Nerve Gas

America's Fifteen-Year Struggle for Modern Chemical Weapons

By Mr. Reid Kirby

Chemical retaliatory plans during World War II called for using mustard gas (H) and phosgene (CG) aerial bombs (the most successful chemical agents used during World War I). Though scientists had discovered many new agents, these agents were generally extensions of the knowledge gained during World War I. For example, the British "secret weapon" of the time was high-altitude, aerial-spray attacks using runcol (HT), a mustard gas variant with a 60:40 mixture of H and O mustard (T). A revolution in chemical warfare was dependent on German development of nerve agents.

In 1936, at the German Leverkusen pesticides laboratory of I. G. Farben, Dr. Gerhard Schrader discovered tabun (GA).[1] The military utility of Schrader's discovery became clear when a single drop on a laboratory bench produced enough vapor to sicken him and a coworker. After performing a demonstration for the chemical warfare section, German army officials provided Dr. Schrader a laboratory at Wuppertal-Elberfeld in the Ruhr Valley to continue his work.

German scientists went on to discover sarin (GB), soman (GD), ethyl sarin (GE), and cyclohexyl sarin (GF). In 1939, GA was manufactured in a pilot plant at Munster-Lager. By 1942, there was also a production plant in Dyerfurth-am-Oder and another plant under construction.

The Chemical Warfare Service (CWS) may have known of the German interest in nerve agents as early as 1941. The United States investigated similar compounds, notably phosphorus (III) fluoride diisopropylflurophosphate (PF3), but concluded that they were only usable as eye irritants. In 1943, the British interrogated a German chemist who had firsthand knowledge of sarin. The Germans wrongly interpreted British censorship of pesticide research as an indication that the Allies were aware of the nerve agents. However, the secret of German nerve-agent research was not apparent until the Allies began to overtake German chemical dumps in April 1945.[2]

The Chemical Corps continued to study nerve agents and create more analogs after World War II. A national effort to create an arsenal with nerve agents did not receive priority until the Stevenson Ad Hoc Committee and the Korean War. Another impetus was the decision by the Air Force to be completely capable with chemical and biological weapons by 1954.

GA: The Interim Nerve Agent

Chemical warfare plans for the European theater depended on a chemical arsenal located in England. Within 24 hours, Army Air Force units could conduct attacks on tactical and strategic targets. Although these plans initially called for large-scale strategic employment, by September 1944 the Allies had scaled back plans to include only immediate tactical support for the Normandy invasion.[3]

The retaliatory plans for the Pacific theater were more problematic. Despite requests from the CWS in the mid-Pacific, appropriate stocks were not located closer than the California coast. This meant a retaliatory response time of 30 to 60 days. More importantly, plans for chemical retaliation against Japan called for quantities of chemical weapons that were not available. A survey of the zone of interior (Asiatic-Pacific and European-Mediterranean theaters) showed that only 855,000 persistent and 271,000 nonpersistent bombs were available. The retaliatory requirements against Japan called for 5,181,000 persistent bombs and 776,000 nonpersistent bombs. The CWS believed that the German arsenal could fill the gap and embarked on a crash program to evaluate the utility of these weapons.

The United States had captured 23,000 tons of GA in aerial bombs and 6,000 tons in 10.5-centimeter projectiles. The Army Air Force could deliver the aerial bombs without modification, but the 10.5-centimeter projectiles were too wide for Army 105-millimeter artillery. The CWS sent 3,000 tons of aerial bombs and 5,000 tons of projectiles to Edgewood Arsenal, Maryland, for further evaluation.

The German ordinance was punched and drained at Edgewood Arsenal to evaluate GA in the 4.2-inch mortar rounds and the M70 (E46) aerial bomb. Field trials showed that standard bursters were too small to disseminate GA

due to the low volatility of the agent. Only 10 to 20 percent of the agent was dispensed as aerosol or vapor. Furthermore, the CWS initially believed that the LCt_{50} (median lethal dosage) of GA was about 800 milligram-minute per cubic meter (mg-min/m^3). The conclusion was that GA was useful for harassment but was not suitable for chemical retaliation.[4]

During the Cold War (1950s), the British believed that the Soviet Union had standardized the use of GA. The United States estimated the Soviet stockpile at about 18,000 metric tons of GA in 1952, in addition to about 120,000 tons of older chemical munitions. The implications that Germany's nerve-agent production facilities and scientists had fallen into Soviet hands at the end of World War II was not lost on anyone.[5]

Replying to a request from the Commander In Chief of the Far East for a chemical capability by 7 June 1952, the Joint Chiefs of Staff stated that it would provide World War II vintage chemical weapons within six months and newer chemical weapons (such as nerve agents) after 1954.[6] When the Far East Air Force requested guidance on chemical employment against North Korea in January 1953, the discussion was exclusively on using World War II weapons containing CG, cyanogen chloride (CK) (a blood agent), and mustard gas, with particular interest in CK to penetrate protective masks.[7]

In November of 1952, Air Force officials at a GB aerial spray trial at Dugway Proving Ground, Utah, observed 2,171 German aerial bombs. The Army reported that 60,000 to 70,000 more bombs were stored at Rocky Mountain Arsenal, Colorado. Though surprised by the discovery, Air Force officials immediately came to the conclusion that GA needed consideration until GB became readily available.[8] By January of 1953, weapon systems intended for GB were being field-tested using GA. In the opinion of a veteran F80 pilot who participated in a field trial with GA in M10 and E28 spray tanks, the GA-filled E28 would have been suitable for use in Korea. It was also planned to use GA-filled E101 cluster bombs on a square-mile target at Dugway Proving Ground during the Air Force portion of Exercise Shorthorn.

By June 1953, the Far East Air Force was to receive 400 tons of GA weapons and World War II vintage chemical weapons for use as chemical retaliation. In the end, the chemical weapons remained stateside to avoid complications with the truce negotiations in Korea.[9]

GB: The Standard Nonpersistent Nerve Agent

Though GB and GD are relatively comparable in terms of toxicity, the physical properties of GD make it superior in penetrating the lungs and skin. GD requires pinacolyl alcohol—a chemical not widely available until the personal computer boom—as a feedstock. The Chemical Corps standardized GB in 1948, but research continued on GD and GH as potential replacements.[10]

The Chemical Corps, after erecting a pilot plant at Edgewood Arsenal in 1948, decided to manufacture GB at two locations. The critical component of GB—dichlorophosphinate (dichloro)—was manufactured in a regular mustard gas reactor at the Muscle Shoals Phosphate Development Works (Site A), located at the Tennessee Valley Authority Wilson Dam, Alabama. The dichloro was then sent to the Rocky Mountain Arsenal (Site B) for a two-step production process, distillation, stabilization, and munitions filling.

The construction of production facilities progressed slowly from 1951 to 1953. The Air Force expedited materials to provide assistance, at one point airlifting air filters from Andrews Air Force Base, Maryland, to Lowery Air Force Base, Colorado. There were also process hurdles to overcome. GB is a penetrating liquid, and finding the proper means to seal the fill plug on the weapons proved difficult. Stability was a lingering issue. Double-distilled GB proved too deleterious to the aluminum bomblets of the Honest John warhead. The problem was eventually solved by the addition of the stabilizing agent tributylamine, and later with diisoproplycarbodiimide.

The Air Force favored the use of GB over tactical nuclear weapons against Soviet aggression. Mobilization requirements assumed that 25 percent of sorties in the first month and 5 percent of sorties thereafter would employ GB in a war in Europe. These requirements were well into the tens of thousands of tons. When the British requested 2,500 tons of GB in 1953, the Joint Chiefs of Staff rejected the request, noting that production was insufficient for mobilization due to a scarcity of the mineral fluorspar (0.483 pounds of fluorspar is required per pound of GB).[11] The Chemical Corps produced GB from 1953 to 1957. In July 1957, the Muscle Shoals Phosphate Development Works terminated operations. A month later, the Rocky Mountain production facility also closed. The United States had acquired a stockpile of GB that it believed would be necessary for any future conflicts.

VX: The Standard Persistent Nerve Agent

Mustard gas remained the standard persistent, casualty-producing agent long after World War II, even after the standardization of GB. Though the Air Force believed that World War II munitions were not suitable for agent use, the Army contended that they had a requirement for tactical air support with a persistent agent. The Air Force, recognizing the power of GB, wanted a

persistent G-series agent. The Chemical Corps recommended GF. The Air Force was interested in aerial spray tanks with GF if it proved to be superior to GB for a skin effect and was more persistent than mustard gas. Some alternate possibilities included GB, GB-GF combinations, and 2-methyl GF. The Air Force asked the Chemical Corps to evaluate the persistency of GF in field trials. The Chemical Corps, wanting to avoid building another pilot plant, compromised with the Air Force on laboratory-scaled experiments.[12] The Air Force believed GF would provide them with the capability to attack enemy air bases. Calculations by the Air Force Directorate of Requirements concluded that the tonnage required for mustard gas or GF eliminated the possibility, unless there was a "miracle" chemical agent on the horizon. The prospects for a persistent, air-delivered, casualty-producing agent did not look promising.

The "miracle" came in 1953 when British chemical warfare researchers shared information on a new class of nerve agents. Doctors R. Ghosh and J. F. Newman from the British chemical conglomerate, Imperial Chemical Industries, discovered a new class of agents. Their discovery made its way through British chemical warfare researchers to the Chemical Corps, and in 1955, a new series of agents was termed *V* for venom. These agents were hundreds of times more potent than G agents for a liquid skin effect and several times more toxic for an aerosol lung effect. And the V-series agents were far more persistent than mustard gas.

The Chemical Corps began investigating new candidate agents. But stability was a problem and affected the ability of the agent to penetrate clothing. Initially, the Chemical Corps decided to pursue O-ethyl S-(2-diethylaminoethyl) ethyl phosphonothiolate (VE) as a persistent nerve agent and work on improving the stability of these agents with additives. O-ethyl-S-(2-diisopropylflurophosphate) methyl phosphonothioate (VX) later became the focus agent of the V series and, in 1958, became the standard persistent nerve agent. A pilot plant was erected at Edgewood Arsenal that same year; a production facility was constructed in Newport, Indiana, in 1960; and VX was produced and placed in munitions between 1961 and 1968.

The Next Wave

The introduction of nerve agents ended the dominance of World War I chemical warfare agents. The standard nonpersistent agent, CG, was replaced by GB. The standard persistent agent, mustard gas, cowered under VX. By 1960, the United States had finally devised the means to produce the modern chemical weapons it sought to replace its World War II arsenal.

But the potency and lethality of the nerve agents led to concerns over safety in transport and storage. Just as the Chemical Corps started to acquire its nerve-agent arsenal of GB and VX, the military establishment began to demand safer binary weapons. Around the same time, another series of nerve agents, the GV series, was maturing. But its extremely poor stability also required binary technology. Unlike the first fifteen years of the Cold War, the political climate of the 1970s and 1980s delayed the replacement of these unitary nerve-agent weapons. When binary weapons became available 30 years later, disarmament agreements mandated the destruction of the entire chemical arsenal.

Endnotes

[1]Tabun was originally called taboon. The military symbol was originally G, and GA was used for tabun doped with chlorobenzene.

[2]An overview of the early history of the nerve agents can be found at <*http://www.mitretek.org/home.nsf/homelandsecurity/HistoryNerveGases*>, accessed on 30 January 2006.

[3]National Archives RG331, Entry 276J, Box 140, File CWS/373.2/1, "Chemical Policy."

[4]Reid Kirby, "The CWS Efforts to Obtain German Chemical Weapons for Retaliation Against Japan," *CBIAC* Newsletter, Vol. 5, No. 1, Winter 2004, pp. 3 and 13.

[5]British Joint Intelligence Committee memorandum JIC 156/11/D, George Washington University, National Security Archives, CBW Collection, Box 2, Miscellaneous British Archive Documents File.

[6]Joint Chiefs of Staff memorandum JCS 1837/46, "Overseas Deployment of Toxic Chemical Agents," 12 March 1953, George Washington University, National Security Archives, CBW Collection, Box 12.

[7]The Air Force requested guidance on the use of chemical weapons against communist forces equipped with 45,000 gas masks, particularly the appropriateness of figures in FM 3-6 (1946) as applied to North Korea. See memorandum from MG Howard Bunker, USAF Assistant for Atomic Energy, to Chief Chemical Officer, Department of the Army, "Protective Equipment of Enemy Forces in North Korea," 30 January 1953.

[8]LTC George Criss, USAF BW-CW Division, "Dugway GB Spray Test," memorandum for record, 25 November 1952. BG Alonzo Drake, USAF Chief of Staff to USAF Deputy Chief of Staff–Operations, "Chemical Warfare Capability," memorandum, TAC AAG Reg. No. 52-1538, 10 December 1952.

[9]NARA FAEF briefing.

[10]CCTC Item 1890 "Classification of Quick-Acting, Nonpersistent Agent GB, as a Substitute Standard Type," 19 May 1948.

[11]Referenced in JCS 1837/47.

[12]Memorandum, Dr. Herbert Friedlander, USAF Chief BW-CW Agents Section to COL Seiler, "GF Requirement for ISCC September Meeting," memorandum, 11 September 1952.

Mr. Kirby is a project manager for TALX Corporation. He holds a bachelor's degree in valuation science from Lindenwood College, with a minor in biology and special studies in behavioral toxicology and biotechnology.