# CHEMICAL WEAPONS AND ANTI-CHEMICAL PROTECTION

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* For presentation at the conference Toward a Global Chemical Weapons Convention, Ma'in, Jordan, May 7-9, 1990.

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Introduction. Most kinds of weapons that made their first large-scale appearance in World War I -- machine guns, tanks, aircraft, and submarines -- quickly became mainstays of the world's military establishments. Not so with poison gas. Although massively employed during the war, gas was used in only a few of the approximately 200 wars fought since 1918, and has generally been relegated to the outer fringes of military thought and planning. Recently, with the use of gas in the Middle East and reports that chemical weapons are proliferating beyond the few states that have hitherto possessed them, international concern regarding chemical weapons is on the rise. At the same time, the entire category of toxic weapons appears to be headed for outright prohibition by the Chemical Weapons Convention now in an advanced phase of negotiation in Geneva.

Against this background of conflicting trends, it may be assumed that issues regarding chemical weapons, anti-chemical defense, and chemical disarmament are being considered at high levels in many national governments. Despite widespread current interest, the subject of chemical weapons is one on which there is much ignorance, misinformation, and even disinformation. It seems appropriate, therefor, to begin a conference of this kind with a summary of the technical and operational characteristics of chemical weapons and anti-chemical protection.

Characteristics of chemical weapons and anti-chemical defenses. Modern chemical warfare agents are few in number. Three types are stockpiled by the armed forces of the United States and the Soviet Union. These are the highly lethal organophosphorus nerve agents, first produced but not used during World War II; the blister agents, mainly mustard gas, extensively used in World War I; and the irritant or riot-control agent CS, introduced in the 1950s. None of these agents is new. Even the US binary chemical artillery projectiles now in production release a nerve agent first made for warfare almost 50 years ago.

Why so little change? It is not for lack of searching for improved agents. Since 1915, military and civilian chemists in several countries have screened hundreds of thousands of substances for weapons potential. Despite this effort, nothing has proved superior to the nerve and blister agents now stockpiled.

What are the toxic effects of chemical warfare agents? A droplet of liquid mustard on the skin causes a severe chemical burn that can take weeks to heal. Exposure to mustard vapor, if prolonged, can cause eye and respiratory damage and skin burns, particularly on moist skin. Liquid mustard on the ground evaporates at a rate such that a site heavily contaminated with it can remain hazardous for hours or even days. The effects of mustard are delayed, generally becoming incapacitating only several hours after exposure. Although high dosages can kill, mustard is primarily effective as a casualty-producing agent, not a lethal one. The considerable margin between its incapacitating and lethal dosages is reflected, for example, in the fact that only 2-3% of American and British mustard casualties in World War I were fatal.

Nerve agents are more deadly and can act more rapidly than mustard. About a milligram of the vapor of the volatile nerve agent GB (or Sarin) is almost immediately lethal if inhaled. Because of its rapid rate of evaporation and the relatively low toxicity of nerve agent vapor to the skin, the hazard from GB is almost entirely inhalatory. In contrast, the relatively non-volatile liquid nerve agent VX presents mainly a contact hazard. A small drop, 10-20 milligrams, will kill within several hours if left for more than a few minutes on the bare skin of the forearm.

This is not to say, of course, that these small quantities, milligrams, are militarily significant. Under common meteorological conditions of light wind and a moderately stable atmosphere, as often occurs, for example, at night and in the early morning, approximately one ton of nerve agent GB or approximately 5 tons of mustard delivered in artillery projectiles or bombs would be required to cause heavy casualties to unprotected people throughout an open square kilometer target area. In terms of munitions, this corresponds, for nerve agent GB, to about 300 heavy (155-mm) chemical artillery projectiles or about seven 500-pound chemical bombs. The actual requirements depend on atmospheric stability, wind velocity, temperature, and terrain and can vary by a factor of 10 or more under commonly encountered conditions.

It is of interest to compare the casualty-producing potential of chemical munitions with that of conventional high-explosive munitions. Such comparisons will be strongly affected by the degree of protectedness of the target population and, for chemicals, by local atmospheric conditions. A further complexity in evaluating the effects of chemicals results from the fact that more than a threshold dosage is required to cause casualties. A poorly designed chemical attack may fail to build up a casualty-producing dosage anywhere in the target area. In contrast, even a single fragmentation munition creates a casualty hazard. Nevertheless, for causing casualties to soldiers lacking anti-chemical protection, chemical munitions containing nerve agent or mustard could often be competitive with or superior to an equivalent weight of conventional high-explosive fragmentation munitions and could be much more effective than conventional munitions against troops protected from conventional munitions by fox holes or armor.

The situation is dramatically reversed, if the target personnel are wearing gas masks and protective clothing or if they are in combat vehicles or shelters with filtered air. A properly-fitted gas mask provides complete eye and respiratory protection. Because the eyes and lungs are the most vulnerable parts of the body to chemical attack, the mask is the single most important item of anti-chemical protective equipment. In addition, absorptive or impermeable clothing, such as widely deployed by modern armies, affords protection against liquids and vapors that threaten the skin. A modern personal protective ensemble consisting of mask, overgarment, gloves, and overboots gives essentially complete protection against all known chemical warfare agents. In this respect, gas is unique, for against weapons based on kinetic energy, blast, or flame there exists no similarly effective defense.

The effectiveness of the defense in chemical warfare goes far toward explaining why chemical weapons are seldom used and why such uses as have occurred were, without exception, against forces initially lacking gas masks. The effectiveness of chemical defense also provides a practical explanation of why virtually all modern military establishments deploy gas masks, while only a few have troubled to acquire chemical weapons.

Because personnel with good anti-chemical protection are far less vulnerable to the casualty-producing effects of chemicals than they are to the effects of an equal weight of conventional high-explosive weapons, it would generally be wasteful of logistic and combat assets and effort to deploy and use chemicals rather than conventional munitions for causing casualties. And, of course, chemical weapons have no value for the destruction of combat vehicles, artillery or other equipment or installations.

Rationale and doctrine for chemical weapons. If anti-chemical defense is so effective, why have the US and the USSR produced and maintained large chemical stockpiles, tens of thousands of agent tons on each side? While no analysis of this question would be complete without addressing institutional factors in military procurement decisions, our concern here is with considerations and perceptions of military utility.

Chemical warfare specialists writing between the world wars argued the case for chemical weapons mainly in terms of casualty producing effectiveness. An additional argument, referring particularly to mustard gas, was that chemical casualties were less often fatal than bullet and shrapnel casualties, making them more humane and, at the same time, possibly imposing a greater burden on the medical services of the defender.

After World War II, these two arguments for chemicals lost most of their cogency. First, for nerve agents, the humanity argument did not apply. The slight margin of difference between an incapacitating dose of nerve agent and a lethal dose meant that a high proportion of casualties would be fatal. And for relatively non-lethal agents, such as tear gases, the humanity argument, although still encountered, was always largely specious. In war, as distinguished from civil police actions, non-lethal gases have seldom been used as alternatives to lethal weapons but rather have nearly always been used in conjunction with them, as force multipliers against personnel lacking gas masks. The most recent large-scale illustration of this was the use of riot-control agent CS in combination with conventional munitions in the Vietnam war.

Second, and more important, it came to be realized, as already noted, that against personnel with modern protective equipment and adequate anti-chemical training, chemicals are generally much less effective in causing casualties than are conventional weapons based on kinetic energy, blast, or flame. This was the conclusion of influential studies done under auspices of the U.S. Army in the 1960s. It necessitated a changed rationale for chemical weapons.

Even before that time, indeed in World War I, it was well-recognized that wearing anti-chemical protective equipment and taking other anti-chemical protective measures imposes an additional burden on military units. The principal militarily significant effect of this in a modern war of maneuver would be to slow the tempo of operations. The utility or disutility of chemicals then depends on whether this effect on tempo is sufficient to offset the complications to one's own operations and the reduction of conventional fire power necessitated by maintaining and using chemicals.

<u>Evaluating the military utility of chemical weapons</u>. Wearing anti-chemical protective gear can slow the tempo of military operations for two kinds of reasons. First, masks, gloves, and other protective equipment can interfere with vision, speech intelligibility, and dexterity. In most situations, these effects are minimal and improvements in mask and glove design can reduce them still further. Second, the addition of anti-chemical protective overgarments to the soldier's other clothing reduces the rate at which metabolic heat can be dissipated by convection and perspiration. In cool and temperate weather, this is of little consequence. But in hot weather, it seriously reduces the level of physical exertion that can be undertaken without risk of heat exhaustion, in the form of extreme weakness, loss of consciousness, or even death. The magnitude of this effect may be gauged from the fact that adding the complete U.S. Army personal protective ensemble to the regular battle dress uniform is approximately equivalent to raising the ambient temperature by 10 degrees Fahrenheit.

In hot weather, soldiers in anti-chemical protective posture have three options to avoid becoming heat casualties: Avoid strenuous activity; take frequent rests; or partly open or remove the protective overgarment. Heat exhaustion is unlikely to be a problem at all in vehicles equipped with air cooling. U.S. tanks, for example, have a centralized source of cooled charcoal-filtered air with supply outlets for hose connection to light-weight face pieces worn by the crew.

While it is clear that anti-chemical protective posture must hamper military operations to some degree, this does not tell us in any particular case if the diversion of military assets spent in acquiring, deploying, and delivering chemical weapons is justified by their combat effectiveness, when these assets might be spent doing something else that contributes more to winning.

How then can we assess the overall military utility of using chemical weapons? There are three ways to do it. One is to look at the history of chemical warfare; another is to build mathematical models; and the third is to evaluate field tests in which military units conduct simulated combat operations in anti-chemical protective posture.

Effectiveness of chemicals in World War I. About 100,000 tons of various chemical warfare agents were used in World War I, from the first tentative use of irritants in 1914 and the famous German cloud-gas attack with chlorine at Ypres in 1915, leading on through phosgene and arsenicals to the introduction of mustard in 1917. Chemical weapons caused about 3% of the 15 million casualties on the Western Front. They caused much misery and contributed to the attrition of static trench warfare. Records of German ammunition procurement and of British casualties in Europe for 1917 and 1918 indicate that chemical artillery projectiles and conventional high-explosive projectiles were approximately equal in casualty-producing effectiveness. American records indicate a considerably higher casualty rate for chemicals, but are made suspect by a 1926 Army Medical Department study that attributed a majority of the casualties recorded as chemical to malingering.

In any case, as noted in a detailed study done for the U.S. Army by the Operations Research Office at Johns Hopkins University in 1959, gas was used mainly against troops in fixed positions. When men were ordered out of the trenches and onto the attack, it was concentrated fire from machine guns and artillery that was used to stop them, not gas. High explosive weapons could present an immediate and inescapable threat of casualties to troops advancing in the open, but gas could not, owing to the protection afforded by the mask and, in the case of mustard, which could attack the skin, its slowness of action.

Attrition in trench warfare, as in the huge but futile "preparatory" artillery bombardments at the Somme and Passchendaele, contributed little to military success. The point is that casualty production, never an adequate measure of military effectiveness, becomes even less relevant if the casualties are largely confined to static forces or if they are delayed.

By far the most effective chemical in producing casualties in World War I was mustard, introduced on the battlefield by Germany in June, 1917 and called "The King of Gases". The persistence of liquid mustard meant that sites heavily contaminated by chemical artillery fire could remain hazardous hours or days after the shells stopped falling. Inadequate appreciation of this fact by officers and men greatly magnified the hazard. Most of the British and American mustard casualties resulted from failure to put on the gas mask or from removing it too soon. Substantial numbers of casualties also resulted from skin burns among men remaining for prolonged periods at contaminated sites. Relatively few casualties resulted from passing through contaminated areas and fewer still from direct exposure to liquid mustard from exploding munitions. Although masks could give good protection against the eye and respiratory effects of mustard, the protective clothing then available was not very effective and was not widely deployed, except to certain special high-value relatively fixed units such as gun crews. Neither Allied anti-chemical doctrine and training nor Allied protective clothing managed to accommodate to the threat of mustard before the war ended. Because of difficulties in Allied production efforts, Germany had a monopoly on mustard from the time of its great offensives in the summer of 1917 until the last weeks of the war, in the Autumn of 1918, when French supplies became available. Nevertheless, the extensive and largely one-sided use of mustard by Germany had no evident effect on the course of battle.

The official British history of WWI concluded that "Gas achieved but local success, nothing decisive; it made war uncomfortable, to no purpose." The same conclusion was reached by the Operations Research Office study cited above. And in his "History of the First World War", the British military historian Basil Liddell Hart wrote that gas had a chance to accomplish something when it was first used, but not afterward, owing to the introduction of effective anti-chemical defenses. Despite its massive use, gas was a failure in World War I.

<u>Non-use of chemicals in World War II</u>. Why were chemical weapons not used in World War II? They were used on a limited scale by Japan against China, but they were not used in Europe, even though large stockpiles of mustard and other agents were produced by both sides. It is commonly said that chemicals were not used in World War II because of the threat of retaliation in kind. But reference to the available documents shows this to be an inadequate explanation. Instead, military skepticism regarding the

effectiveness of gas provided an effective prior constraint.

Military staffs generally did not consider chemical weapons to be particularly effective and did not recommend their use to higher authorities. For example, in 1944 Churchill instructed his Joint Planning Staff to examine whether chemical weapons might be useful against the launching of the German cruise-missiles then bombarding England. The report he got back concluded that: "Gas attacks are unlikely to be any more effective than bombing with high explosives..." At the end of the war the commander of the German chemical troops, Generalleutnant Hermann Ochsner, said when interrogated by British Intelligence that: "Gas was not considered a useful weapon compared to other munitions." Of course each side knew that the military forces of the other had good anti-chemical protection.

This is not to say that the threat of chemical retaliation was not also a factor, but rather that skepticism regarding tactical battlefield effectiveness acted to keep military interest in initiating gas warfare at a low level. Moreover, when a policy of retaliation in kind was explicitly declared by Churchill in 1942 and Roosevelt in 1943, it was not the threat of battlefield use but rather that of massive strategic attack on or near population centers that was invoked.

<u>Other conflicts</u>. Poison gas has been used in only a few of the 200-odd wars fought since World War I. In every case the forces attacked with gas initially lacked gas masks. This was so in Ethiopia (1935-36), China (1938-42), the Yemen (1966-67), and in the recent use of gas in the Gulf War.

Some have claimed major battlefield effectiveness for chemical weapons in the Gulf War, but the available facts support the opposite assessment. Against the unprotected and inadequately trained Iranian Revolutionary Guard Militia, the Pasdaran, and against the even less well trained and equipped Basij, gas could well have been locally effective, particularly in its psychological effects. But the small number of battlefield gas casualties claimed by Iran, a very small fraction of the total number of its battle casualties, accords with no more than a minor effect of gas on military outcome. Factors other than the use of gas were far more important to Iraq's achievement of a stalemate after 8 years of war. These include the execution or dismissal of thousands of members of the former professional military establishment by Iran's new revolutionary government and the gross Iranian inferiority in deployable armor, artillery, and aircraft. The scarcity of war supplies became critical as the war dragged on, enforced by a combination of international isolation and financial stringency that prevented Iran from obtaining sufficient weapons, replacement parts, and ammunition. In contrast, these items flowed copiously into Iraq, financed by oil revenues and by grants and loans. According to figures compiled be the International Institute of

Strategic Studies, defense expenditure by Iran actually declined by more than 50% from 1984 to 1987, while that of Iraq held steady. A study of the Gulf War done by the Assembly of the Western European Union concluded that: "Iraq's use of lethal gas...seems to have had only slight tactical effects but constituted a further demoralizing factor for its enemy".

In short, there is no historical evidence from World War I or any of the several other conflicts in which gas was used that it was any more than marginally effective against forces with anti-chemical protective equipment and training.

Modeling the effectiveness of chemical weapons. What about the second way of looking at the utility of chemical weapons, the use of mathematical models and their use in war game simulations? Such models can yield approximate estimates of chemical casualty production against unprotected people. Models can also provide help in calculating quantitative ammunition requirements from given assumptions. But models are of dubious value in evaluating the battlefield utility of chemical weapons against forces with anti-chemical protection. A striking illustration of this occurs in the final report of a large chemical model study done by the BDM Corporation for the US Department of Defense in 1975 which states: "The conclusion of this analysis is that the model predicts degradation in unit mission effectiveness that is quite severe and is not supported by any troop tests or field experiments currently available".

Field exercises. The third way of assessing the impact of chemical weapons, the evaluation of field exercises, can be more realistic than mathematical modeling. Field exercises show that the mission performance of dismounted units engaged in prolonged strenuous effort in hot weather and of units poorly trained and motivated to operate in anti-chemical protective posture is seriously degraded by the wearing of protective gear, especially the protective suit.

In contrast, field exercises in temperate or cool weather with units that have had basic anti-chemical training show little effect of anti-chemical protection on the accomplishment of military missions, even in sustained operations. It may also be noted that under common European weather conditions, military units have routinely exercised at or near full anti-chemical protectedness for several days continuously. While it would be wrong to conclude that wearing masks and suits and taking other precautions is without effect on military operations, the evidence from field exercises does not provide a persuasive rationale for using chemicals against modern battlefield forces.

High-value high-tempo targets. As support for battlefield missions for chemical weapons has eroded, their possible utility for use against certain high-value high-tempo targets has received more attention. Examples of such targets are port installations, ammunition supply centers, and air bases. Of course, other weapons already well-integrated into modern forces, employing blast, flame, and fragmentation, can also disrupt operations at such sites. Again, therefor, the military issue is whether the utility of chemical attack outweighs the diversion of assets it requires.

A case in point is an argument formerly made for U.S. acquisition of the Bigeye binary spray bomb, a weapon that now seems unlikely ever to enter production but whose history is nevertheless informative. The argument envisaged the use of Bigeye to deposit the persistent nerve agent VX on airfield runways also attacked with high-explosive cratering munitions. The rationale for using Bigeye in this role was to slow down the work of runway repair crews, particularly in warm weather, by forcing them to wear suits and masks. But the use in heavily defended airspace of one or more aircraft per mission for the delivery of Bigeye diverts and risks substantial losses of high-value aircraft and air crews. In contrast, the defender can offset the slowing effect that anti-chemical protection has on his runway repair crews in a number of ways, including the assignment of additional labor and equipment to runway repair or decontamination -- labor and equipment assets that are relatively cheap and plentiful on his own territory. The trade-off in using Bigeye to delay runway repair was therefor highly questionable, and could in some circumstances have been to the advantage of the defender rather than the attacker.

Threat to civilians. While chemical weapons have little utility against well-trained and equipped forces, their effects can be devastating for unprotected civilians exposed either deliberately or as a result of down-wind drift from chemical targets. If soldiers have anti-chemical protection but civilians do not, the use of nerve gas in populated areas could kill far more civilians than soldiers.

But here too, anti-chemical protection can make an immense difference. Civilians can be provided with gas masks, shelters, and anti-chemical training, as indeed they are today in a few countries. Early in World War II, tens of millions of gas masks were distributed to civilians in major British cities. As a result, both British and German chemical warfare experts came to the conclusion that gas would be less effective in causing casualties in the air war against London than an equal weight of conventional bombs. Regarding the possible effects of gas delivered by German cruise missiles (V-1 and V-2), each of which could deliver a one-ton payload, the German Chemical Troop Commander, Ochsner, wrote in a 1949 report for the US Army that "there was no room for hope that if the V weapons had been given a gas charge, the effect would have been any greater than that of an explosive charge. Under existing circumstances [of British anti-chemical protectedness] gas casualties undoubtedly would have been less than those caused by explosive bombs." The same conclusion was reached by the British biologist and chemical warfare expert J.B.S. Haldane, who advised US military representatives in 1940 that gas was unlikely to replace high explosives in the German bombing of London then occurring, because "people would soon learn to protect themselves, since they have been educated to it, and all have gas masks".

Of course such protective measures, while relatively accessible in advanced industrialized societies, are less likely to be available and would be much more difficult to institute in less developed regions.

Conclusion. Consideration of the technical and operational characteristics of chemical weapons and anti-chemical defenses and of evidence from historical uses of gas and from field exercises all point to the same conclusion: Against battlefield forces with modern anti-chemical protection, gas is of dubious value in comparison with conventional weapons. As a strategic weapon against military and industrial targets and against civilian populations gas is also likely to be less effective than conventional high explosive bombs and fragmentation weapons unless the target population is without anti-chemical protection. The principal threat of gas is therefore against unprotected forces and populations, especially in the under-developed nations of the Third World where anti-chemical protection is likely to be less available than elsewhere.