the blister producing mustard gas. Military clothing, even with a respirator, gave little protection against this agent. Chemical agents were not used in World War II, but at the end of the war stockpiles of newer agents, called “nerve gases,” were discovered. These were found to be effective in much lower concentrations than those agents known up to that time. The standard of training and preparedness of the Services and the fear of retaliation were possible reasons why chemical agents were not used.

b. Between World Wars I and II, mustard gas was used with considerable effect against unprotected troops. Since World War II, there have been several confirmed reports that chemical agents have been used in armed conflicts including the Iran-Iraq conflict.

c. Riot control agents such as CS (tear agent) have been used repeatedly, for example, in South-East Asia to support tactical operations: in particular to flush out guerrillas from hiding and to render places of concealment untenable. These compounds and other tear agents are frequently used as riot control agents by police forces.

d. The advent of nuclear weapons and the fact that chemical agents were not used in World War II did not prevent their use in recent conflicts and do not exclude the possibility of their use in a future war. The effectiveness of chemical agents as tactical weapons was clearly demonstrated in World War I and in the Iran-Iraq conflict. They can equally affect both forward and rear areas. It seems probable that

the nature and severity of casualties may differ in future from those recorded in World War I.

103. General Factors Influencing the Employment and Choice of Chemical Agents.

a. The effective use of any chemical agent is dependent on its physical and chemical properties and on meteorological conditions.

(1) *Persistency*. Chemical agents may be divided into two main categories as follows: Non-persistent and persistent agents.

(a) Non-persistent agents disperse rapidly after release and present an immediate, short duration hazard. They are released as airborne particles, liquids and gases, and intoxication usually results from inhalation.

(b) Persistent agents continue to present a hazard for considerable periods after delivery by remaining as contact hazard or by vaporizing over a period to produce a hazard by inhalation. Non-persistent agents may be made persistent by thickening.

(2) *Effectiveness.* Effectiveness is the capacity of an agent to produce the maximum number of casualties or amount of disruption of operations with the least amount of agent, although other tactical criteria may be used to gauge this effectiveness. "Effectiveness" is a general term which takes in such criteria as suitability, toxicity, irritancy, etc. For instance, of two similar volatile toxic agents, the one which is toxic at a lower dose can be said to be more effective. Similarly, of two irritant compounds, the one which is irritant at a lower dose can be said to be the more effective. Effectiveness is also dependent on the ability of the population attacked to neutralise or counter the effects of agents once they have been delivered. The duration of effectiveness depends on the physical characteristics of the agent, the amount of agent delivered, the weapon system used and the terrain and weather in the target area at the time the agent is delivered and later.

b. The following meteorological factors will influence the duration of effectiveness of chemical agents:

(1) *Winds.* The effect of wind is to disperse agents rapidly in open country. However, dangerous concentrations may remain longer in woods, trenches, dug-outs and built-up areas.

(2) *Temperature.* High temperatures decrease the persistency of agents and cause higher vapour concentrations. Low temperatures increase the persistency of agents. Some agents may freeze thus reducing the immediate contact hazard. There is a danger of carrying such frozen agents on clothing and equipment into a warm building with the subsequent risk of toxic vapour being given off.

(3) *Rain.* Rain disposes, dilutes and promotes hydrolysis of agents. This reduces their effectiveness but does not make them impossible to use.

(4) *Atmospheric Stability.* When the air temperature is higher than that at ground level (a state of inversion), agents in the vapour state will persist for longer periods than when the air temperature is lower than that at ground level (a state of lapse).

104. Characteristics.

a. *Physical.* Known agents cover the whole range of physical properties. Under ambient conditions their physical state may be gaseous, liquid or solid. Their vapour pressures vary from high to negligible. Their vapour densities vary from slightly lighter to considerably heavier than air. The range of odours varies from none to highly pungent or characteristic. They may be soluble or insoluble in water. In the following chapters the physical properties of various agents are given in tables in the appropriate chapter. These may give an indication of the behaviour of the agents in the field with regard to vapour hazard, persistency and possible means of decontamination, etc. Agents with a low boiling point and high vapour pressure tend to be non-persistent. Agents with a high boiling point and low volatility tend to be more persistent.

b. *Chemical.* The only general characteristic of the known agents is that they are sufficiently stable to survive dissemination and transport to the site of their biological action. Their inherent reactivity and stability can vary widely. Some chemically reactive agents denature rapidly, whereas other less reactive agents require, for example, bleach solutions to inactivate them. Solid absorbents (e.g., fullers' earth) are very effective decontaminants but do not denature agents and the potential for off-gassing should be recognised.

c. *Toxicological.*

(1) It should be realised that not all individuals of a species react in the same way to a given amount of agent, some being more or less sensitive as a result of many factors, of which genetic background, race and age are examples. Also, toxicological studies estimate the biological effects of potential agents by different routes of exposure. The physical properties of such materials may affect the toxicological studies since the response of the biological system concerned may vary depending on the physical state of the material.

(2) Studies of the mode of action are related to the development of medical countermeasures and physical protection devices.

105. Terminology.

The terminology used in this manual is as follows:

a. *Dose.* The dose is the quantity of the compound received by the subject.

b. LD_{50}. The LD (lethal dose)$_{50}$ is the dose which kills 5070 of the exposed population.

c. ID_{50}. The ID (incapacitating dose)$_{50}$ is the dose which incapacitates 50% of the exposed population.

d. *Ct (Concentration time).* The Ct is a measure of exposure to a vapour or aerosol. The concentration in the air and the time of exposure govern the dose received, as does rate of respiration. It is assumed that, when the product of concentration and time is constant, so is the biological effect over a limited range of concentration and time. For very short or long exposures the biological effect may vary. Concentration is expressed as $mg.m^{-3}$ and time as minutes, so that the concentration time (Ct) is expressed as $mg.min.m^{-3}$.

e. LCt_{50}: The LCt (lethal concentration time)$_{50}$ is the Ct which will kill 50% of the exposed population.

f. ICt_{50}: The ICt (incapacitating concentration time)$_{50}$ is the Ct which will incapacitate 50% of the exposed population.

106. Routes of Absorption.

Chemical agents may enter the body by several routes and the nature and onset of signs and symptoms may vary accordingly. Gases, vapours and aerosols, when inhaled, may be absorbed through any part of the respiratory tract, from the mucosa of the nose and mouth to the alveoli of the lungs. They may also be directly absorbed by the eye. Aerosol particles larger than 5 µm tend to be retained in the upper respiratory tract, while those smaller than 1 µm tend to be breathed in and out again, although some of these smaller particles may be retained. Droplets of liquid and, less commonly, solid particles may be absorbed through the surface of the skin and mucous membranes. Toxic compounds with a characteristic action on the skin can produce their effects when deposited on the skin as solid or liquid particles. Agents which penetrate the skin may form temporary reservoirs so that delayed absorption may occur. Even the vapour of some volatile agents can penetrate the intact skin and intoxication may follow. Wounds or abrasions (even minor injuries caused by shaving or by chemical depilation) present areas which are more permeable than intact skin. Chemical agents may contaminate food and drink and so be absorbed by the gastrointestinal tract. The penetration of agents by these various routes may not be accompanied by irritation or damage to the surfaces concerned.