

Chapter 4

HISTORY OF THE CHEMICAL THREAT, CHEMICAL TERRORISM, AND ITS IMPLICATIONS FOR MILITARY MEDICINE

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INTRODUCTION

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SUMMARY

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INTRODUCTION

This chapter is the third in the series of historical investigations into the use of chemicals as weapons, following Chapter 2, History of Chemical Warfare, which focuses on the history of chemical warfare on the battlefield, and Chapter 3, History of the Medical Management of Chemical Casualties, which describes the organizational management of the resultant casualties. Over the last 20 years, the nature of the

chemical threat dramatically changed. This chapter outlines the historical progression of chemical weapon development, summarizes how conventional and unconventional agents may be delivered in the contexts of conventional conflict and terrorism, and addresses the status of current chemical warfare capabilities in relation to the evolution and implementation of international chemical warfare agreements.

DEVELOPMENT OF CHEMICAL WEAPONRY

Before World War I, the United States knew little about the potential of chemical warfare, particularly in terms of preparing soldiers for future wars. By the end of the war, the large-scale chemical warfare used by and against American soldiers on the battlefield had drastically changed the situation (Figure 4-1).

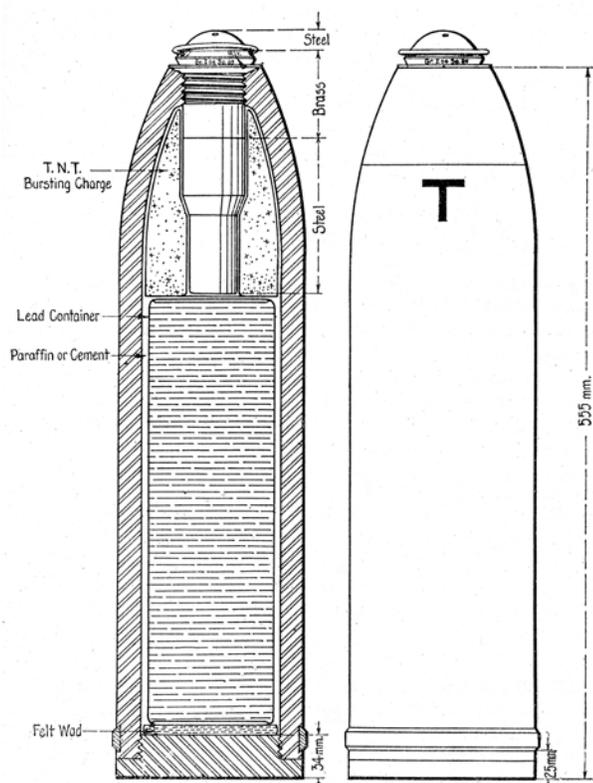


Fig. 4-1. The German 150-mm T-Shell, which mixed xylyl bromide with an explosive charge. The explosive charge was in the front and the chemical agent in the rear compartment. This design is similar to the one proposed in 1862 by John Doughty during the American Civil War. Reproduced from: Army War College. *German Methods of Offense*. Vol 1. In: *Gas Warfare*. Washington, DC: War Department; 1918: 59.

Early History

Few of the chemical agents first used in combat during World War I were 20th-century discoveries. Many of the key agents (Table 4-1) were already known to chemists; they were actually discovered during the 18th and 19th centuries and could have been used on earlier battlefields. The 18th-century finds included chlorine (Cl₂), discovered by Carl Wilhelm Scheele, a Swedish chemist, in 1774. Scheele also determined the properties and composition of hydrogen cyanide (HCN; North American Treaty Organization [NATO] designation: AC) in 1782. In the 19th century, Charles A Wurtz first discovered cyanogen chloride (NATO designation: CK), which was synthesized in 1802 by a French chemist, Comte Claude-Louis Berthollet. In 1812 phosgene (NATO designation: CG) was synthesized by a British chemist, Sir Humphry Davy. Dichlorethylsulphide (commonly known as mustard agent, H, or HS) was synthesized by Cesar-Mansuete

TABLE 4-1
EARLY CHEMICAL WARFARE AGENTS

US Army Code	Agent
Cyanide	
AC	Hydrogen cyanide
CK	Cyanogen chloride
Lung agents	
CG (phosgene)	Carbonyl chloride
DP (diphosgene)	Trichloromethyl chloroformate
Vesicants	
HD (mustard)	<i>bis</i> -2-Chloroethyl sulfide
Tear gas	
CN	2-Chloro-1-phenylethanone
CS	2-Chlorobenzalmalonitrile
Vomiting gas	
DM (adamsite)	10-Chloro-5,10-dihydrophenarsazine

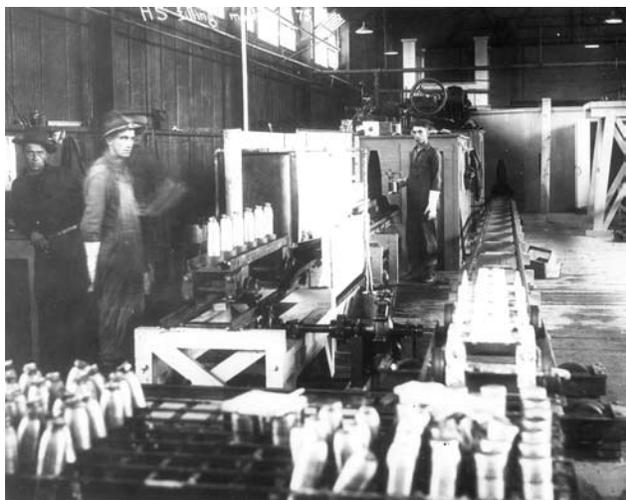


Fig. 4-2. Filling 75-mm artillery shells with mustard agent at Edgewood Arsenal, Maryland. Facilities designed to fill shells with chemical agents were notoriously hazardous. Anecdotal reports from mustard shell-filling plants indicated that over several months, the entire labor force could be expected to become ill.

Photograph: Courtesy of Chemical and Biological Defense Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

Despretz in 1822, by Alfred Riche in 1854, and finally fully identified in 1886 by a German chemist, Victor Meyer. In 1848 chloropicrin (PS) was synthesized by a Scottish chemist and inventor, John Stenhouse.¹

Numerous chemical weapons were used or proposed for use during campaigns and battles prior to World War I (see Chapters 2 and 3). In 1887 Germany apparently considered using lachrymators (tear agents) for military purposes. The French also began a rudimentary chemical weapons program, developing a tear gas grenade containing ethylbromoacetate and proposing to fill artillery shells with chloropicrin.^{2,3}

World War I

Chemical Agent Production

Shortly after entering World War I in April 1917, the United States initiated a large-scale chemical weapons program. Chemical agent production and chemical shell filling were initially assigned to the US Army Ordnance Department, and then to the Chemical Warfare Service (CWS) when it was organized in June 1918. The primary facility for production and filling was Edgewood Arsenal, Maryland, erected in the winter of 1917–1918 (Figures 4-2 and 4-3). The facility was designed to have four shell-filling plants

and four chemical agent production plants. The first shell-filling plant filled 75-mm shells with a mixture of chloropicrin and stannic chloride (designated NC) and Livens projectiles with phosgene. A second plant filled 75-mm shells with mustard agent. Two additional shell-filling plants were started but not completed before the end of the war.

The four agent production plants made the agents thought to be the highest priority for use on the western front in 1917. These were chlorine, chloropicrin, phosgene, and mustard agent. By 1918 the first two were no longer considered critical agents, although chlorine was used in phosgene production. Over 935 tons of phosgene and 711 tons of mustard agent were produced at the arsenal by the end of the war. Government contractors also produced these four agents and lewisite, named after Captain W Lee Lewis, a member of the CWS Research Division. Lewisite, however, never reached the front and was disposed of in the Atlantic after the armistice.^{4,5}

Chemical Weapons

The CWS used foreign technology during the war for offensive weapons (see Chapters 2 and 3). The initial mode of offensive chemical attack was the portable chemical cylinder, designed to hold 30 to 70 lb of agent. To release the agent from the cylinders, soldiers opened a valve and relied on the wind to carry the agent in the correct direction. The resulting cloud could drift many miles behind enemy lines or, if the wind changed, contaminate friendly troops. The British improved on

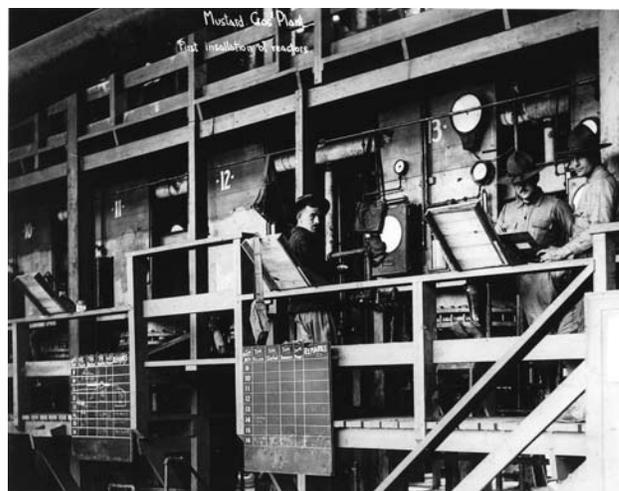


Fig. 4-3. Interior view of the mustard agent production plant at Edgewood Arsenal, Maryland. Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

this delivery system by developing the Livens projector, an 8-in, mortar-like tube that shot or projected a cylinder into the enemy's lines (Figures 4-4 and 4-5). Its range was 1,700 yd, with a flight time of 25 seconds. The Livens system had several problems; a battery of the projectors required extensive preparation because they were electrically fired and could not be moved once they were set up, and a battery could normally only be emplaced and fired once a day. This limited mobility required the element of surprise to prevent the Germans from taking counter measures.

British 4-in trench mortars, called "Stokes mortars" (Figure 4-6), provided a solution to some of the problems with the Livens projectors. Stokes mortars did not require extensive preparation and could be moved as needed. Because it was not rifled, the mortar's range was only 1,200 yd, which meant about a 14-second flight time. The small shell held only about 6 to 9 lb of agent, but experienced gunners could fire 25 rounds per minute. American troops used both Livens projectors and Stokes mortars during the war. An American version of the Stokes mortar failed to reach the front before the end of the war.

In addition to the special chemical weapons, the CWS fired chemical rounds from 75-mm, 4.7-in, 155-mm, and larger caliber guns. Many of these guns had ranges of 5 to 10 miles and payloads of as much as 50 lb of agent. Because of a shortage of shell parts and the

late completion of US shell-filling plants, US artillery primarily fired French chemical rounds.^{2,4,5}

The 1920s

The 1920s brought reports of isolated chemical attacks during the Russian civil war, as well as later accounts of the British, French, and Spanish using chemical weapons at various times during the decade (see chapter 2).⁶ In addition, reports of Italy's developing chemical warfare service particularly alarmed the United States.⁷⁻⁹ The CWS improved various delivery systems for chemical weapons during the 1920s. As early as 1920, Captain Lewis M McBride experimented with rifling the barrel of the Stokes mortar, and in 1924 a rifled Stokes mortar barrel was tested. Truing the inside diameter of the 4-in barrel before rifling expanded the bore's diameter to 4.2 in. This increased the range of the mortar from 1,100 yd (0.63 miles) to 2,400 yd (1.3 miles). In 1928 the improved mortar was standardized as the M1 4.2-in chemical mortar and became the CWS's prized ground weapon for delivering toxic chemical agents as well as smoke and high explosives.⁵

An expanded role for airplanes in the next chemical war was predicted in 1920:

The dropping of gas bombs of all kinds upon assembly points, concentration camps, rest areas and the



Fig. 4-4. A battery of dug-in Livens projectors, with one gas shell and its propellant charge shown in the foreground. Electrically-controlled salvo firing was the usual mode of operation. Emplacement was a slow process that limited the possibility of a surprise attack.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

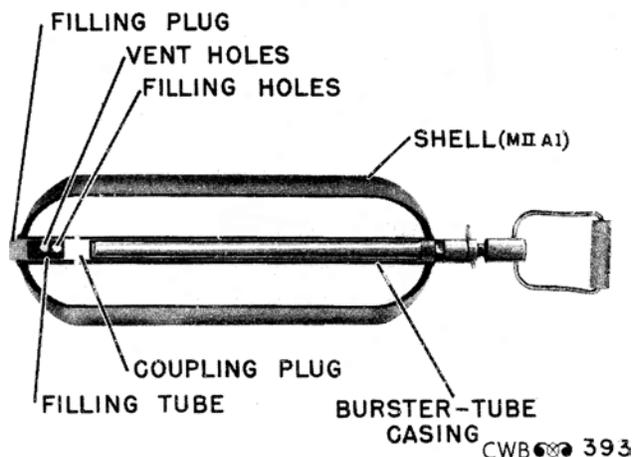


Fig. 4-5. Sectionalized view of a Livens projectile. The central tube contains a small explosive charge, which, when detonated by the contact fuse, breaks the shell, aiding in the dissemination of the chemical agent. The usual weight of the chemical agent was 30 lb; the shell weighed an additional 30 lb. Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.



Fig. 4-6. A complete Stokes mortar with ammunition and accessories for firing.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

like, will be so fruitful a field for casualties and for wearing down the morale of armies in the future that it will certainly be done and done on the very first stroke of war.^{10(p4-5)}

In response to this prediction, the CWS standardized the M1 30-lb chemical bomb, which held only about 10 lb of agent because of its thick shell.² To test the use of airplanes in a chemical war, the CWS simulated chemical attacks against battleships in 1921.¹¹ In 1928 the CWS began stockpiling select chemical agents (see Chapter 2).¹²

The 1930s

New Chemical Agents

The CWS continued to maintain stockpiles of the key World War I chemical agents during the 1930s. In 1935 Captain Alden H Waitt, then secretary of the US Army Chemical Warfare School at Edgewood Arsenal and later chief chemical officer, summed up the CWS's planning for the next war:

Foreign writers agree that at least for the first few months of any war, should one occur within a few years, the gases that were known at the end of the World War would be used. Of these, the opinion is unanimous that mustard gas would be the principal agent and the most valuable. Opinion in the United States coincides with this.^{13(p285)}

In 1937 Edgewood Arsenal rehabilitated its mustard agent plant and produced 154 tons of mustard agent to increase its stockpile. The same year, the phosgene plant was renovated for additional production and the CWS changed phosgene from substitute standard to standard chemical warfare agent.¹⁴

The confidence in these selected agents resulted in the CWS overlooking the development of several key new agents. In the same article quoted above, Waitt wrote:

Occasionally a statement appears in the newspapers that a new gas has been discovered superior to any previously known. Such statements make good copy, but not one of them has ever been verified. Today no gases are known that are superior to those known during the World War. It is unlikely that information about a new gas will be obtained until it is used in war. The chemical agent is too well adapted to secrecy. The only insurance against surprise by a new gas is painstaking research to find for ourselves every chemical agent that offers promise for offensive or defensive uses. It seems fairly safe to say that today mustard gas is still the king of warfare chemicals and to base our tactical schemes on that agent as a type.^{13(p285)}

However, the reign of mustard agent was already ending. In 1935 Kyle Ward, Jr, published an article describing nitrogen mustard, an odorless vesicant agent. The CWS investigated the substance, but found it less vesicant than mustard. It was eventually standardized as HN-1, and while the United States discounted it, Germany took a great interest in the new vesicant.⁵ Germany also developed tabun and sarin in the late 1930s and began production of the new agents by the time World War II began in 1939 (see chapter 2).^{15,16}

New Chemical Weapons

In preparation for a future war, the CWS continued to stockpile chemical agents and weapons, primarily the Livens projectors, Stokes mortars, and portable cylinders, as well as chemical shells for 75-mm, 105-mm, and 155-mm artillery pieces. The production of the new 4.2-in chemical mortar eventually made that weapon the key ground delivery system for the CWS (Figures 4-7 and 4-8). Between 1928 and 1935 the Army attempted to make the 4.2-in a mechanized weapon by mounting it on various vehicles. The CWS also began experiments in 1934 to make the mortar a more versatile weapon by testing high explosive shells as an alternative to chemical rounds.

The improved M1A1 mortar was standardized in 1935. It had an improved barrel, an improved base-



Fig. 4-7. An experimental 4.2-in chemical mortar, showing (1) the standard, (2) the barrel with the shock-absorbing mechanism, and (3) the tie rods connecting the standard to the baseplate. This weapon differed from the Stokes mortar, its predecessor, in that it was easier to set up and it was rifled; the spiral grooves can be seen on the inside of the barrel at its muzzle.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

plate, and a new standard connected to the baseplate by two tie rods for support. The M1A1 had a maximum range of 2,400 yd. Each shell held 5 to 7 lb of phosgene, mustard agent, cyanogen chloride, white phosphorus, or smoke agent.^{2,5} Additional new delivery systems included the first standardized chemical land mine for mustard agent, developed in 1939. Designated the “M1,” this 1-gallon, gasoline-type mine held 10 lb of mustard agent and required a detonating cord to burst the can and disseminate the agent.⁵

The 1940s: World War II and the Nuclear Age

The most important ground weapon for chemical agent delivery during the 1940s was the 4.2-in chemical mortar. In December 1941 there were only 44 chemical mortars on hand, but the supply quickly increased as the demand for the versatile weapon rose. The continued need for greater range, accuracy, durability, and ease in manufacturing resulted in the improved M2 4.2-in mortar in 1943. The M2 had a maximum range of 3,200 yd when standardized, which was later increased to 5,600 yd by modifying the propellant in test firings at Edgewood Arsenal in 1945. Despite a slow start, the M2 series 4.2-in chemical mortar rapidly became the central weapon of the CWS, not only for chemical agent delivery, but also for high explosive, smoke, and white phosphorus rounds. Over 8,000 chemical mortars were procured

by the CWS for chemical mortar battalions during the war.^{5,17} The other offensive weapons for chemical agent attack were to be delivered by artillery or by airplanes. The artillery had 75-mm, 105-mm, and 155-mm chemical rounds that were primarily filled with mustard agent.

In 1945 the CWS standardized the first chemical rockets: a 7.2-in version used phosgene and cyanogen chloride, fired from a 24-barrel, multiple-rocket-launcher platform, and a smaller, 2.36-in rocket fired cyanogen-chloride-filled bazooka rounds.¹⁸ The Army Air Force had 100-lb mustard agent bombs, 500-lb phosgene or cyanogen chloride bombs, and 1,000-lb phosgene, cyanogen chloride, or hydrocyanic acid bombs. The CWS standardized the first good airplane smoke tank, the M10, for air delivery in 1940. This tank held 30 gallons of mustard (320 lb), lewisite (470 lb), or smoke material (Figure 4-9). The system was simple: electrically fired blasting caps shattered frangible seals in the air inlet and the discharge line, allowing air and gravity to force the liquid out; the plane’s slipstream then broke the liquid into a spray. In addition, a newer M33 spray tank could hold 750 to 1,120 lb of mustard agent or lewisite. None of these weapons was used on the battlefield to disseminate chemical agents during the war.^{19,20}

The 1950s: Heyday of the Chemical Corps

In response to the deterrence lesson learned in World War II and the growing Soviet threat (see Chapter 2), the Chemical Corps increased its chemical weapons capacity. Following the discovery of the German nerve agents after the end of World War II, the United States selected sarin for production. The first items standardized in 1954 for air delivery were the 1,000-lb M34 and M34A1 cluster bombs. These clusters held 76 M125 or M125A1 10-lb bombs, each containing 2.6 lb of sarin.²¹ The corps standardized the M360 105-mm and the M121 155-mm shells for ground delivery in 1954. The smaller shell held about 1.6 lb of agent and the larger about 6.5 lb. In 1959 the corps standardized the first nonclustered bomb, designated the “MC-1 750-lb GB bomb.” This was a modified general purpose demolition bomb that held about 215 lb of sarin filling and was suitable for high-speed aircraft.²²

The 1960s

Having concentrated on sarin nerve agent bombs during the 1950s, the corps turned its attention to artillery, rocket, and other delivery systems, particularly for the newly standardized VX (O-ethyl-S-[2(diisopropylamino)ethyl]) nerve agent, in the 1960s. In 1960 the corps standardized the first nerve agent land mine, the M23 2-gallon VX mine (Figure 4-10). This mine resembled the conventional high-explosive



Fig. 4-8. Chemical weapons of the 1920s and 1930s. From left to right: the 75-mm mustard shell; the 4.2-in white phosphorus shell; the M1 30-lb mustard bomb; the Mk II 155-mm mustard shell; the Livens phosgene projectile; and the Mk I portable chemical cylinder.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.



Fig. 4-9. Aerial spraying of a Chemical Warfare School class with tear gas during a training event, 1937. Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

land mine, but held about 11.5 lb of agent. It was designed to be activated either by a vehicle running over it or with an antipersonnel, antitampering fuse.²³

In 1961 the corps standardized two new VX projectiles for artillery. The M121A1 was an improved version of the earlier sarin round. Each round held about 6.5-lb of agent. The M426 8-in sarin or VX projectile held over 15.5 lb of agent.

The early 1960s was the peak of the nerve agent rocket program. The program was first started at the end of World War II to duplicate the German V-2 missiles used against England. The United States eventually developed both short-range and long-range rockets. The corps standardized the M55 115-mm rocket in 1960 for short-range tactical support (Figure 4-11). Described as the first significant ground capability for the delivery of chemical agents since the 4.2-in chemical mortar, the M55 was loaded with 11 lb of VX or sarin nerve agent. When fired from the M91

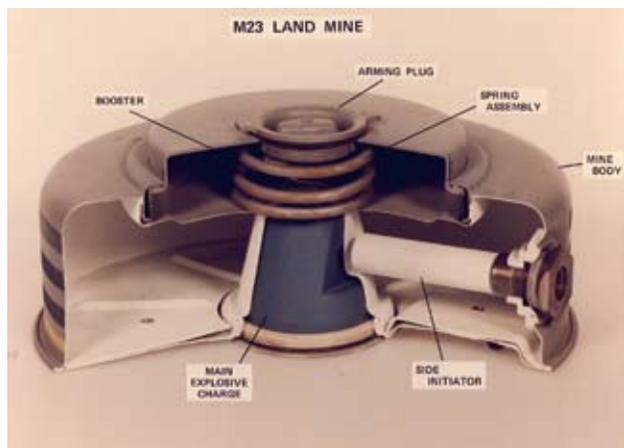


Fig. 4-10. The M23 VX land mine. Most of the interior was intended to be filled with the nerve agent VX. Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

multiple rocket launcher, its range was over 6 miles. Each launcher held 45 rockets that could be fired simultaneously. The Army initially approved 40,000 sarin-filled and 20,000 VX-filled rockets, but many more were actually filled.²³

For middle-range tactical support, the corps standardized the M79 sarin warhead for the 762-mm "Honest John" rocket in 1960 (Figure 4-12). The rocket had a range of 16 miles and the warhead held 356 M135 4.5-in spherical bomblets, each containing about 1 lb of sarin. A smaller warhead was standardized in 1964 for the 318-mm "Little John" rocket, which contained 52 of the improved M139 bomblets, each holding 1.3 lb of sarin (Figure 4-13). The first long-range rocket warhead was standardized the same year for the Sergeant missile system. The missile had a range of 75 miles and the warhead held 330 M139 sarin bomblets. Additional developmental projects added chemical warheads to other long-range missiles, such as the Pershing missile, which had a range of over 300 miles.²⁴

In addition to the rocket program, the corps examined several drones for chemical agent delivery. The SD-2 drone was a slow (300 knots), remote controlled, recoverable drone that could hold over 200 lb of nerve agent. It had a range of about 100 knots and could disperse agent over about 5 to 10 knots. The SD-5 was an improvement that used a jet engine to achieve speeds of over Mach .75 and a range of over 650 knots. The added horsepower allowed it to hold about 1,260 lb of chemical agent that was discharged through a tail nozzle.²⁵



Fig. 4-11. The M55 115-mm rocket could hold the nerve agents VX or sarin, but the aluminum warhead began leaking soon after production. Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

The BZ (3-quinuclidinyl benzilate) incapacitant program also reached weaponization status in the 1960s. In 1962 the corps standardized the M43 750-lb BZ bomb cluster and the M44 175-lb BZ generator cluster. The M43 held 57 M138 BZ bomblets. The M44 held three 50-lb thermal generators, each containing 42 BZ canisters.²⁵

The 1970s: Emergence of Binary Weapons

The end of the chemical weapons production program, as ordered by President Richard Nixon in 1969, stopped all production but left one type of chemical retaliatory weapon still in development: binary weapons, which the Army first investigated in the 1950s. Until that time, chemical weapons were unitary chemical munitions, meaning that the agent was produced at a plant, put into the munitions, and then stored ready



Fig. 4-12. A chemical warhead for the Honest John rocket. It was designed to break apart and disperse the spherical bomblets of nerve agent.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

to be used. Because most agents were extremely corrosive, long-term storage of unitary munitions was logistically problematic.

The idea behind binary munitions was to create nerve agent in the weapon after firing or dropping by mixing two nonlethal chemicals. The two nonlethal chemicals could be stored separately, solving the problem of long-term storage and making handling safer. The Navy initially took more interest in the binary program during the 1960s and requested a 500-lb bomb designated the "Bigeye." In the Army, however, the binary program received high priority only after the production of unitary chemical munitions was halted.

The M687 projectile used a standard M483A1 155-mm projectile to carry the chemical payload. The chemical reactants were contained in two separate, plastic-lined, hermetically sealed containers. These leak-proof canisters were loaded through the rear of the shell and fitted one behind the other in the body of the projectile. The forward canister contained methylphosphonic difluoride and the rear canister contained isopropyl alcohol and isopropylamine solution.^{26,27}

M687 projectiles were shipped and stored with only the forward methylphosphonic-difluoride-filled canister in place to ensure safe handling. A fiberboard spacer occupied the cavity provided for the isopropyl alcohol and isopropylamine solution canister. Projectiles were secured horizontally on a pallet, as opposed to the conventional vertical position used for other



Fig. 4-13. The M139 4.5-in spherical sarin bomblet used in the Little John rocket. The vanes on the outside of the bomblet created a spin, which armed the impact fuse. The explosive burster is in the center, and sarin fills the two outer compartments.

Photograph: Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Maryland.

155-mm projectiles. This orientation permitted rapid removal of the projectile's base with a special wrench. The fiberboard spacers were removed and replaced with the isopropyl alcohol and isopropylamine solution canisters. The fuse was installed just prior to firing. Upon firing, setback and spin forces caused the facing disks on the canisters to rupture, allowing the reactants to combine to form sarin while en route to the target.^{26,27}

The last open air test of lethal agents took place at Dugway Proving Ground on September 16, 1969, when a 155-mm projectile filled with sarin binary reactants was test fired. Throughout the early 1970s additional test firings took place using simulants. In 1976 the Army standardized the M687 binary GB2 155-mm projectile (Figure 4-14).

In addition to the M687, the Army also worked on the Bigeye bomb and other projectiles, including an 8-in projectile. None of these was ever standardized. Standardization of the M687 did not lead immediately

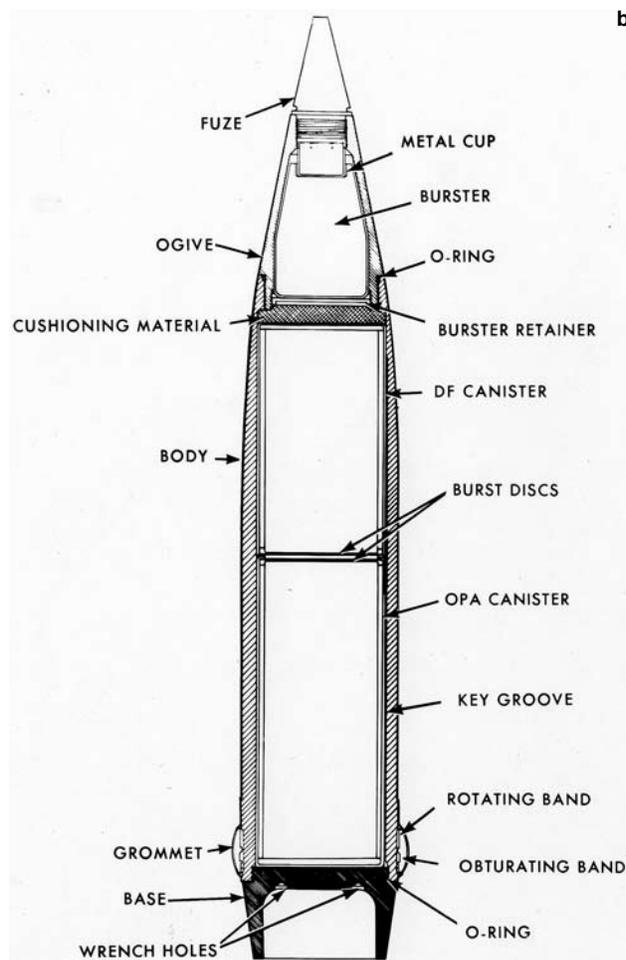


Fig. 4-14. (a) The M687 GB2 binary 155-mm projectile, which was standardized in 1976 but not produced until a decade later. **(b)** A diagram of the M687 GB2 binary 155-mm projectile.

Photograph (a): Courtesy of Research, Development and Engineering Command Historical Research and Response Team, Aberdeen Proving Ground, Md. (b) Reproduced from: Department of the Army. *Binary Chemical Munitions Program*. Aberdeen Proving Ground, Maryland: Chemical Systems Laboratory; 1981: 5. Programmatic Environmental Impact Statement ARCSL-EIS-8101.

to production. In 1976 Congress passed a Department of Defense (DoD) appropriation authorization act that restricted the development and production of binary chemical weapons unless the president certified to Congress that such production was essential to the national interest. The Army took another decade to locate the production plants, pass environmental inspection, receive presidential approval, and begin production of binary chemical weapons.

The 1980s: Production of Binary Weapons

In 1981 the secretary of defense issued a memorandum to proceed with acquiring binary chemical bombs. However, the appropriation restrictions of 1976 blocked procurement of binary munitions for several more years. In 1984 Congress created a chemical warfare review commission to consider several issues related to the military's chemical warfare preparedness. The committee visited numerous sites, interviewed experts, reviewed policy, and examined intelligence reports. Among their findings was the following:

The Commission has concluded, however, that in spite of the approximately \$4 billion that the Congress has appropriated since 1978 for defense against chemical warfare, that defense, measured either for purposes of deterrence or for war fighting utility, is not adequate today and is not likely to become so. Chemical combat as it would exist in the late twentieth century is an arena in which because defense must be nearly perfect to be effective at all, detection is so difficult, and surprise offers such temptation the offense enjoys a decisive advantage if it need not anticipate chemical counterattack. Defense continues to be important to pursue, because it can save some lives and preserve some military capabilities. But for this country to put its faith in defense against chemical weapons as an adequate response to the Soviet chemical threat would be a dangerous illusion.^{28(p50)}

The answer to the problem was simply stated by President Ronald Reagan:

The United States must maintain a limited retaliatory capability until we achieve an effective ban. We must

be able to deter a chemical attack against us or our allies. And without a modern and credible deterrent, the prospects for achieving a comprehensive ban would be nil.^{29(p23)}

In 1985 Congress passed Public Law 99-145³⁰ authorizing production of chemical weapons, and in 1987 President Reagan certified to Congress that all the conditions had been met to start binary chemical weapons production. The production of the M687 binary projectile began on December 16, 1987, at Pine Bluff Arsenal, Arkansas, despite public resistance incited by environmental and safety concerns. To resolve political concerns, the M20 canisters were filled and stored at Pine Bluff Arsenal, while the M21 canisters were produced and filled at Louisiana Army Ammunition Plant. The filled M21 canisters and shell bodies were then stored at Tooele Army Depot, Utah. The parts would be combined when necessary to provide the Army with a chemical retaliatory capability.³¹

In addition to the M687 round, development continued on the BLU 80/B Bigeye bomb and the XM135 multiple-launch rocket system binary chemical warhead. The Bigeye bomb was compatible with Air Force, Navy, and Marine Corps fixed-wing aircraft. The bomb dispersed persistent nerve agent VX after mixing two nonlethal chemical agents, NE and QL. The XM135 binary chemical warhead was designed as a free flight, semipersistent, nerve-agent-dispersing system. The XM135 was fired from the MLRS, a 12-round rocket launcher mounted on a tracked vehicle.³¹

The 1990s: The Threat Materializes

Despite Iraq's chemical warfare use in the 1980s (see Chapter 2), operations Desert Shield and Desert Storm were free of tactical chemical warfare operations, although an accidental chemical exposure occurred in the Army's 3rd Armored Division (see Chapter 3). Counterterrorism agencies also attempted to use some of the items developed by the Chemical Corps in the civilian world. In 1993 the Federal Bureau of Investigation (FBI) decided to use a riot control agent to attack the Branch Davidian compound in Waco, Texas. Fires broke out, destroying the complex and killing 80 occupants, though whether the fire was started from the inside or was the result of FBI tactics remains unresolved.³²

After Waco, many state and local officials told Congress that they did not have the training or equipment to combat a chemical act of terrorism. Senator Sam Nunn of Georgia expressed his concerns, saying, "I, like many of my colleagues, believe there is a high likelihood that a chemical or biological incident will take place on American soil in the next several years."³³

After the Aum Shinrikyo attacks of 1995 and other terrorist incidents that will be described in the next section, the use of chemical weapons for terrorism became a key concern of the Army. In 1996 Congress responded by passing a new antiterrorism training bill to prepare the United States for future chemical terrorism incidents. In addition to using military experts to equip and train local chemical response teams, the bill provided funding for former Soviet republics to destroy their own chemical weapons to keep them out of the hands of terrorists.^{33,34}

HISTORY OF CHEMICAL TERRORISM

Definition of Terms

The term "terrorist" can be traced back to the French Revolution's "Reign of Terror" in the late 18th century, when the French government executed 12,000 people as enemies of the state. After World War II, colonies began to fight for independence, and acts of "terrorism" were one method of attacking the government. In the 1960s and 1970s several terrorist organizations became active, such as the Basque separatists in Spain, the Irish Republican Army in Ireland, Marxist groups in Africa and Latin America, the Baader-Meinhof Gang in West Germany, the Red Brigades in Italy, and the Japanese Red Army. A number of terrorist organizations in the Middle East began operations, most attempting to carry out attacks against Israel and its allies following the Arab-Israeli conflict of 1973. Many Middle Eastern

groups, such as Hamas, Hezbollah, and Al Qaeda, have strong religious connections with extreme Islamic fundamentalism.

The DoD defines terrorism as "the calculated use of unlawful violence or the threat of unlawful violence to inculcate fear; intended to coerce or intimidate governments or societies in the pursuit of goals that are generally political, religious, or ideological."³⁵ Terrorists often target noncombatants to show that no one is safe and to cause the greatest amount of fear. The State Department defines "noncombatants" as civilians and military personnel who are not deployed in a war zone or a war-like setting.³⁶ In addition, military law defines specific members of the armed forces, such as chaplains or surgeons whose duties lie outside combat, as noncombatants. Definitions are important to distinguish true terrorist activities from those of

criminal organizations, pirates, psychotics, disgruntled employees, and covert state operations. Title 22 of the US Code also identifies these key terms:

- terrorism: premeditated, politically motivated violence perpetrated against noncombatant targets by subnational groups or clandestine agents;
- international terrorism: terrorism involving citizens or the territory of more than one country; and
- terrorist group: any group practicing, or which has significant subgroups which practice, international terrorism.³⁷

In addition, domestic terrorism includes activities that “involve acts dangerous to human life that are a violation of the criminal laws of the United States or of any State” that “appear to be intended to intimidate or coerce a civilian population; to influence the policy of a government by intimidation or coercion; or to affect the conduct of a government by mass destruction, assassination, or kidnapping; and occur primarily within the territorial jurisdiction of the United States.”³⁷ While most discussions of domestic terrorism focus on the attempts by terrorist organizations to attack civilians and to influence governments along political, religious, or ideological lines, the potential also exists for lone individuals to attack symbols of the government or the civilian populace (eg, the 1995 Oklahoma City bombing incident and the 1996 Atlanta Olympics pipe bomb incident). Whether they work alone or in groups, the goal of terrorists is to intimidate.

State intimidation through terrorism, or fascism, wherein a village may be exterminated by an oppressive occupier as an example to others, was demonstrated in the 1988 indiscriminate gassing of civilians in Halabja, Birjinni, and other towns in the Kurdish region of Iraq. Over 5,000 citizens lost their lives in these attacks, which were later confirmed by the United Nations (UN) to have been poisoning by sulfur mustard and nerve agent.³⁸ According to Captain Kifah Ali Hassan, director of the Intelligence Center of Kalar, “During the month of March 1988, our aircraft bombed the headquarters of the sabotage bands in the villages of Saywan . . . and Balakajar . . . in a chemical strike. This resulted in the death of 50 saboteurs and the wounding of 20 other saboteurs.”³⁹

Despite the deaths of more than 200 Marines in the Beirut bombing in 1983, the military did not have a clear approach to addressing terrorism until the Khobar towers bombing incident in 1996. This event caused the chairman of the Joint Chiefs of Staff to appoint a deputy director for antiterrorism and force

protection to lead the development of joint doctrine, training, and tactics for antiterrorism efforts. These efforts to protect individuals on military installations and in DoD-owned or leased facilities has been termed “installation preparedness.” Traditionally, installation preparedness has focused on conventional forms of terrorism, such as the use of small, conventional explosives, handguns, knives, and threats of violence or kidnappings. In 2002 the Office of the Secretary of Defense directed an effort to improve the protection of US military installations and facilities against the potential effects of chemical, biological, radiological, and nuclear incidents caused by terrorists. Although each service and combatant command is responsible for addressing and executing antiterrorism efforts within its respective area of responsibility, the DoD focus directed the addition of chemical, biological, radiological, and nuclear defense equipment to installations and facilities. Following a pilot project initiated in the fall of 2002, military installations began to acquire the equipment in the fall of 2004.⁴⁰

Incidents of Chemical Terrorism

Compared to chemical agents, biological agents are decidedly more subtle, and conventional explosives are considerably cheaper and more readily available. Biological agents offer a much wider impact than chemical ones because they can be quietly delivered and it can take days for infection to manifest. Chemical agents, however, are appealing to terrorists because compared to biologicals, chemicals are ubiquitous, inexpensive, and more stable.⁴¹ Chlorine and cyanide are extremely common, and the technology required to produce a nerve agent like sarin is readily accessible to any moderately experienced chemist. Additionally, chemical agents used as weapons, especially nerve agents, are more dramatic than biological weapons. As history has shown, chemical agents can wreak havoc in urban settings; onlookers bear witness to the convulsive sequelae of an insidious chemical poisoning that needs no heralding of an exploding shell.

The general tendency of many terrorism experts is to declare “it’s not a question of if, but when” terrorists will use chemical agents against noncombatants. This view is focused primarily on the vulnerability of unprotected civilians, increased access to education sources, and increased availability of technology with hazardous materials in a global economy. Additionally, pound for pound, chemicals are much more potent than conventional explosives, causing many experts to speculate that terrorists would naturally be interested in weapons that could cause the most casualties. However, despite documented examples of terrorist

interest in chemical warfare agents and the concern of government officials about the impact of a terrorist chemical incident, the actual history of any such incident is minimal.

The Alphabet Bomber (1974)

Muharem Kurbegovic, known as the “Alphabet Bomber,” may be the first lone terrorist to have sought to use chemical warfare agents against citizens on US soil. Kurbegovic, who was apparently mentally disturbed, had a background in engineering and could have posed a greater chemical threat had he not been captured. He threatened to fire chemical-laden artillery shells at Capitol Hill and mailed postcards to each of the nine Supreme Court justices, securing tiny, liquid-filled vials under the stamps and claiming that the vials contained nerve agent (which was later proven untrue). He also detonated a series of bombs in Los Angeles, leaving behind tape cassettes labeled with letters (hence his nickname) that, had he not been captured, were to eventually spell out the name of his fictitious terrorist organization, Aliens of America. A search of his apartment 2 months after his arrest revealed a hidden cache that included 25 lb of NaCN and other chemicals capable of volatilizing cyanide or being assembled to manufacture phosgene or nerve agent.⁴²

The Covenant, the Sword, and the Arm of the Lord (1986)

The Covenant, the Sword, and the Arm of the Lord (CSA) was a paramilitary survivalist group numbering about a hundred people living in the Ozark Mountains in Arkansas. Their ideology was based on a movement known as “Christian identity,” that in part envisioned an apocalypse that would destroy “sinners” and allow believers to survive. CSA had largely been ignored until one of its members allegedly murdered a woman and another killed a Missouri state trooper in 1985. The second incident provoked a massive search, leading to a law enforcement raid on the CSA’s main complex. In addition to a sizeable amount of conventional weaponry, the task force found 30 gallons of potassium cyanide. CSA’s leader initially claimed that the chemical was meant for killing pests, although the group’s second-in-command admitted that the potassium cyanide was obtained to poison urban water supplies. Although the 30 gallons of poison would have been diluted in a large city reservoir, the group was convinced that God would make sure the right people died. CSA appears to have decided on potassium cyanide because it was easy to purchase. Although

its initial attack with potassium cyanide would have been unsuccessful, CSA may have pursued additional attempts to use chemical weapons.⁴³

Aum Shinrikyo (1995)

The story behind Aum Shinrikyo’s use of sarin nerve agent in the Tokyo subway on March 20, 1995, is perhaps the most famous and repeated example of chemical terrorism. It remains the only case of a nongovernmental group successfully manufacturing a modern military chemical warfare agent and using it against unprotected civilians. Aum Shinrikyo, or “Supreme Truth,” was founded around 1987 by Shoko Asahara, a partially-blind guru espousing a faith system that incorporated aspects of Buddhism, Hinduism, and Christianity. Failing to achieve legitimate political influence and reacting to outside pressures, Asahara eventually incorporated an Armageddon involving chemical agents into his teachings, and even predicted his own death by sarin.⁴⁴

Aum Shinrikyo was well-financed, claiming to have a membership of some 40,000 by 1995, including 10,000 in Japan and 30,000 in Russia (where the recent fall of communism had left citizens vulnerable to new spiritual ideologies and charismatic leaders). Well-funded, organized, and centrally controlled terrorist groups are more likely to be capable of acquiring, developing, and implementing a sophisticated chemical warfare capability. The Aum was particularly controlling over its hierarchical structure, and members acquiesced to a “Supreme Truth” that effectively stifled any independent thought or questioning of its authoritarian spiritual leader. The Aum facilitated internal organizational control and intimidated police scrutiny and access to its members and workings in three ways: (1) demanding its members sever all family ties, (2) seeking and acquiring the status of a formal and protected religion, and (3) responding vigorously to any and all criticisms and legal challenges with defamation suits.⁴⁴ Bellicose intimidation, both externally and internally, was routine, and included murder; at least 20 of its members appear to have been killed with sarin or VX.⁴⁵

Asahara had been interested in manufacturing both chemical and biological warfare agents since at least 1990, when cult members began to run for political office. The group researched how to manufacture sarin nerve agent and planned to build a facility capable of producing 2 tons of sarin daily. After failing to cause casualties by attacks with anthrax the group had manufactured, the Aum began using sarin in 1993. On June 27, 1994, the Aum targeted a neighborhood in Matsumoto, about 200 miles northwest of

Tokyo, where three judges were hearing a real estate lawsuit against the cult. The decision seemed likely to go against the Aum, who then decided to murder the judges. Using a modified refrigeration truck that held a heater, an electric fan, and 30 kilograms of sarin, the assassination team arrived at the courthouse too late to intercept the judges. They traveled to the judges' living quarters, an apartment complex, and released the sarin near midnight, spreading a cloud of agent over a 500 by 100-yd area. Seven people were killed and 144, including the three judges, were injured.^{44,45}

In March 1995 the Japanese police planned to raid Aum's major facilities. In an attempt to disrupt the raid, cult leaders decided to attack the Tokyo subway, focusing on subway stations that served key government agencies, including the national police agency. Five teams of two cult members boarded three major lines of the subway, each with two polyethylene bags of 600 g of sarin sealed inside a second bag. Once on board the trains, the terrorists punctured the bags with umbrellas and quickly left. As the sarin evaporated, passengers at more than 15 subway stations were exposed. Twelve people died, 54 were in critical condition, and about 900 required hospitalization (including about 135 emergency responders). More than 5,500 "worried well" individuals stormed to the hospitals, demanding screening and treatments.⁴⁶

Two HCN attacks followed the Tokyo subway incident in an attempt to cause further panic. Cult members also attempted to mix bags containing sulfuric acid and NaCN to release HCN gas in a subway restroom. Over a period of 5 years, the Aum probably attempted to release chemical agent 17 times, including squirting VX and phosgene through keyholes and mail slots.^{47,48}

When police finally raided the cult's chemical agent facility at Kamikuishiki, near Mount Fuji, they found extensive amounts of agent precursors, including around 500 drums of the sarin ingredient phosphorus trichloride, several forklift pallets of sodium fluoride, and isopropyl alcohol. Other chemicals included 34 large containers of acetonitrile, cyanide compounds, and even atropine. Ultimately, around 150 tons of about 40 compounds were reported to have been found, enough to yield 50 tons of sarin. Furthermore, the Kamikuishiki facility may have been capable of manufacturing tabun. The Aum reportedly invested around \$10 million to \$30 million toward the development of a large-scale sarin manufacturing facility and had tried, unsuccessfully, to recruit Russian chemical weapons engineers in the fall of 1994. The building was well-equipped with state-of-the-art components from commercial sources to produce thousands of kilograms

of agent per year.⁴⁹

There may have been plans for cultists to bring sarin into the United States for attacks on Disney World; New York, New York; and Washington, DC. Investigations and hearings on the Aum Shinrikyo incident led directly to the Nunn-Lugar-Domenici Act (within Public Law 104-210, National Defense Authorization Act for FY 1997, dated September 23, 1997⁵⁰). This act directed the DoD to initiate a domestic preparedness program that included training the emergency responders of 120 major cities, creating a rapid response force, and developing an emergency hotline and a nonemergency "helpline," among other initiatives. The FBI and the Federal Emergency Management Agency formalized Presidential Decision Directive 39, issued in June 1995, which outlined federal counterterrorism plans, and created a terrorism annex in the Federal Response Plan in 1997.

The Aum cult was short lived but enormously successful.⁵¹ Immensely wealthy (contributions reportedly reached \$1.4 billion,⁵² Aum Shinrikyo was also well networked, owned extensive property, and had even won the confidence of the head of Russia's national security council. The group had bought access to Russian television and radio, purchased small arms and a retired Russian military helicopter, sought both weapons training and technology, and maintained offices around the world. If its leadership had been less impetuous and aggressive, the group might have developed a functional biological weapons capability and a better chemical agent capability. The Aum was poised to evolve into a global menace.

Cyanide Plot Against the US Embassy, Italy (2002)

In March of 2002 Italian authorities arrested a group of suspected terrorists, most of them Moroccans, apparently plotting to attack the US Embassy in Rome. The group had about 9 lb of potassium-ferrocyanide, a compound used in agriculture, and some explosive powder possibly intended to create the heat necessary to release the cyanide. They were said to possess maps of water pipes leading to the Embassy, although potassium-ferrocyanide will only release cyanide when treated with acid and high temperatures, does not readily permeate tissue cells, and was not expected to have caused significant toxicity if directly applied to the water system.⁵³

William Krar (2003)

In April 2003 federal and state law enforcement agents raided the Noonday, Texas, home and storage units of William Krar and his common-law wife, Judith

Bruey, uncovering a small arsenal of ammunition, pipe bombs, machine guns, remote-controlled bombs disguised as briefcases, pamphlets on making chemical weapons, 2 lb of NaCN, and bottles of hydrochloric, nitric, and acetic acids. The search was ordered after Krar attempted to send false identification documents to a self-described militia member. It is unclear what he was intending to do with the cache found at his storage unit and who else may have been involved.⁵⁴

Al Qaeda

Osama bin Laden, born into a wealthy Saudi Arabian family, formed Al Qaeda, or “the Base,” toward the end of the Soviet Union’s involvement in Afghanistan, around 1988. This organization was dedicated to opposing non-Islamic governments and to driving US armed forces out of Islamic countries such as Saudi Arabia and Somalia. Initially establishing a headquarters in Sudan in 1991, bin Laden set up a number of legitimate front companies to provide income and support to the group’s members, as well as to obtain explosives, weapons, and chemicals. Although terrorist groups had been suspected of seeking to obtain and use chemical weapons for some years, it was not clear what Al Qaeda’s goals were until the publication of a November 2001 interview with bin Laden. A Pakistani newspaper quoted bin Laden as saying, “I wish to declare that if America used chemical or nuclear weapons against us, then we may retort with chemical and nuclear weapons. We have the weapons as a deterrent.”⁵⁵

The US intelligence community acknowledged that Al Qaeda was seeking weapons of mass destruction but believed it possessed neither the weapons nor any means to deliver them. Yet when US forces invaded Afghanistan to attack and defeat Al Qaeda and the Taliban government in October 2002, attempts were made to identify any possible sites at which Al Qaeda might be developing chemical or biological weapons or training people to use such weapons. US Central Command, with support from other government agencies, developed “sensitive site exploitation” units to search for and collect such evidence. No weapons or agent stock were recovered, but training materials, including videos demonstrating the use of toxic industrial chemicals on dogs, were discovered. Symptoms displayed by the dogs, initially judged to be from nerve agent, were probably from cyanide poisoning,⁵⁶ a mode of killing previously revealed in Al Qaeda plots. Later in 2002 reports emerged that Al Qaeda members had acquired old Iraqi VX munitions, a proliferation of concern because UN inspectors in Iraq failed to ac-

count for some 1.5 tons of VX, of which some portion was weaponized.⁵⁷

In April 2004 Jordanian police arrested Al Qaeda operatives in a plot involving 20 tons of chemicals, purchased for \$170,000. The chemicals, which included a large amount of sulfuric acid, were speculated to be intended for deadly explosions in the city of Amman.⁵⁸

Once openly able to attract and train Islamic militants to disseminate its terrorist missions, Al Qaeda’s infrastructure has been under pursuit and, without the protection of a national benefactor, remains clandestine and unlikely to be able to establish a highly structured base of operations. Hence, the current Al Qaeda model contrasts sharply with Aum Shinrikyo in that its adherents often appear loosely connected by time spent in training camps, exposure to common indoctrination and technical manuals, and shared religious contacts and extremism. They are more likely to engage in chemical terrorism in an opportunistic way, as seen in their attempt to poison the water supply of the US Embassy in Rome. However, local Al-Qaeda-affiliated groups have shown the ability to implement coordinated attacks, and the possibility of orchestrated attacks, such as that of September 2001, cannot be discounted.⁵⁹

Accidental Battlefield Exposure in Operation Desert Storm

An unclassified analysis by the Central Intelligence Agency⁶⁰ lists all potential chemical agent releases that may have occurred in the context of the first Persian Gulf War. In March 1991, after the conclusion of Operation Desert Storm, US Army demolition teams destroyed captured Iraqi munitions in bunkers and pits in the same way it eliminated conventional arms in similar situations. In 1996 it was determined that two Khamisiyah sites contained 122-mm rockets weaponized with a mixture of sarin and cyclosarin. Although no symptoms of nerve agent exposure were noted at the time, a considerable modeling and research effort was initiated by the DoD to evaluate possible exposure dosage and long-term health effects of low-level nerve agent exposure.

Initial 1997 atmospheric modeling studies⁶⁰ of the plume associated with the demolition indicated that the prevailing winds at the time were not directed at any large concentrations of troops and that concentrations of agent were likely many-fold lower than those required to elicit threshold agent symptoms such as miosis. Employing field studies of agent deposition, the studies determined that only shells with charges placed immediately beneath them would have ignited

a rocket's aerosolizing burster tubes. Therefore, aerosolized droplets were largely removed from the model, and most agent was represented as vapor or as pooled liquid in the storage site. Meteorological data, as well as the distribution of soot deposited around the blast sites, was used in the plume model. Several Czech chemical agent detectors that had sounded alarms were not located in the vicinity of the plume.

These conclusions were met with criticism from government and public sectors. In response, further model refinements and better data on topography, ground cover, deposition of agent onto physical surfaces encountered by the plume, nerve agent stability, and soldier deployment positions were incorporated into the studies.⁶¹ The revised models of 2000 also incorporated previously classified information on munitions and agent quantity and quality, including a revision of the number of projectiles from 500 in 1997 to 225. A potentially higher toxicity of cyclosarin (25% of the fill) was also incorporated. The outcome of the 2000 modeling study showed a narrower plume distribution and the conclusions remained effectively unchanged.⁶¹

Although up to 100,000 veterans were involved, epidemiological studies proved unhelpful because of the diversity of reported symptoms and the varied placement of personnel relative to the release site. No increased hospitalization rates were observed,^{62,63} and demographically adjusted mortality rates were not found to be higher than those in the general population; rather, they were possibly lower.⁶⁴ Troops within 50 km of the explosions were found to fare no worse than those deployed further away. Although sarin is not known to be a carcinogen, a 1995 study found a doubling of brain cancer incidence, from 12 to 50 cases/100,000 population, among veterans in the vicinity of the demolition.⁶⁴ However, chemically induced brain cancer within 4 years of exposure is questionable; the data suggest that preexisting conditions may more likely have been the cause.⁶⁵

Overall the general conclusion drawn from model-

ing studies and from reviews of a considerable number of animal studies of low-level agent effects, including one by the US Institute of Medicine,⁶⁶ provide no basis for supporting that personnel in the Khamisiyah area were affected by the detonations. While some low-level exposure impacts were observed in animal studies, many of these employed subsymptomatic exposures at levels much higher than were likely to have been present at Khamisiyah. Furthermore, considering the apparent rapid sequestration of low levels of nerve agent, the estimated low levels of these toxicants are unlikely to reach most tissues.

Chemical Weapons and the Improvised Explosive Device

In 2003 Operation Iraqi Freedom brought US ground forces back into the Iraqi theater. Beginning in May 2004, coalition forces recovered 53 chemical munitions. Based on their physical conditions and residues, all of them appeared to have been part of pre-Operation Desert Storm war logistics. These included mustard, sarin, cyclosarin, and riot control agents. Among these was a 152-mm binary sarin artillery projectile that contained a 40% concentration of sarin; insurgents had attempted to use it as an improvised explosive device. The existence of this weapon raises questions about the number of viable chemical weapons remaining in Iraq and engenders the possibility that an unknown quantity of long-lasting chemical weapons still exists, possibly in binary form.⁶⁷

Iraqi troops uncovered a chemical facility in Fal-lujah and discovered instructions on how to create improvised explosives and disseminate blood agents. In addition to explosive materials, such as various nitrate salts, they found cyanide and hydrochloric acid, along with instructions on disseminating hydrogen cyanide gas and cyanogen chloride.⁶⁸ Also notable was the discovery of a warehouse in Mosul, Iraq, containing 1,500 gallons of unidentified toxic chemicals that could be used to implement an attack.⁶⁹

CHEMICAL WARFARE CAPABILITIES

The Chemical Threat

Thus far this chapter has discussed the development of chemical weapons, as well as the groups and individuals who used (or threatened to use) them. The term "chemical threat" is an attempted measure of enemy capability considering those subjects as well as the following:

- the availability and supply of specific agents,

- the delivery systems that could be used in different battle situations,
- the facilities used to produce these agents and munitions,
- plans and procedures for the employment of such weapons, including training for weapons delivery and handling, and
- the will to use such weapons.

Historically, combatants with chemical warfare

capability were well-equipped for chemical warfare protection; they had defined procedures on decontamination, individual and equipment protection, and detection and surveillance. Because chemical warfare agents are dangerous for the user as well as the enemy, they required that offensive and defensive programs be developed simultaneously. Special military teams (eg, logistical, medical, and chemical corps teams trained to operate in a chemical environment) and the ability to monitor meteorological conditions were characteristic of nations with offensive or defensive programs. In assessing enemy capability, chemical stockpiles, production capacities, and the control of use are evaluated when an offensive or defensive posture is being determined. Such assessments are complicated by the possibility that industrial plants, manufacturing products with peaceful applications, may be “dual use”; that is, their manufacturing processes may be redirected toward chemical agent production.

Over recent decades, the chemical threat has shifted appreciably, from fully structured military offensive and defensive capabilities to more clandestine activities by rogue nations and terrorist elements. Today, the greatest chemical threat comes from the accidental or intentional release of industrial toxicants, a lesson that should be learned from the catastrophe of Bhopal,⁷⁰ and accidents involving extremely common toxicants, such as those involving chlorine in Henderson, Nevada, in 1991⁷¹ and in Graniteville, South Carolina, in 2005.⁷² Although only 11 chlorine railcars are known to have been breached between 1956 and 2006, these cars are extremely common and represent a particularly significant urban threat.⁷³ The widespread acceptance of the Chemical Weapons Convention (CWC)—a near-global chemical weapons ban—and promotion of laws governing chemical export controls⁷⁴ have substantially reduced the risk of national chemical weapon use, though likely possessor nations, such as North Korea, must continue to be monitored for potential clandestine weapons proliferation. Modern chemical threats appear to originate most frequently from rogue groups with little or no sophisticated chemical warfare capability; hence, chemical agent employment from terrorist elements may present differently than they would from nation states. Chemical toxicants can be applied unaltered, or chemical warfare agents can be manufactured virtually undetected in relatively crude laboratories and used to create disruption. Political instability and radicalism heighten these inherent dangers.

National Chemical Warfare Capabilities of Nations

Since World War I, the reluctance of possessor states

to employ chemical weapons has been relatively high. However, the Iraqi precedent, the ineffective world response to Iraq’s use of chemical warfare, and the perceived effectiveness of this use all suggest that the chemical warfare threshold has been substantially lowered. The growing list of states motivated, for reasons of offense or deterrence, to develop relatively low-technology, low-cost weapons of mass destruction greatly increases the likelihood that military personnel will need to contend with casualties of chemical warfare.

On March 15, 1991, an article in *The Washington Post* described the latest annual report of the Office of Naval Intelligence, listing 14 nations with “an offensive chemical-warfare capability.”⁷⁵ The list included Egypt, Israel, Pakistan, and South Korea, four nations that receive large quantities of military aid from the United States.⁷⁵ Four additional nations (Saudi Arabia, Indonesia, South Africa, and Thailand) were purported to possibly possess such a capability, and more nations were believed to be in the process of developing or seeking to develop chemical weapons. In a 1993 US House of Representatives Committee on Armed Services report, 31 nations were mentioned as possessing or having the ability to develop offensive chemical weapons.⁷⁶

Because chemical weapons are less expensive and easier to acquire than nuclear weapons, they are a credible threat from developing nations. The adaptation and incorporation of chemical-agent-containing munitions to conventional or missile delivery systems can give a weaker nation a military threat to counterbalance neighbors with greater conventional capabilities. Nations may initially acquire a limited chemical warfare capability through the transfer or purchase of bombs or artillery-compatible chemical weapons shells. In some cases, unweaponized agent may be transferred.⁷⁷ Alternatively, nations may invest in the development of chemical industries that involve the manufacture or acquisition of chemical precursors or intermediates. In this way, wealthier nations or those under a strong, perceived threat may increase their chemical warfare potential by acquiring the technology and facilities to synthesize agents and incorporate them into munitions compatible with existing or newly acquired delivery systems. Industrial compounds such as organophosphates (pesticides), phosgene, chlorine, and cyanide are not difficult to obtain.

Inevitably, a trickle-down effect occurs in the arms world as aging munitions and weapons systems are replaced and move from the major weapons producers to their client states in developing nations, and from there to other nations. For example, the Soviet Union probably supplied a chemical warfare capability to

Egypt,⁷⁷ which in turn supplied Syria,⁷⁸ which then supplied Iran.⁷⁹ Some weapons systems, especially from the former Eastern Bloc countries, were designed to operate in a chemical warfare theater.⁸⁰

Tactical and Strategic Use of Chemical Weapons

Chemical agents can be delivered by a range of weaponry. Liquid agents may be dispensed with land mines, spray tanks, artillery projectiles, aerial bombs, rocket and missile warheads, or even cruise missiles. This means that all battlefield areas, from front lines to rear reserves, are vulnerable to chemical warfare attack, and medical practitioners should be fully prepared to treat chemical warfare casualties from a variety of locations. Medical personnel must be similarly prepared for the possibility of isolated and spontaneous chemical attacks on both military personnel and civilians in areas subject to low-intensity conflict via acts of terrorism.

To be effective, chemical agents must be efficiently dispersed over their intended targets. Most applications call for large-scale agent distribution over large target areas occupied by, or of interest to, military units. For example, documents recovered from the former German Democratic Republic called for Warsaw Pact forces to employ heavy chemical weapons attacks early in any conflict with the West.⁸¹ Considerable quantities of an agent may be needed to ensure adequate coverage in the face of wind, heat, or agent volatility. Effectiveness is also increased by surprising the enemy and catching them unprotected (eg, unmasked).

Chemical Agent Delivery Systems

The four methods of delivering chemical agents are (1) explosive release, (2) bulk release, (3) base ejection, and (4) spray delivery (Figure 4-15). The most common method is explosive release. Bursts from individual explosive munitions are, effectively, point sources for chemical weapons dissemination. Chemical weapons artillery shells, which serve as smaller point sources, might be laid down in a grid to cover a large area. The same effect could be accomplished with fewer missiles that carry larger payloads and have longer ranges. Agents can also be delivered from multiple explosive point sources using submunitions to cover a larger area or, if detonated in sequence, to lay the agent down along a trajectory line. Such line deliveries may be distributed directly over the target or upwind of the target, preferably perpendicular to the wind.

Bulk release, base ejection, and spray delivery also distribute chemical warfare agents along trajectory lines. In bulk release, the forward covering, or "skin,"

of a warhead is blown off, aerodynamically breaking up the agent via high-speed air flow. In base ejection, an explosive charge causes an internal piston-like action to force the agent out of the back of the warhead, either by pushing it through small apertures, aerosolizing it, or sending it into a high-speed air stream for aerodynamic breakup. Explosive, bulk release, and base ejection methods are primarily suited for the dispersal of liquid chemical agents. For solid agents such as the tear gas CS (2-chlorobenzalmalononitrile) and the incapacitating agent BZ (3-quinuclidinyl benzilate), effective aerosolization is often achieved by pyrotechnic munitions.

Spray delivery is more efficient than the other three methods in providing a very fine aerosolization (with average droplet diameter < 5 μm), which can be inhaled far down into the lungs. This method is particularly suited to toxin delivery, which requires deep inhalation and differs from most chemical agents in that toxins are solids and do not vaporize. Spray delivery requires slow speeds and low altitudes, conditions that render aircraft particularly vulnerable to attack. Spray tanks could also be mounted on trucks or boats, and unpiloted aircraft could be designed to deliver agent. The increased vulnerability of spray-delivery systems makes their use more likely against unarmed or poorly equipped opponents, or on carefully targeted sites under cover of surprise. Spray delivery could also be applied to closed ventilation systems in more focal applications.

From a tactical military standpoint, explosive munitions, the dominant mode of chemical agent delivery, vary with respect to effective agent delivery (Figure 4-16). Explosion of a chemical agent shell at ground level or some height over the target site generates two products: (1) vapor and (2) droplets. Droplets (average diameter range of 100 μm to 1 mm for pure agents) fall to the ground in a fine rain to coat the target surface with liquid.

Agent vapor, which poses the greatest threat for inhalational intoxication, derives from three sources. First, agent vaporizes from explosive burst energy, which varies with shell design and specific agent payload. Shell casing thickness, shell casing material, and the agent-to-burster ratio are all important shell design factors. Second, additional vapor is generated as falling droplets vaporize. Heat from the explosion dissipates quickly, and ambient air temperature is the most important factor driving this volatilization. Third, the liquid coating of agent on the ground evaporates, making ground temperature an important factor. Vapor produced by explosive energy and droplet vaporization is called "primary" vaporization, and that rising from the ground is called "secondary"

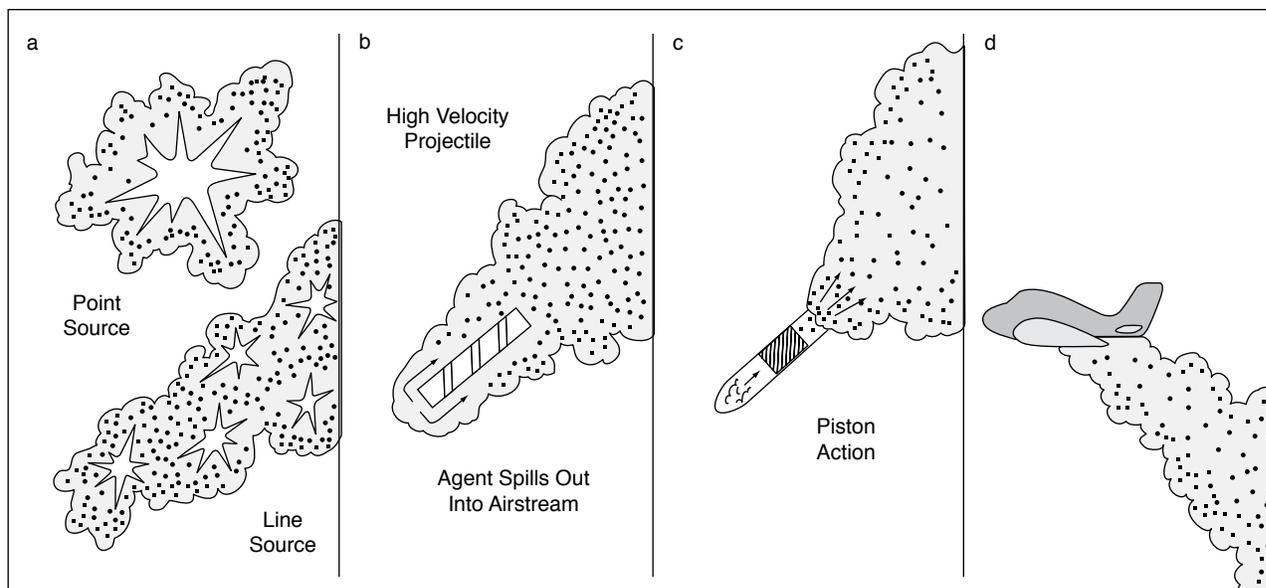


Fig. 4-15. Four modes of chemical agent release. **(a)** Explosive-release devices are predominantly represented among the major chemical warfare arsenals. While some agent is lost to decomposition, their simplicity makes these the weapons of choice. Point-source explosives are single detonation devices, and line-source munitions release a series of time-delayed explosions that lay agent toward the end of the trajectory. **(b)** Bulk-release munitions spill agent into the air stream of the projectile. **(c)** Base-ejection devices are relatively uncommon because of their cost and complexity. Like explosives and bulk-release devices, these munitions can be carried on longer-range missiles. **(d)** Spray delivery can be used to achieve large-area coverage, such as that required for terrain denial. However, because of aircraft vulnerability, spray delivery is generally limited to application on undefended territory or against a poorly defended foe.

vaporization.

A scenario in which chemical agent shells are dropped on a desert area at different times of the day can be used to demonstrate the differences in agent threat caused by liquid persistence and deposition versus vaporization. The influence of wide environmental temperature fluctuations over the 24-hour cycle, combined with the agent used, can make a substantial difference: increased surface deposition and skin-contact threat during cool nights, and a considerably increased inhalational toxicity threat during the heat of the day are expected. Successful employment of chemical agents is influenced by many variables, most notably weather, because the agent is transported by the wind and air currents when released as a vapor or an aerosol. Unfavorable meteorological conditions frequently preclude successful agent deployment because of the inordinately high number of weapons used. Once deployed, the persistence of liquid contamination is affected by temperature, sunlight, wind action, and rainfall.

Military Chemical Agents

Military chemical agents are characterized accord-

ing to several features, including nature of use, persistency in the field, and physiological action. Toxic chemical warfare agents are capable of producing incapacitation, serious injury, and death. These agents are further characterized by their physiological action and are discussed in detail in their individual chapters (Table 4-2). The most common agents in modern arsenals are vesicants and nerve agents. Cyanides and pulmonary toxicants are thought to be represented in some stockpiles, but are typically less toxic and more difficult to employ because of their physical characteristics. Some cyanides and pulmonary toxicants have specific characteristics that make them appropriate for military use, such as rapid rate of action, very low persistency, and the ability to penetrate or damage protective equipment.

Other chemicals present in military arsenals include incapacitating agents, which produce physiological and mental effects, rendering individuals incapable of performing their assigned duties. Recovery may take several hours to several days, although intensive medical treatment may not be required. Riot control agents produce intense effects, such as irritation of the skin, eyes, and respiratory tract, but recovery is normally rapid when exposure is terminated. Some

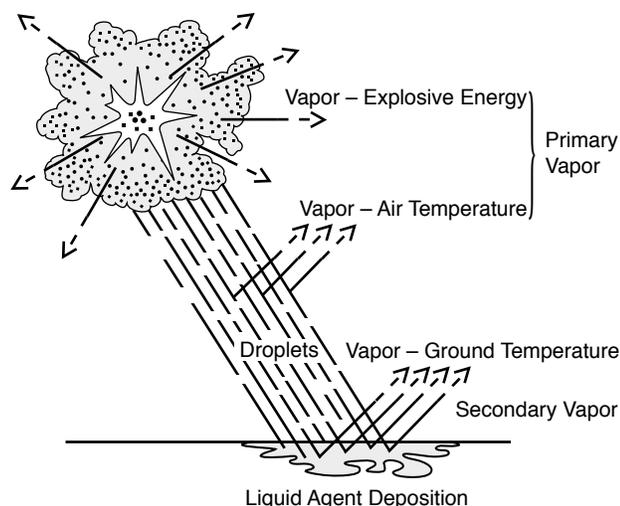


Fig. 4-16. Agent vaporization increases in proportion to energy sources, such as heat from explosive charges or from ambient heat (as measured by air or surface temperatures). Vapor persistence is then determined by weather factors such as wind and humidity. Hydrolysis rates are affected by factors such as temperature and solubility. Agents show characteristic hydrolysis rates in water, and water vapor, as described by humidity, may cause significant hydrolysis of vaporized agent. The vesicant lewisite, for example, shows relatively rapid hydrolysis in water vapor, while the nerve agent VX is more resistant to hydrolysis.

studies provide epidemiological data on CS, such as the 1969 and 1971 Himsforth reports.^{82,83} Additionally, the National Institutes of Health provides data on carcinogen bioassays on both CS and chloroacetophenone.⁸⁴ Unfortunately, little is known about the long-term effects of many of these agents, an area of increasing medical concern. Chemical smoke agents are used to obscure objects or areas from observation or from engagement by weapons with electrooptical control systems. They are usually not toxic in field concentrations, but may cause eye or respiratory irritation in higher concentrations. Some smokes have adverse chronic exposure effects.

Other compounds with military applications include agents used in flame warfare, such as thickeners for napalm and incendiary materials, and herbicides (defoliants). Other highly toxic industrial chemicals also pose a potential risk to the military. The disaster in Bhopal, India, in December 1984, when an estimated 8,000 people died and another 30,000 were injured from breathing methylisocyanate and chlorine released in an industrial accident, is just one of many examples of the devastating effect of poisonous gases.⁸⁵

Chlorine and phosgene are industrial compounds

TABLE 4-2
MODERN CHEMICAL WARFARE AGENTS

US Army Code	Agent
Cyanide	
AC	Hydrogen cyanide
CK	Cyanogen chloride
Nerve agents	
GA (tabun)	Ethyl N,N-dimethyl-phosphoramido-cyanidate
GB (sarin)	Isopropyl-methylphosphonofluoridate
GD (soman)	1,2,2-Trimethylpropyl methylphosphonofluoridate
GF	Cyclohexyl-methylphosphonofluoridate
VX	o-Ethyl S-[2-(diisopropylamino)ethyl] methylphosphonothiolate
Lung agents	
CG (phosgene)	Carbonyl chloride
DP (diphosgene)	Trichloromethyl chloroformate
Vesicants	
HD (mustard)	bis-2-Chloroethyl sulfide
L (Lewisite)	2-Chlorovinyl dichloroarsine
HL	Mustard-lewisite mixture
Incapacitating agents	
BZ	3-Quinuclidinyl benzilate (QNB)
Tear gas	
CN	2-Chloro-1-phenylethanone
CS	2-Chlorobenzalmalononitrile
Vomiting gas	
DM (Adamsite)	10-Chloro-5,10-dihydrophenarsazine

that have been and could again be used as military weapons. Medical personnel should be prepared for such chemical emergencies when military missions are in close proximity to industry. During World War I, the list of chemical agents was expanded to include mustard, phosgene, adamsite, and cyanide.

Physical Properties of Chemical Agents

The physical properties of an agent and its formulation also present important threat considerations. Selection of agents and agent formulations can be used to affect differential impacts with respect to droplet size and liquid deposition, agent persistence, and agent volatility. The classic chemical warfare agents have a wide range of volatility (Table 4-3), and volatility can be a determinant in deciding which agents to use.⁸⁶ Agents such as HCN and sarin are relatively volatile;

they present an immediate but short-lived threat. These agents are referred to as “nonpersistent” because they vaporize rapidly after delivery. Alternatively, agents such as VX and sulfur mustard tend to fall largely in droplets with less vaporization and remain on exposed surfaces for at least 24 hours. These agents are called “persistent.”

Wind is an important consideration in determining the distribution of an agent cloud. As in any fluid-solid interface, the earth’s surface exerts a drag on wind currents. Under a moving cloud, volatile agent concentrations can be expected to mix more slowly at the surface and increase in concentration with height. Vegetation further exacerbates this drag and increases the height of the protective layer in which agent concentration is low.

Formulation is also used to manipulate the fate of an agent. Soman, VX, lewisite, and sulfur mustard can be mixed with thickeners of high molecular weight to increase droplet size and thereby decrease primary vaporization. Such additives are generally used to promote efficient agent deposition on the target site. Thickeners can also increase agent persistence and may hamper decontamination efforts. Adding silica powder to sulfur mustard (“dusty mustard”) can propel the agent in a dust cloud. Stabilizers increase agent shelf life.

Nonpersistent Agents

In tactical use, the threat of nonpersistent, volatile agents, such as HCN or sarin, is greatest to the respi-

ratory systems of unprotected soldiers. A sudden, heavy bombardment of these agents may affect many casualties if unmasked soldiers are caught by surprise. When used against an unprotected force, nonpersistent agents are particularly effective in generating casualties, thereby creating breakthrough points in enemy front lines. Iraq successfully used nonpersistent nerve agent in counterattacks against Iranian forces during 1988.⁸¹ Nonpersistent agents can be used to slow enemy advancement by forcing the enemy to wear protective equipment. They can also circumvent an enemy’s protection against conventional high-explosive munitions and may be used in night attacks to harass troops.

Persistent Agents

Given favorable weather conditions, the use of persistent agents such as mustard and VX may pose a threat for many days. Such agents can deny or interfere with enemy occupation of terrain or equipment use and could be used defensively to protect vulnerable flanks. However, although persistent agents can slow enemy movement, they can also hamper the movement of friendly forces through a contaminated area. Delayed casualties may occur even among protected troops operating in a contaminated area for an extended period. Hence, persistent agents, which can linger as coatings or in puddles for weeks, may not be the agents of choice when occupation of territory by friendly forces is imminent.

Chemical land mines that disperse persistent agent may be used in conjunction with military barrier systems to complicate breaching or clearing the barriers. The mines are typically based on high-explosive mine designs, with several pounds of agent substituted for most of the explosive charge. High-explosive land mines cause contaminated open wounds, primarily on lower extremities, that must be properly decontaminated; decontamination could be more difficult when persistent agents are used.

Sulfur mustard, a blistering agent, tends to linger on skin, promoting percutaneous absorption, and offers strategic benefits besides those considered above. It was used very effectively both during World War I and the Iran-Iraq War to generate thousands of casualties. Although deaths among unprotected sulfur mustard exposure victims are relatively few, mustard casualties can overwhelm medical treatment facilities.⁸⁷ Survivors of other agent exposures stabilize relatively quickly, but mustard lesions demand months of medical care. This was the fate of many thousands of unprepared or poorly equipped Iranian recruits exposed to sulfur mustard agent.

Underscoring the importance of ambient tempera-

TABLE 4-3
COMPARATIVE VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Volatility (mg/m ³) at 25°C
Hydrogen cyanide (HCN)	1,000,000
Sarin (GB)	22,000
Soman (GD)	3,900
Sulfur mustard	900
Tabun (GA)	610
Cyclosarin (GF)	580
VX	10
VR (“Russian VX”)	9

Data source: US Departments of the Army, Navy, and Air Force. *Potential Military Chemical/Biological Agents and Compounds*. Washington, DC: Headquarters, DA, DN, DAF; December 12, 1990. Field Manual 3-9. Naval Facility Command P-467. Air Force Regulation 355-7.

ture and climate, persistence can also change greatly with temperature; sulfur mustard volatility increases nearly 40-fold between 0°C and 40°C. The threat of respiratory intoxication from sulfur mustard, which is always present, is considerably greater at higher temperatures, although its persistence is reduced.

Rapidity of action also factors into agent selection. Volatile agents such as cyanide and sarin can act very swiftly, primarily via the respiratory tract. In general, nerve agent effects follow immediately after exposure, culminating in seizures and death within a few minutes of inhalation, cutaneous dosing, or both. Other agents, such as mustard, lewisite, and phosgene, act only after a delay. For example, both the blistering and the edematous effects of skin exposure to sulfur mustard occur only many hours after contact, and skin exposure to mustard may not be noticed for quite some time. By contrast, lewisite, which is also a vesicant, heralds its presence by immediate pain and irritation.

Choice of Agent and Delivery System

By selecting the appropriate agents, formulations, and delivery systems, a well-equipped military is in a better position to achieve its tactical objectives. Field manuals, such as the now-limited US Army Field Manual (FM) 3-10, *Employment of Chemical Agents*, discuss how chemical munitions could be used separately or integrated with conventional weapons. Chemical warfare agents can be used to cause casualties, harass the enemy, and hamper or restrict the use of terrain. Although an offensive capability no longer exists, FM 3-10 provides useful information on how chemical warfare agents can be used defensively on the battlefield.⁸⁸ In his classic 1937 book, *Chemicals in War*, Brigadier General Augustin M Prentiss, a CWS officer, describes the offensive tactical uses of chemical agents that were in place following World War I.²

CHEMICAL WEAPONS AGREEMENTS

Although world terrorism has shown no signs of recession, the CWC has recently been implemented among nations. This ban is the product of the evolution of ideas driven by 20th-century global conflicts and imperatives. Although the idea of a global agreement to ban the use of chemical weapons actually preceded the development of effective chemical weapons, the rapid development and effective use of chemical weapons during World War I created a more favorable climate for seeking a limited international agreement to restrict agent use in war: the Geneva Protocol. This protocol served as a precursor to the much more complicated CWC treaty.

Development of the Geneva Protocol

The earliest international agreement banning chemical weaponry was the 1675 Strasbourg Agreement between France and Germany, which prohibited the use of poisoned bullets between forces. Later, 19th-century battlefield carnage led to international efforts to protect civilians and reduce the suffering of injured combatants. Initial efforts to improve medical care in the field in the 1860s were followed by the Brussels Convention of 1874, which called for a ban on the use of poison or poisoned weapons. Although never ratified, the Brussels Convention served as a model and catalyst for future international agreements and unilateral policies governing military conduct on the field.

The industrial revolution of the 19th century and technological innovations in weaponry combined to create an atmosphere of insecurity and fear resulting from the prewar buildup of weaponry among Euro-

pean nations. This led to the First Hague Conference of 1899, in which arms control measures were considered but never ratified. Although effective chemical weaponry had yet to emerge, negotiations included language to curb the use of chemicals in warfare: "Three propositions were . . . adopted . . . one forbidding the use of projectiles the sole purpose of which was, on bursting, to spread asphyxiating or deleterious gases. . . ."⁸⁹

Although unsuccessful in implementing arms control, the Hague conferences of 1899 and 1907 established a permanent court of arbitration at The Hague, providing both a future venue for the potential arbitration and peaceful resolution of international disputes and an initial framework for developing multilateral entities, such as the League of Nations and the UN.

The extensive chemical industry of World War I Germany probably provided the impetus for the rapid development of chemical arms. Germany's capitulation led to the 1919 Treaty of Versailles, which imposed a unilateral ban on Germany's use, manufacture, storage, and importation of chemical agents and munitions. However, even with fresh memories of gas warfare and widespread public revulsion to chemical weapons, governments were loathe to part with their own chemical warfare capabilities for fear of having such weapons used against them.⁹⁰

After World War I, armament stockpiles and fresh memories of carnage led the newly formed League of Nations to convene the May 1925 Conference for the Supervision of the International Trade in Arms and

Ammunition. Although the conference was unsuccessful in curbing the international arms trade, a subtext to these negotiations became the well-known Geneva Protocols. In addition to setting international rules governing the protection of civilians and wounded and captured combatants, the Geneva conventions included the first multinational agreement banning the use of chemical weapons.⁹⁰

During negotiations, efforts to implement a ban on the export of chemical agents forwarded by the US delegation were ultimately foundered by issues such as difficulty of import and export verification, extensive and dual use in the chemical industry, and the concerns of inequity raised by nonpossessor nations or those with a less-advanced chemical infrastructure.⁹⁰ These concerns led to the adoption of compromise language, which limited chemical warfare agent use:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilized world; and Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the World are Parties; and To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations. . . .⁹¹

Signed June 17, 1925, for implementation on February 8, 1928, the Geneva prohibition was ultimately signed by 133 “states parties.” Many signatories, including the United States, ratified the treaty on a no-first-use basis. Other nations reserved for themselves the right of first use against a nonsigning nation. Finally a number of nations, including Iraq, a 1931 signatory, limited their application of the protocol to international conflicts, retaining their internal sovereignty.

An inevitable weakness of the Geneva Protocol as a ban is that multinational agreements are difficult to enforce. Chemical weapons use by a weaker nation may elicit intervention by superior external forces, but responding to militarily powerful offenders would be difficult or impossible. Italy’s use of mustard gas in its invasion of Abyssinia (Ethiopia) in 1935–1936 drew no significant repercussions from the League of Nations nor from other signatories, even though both Ethiopia and Italy had ratified the protocol prior to the invasion. The International Red Cross, wishing to retain neutrality during the conflict, declined to testify on the issue before the League of Nations,⁹² and sanctions from the latter were ineffectual.

Excepting the United States and Japan, most major powers ratified the treaty soon after its de-

velopment. Despite being favorably reviewed by the Senate Foreign Relations Committee in 1926, the treaty was kept from reaching a vote by opposition, and it was withdrawn from consideration by President Harry S Truman after World War II. However, like many unratified treaties, signatories generally abide by them without ratification. Warned that the Axis powers might employ chemical weapons, President Franklin D Roosevelt reaffirmed the US no-first-use policy in June 1943. Subsequent US rejections of ratification were based on a stated preference in favor of verifiable disarmament.⁹¹ The US use of defoliant herbicides and riot control agents during the Vietnam War led to further conflicts in interpretation of the protocol and a continued reluctance to sign.

In 1969 President Nixon resubmitted the protocol, affirming a no-first-use policy and offering to ban incapacitating agents under the treaty. Ultimately the US Senate delayed ratification of the treaty until January 22, 1975, when the Ford administration proposed a version that retained a more limited use of herbicides and riot control agents, promising neither would be employed in first use in war.⁹¹ Herbicide application was limited to defensive perimeters around military installations, and riot agents were generally limited to quelling prisoner disturbances, reducing civilian injuries, implementing rescues, and supporting rear echelon defensive responses by besieged convoys.

The United Nations Disarmament Committee

Nuclear, chemical, and biological stockpile accumulation in the context of the political and armed conflicts of the Cold War created momentum for the development of effective dialogue toward the eventual negotiation of disarmament treaties. Although conventional weapons issues and nuclear proliferation and testing took precedent over chemical weapons arms control, the implementation of the Eighteen-Nation Disarmament Committee by the UN General Assembly in 1962 provided a forum for discussions addressing all aspects of disarmament, including chemical weapons. This body, initially composed of eight nonaligned and five aligned nations each from the Eastern Bloc and Western sides, was renamed several times as membership expanded, and became instrumental in developing workable positions in support of chemical and biological arms control.⁹³

The Biological Weapons Convention

Because military biological capabilities were much

less developed than chemical ones, negotiating a treaty for biological pathogens and toxins posed a much greater probability of success. Chemical weapons were already widely distributed among large and small nations as a valued retaliatory deterrent in the event of a chemical weapons attack or an attack by a stronger aggressor. Extensive and intrusive verification and assurance mechanisms would have to be developed, a challenging demand for hostile and mistrusting Cold War adversaries. Linking the seemingly intractable problem of chemical arms to the more manageable biological weapons issue caused considerable deliberative conflict, although treaty negotiations ultimately arrived at the Soviet Union's position: chemical and biological arms control would be linked as they had been in the Geneva Protocol.

In 1969 and 1970 President Nixon facilitated discussions by declaring a unilateral ban on the offensive development of biological warfare agents, including toxins. Deliberations leading up to the Biological Weapons Convention of 1972 resulted in formal language that provided an impetus for discussions toward eliminating the much more extensively developed chemical warfare capabilities of Eastern Bloc and Western nations:

Article IX: Each State Party to this Convention affirms the recognized objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.⁹⁴

The treaty, negotiated by the UN, called for confidence-building measures through the exchange of technical and scientific information and material support. It also set the framework for the provision of future data exchanges and negotiations toward the elimination of chemical weapons.

US-Soviet Weapons Destruction Agreement

With the fall of many of the communist governments in Eastern Europe and improved relations with the Soviet Union, the United States and Soviet Union signed a bilateral chemical weapons destruction agreement on June 1, 1990. In support of this agreement, the secretary of defense canceled most of the new chemical retaliatory program and the Army decided to suspend its new binary chemical production faci-

ties in 1990.^{76,95,96}

The Chemical Weapons Convention

The Eighteen-Nation Disarmament Committee was expanded in 1969 and renamed the "Conference of the Committee on Disarmament," and in 1984 renamed the "Conference on Disarmament." In 1980 a Conference of the Committee on Disarmament working group was tasked to design an acceptable text for a convention banning chemical weapons.⁹⁷ Over the 12-year period of its development, the CWC treaty involved consultation with military and chemical industry representatives, which led to carefully defining regulated chemicals and working out effective inspection and verification procedures.

A high-level state department meeting in 1989 formalized mechanisms allowing for visits, data exchanges, and challenge inspections required for a demilitarization treaty, including that for chemical weapons. On May 13, 1991, US President George Bush advanced his 1989 plan before the UN to destroy 98% of the US stockpile of chemical weapons in the first 8 years of a new, proposed treaty. Under the new treaty's conditions, Bush pledged to destroy all US chemical weapons within 10 years and never to use chemical weapons again.⁹⁸ However, anticipated difficulties in chemical weapon demilitarization and destruction might prolong the presence of chemical weapon depots. This message sent a clear challenge to other nations to eliminate their chemical weapons. The Bilateral Verification Experiment and Data Exchange Agreement, nicknamed the "Wyoming MOU" (Memorandum of Understanding), called for visits and data exchanges in 1990, followed by further data transfer and a limited number of challenge inspections in 1994. A final chemical weapons treaty draft was submitted to the UN General Assembly in June of 1992. The Organization for the Prohibition of Chemical Weapons (OPCW), located in The Hague, was to be responsible for overseeing the CWC treaty. The CWC was convened in Paris in 1993 and the treaty was implemented in April 1997. The United States ratified the treaty on April 24, 1997, a few days before it went into effect.⁸⁷

By April 2006 178 nations, or "states parties," had ratified the CWC. Eight nonsignatory states remain, including the Syrian Arab Republic, Egypt, Iraq, Somalia, Lebanon, and North Korea (Democratic People's Republic of Korea). Eight states have signed but not ratified the treaty, including Burma (Myanmar) and Israel.⁹⁹ The treaty leaves in doubt the development and use of chemical warfare agents by developing nations or nonsigners of such agreements, most notably Libya, Iraq, and North Korea. Chemical warfare treaty

ratification by nations such as Iran that border nonsignatories may prove difficult in the short term.

The CWC is a complicated document because it was designed to effect the demilitarization of chemicals that may be in widespread commercial use while minimally impacting the world's extensive chemical industries.^{100,101} Its basic tenets are listed in Article I:

Article I General Obligations:

1. Each State Party to this Convention undertakes never under any circumstances:
 - (a) To develop, produce, otherwise acquire, stockpile or retain chemical weapons, or transfer, directly or indirectly, chemical weapons to anyone;
 - (b) To use chemical weapons;
 - (c) To engage in any military preparations to use chemical weapons;
 - (d) To assist, encourage or induce, in any way, anyone to engage in any activity prohibited to a State Party under this Convention.
2. Each State Party undertakes to destroy chemical weapons it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.
3. Each State Party undertakes to destroy all chemical weapons it abandoned on the territory of another State Party, in accordance with the provisions of this Convention.
4. Each State Party undertakes to destroy any chemical weapons production facilities it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.
5. Each State Party undertakes not to use riot control agents as a method of warfare.¹⁰¹

The authors of the CWC sought to implement many of the concepts discussed in the development of the Geneva Protocol and incorporate the concerns and caveats of its signatories. The CWC bans the use of chemical weapons proliferation and requires the timely destruction of all chemical weapons manufacturing facilities, weaponized and unweaponized agent, and any devices or structures specifically intended for chemical warfare. Negotiations leading to the development of the CWC involved industry representatives early in the process, creating multiple lines of communication and accommodating both industrial and arms control interests. Some of these representatives came forward to support the document's ratification in the

US Senate.¹⁰⁰

The CWC defines chemical capability in terms of chemical weapons and chemical weapon production facilities (Table 4-4). The term "chemical weapon" denotes everything that is specifically manufactured for conducting chemical warfare, ranging from small machined parts to bulk-stored agent and agent weaponized mines, spray tanks, and projectiles. The order of priority for chemical weapons destruction depends on the type or presence of agent. The CWC also includes riot control agents and biological toxins.

Declarations, Scheduling and Order of Destruction

Within 30 days of acceding to the CWC, a nation or "state party" must declare all of its chemical weapons and facilities that have made chemical weapons at any time since 1946, any old or abandoned chemical weapons (including those abandoned on the territory of another state party), and plans for the destruction of chemical weapons and facilities.

The CWC requires the elimination of all chemical weapons and chemical weapons facilities over a 10-year schedule (Table 4-5). Destruction of schedule-1 and non-schedule-1 manufacturing facilities must

TABLE 4-4

CHEMICAL WARFARE CONVENTION SCHEDULE AND CATEGORY OF CHEMICALS AND CHEMICAL WEAPONS

Schedule 1 chemicals	Chemicals that have no or little purpose other than to be used in chemical warfare. Examples: nerve agents, sulfur mustard.
Schedule 2 chemicals	Chemicals that have limited commercial use or precursors, such as thiodiglycol, a precursor to sulfur mustard.
Schedule 3 chemicals	Chemicals, such as phosgene, that can either be used as weapons or in the manufacture of chemical weapons and have legitimate large-scale industrial uses.
Category 1 CWs	CWs containing schedule 1 chemicals.
Category 2 CWs	All weaponized schedule 2 and 3 chemicals.
Category 3 CWs	Unfilled munitions and CW-specific devices and equipment.

Data source: Carpenter WD. How industry came to support the CWC. *OPCW Synthesis*. November 2000.

commence by 1 year after accession and be completed 10 and 5 years later, respectively. The schedule was designed to activate at a date when a large portion of the world's nations had ratified and acceded to it to promote a mutual, gradual rate of "leveling out" over the 10-year implementation period. The time schedule allows for the development, testing, and sharing of destruction technologies, and for confidence building. Disparities in arsenal size and economies are partially reduced through international technology exchange and financial assistance. States parties can request extensions for up to 5 years.

Having agreed to the CWC in April 1997, the United States and the Russian Federation had to eliminate all category 2 and 3 chemical weapons by April 2002 and category 1 chemical weapons in phases by 2007. Nations acceding to the CWC after April 1997 must implement this time schedule relative to their implementation date.

Inspection and Verification

Over 3,200 inspections were conducted by February 2008. They are minimally intrusive, although the treaty does allow for challenge inspections in which any state party can request the immediate "challenge" inspection of the facilities of another state party. Challenge inspections cannot be refused by the state party being investigated and are done with as little warning as possible. Schedule 1, 2, and 3 site inspections are negotiated under facility agreements by the technical

secretariat to be minimally inconvenient and disturbing, employing detailed, advanced scheduling and arrangements. Advanced notice is generally given between 36 and 48 hours. By December 2006 over 9 years had passed without a challenge inspection, likely due to the largely unfettered access of inspectors to declared sites.¹⁰² The CWC language strives to reduce tensions, build confidence, and promote international liaisons and cooperation. Because this spirit is central to both process and progress, challenge inspections are deemed less an implementation tool than a last resort.

Noncompliance

In the event of noncompliance, article VIII of the CWC instructs the executive council to seek corrective actions by the offending state party. Depending on the latter's response, the executive council may variously involve the conference or, in the event of a crisis, it may inform but bypass the conference and bring its concerns directly to the UN General Assembly or Security Council. For example, following complaints of poor compliance with article VII, the OPCW demanded that states parties implement domestic legislation and controls consistent with the objectives of the CWC by November 2005.¹⁰³

Issues in Implementation

An appeal was raised in 2003 by 60 former OPCW officials, diplomats, negotiators, legal scholars, and scientists to reinvigorate the unique spirit that convened to create the CWC. This public appeal, directed at the states parties and citizen observers, expressed concern over the fundamental lack of candor and the politicized direction in which the OPCW was implementing the CWC. It also protested that national governments were becoming complacent, failing to seek ratification or enact domestic laws supporting the CWC. Wealthier states parties were accused of undermining the CWC timeline by failing to provide timely support to international demilitarization efforts.¹⁰⁴

A number of these criticisms and concerns were summarized and elaborated upon a few years later by Walter Krutzsch, a former technical secretariat official and CWC negotiator.¹⁰⁵ Krutzsch criticized the executive committee for failing to respond to CWC violations, including arbitrary misinterpretation of provisions, violations of OPCW diplomatic immunity, and failures to keep schedules. He suggested that such compliance issues could be resolved in a context of greater public transparency, claiming that the public record, OPCW's *Annual and Quarterly Reports*, diminishes overall CWC accountability by providing only agree-

TABLE 4-5
CHEMICAL WEAPONS CONVENTION
SCHEDULE OF IMPLEMENTATION PLAN

Category 1 Implementation Phase	Percentage of Category 1 Chemicals Destroyed	Years After Entry into Force	From April 1997
	Planning and testing	1-2	April 1999
1	1	3	April 2000
2	20	5	April 2002
3	45	7	April 2004
4	100	10	April 2007

Data source: Organisation for the Prohibition of Chemical Weapons Web site. Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction. Accessed April 22, 2008. Available at: http://www.opcw.org/html/db/cwc/eng/cwc_menu.html.

gate summaries and fails to inform both the public and states parties of the extent of noncompliance.¹⁰⁵

Krutzch went on to explain inspection and verification as described to be unduly influenced through the state parties' control of the budget, greatly limiting the ability of the technical secretariat to prioritize its mission activities. By defining, in the budget, the number of inspections to be held in each schedule category, the technical secretariat had to revisit a schedule 1 site of minimal concern six times, while large numbers of chemical production facilities were disproportionately uninspected.¹⁰⁵

Progress Made Toward Compliance

Unless a nation declares its own state of progress in implementing the CWC, any effort to compile a listing of progress by state party is incomplete because the OPCW generally reports only numbers in aggregate form. Many nations, including smaller ones such as Albania, have or had modest stockpiles and may depend on foreign assistance for their elimination.¹⁰⁶ The OPCW scorecard shows the United States and Russian Federation declared an overall total of 64,260 metric tons of agent. The remaining 167 declarations total an additional 7,055 metric tons of agent⁹⁹ (Table 4-6).

Chemical Demilitarization

The CWC does not specify how chemicals are to be destroyed.¹⁰⁷ It provides language requiring that destruction be completed in a safe manner and in compliance with a state party's environmental regulations. Both incineration and various chemical elimination methods are employed. The CWC requires elimination of the offending chemical; as long as the reaction products are not CWC scheduled compounds, the agent is considered destroyed. Demilitarization is generally a multistep process. VX nerve agent hydrolysis, for example, yields a mixture of schedule 2 products based not on toxicity but on the presence of residual phosphonate alkyl groups. Hence this product is subsequently subjected to further oxidation or biodegradation. A Russian plan incorporated the unwanted products into asphalt. Concrete embedding can also be used.

US Program

The Army has been responsible for destroying leaking or obsolete chemical weapons since it began developing them. In October 1972 Army Materiel Command headquarters formalized the mission through the creation of a Program Manager for Demilitarization of Chemical Materiel, headed by Colonel Samp-

TABLE 4-6

CHEMICAL WEAPONS CONVENTION PROGRESS, FEBRUARY 2008

Total weight of declared chemical agents	~ 71,315 metric tons
Total number of declared munitions/containers	~ 8,679,000 items
Total destroyed agent	~ 27,199 metric tons (38%)
Total destroyed munitions/containers	~ 2,930,000 items (34%)
CWPFs certified as destroyed	42 of 65 declared
CWPFs certified as converted	19
Number of states parties (as of December 2007)	183
Initial declarations received	169
Implementing legislation submitted enacted in all key areas	79

CWPF: chemical weapons production facility
Data source: Organisation for the Prohibition of Chemical Weapons Web site. Accessed: May 16, 2008. Available at: www.opcw.org/index.html.

son Bass. This office was to plan, direct, and control the chemical demilitarization program, including the design, development, and acquisition of special equipment and facilities. Its initial projects included addressing leaking munitions and bulk agent at the nine chemical weapons stockpile sites and Dugway Proving Ground, Utah, in addition to chemical remediation efforts at Rocky Mountain Arsenal, Colorado, and finishing biological warfare agent disposal efforts at Fort Detrick, Maryland. Between 1969 and 1985 the Army destroyed nearly 15 million lb of chemical agents through neutralization and incineration technologies at Rocky Mountain Arsenal alone.

The duties and scope of disposal operations eventually prompted Army leadership to propose that a formal agency take responsibility for chemical demilitarization, which had grown to include developing disposal technologies, building permanent facilities, coordinating with interagency government offices, and running disposal operations. The US Army Toxic and Hazardous Materials Agency began operations in 1978. One of its first major efforts was to build the US Army Chemical Agent Materiel Disposal System at Tooele Army Depot, Utah, as a test facility to develop proven industrial and military processes and equipment and to demonstrate their applicability to large-scale demilitarization facilities. The test facility

was the primary tool for evaluating technologies and processes to destroy chemical munitions and agents between 1979 and 1986. Based on extensive testing and evaluation, the Army decided that a reverse-assembly approach to disassembling the munitions, followed by incineration and treatment of off-gases by a pollution abatement system, should be used for constructing a pilot disposal facility at Johnston Island in the Pacific Ocean.

In the 1980s Congress tied the binary program to the chemical demilitarization program by language that directed the Army to destroy an equal amount of unitary weapons as they built the new binary weapons.¹⁰⁸ In 1985 Congress authorized the Army to execute the binary weapons production with a number of constraints, one of them being the elimination of the existing chemical agents and munitions by September 1994. This language also authorized the creation of a new Army management organization, headed by a general officer, to execute the disposal mission.^{30,38} As a result, the Army's Program Manager for Chemical Munitions (Demilitarization and Binary) was established at Aberdeen Proving Ground on May 1, 1986. In 1987 the binary munitions project split off, and in 1988, the office was renamed the "Program Manager for Chemical Demilitarization."

The US Army Chemical Materials Agency, which assumed the responsibilities of the Program Manager for Chemical Demilitarization in 2003, employs manual and robotic technologies to carry out either high-temperature incineration or chemical elimination. Several of the agency's facilities use high-temperature incineration for agent, explosive, and propellant components. Prototype studies were conducted at Johnston Island (1990–1993), and the technology was then transferred to the Tooele, Utah, facility, which commenced operation in 1996. Public unease with incinerator-based technologies resulted in the creation of the Assembled Chemical Weapons Alternatives Program in 1997. Under this DoD program, the Pueblo Chemical Depot in Colorado will neutralize HD with hot water followed by bacterial elimination of the products. At the Bluegrass Army Depot in Kentucky, agent will be hydrolyzed and the hydrolysate subjected to fundamental decomposition under high temperature and pressure. The Newport Army Depot in Indiana became fully operational in 2005, hydrolyzing its nerve agent stocks.

Nonchemical weapons are typically rendered inoperable through mechanical means such as crushing, sawing, or detonation. Contaminated materials are incinerated or chemically decontaminated. The United States has also developed a portable, flatbed-mounted explosive destruction system to destroy old, unstable

chemical warfare munitions.

From a medical perspective, the chemical demilitarization program upholds occupational safety standards enacted to protect workers and maintains public health measures to protect citizens. Both the Environmental Protection Agency (EPA) and the Centers for Disease Control and Prevention (CDC) worked with the Army surgeon general and the Army Center for Health Promotion and Preventive Medicine to develop worker and public health standards in line with similar Occupational Safety and Health Administration and National Institute of Occupational Safety and Health guidance for working with hazardous materials.

For personnel working at the stockpile sites and disposal facilities, the CDC promulgated airborne exposure levels as occupational safety standards for various timeframes and purposes. These include the following limits:

- Immediately dangerous to life or health: the maximum exposure concentration at which one could escape within 30 minutes without any escape-impairing symptoms or permanent adverse health effects.
- Short-term exposure limit: the maximum concentration at which unprotected chemical workers may be exposed for up to 15 minutes.
- Worker population limit: the maximum allowable concentration at which unprotected chemical workers may be exposed for an 8-hour workday and 40-hour workweek over 30 years.
- General population limit: the maximum concentration at which the general population may be exposed continuously, based on exposure 24 hour per day, 7 days per week, over a 70-year lifetime.¹⁰⁹

In addition to protecting civilians and military employees on post, the Army's chemical demilitarization program supports the development and implementation of medical emergency response protocols for any chemical accidents or incidents that involve an off-post exposure hazard. The Chemical Stockpile Emergency Preparedness Program, established in 1988, has funded both on-post and off-post efforts to ensure that state and local emergency responders can react to chemical accidents or incidents, protecting the public living around the stockpile sites. The medical agencies at those sites work to prepare emergency medical technicians and hospitals to receive and treat potentially exposed civilians by providing advice on the procurement of personal protective equipment,

decontamination equipment and practices, and stockpiling medical countermeasures such as atropine injectors.

Additionally, the National Research Council, working with the EPA and the Center for Health Promotion and Preventive Medicine, has developed public safety exposure acute exposure guidance levels (AEGLs) to guide civil decision-makers in determining whether to shelter in place or evacuate the population from the potential hazard effects of a chemical plume. AEGLs exist for hundreds of toxic industrial chemicals, but they have only recently been developed for chemical warfare agents.^{110,111}

- AEGL-1: level above which nondisabling, reversible discomfort may be noted.
- AEGL-2: level above which more serious effects may occur, including possible long-lasting or escape-impairing effects.
- AEGL-3: level above which exposures may become life-threatening or result in death.¹¹²

As the Army's chemical demilitarization program progresses, challenges continue to emerge. With Congress's insistence that the Army use neutralization technologies at four of the eight stockpile sites, the Army must continue to work with the EPA, CDC, and other agencies on liquid waste health risks, in addition to continuing to monitor incineration emissions and comply with emissions standards. To date, the Army has met or exceeded all EPA and CDC

requirements and suggestions. Although leaks and spills have occurred, as the original programmatic environmental impact statement warned, the Army's health safety and environmental record remains unblemished.

Status of US Chemical Weapons Demilitarization

In 1985 there were 29,033 metric tons of chemical agents among the nine stockpile sites and an Army depot in Germany (the contents of which were sent to Johnston Island in 1990) (Table 4-7). By 2008 demilitarization by the US Army Chemical Materials Agency and its predecessor, the Program Manager for Chemical Demilitarization, had successfully disposed of nearly 60% of the original, predeclaration stockpile without incurring serious injury or placing the public at risk. The prototype Johnson Island demilitarization facility eliminated its chemical weapons by 2000 and is now closed. The Tooele facility has eliminated over 70% of its sizeable nerve agent stockpile. Chemical agent destruction at Aberdeen, Maryland, was completed in 2007. The Anniston, Alabama, and Umatilla, Oregon, facilities came on line in 2003 and 2004, while the Pine Bluff, Arkansas, and Newport, Indiana, sites commenced operations in 2005. The United States eliminated 45% of its declared stockpile of category 1 agents in 2007, meeting its first milestone. In 2006 the United States requested an extension of the 100% destruction deadline to the treaty limit of 2012.^{113,114}

TABLE 4-7
US STOCKPILE AGENT DESTRUCTION *

Site	Metric Tons Originally Declared	Percent of Stockpile	Declared Metric Tons Destroyed	Percentage Destroyed	Agents
Aberdeen, Md	1,471	5.3	1,471	100	HD
Tooele, Utah	12,121	43.9	8,705	71	GB
Anniston, Ala	2,045	7.4	867	42	GB, VX, HD
Umatilla, Ore	3,374	12.2	1,085	32	GB, VX, HD
Pine Bluff, Ark	3,492	12.7	528	15	GB, VX, HD
Newport, Ind	1,152	4.2	823	84	VX
Pueblo, Colo	2,371	8.6	0	0	HD
Lexington, Ky	475	1.7	0	0	GB, VX, HD
Closed sites	1,098	4.0	1,098	100	GB, VX, HD
Total	27,599	100.0	9,431	34	

*Status as of March 23, 2008

Status of the Russian Federation Chemical Weapons Demilitarization

By far the most challenging chemical weapon demilitarization is taking place in the Russian Federation, which inherited its chemical weapons stocks from the Soviet Union. The Russians declared 32,480 metric tons of nerve agents (sarin, soman, VX), and another 7,700 metric tons of vesicants (sulfur mustard, lewisite, and combined sulfur mustard-lewisite) at seven storage sites¹¹⁵ (Table 4-8).

Russian destruction of chemical weapons employs a two-step chemical inactivation and detoxification strategy. The CWC time schedule for agent destruction applies to the first chemical step, which eliminates the agent, although the resulting product residues require further treatment.

The establishment of the Russian chemical destruction program in 1996, set to take place at seven facilities, was followed by several years of delay due to economic instability and a lack of intragovernmental coordination, which undermined the willingness of outside nations to offer financial aid. Program planning was lacking in technological detail, scheduling, and cost analysis. Further issues included poor public transparency, bureaucratic unresponsiveness, burdensome and expensive visa requirements, and contracting issues.¹¹⁶ In 2002 the G8 Global Partnership against Proliferation of Weapons and Materials of Mass Destruction encouraged other nations to support Russia in eliminating

its vast chemical stockpile. Since that time, with the increased obligation of foreign funds from the United States and other (mostly European) nations and the strengthening of the Russian economy, the Russian program has undergone profound development, most notably since 2004. Russia increased its investment in chemical agent demilitarization from \$186 million in 2004 to real and projected spending on the order of a billion dollars each year for the 2007–2009 period. The country also met the CWC's 1% and 20% destruction milestones on schedule.^{117–119}

By the end of 2007 Russia estimated that its elimination program would total about \$7.18 billion, of which \$2 billion would be provided by other nations. The US commitment to the overall effort, totaling just over a billion dollars, is limited to constructing a CW elimination facility at Shchuch'ye. By 2007 foreign funds had contributed about \$430 million to Russia's chemical demilitarization program, with \$240 million expected the following year. The country has substantially funded its own program. Of the three sites having achieved operational status by 2007, the Maradykovsky facility was entirely internally funded. Germany provided extensive support for the cost of the Kambarka and Gornyy facilities.¹²⁰

Gornyy, now closed, was the first operational facility, and eliminated all of its stocks of lewisite, sulfur mustard, and mixed vesicants by December 2005. In June and August of 2006, the Kambarka and Maradykovsky facilities became operational, and by March and April of 2008, these had destroyed 5,279 and 4,394 metric tons of agent, or 83% and 63% of the agent stockpiles, respectively. Kambarka contained 80 metric-ton containers of lewisite, and aerial bombs containing nerve agent were stored at Maradykovsky.¹¹⁶

The US contribution to Russian chemical weapons demilitarization is mediated through the Nunn-Lugar Cooperative Threat Reduction Program, which was established under the Nunn-Lugar Act of 1991, and is focused on Shchuch'ye. Shchuch'ye was recognized as a potential site for the theft and proliferation of chemical weapons munitions because its nearly 2 million portable chemical artillery shells are surrounded by an economically impoverished population. The United States initially provided funding to help secure the facility, but has also funded one of two destruction facilities there. US release of \$160 million in start-up funds was delayed until 2003. Although operations were set to begin at Shchuch'ye in 2006, they have been delayed for an estimated 2 to 3 years.¹²¹

Of the three remaining destruction sites in Russia, Leonidovka is reported to be under construction, while Pochep and Kizner are known to be either in the planning phase or possibly developing early infrastructure.

TABLE 4-8

RUSSIAN FEDERATION STOCKPILE DESTRUCTION *

Site	Metric Tons	Percent of Stockpile	Percentage Destroyed
Shchuch'ye	5,435	13.6	0
Gornyy	1,159	2.9	100
Kambarka	6,355	15.9	83
Leonidovka	6,874	17.2	0
Maradyk-ova	6,954	17.4	63
Pochep	7,513	18.8	0
Kizner	5,675	14.2	0
Total	39,965	100	27

*Status as of March/April 2008

Data source: Green Cross International Web site. Available at: http://gci.ch/index.php?option=com_frontpage&Itemid=1. Accessed August 18, 2008.

Germany, Italy, and Switzerland are assisting with the construction of Pochev, where nerve agent is stored. Switzerland is supporting construction at Leonidovka, and Canada and the United Kingdom are supporting construction at Kizner between 2007 and 2009.¹²²

It has become clear that, while eliminating chemical weapons is imperative, it is a very costly and time-consuming process to design acceptable and reliable technologies to address public safety concerns and environmental impacts. Both the United States and Russian Federation have been granted the maximum 5-year extensions under the CWC (to April 2012). The CWC does not address extensions beyond that date, although it is currently anticipated that chemical weapons demilitarization will exceed that date for both nations. Either these states parties will continue chemical weapons demilitarization under a technically “noncompliant” status or components of the CWC will be modified to accommodate the delays in progress.

Status of Chemical Proliferation

With the implementation and wide acceptance of the CWC, world security has improved immensely with respect to the proliferation of chemical capability at the governmental level. Although some unpredictable countries, such as North Korea,¹²³ potentially possess chemical weapons, the remaining threat has largely become nongovernmental entities such as terrorist groups.

Governmental Proliferation Threat

North Korea has developed an extensive chemical weapons capability and reportedly possesses an arsenal of between 2,500 and 5,000 metric tons of agents distributed over 12 locations. Suspected chemicals in its supply include sulfur mustard, lewisite, phosgene, HCN, sarin, and V-type nerve agents. North Korea’s arsenal includes agent-weaponized, long-range missile and artillery delivery systems that are forward-deployed, threatening highly populated regions of South Korea. North Korean military doctrine considers chemical weaponry an integral part of its force and has resisted joining the CWC.

Some level of government-sponsored terror is also likely to persist. Members of the Palestinian Author-

ity have provided payments to the families of suicide bombers. Other Middle Eastern governments, such as Iran and Syria, have long been suspected of supporting terrorist organizations.¹²⁴

Nongovernmental Proliferation

Individuals seldom present a significant threat, but well-financed, hostile groups have proven capable of recruiting the relatively common and low-level expertise required to manufacture chemical agents, as demonstrated by Aum Shinrikyo, which was in the process of developing an exceptionally large capacity for sarin production. Al Qaeda documents on the manufacture of sarin have also been recovered.⁵⁶ These well-financed groups were able to access the chemicals they desired, as were rogue governments before them.⁷⁴

However, extensive organization and significant financial support are not mandatory prerequisites to acquiring a chemical agent capability. Many terrorist groups that form only loose networks have little difficulty acquiring chlorine, cyanide, and organophosphates. The use of improvised explosive devices demonstrates terrorists’ abilities to readily develop chemical weaponry. Additionally, evidence exists that the agent used in Al Qaeda propaganda films may have been VX recovered from Iraqi munitions.⁵⁷ Incidents involving the acquisition of chemicals by subversive groups, such as Al Qaeda, or individuals prove that emergency response plans would likely benefit most by planning to respond to more accessible toxic industrial compounds, such as cyanide and chlorine.

The protection of chemical industry facilities and transport vehicles must be bolstered to prevent terrorist access and accidental exposures. Sobering lessons have been learned from accidents and incidents involving the release of commercial compounds in an urban context (eg, the 1984 Bhopal disaster).⁷⁰ In 2005 releases of chlorine in Graniteville, South Carolina (killing nine); ammonia near Salt Lake City, Utah; and hydrogen fluoride near Pittsburgh, Pennsylvania, posed challenges to the medical management of casualties. In a densely populated world dependent on industrial chemistry, attention must also be focused on chemicals positioned locally.

PRESENT AND FUTURE IMPLICATIONS FOR MILITARY MEDICINE

The milieu of the chemical battlefield is especially alien to medical personnel, whose usual professional practice includes nothing resembling the management of chemical casualties. Despite strategic or tactical

justification for chemical warfare, medical providers must face the psychologically demoralizing effects and personal ethical concerns about suffering resulting from the deliberate use of chemical weapons.

Although military strategists might view chemical warfare agents as simply one means to immobilize or destroy an enemy force, others may view such weapons as abhorrent extensions of conventional warfare. Current US policy prohibits using chemical weapons against an adversary, but this policy is not shared by all other nations; therefore, to be effective, military medical personnel must be knowledgeable, trained, and prepared. Although healthcare providers are usually not involved in the political or military decisions surrounding the use of chemical weapons, they must be ready to deal with the military and civilian casualties resulting from the use of such agents, cognizant of what constitutes a chemical threat and the military tactics that could be employed against them, familiar with the acute and chronic medical effects of chemical agents to plan appropriate medical support, knowledgeable of the diagnostic tools available to identify specific etiologic agents to which their patients may have been exposed, and aware of the most effective

methods of intervention and prevention.

From the standpoint of military strategy, two reasons are commonly cited for a combatant to employ chemical weapons. First, chemical weapons can be highly effective when densely applied onto concentrated, largely immobile forces or populations. This factor largely accounted for their use against entrenched troop positions during World War I. During the Cold War, military strategists anticipated similar intense chemical warfare bombardments from Warsaw Pact forces in the European theater. The second reason often used to support chemical weapon use is that chemical attacks can be initiated at lower levels to encumber an opponent with defensive equipment or to create panic and disorder among poorly trained or unprepared troops. Application onto enemy troops or civilian populations can also have a strong demoralizing effect. Therefore, the United States military must maintain a strong readiness posture in the face of a continuing chemical warfare threat.

SUMMARY

The military healthcare provider must be prepared to recognize military or civilian casualties of chemical warfare or terrorism, which requires an informed understanding of the historically based likelihood of chemical warfare agent use or threat. Providers must be able to clearly recognize agent-exposure symptoms against a varying background of typical injury and chemical exposure stress behaviors. Providers must also be informed, to the fullest extent possible, about anticipated chemical attacks by hostile forces or terrorist activities. This intelligence requires consideration of an

adversary's political factors and motivation, chemical agent or toxicant possession or access, chemical warfare offensive and defensive capabilities, and any strategic advantage to be realized through agent use. As a healthcare provider manages individuals suspected to have been exposed to chemical warfare agents, initial recognition of the type of agent used may be facilitated through an understanding of tactics, modes of agent dissemination, likely routes of casualty exposure, physical agent properties, and other factors determining the persistence of these toxicants in the environment.

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