U.S. Army Soldier and Biological Chemical Command

HISTORY
OF
DECONTAMINATION

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Introduction

The history of decontamination can be traced back to World War I when chemical warfare was first introduced on a large scale. Throughout the next 85 years, the U.S. Army has found better ways to accomplish decontamination on the battlefield. For the future, the next generation of decontamination capabilities will provide revolutionary advancements.

This brief history covers some of the highlights of the long history of decontamination research and development.

Colonel Christopher J. Parker
PM NBC Defense Systems

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PRE-WORLD WAR I

Early Decontaminating Agents

Decontamination is the removal and/or neutralization of hazardous levels of chemical and biological contamination from personnel, material, or the ground. There are both naturally occurring decontaminants and manufactured decontaminants. Following the introduction of large-scale chemical warfare during World War I, the need to decontaminate after a chemical attack became a major concern of the Chemical Warfare Service, the forerunner of the Chemical Corps. Several of the key decontaminants identified during World War I and after were actually known long before the 20th century.[1]

Water

Water was one of the earliest known decontaminants. Rain showers washed away ground pollutants while bathing eliminated bodily contamination. Water's capability to breakdown and decompose substances, called hydrolysis, was used to change toxic substances into useable products. Hot water was known for its cleansing capabilities. One of the earliest known attempts to use chemical weapons on the battlefield was foiled by water. During the Peloponnesian War in 429 BC, the Spartans and Thebans attempted to destroy the city of Plataea by creating a hot fire and adding brimstone and pitch. A thunderstorm, however, extinguished the fire before it did much damage. Water and steam are still considered natural decontaminants today for physically removing contamination, but neither neutralizes the contaminating chemical or biological agent.[2]

Fuller's Earth

Fuller's earth is a highly absorbent naturally occurring substance well known since at least 5,000 BC. The name came from the term "fulling" which meant to shrink or thicken materials by adding moisture. In ancient times in England, workers added clay materials to water and then soaked raw wool in it to remove dirt and lanolin. It was also used as a natural bleaching agent. Fuller's earth was actually a generic term that was applied to many different earthy substances that had the highly absorbent qualities. Most consisted of hydrated aluminum silicate from clay minerals calcium montmorillonite and palygorskite. Fuller's earth is often used today in pet litter.[3]

Calcium Oxide (Lime)

Calcium Oxide, also known as lime or quicklime, was recognized as a decontaminant in early times. Lime is a whitish powder created by removing carbon dioxide from calcium carbonate (also known as calcite, a naturally occurring mineral in limestone). An example of its use on the battlefield occurred in 1422 during the Hussite siege of Castle Karlstein near Prague. The Hussites used catapults to fling rotting bodies and other filth into the castle walls as an early form of biological warfare. The Catholic defenders, however, countered the attack by using lime on the caucuses and filth as a decontaminant. After five months, the Hussites gave up the siege and signed an armistice. Lime also has a caustic aspect. Finely pulverized lime was used as a weapon during the reign of Henry III (1216-1272) when the English fleet threw it onto French ships to blind and disorient the French crews.[4]

Bleaching Powder

Bleaching powder, one of the first recognized decontaminants, was discovered during the 18th Century. In 1785, a French chemist, Claude Louis Bethollet, discovered that chlorine had strong bleaching capabilities. Several years later, in 1799, Charles Tennant, a Scottish chemist, discovered that calcium oxychloride, also known as bleaching powder or chloride of lime, had strong bleaching powers due to its

chlorine content. It was made by the reaction of chlorine gas on lime. Bleaching powder became the standard bleaching agent to whiten or remove colors from items until the 1920's.[5]

Chlorine Dioxide

Chlorine dioxide is a greenish-yellow gas with a pungent odor that is normally prepared by adding dilute sulfuric acid to a solution of sodium chlorite. First identified in 1811, it was patented in 1985 as a quick and effective sterilizer for drinking water, food processing, and for medical waste. It was also used for paper pulp bleaching. Chlorine dioxide is corrosive and a health hazard that requires the use of the protective equipment.[6]

Methods of Decontamination
From Technical Manual 3-220, Decontamination (1953)

WORLD WAR I

Decontaminating Agents

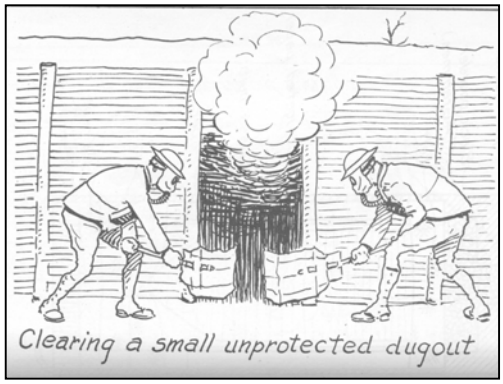
Bleaching Powder

During World War I, mustard agent, a persistent blister agent, was first used on the battlefield. Used in such large amounts that it collected in shell holes and puddles, the agent could remain dangerous for weeks and in some cases even years. Decontaminating ground contaminated by the agent was a significant problem.

The Germans began planning for the first use of mustard agent on the battlefield in early 1917. Before they could stockpile enough of the agent, there was an explosion at their mustard agent filling plant in Adlershof, near Berlin. To clean up the mess, the Germans used bleaching powder to neutralize the agent on the ground and on equipment. Obtained from their dye industry, bleaching powder neutralized the mustard agent by providing liberated chlorine. Mustard agent then decomposed into relatively harmless compounds after being chlorinated. The success of this initial decontamination operation led to the birth of the modern concept of battlefield decontamination.

By the time the American Expeditionary Force (AEF) entered the war in 1917, bleaching powder was considered the primary decontaminant for mustard agent. The United States produced 2,590 tons of bleach during the war and shipped 1,867 tons to the AEF during the war. The bleaching powder was spread over shell holes and trenches using shovels and buckets. When bleaching powder was not available, fresh earth was recommended instead. For trench dugouts, a small box of bleaching powder was placed at the door for soldiers to use to decontaminate their shoes. Bleaching powder was also used at ammunition dumps for leaking munitions, although the preferred recommendation for a leaking shell was to fire it at the enemy or bury it. The major problem with bleaching powder was that it decayed rapidly in the open air and therefore had to be stored in airtight containers. It could also burst into flame upon contact with mustard agent.[7]

Air



Nonpersistent agents generally were blown away by the wind within a fairly short time and did not contaminate the ground and equipment for several days like persistent agents. Exposing contaminated material and equipment to the air was the easiest means of decontamination for any nonpersistent agent contamination. Following a chemical attack, the recommended procedure was to let contaminate clothing air out to prevent taking the agent into dugouts and other "clean" areas. Natural ventilation was also recommended for clearing dugouts and trenches. To further aid with ventilation, soldiers built fires in the trenches to create drafts to assist with the removal of gases or used trench fans to try to fan away the gas. For mustard contaminated items, it took longer for air to decontaminate them. For clothing, the recommendation was to expose it to the open air for 48 hours or longer if cold weather.[8]

Water

Water was a useful decontaminate because it removed chemical agents. Many of the nonpersistent agents and smokes were extremely acidic and would damage equipment. Washing with soap and water was considered an effective way to help prevent rapid corrosion of metals. Water in the form of steam was also an effective decontaminant, particularly for clothing. Water was also an effective decontaminant for soldiers. The delayed action of mustard agent required quick personnel decontamination actions. One solution was to bath the soldiers thoroughly with soap and water within a half-hour of mustard agent exposure. This was thought to prevent or greatly reduce the severity of the mustard burns. After the showers, the troops were given a drink of bicarbonate of soda water and then had their eyes, ears, mouths, and noses washed with the soda water.[9]

Protective Ointments as Decontaminants

Research to find a way to destroy mustard agent after contact with the skin started during World War I with the development of protective ointments. The objective of the early protective ointment work was to protect the soldier from contamination rather than to decontaminate the skin after exposure. Salve Antigas (Sag) Paste, consisting of zinc stearate and vegetable oil, provided some protection against large amounts of mustard agent. The drawback of the ointment, however, was that it did not neutralize the mustard agent and after a time, the agent penetrated the ointment and then caused worst burns than if the ointment had not been used. Still, the psychological benefit of a having a protective ointment was thought to outweigh the actual performance of the ointment. During the war, the Army produced 1,246 tons of Sag Paste and shipped over 900 tons to Europe. When the war ended, Army researchers expected future research on protective ointments to be the solution to individual protection against mustard agents.[10]

Decontaminating Equipment

Trench Fans

To expedite the exposure of chemical agents to air, trench fans (also called antigas fans) were provided the troops. These fans were made of a cane frame and a canvas sheet with a wood handle. The fan was intended to ventilate trenches and dugouts. Over 27,000 trench fans were shipped to the AEF during the war. The reality was that they helped disseminate the nonpersistent gases and caused more problems than they solved. They were soon discontinued as a decontamination device.[11]

Steam Disinfecting Chamber

A quicker method for decontaminating clothing than exposing it to air for two days was to use a steam-disinfecting chamber. This reduced the decontamination time to three hours. Unfortunately, very few of the units were available to front line troops.[12]

Degassing Truck

To provide decontamination showers for soldiers contaminated with chemical agents, the Army established degassing units that used a 5-ton truck with a 1,200-gallon water tank, fitted with an instantaneous heaters and piping to connect it to portable showers. A second truck held extra uniforms. Two degassing units were assigned to each division. Due to the size and weight of the trucks, they were limited to main roads and were unable to reach most units in the field.[13]

BETWEEN THE WORLD WARS

Decontaminating Agents

Bleach

Throughout the 1920's, bleaching powder remained the number one decontaminant for mustard agent. This was confirmed in 1926 with the preparation of an Army specification for bleaching powder. The Chemical Warfare Service continued to work on finding a better decontaminant for mustard agent since bleach was corrosive to metals, damaging to material and leather, and had only a three-week storage life in the tropics. In 1933 the Army prepared a new specification for bleach that identified three different grades suitable for decontamination.

Grade A, also known as High Test Bleach (HTH) or Penchlor, was calcium hypochlorite that contained 70% available chlorine. Although identified in 1933, it was not standardized until 1941 and then only for tropical use. High-test calcium hypochlorite, however, was expensive and not readily available. During World War II it was needed for higher priority work than decontamination, so Grade A was redesignated a limited standard item in 1942. Grade A bleach was obsoleted in 1945.

Ordinary bleaching powder, containing at least 35% available chlorine, was standardized in 1933 and renamed Bleaching Material Grade B. It was cheap, effective, and readily available commercially. The major problem with Grade B was that it deteriorated rapidly in the tropics. Grade A was standardized during World War II to compensate for this problem, but proved to be unavailable in large amounts. Grade B was reclassified limited standard in 1944 after the development of improved bleach material. Grade B bleach was obsoleted in 1945.

Grade C Bleaching Material was identified in 1933, but not standardized until 1944 and then only as a limited standard article to replace Grade A even though Grade C deteriorated in the tropics. It was essentially the same material as Grade B, but contained only 30% available chlorine. When Grade B bleach was transferred from large storage containers into smaller containers, the bleach lost enough chlorine to make it Grade C. Grade C bleach was obsoleted in 1945.[14]

DR1 Decontaminant

The need for a decontaminant for Navy ships during the early 1930's led to the development of DR1 emulsion. Although water washed away mustard agent, it did not neutralize it. Research determined that adding different ingredients to the water helped neutralize the agent. DR1 was one of the earliest

decontaminants considered for standardization. It was a soap prepared from magnesium carbonate, animal fat, and kerosene. Although it was selected for use in early decontaminating devices designed for the Navy due to it being noncorrosive, nontoxic and inexpensive, DR1 proved unsatisfactory as a decontaminant and was never standardized by the Army.[15]

Chlorinating Compound 1 (CC-1)

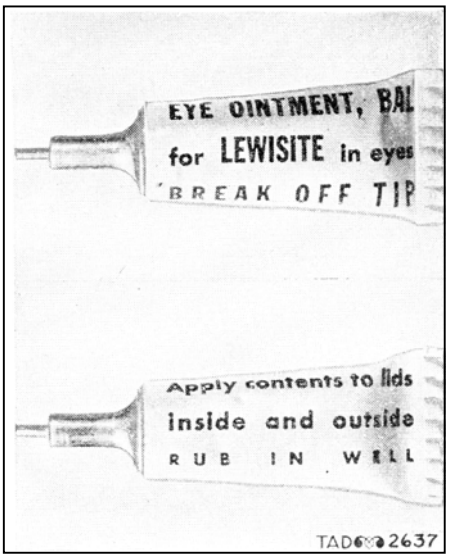
During the early 1930s, the Chemical Warfare Service made the important discovery of the decontaminating capability of dry decontaminating powder mixed with a solvent. The solvent dissolved both the mustard agent and the dry powder and allowed chemical destruction of the mustard agent to take place while both the mustard agent and the dry powder were dissolved in the solvent. The best solvent was determined to be acetylene tetrachloride. Initially, the most effective dry compound was chloroamide, a light tan to white powder, dissolved in acetylene tetrachloride, designated CC1. It was produced only by the Chemical Warfare Service and standardized in 1938 as Non-Corrosive Demustardizing Agent CC No. 1. It was identical with Impregnite CC2 used to make clothing impermeable to chemical agents. CC1 was superior to bleach because it liberated the chlorine most slowly from the mustard agent, which made it less corrosive to metal and destructive to other materials. In 1942, it was redesignated M3 Decontaminating Agent to clarify that it could be used to decontaminate more than just mustard agent. In 1943, CC1 was redesignated substitute standard in favor of RH-195 (M4 Decontaminating Agent), which was cheaper, worked faster, and had a slower rate of deterioration. CC1 was officially obsoleted in 1945.[16]

Decontaminating Agent, Non-Corrosive (DANC)

Another dry compound, RH-195, developed by the E. I. du Pont de Nemours Company, when mixed with acetylene tetrachloride was initially thought to be a less effective decontaminant for mustard agent than CC1 Decontaminant. It was classified substitute standard in 1938 when CC1 was standardized. However, the RH-195 decontaminant was later recognized as the more effective of the two and was later designated Decontaminating Agent, Non-Corrosive (DANC). DANC was a whitish powder that liberated chlorine more slowly than ordinary bleaching material and therefore was more stable in storage and could be used on items that would be damaged or destroyed by bleaching powder. It was superior to CC1 because it did not clog spray lines, was less expensive, and stored better. One gallon of DANC could decontaminate 15 square yards of heavily contaminated soil. It was also somewhat effective against biological agents, but was ineffective against nerve agents. DANC was used by all the services for decontamination. In 1942, it was redesignated M4 Decontaminating Agent. It came in 3-gallon and 4.5-gallon containers that contained the RH-195 in the upper section and acetylene tetrachloride in the lower section. Due to the awkward size of the larger container, it was reclassified limited standard in 1952. During World War II, the Army procured over one million of the 4.5-gallon containers and over 58,000 of the 3-gallon containers of DANC. By the 1950's, the problems with DANC were that it was not non-corrosive, it was unsuitable for long-term storage, and the acetylene tetrachloride was extremely toxic. The Army stopped procurement of DANC in 1958 and it was obsoleted in 1972.[17]

Protective Ointments as Decontaminants

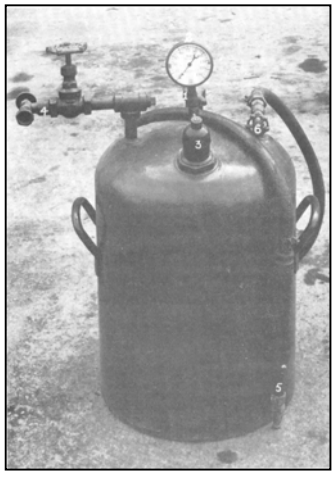
After World War I, the Army continued research on finding protective ointments that would prevent mustard burns as well as lessen the effect of the agent after exposure. Researchers examined numerous compounds in cooperation with the Medical Corps, but none met all the requirements for standardization.[18]



British Anti-Lewisite (BAL) Ointment

Prior to World War II, the British utilized German research to develop an ointment that neutralized lewisite on the skin. Known as British Anti-Lewisite (BAL), it was an oily colorless liquid with a strong odor. BAL reacted with the arsenic in lewisite and changed it to a nontoxic, water-soluble substance. The U.S. Army and several universities modified BAL specifically to neutralize lewisite in and around eyes and gave it a new chemical name, Dimercaprol Ointment, although it continued to be known as BAL Eye Ointment. Dimercaprol Ointment consisted of polyethylene glycol, ethylene glycol, boric acid, ascorbic acid, thiamine hydrochloride, and BAL. During World War II, it was issued in a small tube as part of the M5 Protective Ointment Kit and after the war in later versions of the kit. In 1960, the BAL Eye ointment tube was dropped from the kits due to the lack of perceived threat of a lewisite attack and to the fact that eye decontamination would take too long and prevent quick masking.[19]

Decontaminating Equipment



Early Decontamination Sprayer

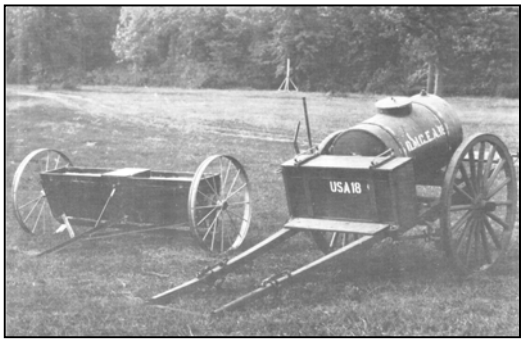
During the 1920's, very little work was done on developing a decontaminating device. Buckets, shovels, and brooms used during World War I remained the normal way of spreading out bleach on contaminated soil. In 1929, the Army developed a demustardizing sprayer that consisted of a 10-gallon pressure tank and spray hose. Air, supplied by an external source, forced a mixture of bleaching powder and carbon tetrachloride out of a nozzle. The unit was field tested by decontaminating a truck, but was never standardized.[20]

Early Decontaminating Devices for the Navy

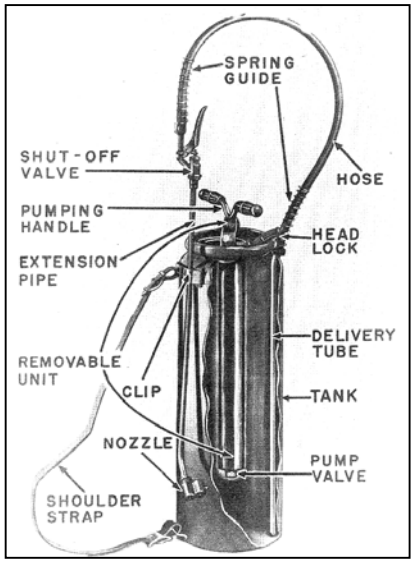
Due to problems with using bleach on ships, the Army was asked to develop devices suitable for spraying a decontaminant on the decks and metal surfaces of a ship. This project, conducted between 1930-1933, led to the design of early decontaminating devices. Under this project, DR1 decontaminant was

developed and selected as the decontaminant of choice. To disseminate the DR1, the Army initially designed a simple 2-gallon pressure tank that used steam and air to spray the DR1. In 1930, the E1R1 apparatus was tested only in the laboratory and was never fielded. The second version, designated the E1R2 increased the tank to 20 gallons. This unit was field tested on the U.S.S. Eagle in 1932, but received negative reviews for being too slow. Additional development work failed to turn up a good device for use with DR1 and the DR1 program was discontinued.[21]

Large Scale Decontaminating Devices

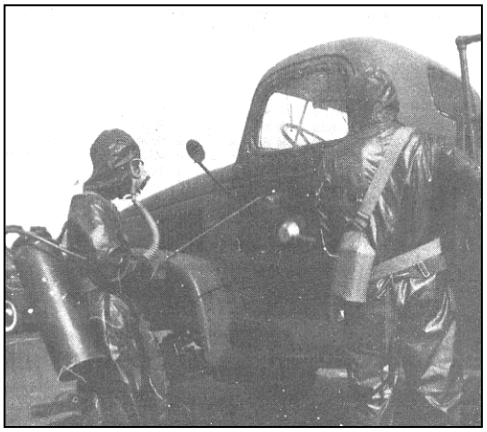


The need to spread bleach over a large area led the Army to examine various commercially available spreaders during the 1930's. These included agricultural lime spreaders and road water sprinklers, most of which proved unsuccessful at disseminating the proper amount of decontaminant. In 1935, the Army began investigating truck mounted commercial orchard sprayers for spreading bleach. The best design used a 300-gallon tank and an 8-horsepower engine mounted on a gun carriage. The unit included a rotary agitator for mixing the bleach with water and CC1 decontaminant.[22]



M1 Decontaminating Apparatus

Throughout the 1930's, the Army experimented with various commercial hand-held insecticide sprayers for use to decontaminate vehicles and equipment in the field. Of those examined, the best sprayer was the Open-Hed No. 4, manufactured by the E. C. Brown Company of Rochester, New York. Designated the E3R4, it was field tested at Langley Field, Virginia, in 1938 and later that same year standardized as the 3-gallon Demustardizing Apparatus, Commercial Type. It consisted of a heavy galvanized steel tank with a hand operated air pump, a two-foot rubber hose, a two-foot brass nozzle assembly, and a carrying strap. When full, the unit weighed 72 pounds and could decontaminate about 50 square yards. CC1 decontaminant was the initial decontaminant used in the device, but DANC and bleach suspensions were also used. In 1942, it was officially redesignated the M1 3-Gallon Decontaminating Apparatus to indicate that the unit could be used on other persistent agents besides mustard agent. During World War II, 287,767 units were procured for the Army. During the Korean War, an additional 49,866 units were procured for the Army, 12,121 units for the Air Force, and 360 units for the Navy. In 1956, the Army canceled the requirement for the M1 and replaced it with a bucket and broom to disseminate small amounts of decontaminant. The Navy and Air Force, however, kept their requirement. In 1968, the M1 was replaced by the M11 Decontaminating Apparatus and was obsoleted.[23]

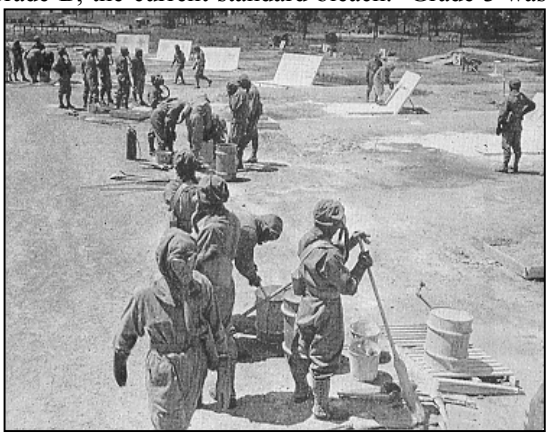


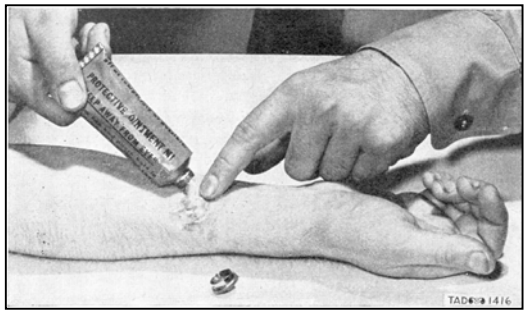
THE 1940'S

Decontaminating Agents

Bleach

During World War II, the British provided information on new grades of bleach that had longer storage life than the U.S. grades. As a result, the Army standardized three new grades. Grade 1 had 35% available chlorine, but was unsuitable for tropic storage. It was classified limited standard in 1944 and then obsoleted in 1945. Grade 2 had 30% available chlorine and could be stored in the tropics for an extremely limited amount of time. It was classified substitute standard in 1944 and obsoleted in 1945. Grade 3, also referred to as British Tropical Bleach, had 30% available chlorine and the lowest moisture content. This allowed for tropical storage up to four years. The cost of Grade 3 was also similar to Grade B, the current standard bleach. Grade 3 was classified standard and Grade B was reclassified limited standard. Finding producers of Grade 3 bleach was a problem during World War II and much of the Army's bleach was imported from the British. During the war, the Army procured over 19,000 tons of bleach from American contractors and over 15,500 tons from the British through the reverse Lend-Lease program. After the war, the Army continued to have problems locating suppliers. The standardization of super-tropical bleach (STB) in 1950 convinced the Army not to pursue construction of Grade 3 production facilities but instead concentrate on STB production. Grade 3 was reclassified substitute standard and eventually obsoleted in 1956.[24]





M4 Protective Ointment

The first standardized protective ointment with some decontamination capability was designated M1 Protective Ointment in 1940. It was a jelly-like compound consisting of dichloramine-T in triacetin and cellulose acetate butyrate that had 4.5% active chlorine. Initial testing indicated the ointment provided some protection against mustard agent. The Chief of the Medical Research Division at Edgewood Arsenal, MD, demonstrated the effectiveness of the ointment by rubbing it on his arm and then adding mustard agent. He still received a burn, but it was considered less severe and localized. Because the vesicant agent lewisite was also known as M-1, the protective ointment was redesignated M4 Protective Ointment in 1942 to eliminate the appearance that it was only for lewisite. Over 56 million tubes of the ointment were procured in 1941-1943. An additional 1.6 million were

procured for special jungle use. Additional testing of the ointment during the war found it too irritating to human skin. After M5 Protective Ointment was standardized in 1943, the remaining stocks of M4 ointment were issued as a skin decontaminant.[25]

M5 Vesicant Agent Protective Ointment

Continued research on protective ointments that were less irritating than M4 Protective Ointment led to the discovery of chloramine S-330 mixed with a jelly-like composition. The S-330, with 7.5% active chlorine, liberated chlorine to neutralize blister agent. In the late 1950's, it was also found effective against V-type nerve agents, but not G-type nerve agents. The ointment could be applied before or after an attack. To be effective after an attack, it had to be used within five minutes or the blister agent would penetrate the skin and cause blisters. It could also be used to decontaminate small nonporous areas of equipment. The ointment was available in a collapsible metal .75-ounce tube as part of the M5 Protective Ointment Kit. After the later versions of the M5 series Protection and Treatment Kits were obsoleted in 1969, M5 Protective Ointment was redesignated a separate end item called M5 Vesicant Agent Protective Ointment. After this action, the Navy kept M5 ointment as a standard item and it also remained a standard item for several Medical Supply Sets.[26]

Biological Agent Decontamination

The establishment of the Army's biological warfare program at Fort Detrick, Maryland, during World War II led to a biological agent decontaminant program. Initial work concentrated on testing the standard decontaminants against biological agents. Bleach, particularly high-test bleach, was the most effective, although DANC was less corrosive on metal items. Other potential decontaminants examined included ethylene oxide, sulfur dioxide, formaldehyde, ethylene imine, and even the standard smoke agents. All had various problems and research on the topic continued after the war. In 1947, the Army initiated a second program to develop a better decontaminant for microorganisms. This program proved a significant challenge and the Army did not standardize a biological decontaminant developed under this program until 1960.[27]

Nerve Agent Decontamination

Following the discovery of the German nerve agent program in 1945, the U.S. Army tested standard decontaminants against the new nerve agents (designated GA, GB, and GD). DANC was found not suitable for the decontamination of nerve agents. Bleach slurry and dilute water solutions of alkalies were reported as effective decontaminants. Hot soapy water was also recommended, while cold water only partially removed the nerve agents.[28]

Decontaminating Equipment

M2 Decontaminating Apparatus

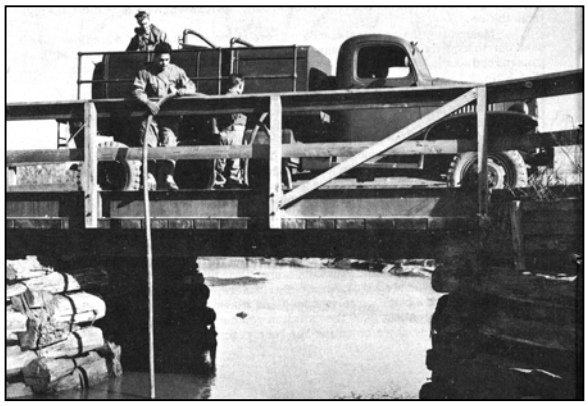
The Army first began testing commercial fire extinguishers as possible decontaminating devices in 1934. The next year, the E4R1 Demustardizing Apparatus, a commercial 1-1/2-quart hand-held fire extinguisher called the Fyr Fyter and filled with CC1 solution, was tested on the U.S.S. Eagle. This was a successful test although the E4R1 was difficult to fill with decontaminant and had a small capacity. Additional tests were held by the Field Artillery at Fort Hoyle, MD, in 1936 using CC1 solution to decontaminate artillery pieces. The success of these tests indicated the need for a small decontaminating device that could be easily carried on a vehicle and then used for decontaminating parts of vehicles and equipment that a soldier touched. In 1940, the E4R1 was standardized as the M2 1-1/2 Quart

Decontaminating Apparatus. The unit held either CC1 or DANC and had a pump handle on top and the spraying nozzle on the bottom. It could decontaminate approximately 12 square yards. During World War II, the Army procured over 1.9 million M2 devices. The primary problem with the unit was that the DANC made the brass parts corrode rapidly. In 1950, it was reclassified limited standard although still used by the Army and the Marines. The M2 unit was obsoleted in 1969 in favor of the M11 Decontaminating Apparatus, standardized in 1960.[29]

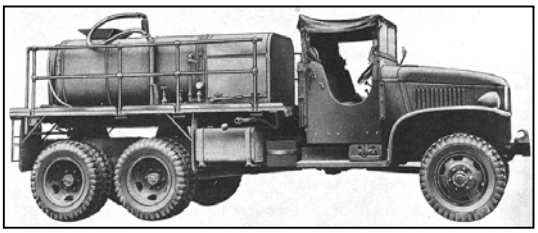
M3 Decontaminating Apparatus

The 1930's investigation of commercial powered orchard sprayers for use as a large-scale decontamination apparatus eventually led to the selection of one particular device for standardization. The Myers Silver Cloud Spray Outfit was modified to handle the corrosive nature of bleaching powder and designated the E6R2. The unit consisted of a 300-gallon storage tank, an engine, a pump, and two spray guns. It was mounted on a steel frame with wooden skids and was designed to fit on a truck bed or a trailer. The unit used either CC1 solution or bleaching powder and water mix. The E6R2 was standardized as the M3 Power-Driven Decontaminating Apparatus in 1940 primarily for use with decontamination companies. Only six of the units were procured by 1941. Further testing of the M3 apparatus determined that the separate engine could be eliminated by mounting the unit on a truck and using the truck's engine. In 1943, the M3 was reclassified limited standard following the standardization of the M3A1 truck mounted decontaminating apparatus and the improved M4 skid mounted unit. Further procurement of the M3 stopped in 1943 and in 1945 the M3 was obsoleted.[30]

M3A1 Decontaminating Apparatus



Following the standardization of the M3 Apparatus, the Army decided that the unit should be an integral part of a truck that used the truck's engine instead of a separate engine. As a result, the M3A1 Power-Driven Decontamination Apparatus was standardized in 1941 for both the Army and the Army Air Corps. The unit consisted of a 400-gallon wood tank mounted on a standard Ordnance truck chassis. It was designed to spray bleach slurry by the use of a high-pressure pump and two spray guns. A separate heater unit was available for when the unit was used for cold weather decontamination or for troop showers. Over 1,500 of the units were produced during World War II. By 1943, it was replaced by improved versions and was reclassified limited standard. To reduce inventories, it was obsoleted in 1958.[31]



M3A2 Decontaminating Apparatus

Minor improvements in the design of the M3A1 Apparatus led to the standardization of the M3A2 Power-Driven Decontaminating Apparatus in 1943. The improvements included an improved pump, agitator, and piping arrangement. The Army procured 426 units during World War II and 62 units during the beginning of the Korean War. The Air Force procured 175 units and the Navy 82 units. One of the major problems with the M3A2 was that the wooden tanks were made of cypress sapwood that rotted in the tropics and allowed fungus growth. In 1952, the standardization of the improved M3A3 unit with a metal tank resulted in the M3A2 being reclassified to limited standard. The unit was then obsoleted in 1971.[32]

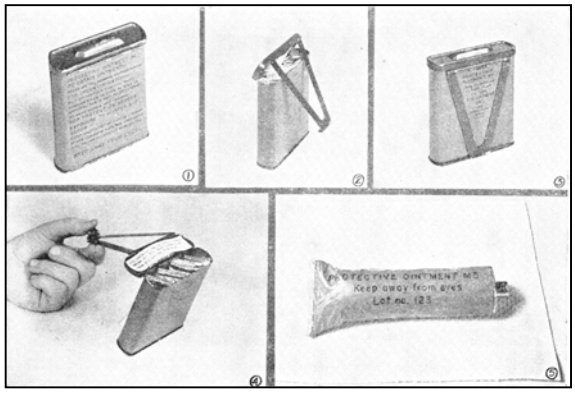
M4 Decontaminating Apparatus

The lack of available truck chasses to use for the M3A1 Apparatus and the need for shipment to the theater of operations led to the Army standardizing a skid-mounted version of the M3A1. Designated the M4 Power-Driven Decontaminating Apparatus, it consisted of a wooden 400-gallon tank, a pump, an integral engine, and two spray guns. It was limited standardized in 1943 for use by the Army, Navy, and Army Air Corps. During the war, 2,625 units were procured. The skid-mounted configuration was thought to be better for shipment overseas, but it proved unpopular with field units. The M4 unit was replaced by the M3A3 Decontamination Apparatus and obsoleted in 1958 due to problems with the gasoline engine maintenance.[33]

M5 Decontaminating Apparatus

During World War II, one problem with the M3 and M4 series apparatus was that water had to first be mixed with the bleaching powder to create slurry. This could take up to 40 minutes to complete. In addition, there was a shortage of M3A2 Decontaminating Apparatus. This led the Army to investigate a commercial modified orchard fertilizer spreader to directly disseminate dry bleaching powder on roads, runways, and fields. By 1944, the Army identified the E2 Dry Agent Motorized Decontaminating Apparatus as the best design. It consisted of a hopper and two distributing fans mounted on a one-ton steel trailer. The unit could decontaminate approximately 14,000 square yards. The E2 was then classified as a limited procurement item. The Army Air Corps then procured 200 units and sent most of them overseas for possible use on airfields. Further development work was dropped on the E2, but in 1947, the Army

standardized the E2 as the M5 Dry Agent Decontaminating Apparatus. Problems with the production of the M5 unit led to its reclassification as limited standard in 1949. The Army then decided there were no further requirements for a dry agent disseminator and obsoleted the M5 in 1951.[34]

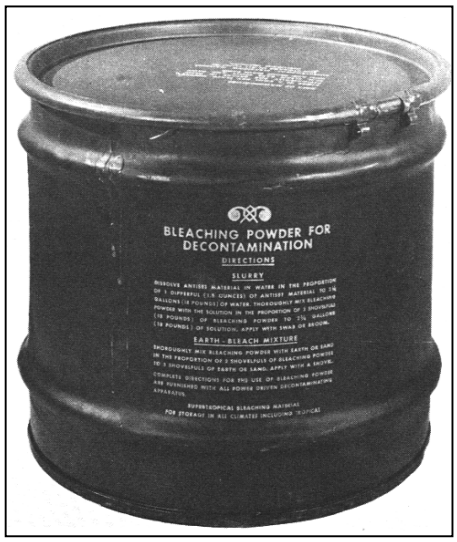


M5 Protective Ointment Kit

The original shipping containers for M5 Protective Ointment tubes consisted of a metal can 3.5-inches wide, 4-inches high, and one-inch deep with a hinged waterproof lid. It held four tubes of M5 Protective Ointment for use with vesicant agents like mustard and lewisite. Each tube was wrapped in cheesecloth for use as an applicator. Under the lid of the container was a spot for a small tube of British Anti-Lewisite (BAL) eye ointment. In 1944, this combination was standardized as the M5 Protective Ointment Kit. During World War II, the Army procured over 26.5 million kits and issued them to soldiers in the field where they were kept in the protective mask carrier. The kit was also part of the Gas Casualty Treatment Set issued by the Medical Corps. In 1950, the M5 kit was reclassified limited standard in favor of the M5A1 kit. The existing stocks of the M5 kit were then converted to M5A1 kits and the M5 kit was obsoleted in 1953.[35]

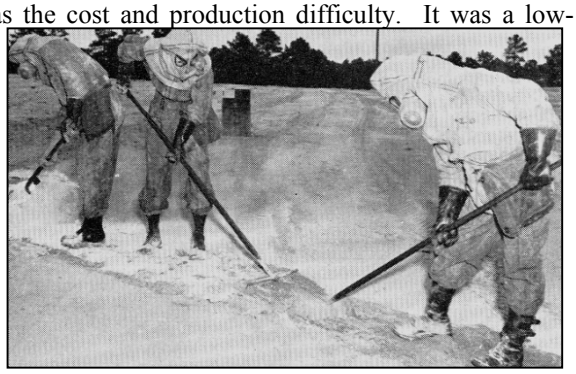
THE 1950'S

Decontaminating Agent



Supertropical Bleach (STB) Decontaminating Agent

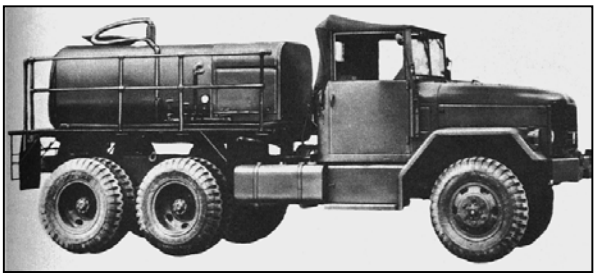
Although the Army concentrated on the decontamination of nerve agents during the 1950s, the decontamination of mustard agent remained a concern. In 1950, the Army standardized Supertropical Bleach (STB), the improved bleaching powder containing about 30% available chlorine with calcium oxide added as stabilizer, to replace Grade 3 bleach. STB was more stable in long-term storage, particularly in temperature extremes, and was easier to spread from a decontaminating apparatus due to its more uniform consistency. It was effective against Lewisite, V and G nerve agents, and biological agents. STB could be used as a slurry paste, dry mix, slurry mix, or camouflaged with a dye mixture. It normally came in a 60-pound drum. Citric acid was used as an antiset agent with STB. During cold weather it helped prevent the slurry from clogging the lines and settling in the tank and during warm weather, it prevented the slurry from foaming. One of the major problems with STB was the cost and production difficulty. It was a low-volume and low-profit item that American industry refused to produce. By the 1970's, India was the sole source for the chlorinated lime used in STB. In 1983, the Army completed a pilot plant production facility at a contractor's plant in Columbus, Ohio, to demonstrate a new process of production to potential domestic industrial bidders. The pilot plant used a liquid reactor process that combined calcium hydroxide with chlorine. After the successful demonstration, the pilot plant was moved to Pine Bluff Arsenal to convert old bleaching agent to STB specifications. Today, STB remains an expendable item still used for decontamination.[36]



Biological Decontamination

During the 1950's, the Army continued to examine the various biological decontaminants indentified during World War II at Fort Detrick. The Army made the most progress on examining ethylene oxide (ETO) as a biological agent decontaminant, although it was never standardized. It was sealed in E7 glass ampoules for use with Quartermaster Corps delousing bags or the Chemical Corps vapor-proof sack to sterilize material in bulk. One of the main problems with ethylene oxide was its flammability in its pure state. Additional research demonstrated that the material was less flammable when mixed with Freon 12. The Army also continued to examine formaldehyde and formalin, an aqueous solution of formaldehyde and methanol. Researchers designed aerosol bomb dispensers for its dissemination. The primary problems with formaldehyde were that it left a deposit on surfaces and the vapors were very toxic.[37]

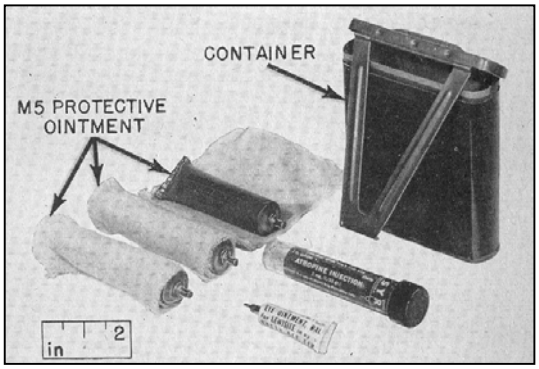
Decontaminating Equipment



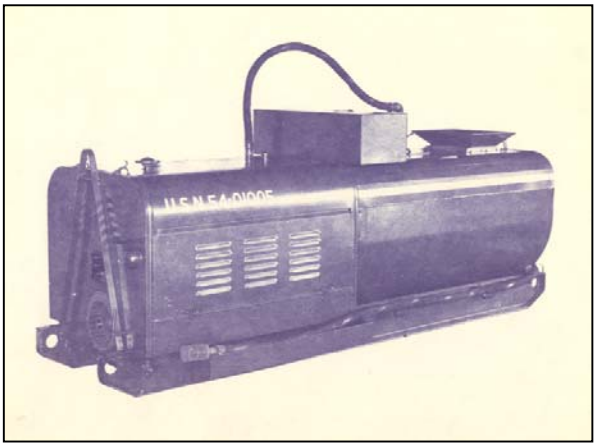
M3A3 Decontaminating Apparatus

One of the major problems with the M3A2 Decontaminating Apparatus was that the wooden storage tank was susceptible to mold and fungus. To solve that problem, a new 400-gallon steel tank replaced the wooden tank. The new version was designated the M3A3 Truck Mounted Power-Driven Decontaminating Apparatus and was standardized in 1952 during the Korean War. Similar to the earlier version, it was designed to spray water, bleach slurry, or other decontaminants and, as a secondary mission, fight fires, spray water-soluble paint, or serve as field showers. During the Korean War, the Army procured 329 units and the Air Force procured 225 units. The M9 Decontaminating Apparatus eventually replaced the M3A3 and it was obsoleted in 1972.[38]

M5A1/M5A2 Protection and Treatment Kits



Following the Allied discovery of the German nerve agents at the end of World War II, antropine was quickly identified as a treatment for casualties. The M5 Protective Ointment Kit was modified in 1950 by the removal of one of the M5 Protective Ointment tubes and the addition of a syrette of atropine sulfate. The kit still contained three tubes of M5 Protective Ointment and one tube of BAL eye ointment. The Army, Navy, Air Force, Marines procured over 1.2 million M5A1 Protective Ointment Kits. The kit was renamed the M5A1 Protection and Treatment Kit in 1955. In 1959, the atropine syrette was replaced by an automatic self-ejector unit. As a result of this change, the kit was standardized as the M5A2 Protection and Treatment Kit. The M5A1 Kit was reclassified Standard B and existing units were to be converted to M5A2 kits. Although the Navy and Marines maintained a separate requirement for the M5A1 and M5A2 kits, the Army reversed their decision in 1960 and did not produce M5A2 kits. Instead, many of the M5A1 kits were eventually modified into M5A3 and M5A4 kits during the 1960's. The Army obsoleted the M5A1 and M5A2 kits in 1969.[39]



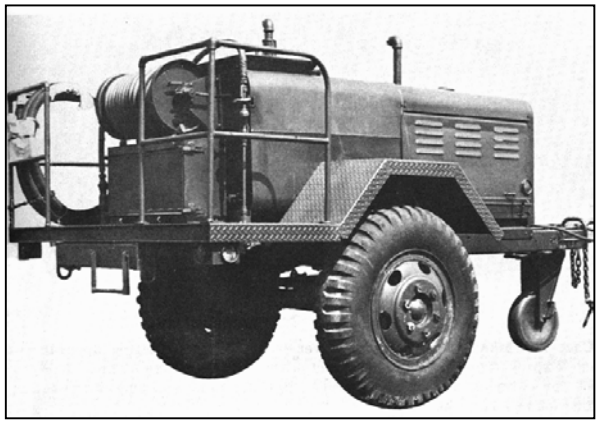
M6 Decontaminating Apparatus

During the Korean War, the Navy requested new production of the M4 Skid Mounted Decontaminating Apparatus for shore installation and barge use. Instead of producing new M4 units, the Army incorporated existing M3A2 400-gallon wooden tank and parts on a skid mount and redesignated the new units the M6 Skid Mounted Power-Driven Decontaminating Apparatus. The M6 apparatus was standardized in 1952 and 40 units were ordered. Before the units were completed, the Army decided to switch to the 400-gallon steel tank. The Army procured 108 M6 units with the

steel tank primarily to meet the Navy requirement. The M6 was eventually replaced by the M12 Decontaminating Apparatus and was obsoleted in 1967.[40]

M7/M7A1 Decontaminating Apparatus

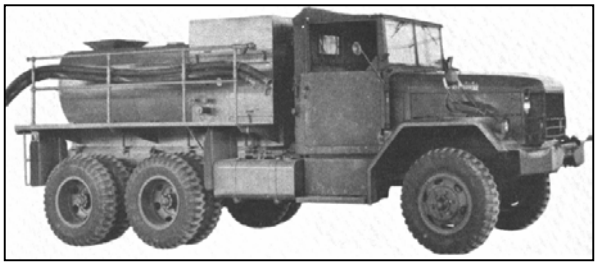
In 1954, the Navy requested the Army to standardize a modernized version of a Navy fire-fighting and decontamination unit. The M7 Trailer-Mounted Power-Driven Decontaminating Apparatus consisted of 150-gallon steel tank, a pump, and a commercial gasoline engine mounted on a two-wheeled trailer. It weighed about 2,600 pounds and could be attached to almost any combat vehicle. At the standardizing of the M7 Decontaminating Apparatus, the Corps of Engineers objected to the use of a non-standard commercial gasoline engine on the unit. To correct the problem, the Army standardized the M7A1 Trailer Mounted Power-Driven Decontaminating Apparatus in 1954 with a standard gasoline engine and reclassified the M7 limited standard. Both the M7 and M7A1 were obsoleted in 1958 and replaced by the M8 Decontaminating Apparatus.[41]



M8/M8A1/M8A2 Decontaminating Apparatus

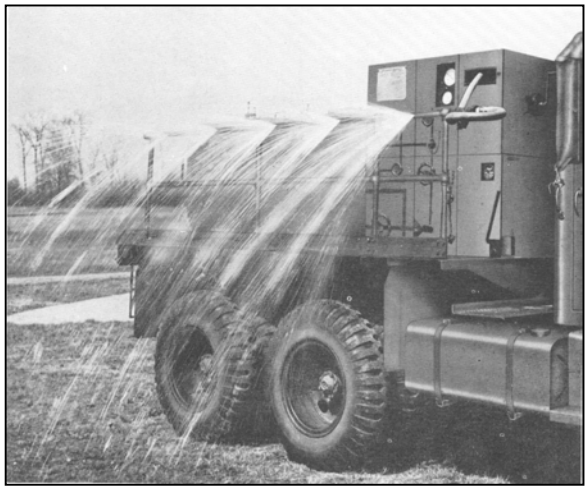
After the standardization of the M7 series decontamination apparatus, the Navy requested a larger, lighter weight, 200-gallon trailer mounted unit that was commercially available. As a result of this request, the Army standardized three versions of the same decontamination apparatus in 1958. The E15 Decontaminating Apparatus was standardized as the M8 Trailer-Mounted Power-Driven Decontaminating Apparatus for Navy use at shore bases. It consisted of a 200-gallon steel tank, gasoline engine, and pump mounted on a commercial trailer. The unit weighed 1,800 pounds. The Navy procured 53 M8 units. To meet a Marine Corps requirement for a standard Ordnance trailer that could handle heavy field duty, the E15R1 was standardized as the M8A1 Trailer-Mounted Power-Driven Decontaminating Apparatus. The Marines and the Navy procured 133 of these units. Additional improvements to the trailer and the tank resulted in the E15R2 version being standardized as the M8A2 Trailer-Mounted Power-Driven Decontaminating Apparatus. The Army, Navy, and Marines ordered 235 of the M8A2 units. It consisted of a 200-gallon metal tank, a pump, a gasoline engine, and two spray guns mounted on a trailer. The entire unit weighed 2,650 pounds empty. Although it was designed to spray bleach slurry or other decontaminants, the unit could also be used to spray paint, fungicides, insecticides, or water to fight fires. The M8/M8A1/M8A2 units were eventually replaced by the M12/M12A1 skid-mounted units and were obsoleted in 1967.[42]

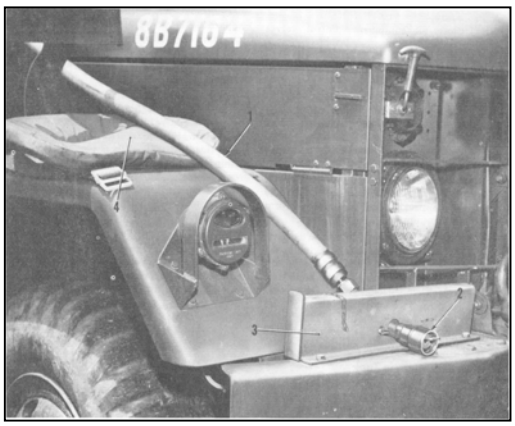
M9 Decontaminating Apparatus

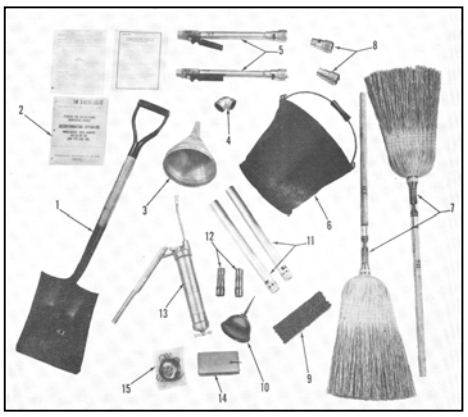


In 1952 the Army initiated a project to make major improvements to the M3A3 Decontamination Apparatus. After a series of test, the M9 (E9) Truck-Mounted Power-Driven Decontaminating Apparatus was standardized in 1958 to replace the M3A3 units. The major improvements included a large pump capacity, a longer pump life without requiring repair, improved piping for winter operations, improved shower rails, additional spray guns for fire fighting, and spring mounts. The M9 could be used for decontamination, as a fluid pump, for firefighting, as a field shower, or even as a water-soluble paint sprayer. It consisted of a 400-gallon steel tank and 20-gallon detergent tank mounted on an M45 truck chasses. There was also an optional water heater. The truck engine provided the power to run the pump. The truck had seats on the front fenders for soldiers using handheld spray nozzles and fender mounted spray hoses for automatic operation. While driving slowly and using both sprayers, the unit could cover a 12-foot wide path. The

Army procured 311 M9 units before the standardization of the M12A1 skid-mounted apparatus in 1966 resulted in the M9 being reclassified as Standard B. After the M9 became uneconomical to repair and support, the Army obsoleted it in 1976.[43]







THE 1960'S

Decontaminating Agent

Decontaminating Solution 2 (DS2)

Decontaminating Agent Noncorrosive (DANC) proved to be particularly corrosive to the brass parts of the M2 Decontaminating Apparatus, so the Army spent a decade trying to develop a replacement. After investigating Decontamination Solution (DS) and then Decontamination Solution 1 (DS1), the Army standardized Decontaminating Solution 2 (DS2) in 1960. DS2 was a clear amber solution of 70% diethylenetriamine, 28% methyl cellosolve (ethylene glycol monomethyl ether), and 2% sodium hydroxide. It came in a five-gallon pail for large-scale decontamination operations or a 1-1/3 quart can used to refill the M11 Portable Decontaminating Apparatus. DS2 was effective against all known chemical agents including the G- and V-series of nerve agents, mustard agent, and against most biological material (except bacterial spores). It was less destructive to metals, plastics, rubber, and fabrics than DANC. On the down side, it was known to remove and soften new paint, and discolor old paint. It was also irritating to the skin. In 1983 the National Institute for Occupational Safety and Health issued a warning that ethylene glycol monomethyl ether was a possible health hazard. Because of DS2's problems, the Army initiated a replacement study shortly after it was standardized. Although many replacements were studied over the years, all were found lacking in at least one requirement. Unable to find a better decontaminant after 40 years of research, the Army continues to keep DS2 as the standard decontaminating agent.[44]

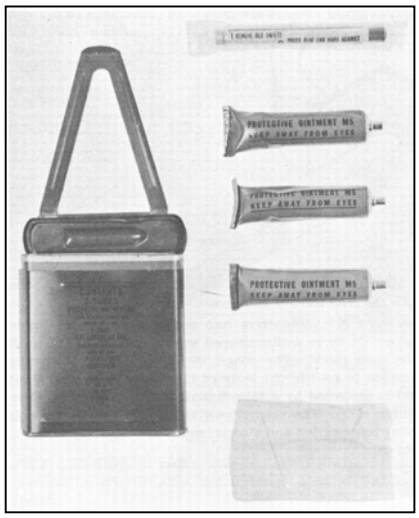
BPL Biological Decontaminating Agent

In 1947, the Army initiated a program to find a biological decontaminating agent. Early work on the project examined Formaldehyde Solution (USP) and ethylene oxide. A commercially available decontaminant called beta-propiolactone (BPL) was standardized in 1960. It was a colorless liquid that was noncorrosive and nonflammable and highly effective against microorganisms. BPL was stored in one-gallon pails that could safely be stored under most conditions. However, BPL was extremely irritating to humans and therefore mask and protective clothing were required during its use. A research program to develop a replacement for BPL proved unsuccessful. Other problems were that BPL could not be procured or shipped without a license from the Department of Agriculture since it was carcinogen and the only producer refused to apply for one. In 1979, the Army decided to use DS2 and STB as biological decontaminants and obsoleted BPL.[45]

Chemical Decontaminant 1 (CD-1)

One of the early possible replacements for DS2 was the Air Force's CD-1 decontaminating agent. CD-1 was developed in 1968 to prevent damage to sensitive aircraft parts caused by DS2. It consisted of monoethanolamine, isopropanolamime, and lithium hydroxide. Further testing during the early 1970's indicated that CD-1 was not an effective decontaminant for mustard agent. In 1974, CD-1 was dropped from consideration as a replacement for DS2.[46]

Decontaminating Equipment

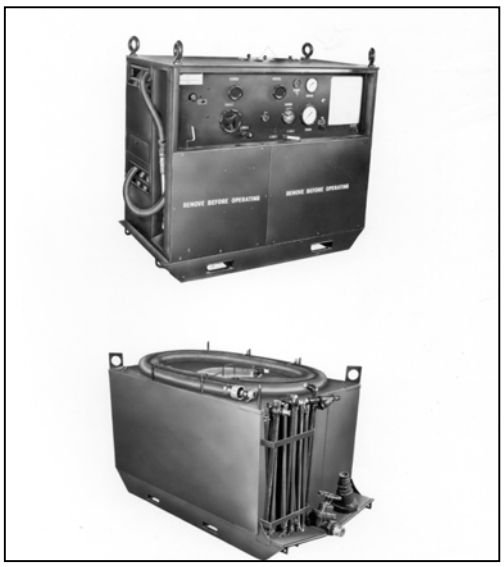


M5A3/M5A4 Protection and Treatment Kits

In 1960, before the conversion of the M5A1 Protection and Treatment Kits to M5A2 kits took place, the Army decided to remove the BAL eye ointment tube from the kit due to the perceived lack of threat from a lewisite attack. This resulted in the standardization of the M5A3 Protection and Treatment Kit. The existing M5A1 kits were then converted to M5A3 kits by the removal of the BAL ointment tube and the addition of an automatic atropine injector. The Marines procured 120,000 of the M5A3 kits. In 1963, the Army decided to issue the atropine injectors separately from the M5A3 kits. As a result of this decision, two years later, the M13 Decontaminating and Reimpregnation Kit was standardized without atropine injectors. A delay in the production of the new M13 kits resulted in the Army removing the atropine injectors and BAL Eye Ointment from existing M5A1 kits and adding a fourth tube of M5 Protective Ointment. This new configuration was standardized as the M5A4 Protection and Treatment Set in 1965. Once the M13 kits were in production, the Army obsoleted the M5A3, and M5A4 kits in 1969.[47]

M11 Decontaminating Apparatus

In conjunction with the standardization of DS2 in 1960, the Army standardized the M11 (E17R2) Portable Decontaminating Apparatus to replace the earlier M2 Decontaminating Apparatus. The M11 was a refillable fire extinguisher type unit used to decontaminate vehicles and weapons. It held 1-1/3 quarts of DS2. A nitrogen filled cylinder provided the pressure for spraying. Raising the unit's handle punctured the nitrogen cylinder and the resulting pressure allowed for a spray range up to eight feet. The unit came with a mounting bracket to attach it to equipment or a vehicle.[48]

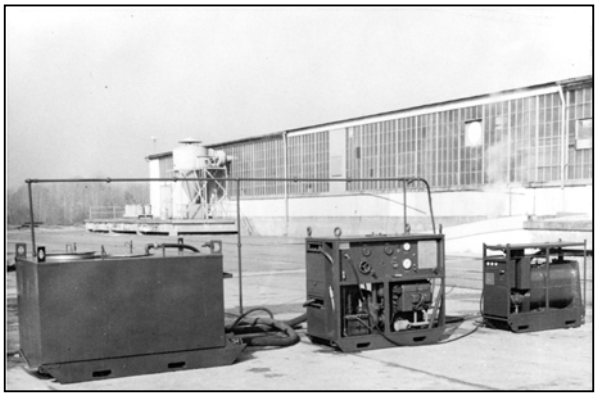


M12 Decontaminating Apparatus

The continuing need for a multipurpose decontaminating apparatus suitable for the Navy, Marines and the Air Force resulted in the standardization of the M12 Skid-Mounted Power-driven Multipurpose Decontaminating Apparatus in 1961. In addition to decontamination, the unit could be used for fire fighting, deicing of aircraft, cleaning of aircraft and vehicles, mixing and pumping of impregnite, general pumping requirements, hot and cold showers, and the spraying of insecticides and fungicides. It could handle bleach slurry, deicing and defrosting fluids, fire fighting foam solutions, and detergent compounds. The M12 consisted of two nonintegral sections, both skid mounted on an aluminum alloy frame and connected only by two hoses. One section held a pump, engine, hose reels, flush water tank, fuel tank, and controls. The other section was either a 200 or 500 gallon stainless steel decontaminant tank, a 20-

gallon detergent tank, a hopper blender for mixing STB with water to make bleach slurry, a mixing unit for detergent or foam liquids, and control functions. An optional heater was also available for showers or deicing operations. The Navy, Marines and Air Force procured 650 M12 units. Of those procured, the Army kept six M12 units and these were eventually converted to M12A1 units. In 1979, the Army obsoleted the M12 in favor of the M12A1.[49]

M12A1 Decontaminating Apparatus



The successful design of the M12 Decontaminating Apparatus for the Navy, Marines, and Air Force, led the Army to reexamine the M12 as a replacement for the M9 truck mounted unit. As a result of this testing, the M12A1 Skid-Mounted Power-driven Multipurpose Decontaminating Apparatus was standardized in 1966. It consisted of three sections, a 500-gallon stainless-steel tank, a water heater, and a pump unit. Similar to the M12 unit, the M12A1 was designed to mix and spray decontaminating agent and hot, soapy water rinses during field decontamination operations. As secondary missions, the unit could also be used for fire fighting with water or foam, deicing operations, washing vehicles, as a pump station, and as field showers for soldiers. The field shower assembly was designed to handle 25 soldiers at a time. The M12A1 was furnished to decontaminating units and to the Air Force and Marine Corps. Initially, the Army ordered 53 of the units in 1967. During Operation Desert Shield/Storm, the M12A1 was deployed to the front to handle most large scale decontaminating operations. Although the M17 Lightweight Decontaminating Apparatus, standardized in 1987, replaced the M12A1 in all but heavy division chemical companies, the M12A1 is currently still a standard Army item.[50]

M13 Individual Decontaminating and Reimpregnation Kit

Prior to the 1960's, the only individual decontamination kit was the M5A1 Protection and Treatment Kit containing M5 Protective Ointment. In 1965, the Army replaced the M5A1 kits with the M13 (E21R7) Individual Decontaminating and Reimpregnation Kit. The kit consisted of an aluminum (later plastic) container containing two cloth bags of chloramide (XXCC3) decontaminating and reimpregnation powder (for clothing and equipment decontamination), a United Kingdom Personal Decontamination Outfit (PDO) pad filled with Fuller's earth (for skin decontamination), a B-1 dye capsule (for use to detect chemical contamination on clothing), and a razor blade (for cutting out heavily contaminated pieces of clothing). The chloramide powder neutralized nerve and blister agents. The fuller's earth was an absorbent that removed the agent from the skin. It did not neutralize the agents and, unlike M5 Protective Ointment, could not be applied prior to an attack. The whole kit weighed about 0.7 pounds and was designed to fit in the M17 Protective Mask carrier. The Army procured 500,000 of the kits in 1966 to replace the M5 series kits. By the 1980's, the kit was no longer recommended for skin decontamination and it was obsoleted in 1989.[51]

THE 1970'S

Decontaminating Equipment

eyes or mouth. Thus, the kit was designed to decontaminate the skin, but not the face. In an emergency, it could also be used to decontaminate individual equipment. The Army also standardized the M58 Skin Decontaminating Training Aid along with the M258 kit. The M58 used simulants instead of the actual decontaminating solutions. Due to the caustic aspects of the decontaminants, the M258 kit was obsoleted in 1989.[52]

M258 Decontamination Kit

The Army standardized the M258 Skin Decontamination Kit in 1975 to replace the earlier M13 Individual Decontaminating and Reimpregnation Kit. While the M13 kit used fuller's earth to absorb liquid chemical agents from the skin, the M258 Kit used two containers of decontamination material to neutralize nerve and blister agents. The kit consisted of an olive drab plastic case holding four gauze pads, two red plastic scrapers, and two plastic capsules containing decontamination solutions. Decontaminating Solution No. 1 was a solution of hydroxyethane, phenol, sodium hydroxide, and ammonia dissolved in reagent water. Decontaminating Solution No. 2 was a solution of hydroxyethane and zinc chloride in reagent water. Within the No. 2 capsule was a separate sealed glass ampoule holding dry chloramine B. Both decontamination solutions were poisonous and caustic and thus were unsuitable for wounds or for use in the

THE 1980'S

Decontaminating Agent

German C8 Emulsion

Starting in the early 1980's, the U.S. Army examined a German decontaminating agent as a possible replacement for DS2 and STB bleach for use in the M12A1 Decontaminating Apparatus. Known as German C8 Emulsion, it consisted of perchloroethylene (PCE), calcium hypochlorite, water, and an emulsifier. During initial testing, C8 Emulsion was an effective decontaminant of chemical agents and the toxin designated T2, but set off chemical agent alarms and was clearly visible due to its white color. The main ingredient, PCE, was also a recognized hazardous waste. The Army attempted to find replacements for the PCE and make other changes, but dropped the program in 1987 in favor of ongoing research on the Improved Chemical/Biological Agent Decontaminant.[53]

Improved Chemical/Biological Agent Decontaminant (ICBAD)

In 1985, the Army initiated a program to develop the Improved Chemical/Biological Agent Decontaminant (ICBAD) using the good aspects of German C8 Emulsion. After attempting to find U.S. suppliers of appropriate ingredients for a new decontaminant, the program concentrated on the same ingredients as the C8 Emulsion, only with green dye for camouflage. Calcium hypochlorite, produced only in Germany, was the major problem. After further attempts to find U.S. suppliers, the ICBAD program was canceled in 1988 in favor of the Multipurpose Chemical Biological Decontaminant program.[54]

Multipurpose Chemical Biological Decontaminant (MCBD)

The Multipurpose Chemical Biological Decontaminant (MCBD) program was initiated in 1982. After over 500 possible decontaminants were examined, the Army concentrated on Fichlor microemulsion as the best candidate. Microemulsions were translucent dispersions containing oil, water, and emulsifier. Further work on the Fichlor microemulsion, however, failed to develop a decontaminant that was better than DS2. Since MCBD contained perchloroethylene, a hazardous waste, and required complicated mixing equipment, the program was terminated in 1989.[55]

Decontaminating Agent: Multipurpose (DAM)

Further attempts to use the knowledge learned from the ICBAD and MCBD programs to find a DS2 replacement resulted in the Decontaminating Agent: Multipurpose (DAM) program initiated in 1989. For the next four years, the Army examined various possible ingredients searching for a better decontaminant that was safe for the environment and easily prepared in the field. In all tests, DS2 proved the best overall multipurpose decontaminant. The DAM program was then terminated in 1993.[56]

Decontaminating Equipment

M13 Decontaminating Apparatus

The need for an improved portable vehicle decontaminating apparatus to replace the M11 Decontaminating Apparatus resulted in the Army standardizing the M13 Portable Decontaminating Apparatus in 1983. It consisted of a hose and wand section with a disposable brush attachment, a manual in-line pump, a disposable 3.7-gallon decontaminant container, and an accessory container. The whole unit weighed 60 pounds when filled and was designed to fit a vehicle's fuel/water can mounting bracket. It used DS2 decontaminant to remove chemical contamination from the sections of all types of vehicles that personnel touch. The scrubber brush was designed to remove mud or soil from the equipment. The primary improvements over the M11 unit were the larger capacity decontaminant container and the scrubbing capability. The initial procurement was approximately 130,000.[57]

XM14 Decontaminating Apparatus

In 1980, the Army initially attempted to improve the M12A1 Decontaminating Apparatus but then made enough changes that the new configuration was designated the XM14 Truck Mounted Power Driven Decontaminating Apparatus. It consisted of a steam generator mounted on a 5-ton truck and a vehicle rinse rack designed to decontaminate large combat vehicles. The storage tank could hold 450 gallons of water or 300 gallons of bleach slurry. The apparatus could decontaminate the ground, spray water for firefighting, and provide personnel showers. Dissatisfaction with the truck mounted version led to the project being canceled in 1981.[58]

XM15 Decontaminating Apparatus

The requirement for a system to decontaminate the inside of Army vehicles, aircraft, watercraft, and shelters led to the Interior Surface Decontaminating System (ISDS) project, started in 1980. The same year, the project was redesignated the XM15 Interior Surface Decontaminating Apparatus and concentrated on the use of hot air generated by a diesel-fired burner to decontaminate both chemical and biological agents. A collapsible 10-foot hose delivered the hot air to the contaminated surface. A second hose captured the vaporized agent and blew it out of the

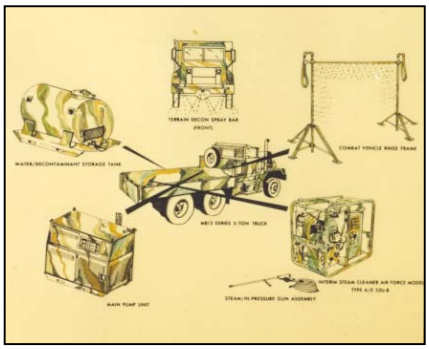
interior. After extensive testing at Fort Knox and Dugway Proving Ground, the Army decided to terminate the program in 1986 in favor of a quicker decontamination system.[59]

XM16 Decontaminating Apparatus

During the 1970's, the Army began researching the use of turbine exhaust from jet engines to decontaminate large equipment. Based on intelligence collected on the Soviet TMS-65 decontamination system, the Army started work on the XM16 Jet Exhaust Truck Mounted Decontaminating Apparatus in 1980. The XM16 consisted of a jet engine, control cab, a diesel fuel tank for the jet engine, and a tank for either decontamination or smoke liquids mounted on a 5-ton military truck. The idea was to direct high velocity streams of hot exhaust gases onto the outer surfaces of vehicles for chemical and biological decontamination. In addition, the jet engine could also disseminate water, decontaminating agent, or even fog oil to create smoke screens. Due to several deficiencies in the system, the project was canceled in 1986, but the principle was continued in related development projects.[60]

M17 Decontaminating Apparatus

The need for a lightweight decontaminating system to replace the M12A1 Decontaminating Apparatus led the Army to examine a Norwegian device called the NBC SANATOR. Designated the A/E32U-8 by the Air Force, it consisted of an air cooled engine, water pump, heater, 1,450-gallon rubberized fabric collapsible tank, and an accessory kit. The Air Force procured over 2,100 A/E32U-8 units. In 1984, the Army type classified the A/E32U-8 for urgent limited procurement of 705 units through the Air Force. After additional developmental work, the XM17E1 unit was standardized as the M17 Lightweight Power-Driven Decontaminating Apparatus in 1987. The standardized version used a 1,580-gallon water tank instead of the smaller version. The M17 was designed to decontaminate equipment and personnel using either water or decontaminating agents. The personnel showers could handle up to 12 soldiers at one time. The unit was designed to draw water from any natural source and deliver it heated and under pressure on demand. The initial deliveries of the M17 went to both the Army and Marines. After standardization of the M17, the earlier A/E32U-8 version remained in the Army supply system as a substitute item (Standard B). During Operation Desert Shield/Storm, the Army expedited the fielding of the M17 to units deploying to Southwest Asia.[61]



XM18 Decontaminating Apparatus

In 1980, the Army attempted to improve the M12A1 Decontaminating Apparatus but then made enough changes that the new configuration was designated the XM18 Skid Mounted Diesel Powered Decontaminating Apparatus. As redesigned, the XM18 consisted of a 450-gallon stainless steel water/decontaminant tank, a pumper unit, a steam generator/heater unit, and a utility kit containing a nozzle and brush set, a personnel shower, combat vehicle rinse rack, terrain spray bar, a hydrant adaptor set, and storage containers. The

XM18 could be used for decontamination of chemical and biological agents, water pumping, firefighting, and for personnel showers. In 1985, the Army decided to terminate the development program after experiencing problems with the experimental units and finding that the unit was too heavy and did not perform as well as the M12A1.[62]

XM19 Nonaqueous Equipment Decontamination System (NAEDS)

The XM19 Nonaqueous Equipment Decontamination System program was initiated in 1985 for the Army and Air Force to provide a closed loop solvent system to decontaminate small items such as weapons, electronics, and optical sights. The NAEDS consisted of a glove box cabinet with hand held spray devices and a solvent distillation and condensation purification system that recycled the solvent. There would be two configurations of the NAEDS: a fixed site system and a mobile system. Problems with the solvent, a chlorofluorocarbon (freon), led to the termination of the program in 1992.[63]

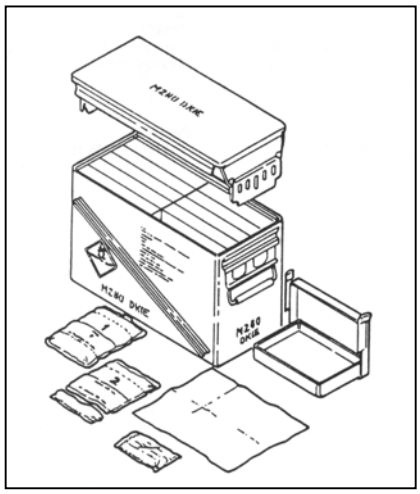
XM20 Nonaqueous Vehicle Decontamination System (NAVDS)

Following the termination of the XM16 Jet Exhaust Truck Mounted Decontaminating Apparatus in 1985, the Army initiated the XM20 Nonaqueous Vehicle Decontamination System program. The NAVDS consisted of a jet engine mounted on a High Mobility Multi-Purpose Wheeled Vehicle (HMMWV). The strong point of the system was that it did not require a water source to decontaminate equipment. Although the hot air provided partial decontamination, the overall performance of the NAVDS was not satisfactory in achieving complete decontamination. In 1986, the Army canceled the program.[64]

M258A1 Personal Decontaminating Kit

The original M258 Personal Decontaminating Kit, standardized in 1975, had two major problems: the decontamination solution bottles were either difficult to break or broke too quickly, and the kit could not be used to decontaminate the face. The M258A1 Personal Decontaminating Kit, a product improvement in 1980, solved these problems by replacing the two decontamination solution bottles and separate gauze pads with six wipe packets holding pretreated towelettes. There were three DECON 1 packets and three DECON 2 packets. Although the decontamination solutions were still poisonous and caustic, the towelettes could be used for partial facial decontamination. The kit could also be used to decontaminate biological agents, although soap and water was considered better. The reconfigured kit

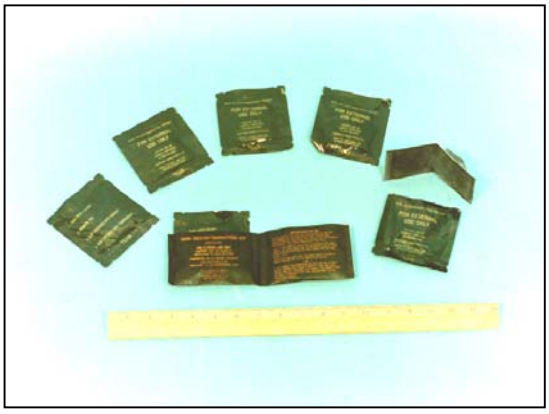
resulted in considerable production cost savings and the initial procurement order was for three million kits. A new training kit, without the caustic materials, was also standardized as the M58A1 Personal Decontaminating Kit Training Aid at the same time. The caustic nature of the decontamination solutions eventually resulted in the M258A1 kit being replaced by the M291 Skin Decontamination Kit in 1989. All remaining M258A1 kits were ordered removed from the supply system by 1999.[65]



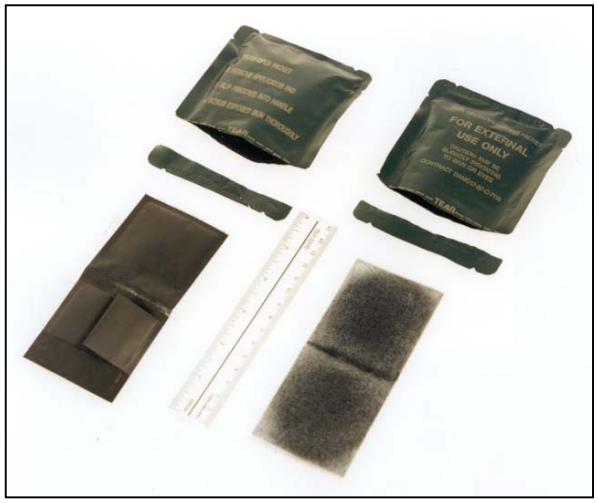
M280 Individual Equipment Decontaminating Kit (DKIE)

The M280 Individual Equipment Decontaminating Kit, known as the DKIE, was standardized expendable in 1985. The DKIE consisted of a squad size container holding 20 individual packages. Each package contained two wipe packets holding treated towelettes similar to the ones used in the M258A1 kit, one for DECON 1 and one for DECON 2. The towelettes were intended to decontaminate protective gloves, overboots, masks, and equipment. They were not intended for decontaminating the skin. The M280 kit was eventually replaced by the M295 Individual Equipment Decontamination Kit and was obsoleted in 1996.[66]

M291 Skin Decontaminating Kit (SDK)



The U.S. Army Medical Materiel Development Activity at Fort Detrick, MD, developed the M291 Skin Decontaminating Kit, standardized expendable in 1989, to replace the M258A1 Kit. The M291 was designed to decontaminate skin by adsorption and neutralization of toxic agents without possible long-term harmful effects. The kit consisted of a wallet-size carrying pouch holding six tear-open packets. Each packet contained an applicator pad filled with decontamination powder. Two packets were necessary for one complete skin decontamination procedure. Initial production was for 1.5 million kits.[67]



THE 1990'S

Decontamination Agents

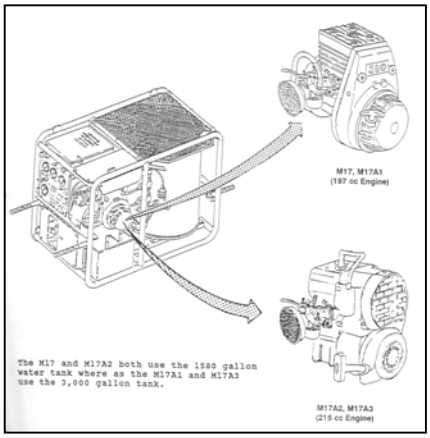
Biological Decontamination

At the end of the 20th century, the Army did not have a standardized biological specific decontaminant in case of a biological attack. Instead, the Army relied on the standardized chemical decontaminants DS2 and STB for biological decontamination. The 1993 field manual for decontamination also recommended using soap and water to remove most biological agents from the skin. An alternative was to use a weak solution of sodium hypochlorite (household bleach). The manual listed a number of non-standard biological decontaminants to include: formalin (formadehyde), detrochlorite (a mixture of diatomaceous earth, anionic wetting agent, calcium hypochlorite, and water), paracetic acid, ethylene oxide (ETO), and carboxide (a mixture of ETO and carbon dioxide). Most of these decontaminants had problems because they were toxic, very corrosive, or flammable.[68]

Decontaminating Equipment

M17A1/M17A2/M17A3 Decontaminating Apparatus

Problems with the production of the original 197 cc engine provided with the M17 Lightweight Decontamination System led to the Army standardizing three additional versions of the unit in 1992. The M17A1 had the original engine but added a 3,000-gallon collapsible tank. The M17A2 included a new replacement 215 cc engine with a 1,500-gallon tank. The M17A3 added the new engine and the 3,000-gallon tank. Additional work for the Marines in 2000 resulted in modifications to the engine that allowed it to use JP 5/8 fuel, the selected "one fuel forward" for the Marines.[69]



M295 Individual Equipment Decontamination Kit

The improved design of the M291 Skin Decontaminating Kit led the Army to design the M295 Individual Equipment Decontamination Kit to replace the M280 Individual Equipment Decontamination Kit. The M295 was standardized in 1992 to enhance a soldier's ability to decontaminate his individual equipment in the field. It consisted of a pouch holding four individual polyester wipe-down mitts holding XE555 Resin that absorbed the chemical agent and then neutralized it. In 1999, the

XE5555 Resin was replaced by Sorbent Powder Decontaminate, used in the newer M100 Sorbent Decontamination System. In 2001, the pouch was replaced by a packet assembly to decrease cost and simplify production.[70]

Modular Decontamination System (MDS)

One of the lessons learned during Operation Desert Shield/Storm was the need for a more easily deployable decontamination system that used water more efficiently in a dry environment. To replace labor intensive and time-consuming decontamination systems such as the M12A1 Power Driven Decontaminating Apparatus, the M17 Lightweight Decontamination System, and the smaller M11 and M13 Decontaminating Apparatus when used for detailed equipment decontamination, the Army standardized the Joint Service Modular Decontamination System (MDS) in 1998. The MDS consisted of one M21 Decontaminant Pumper (DP) and two M22 High-Pressure/Hot Water (HPW) module. The MDS reduced water usage and decontaminated vehicles faster than the older systems. The M21 DP dispensed DS2 or other field decontaminants such as formalin, household bleach, or diesel fuel through two spray wands during the decontaminant application step of detailed equipment decontamination. Currently, the requirement for the M21 DP was temporarily suspended by the Commandant of the U.S. Army Chemical School due predominately to concerns over the use of DS2. The M22 HPW provided high pressure and high volume hot or cold water and liquid detergents to physically remove dirt, mud and agents during the initial wash step of detailed equipment decontamination and then to remove the applied decontaminant in the rinse step. The M22 can pull water from various sources to include hydrants worldwide and natural sources and provide personnel showers. Both the M21 and M22 can be mounted on a trailer for transportation and operation. Additional authorized items included a 3,000-gallon collapsible water tank for each M22 and a water pump. Designed for use by the Army's dual-purpose smoke/chemical companies, the MDS when mounted on trailers will be towed by the M56 Mechanized Smoke Generating System. A mounting kit for standard Army five-ton trucks will be available in the near future. The M22 HPW can also dispense novel decontaminant solutions such as Enzyme Decontamination Solution and Decontamination Foam.[71]

THE 2000'S

Decontamination Agents

Biological Decontamination for Homeland Defense

In October 2001, the need for a biological decontaminant for a bioterror attack became a critical necessity after anthrax-laced letters were mailed to both public and private buildings in several states. Many decontaminants were examined to remove the anthrax from the buildings, but the U.S. Environmental Protection Agency recommended chlorine dioxide gas due to its less harmful side affects. It was successfully used to decontaminate the Hart Senate Office Building after three months of work. Liquid chlorine was also used to further decontaminate office furniture and fixtures. To prevent future contamination through the mail, the U.S. Postal Service began irradiating unopened letters to destroy any additional anthrax spores.[72]

Decontaminating Equipment

M100 Sorbent Decontamination System (SDS)

To replace the M11 and M13 Decontaminating Apparatus, the Army standardized the M100 Sorbent Decontamination System (SDS) in 2002. The SDS consisted of two packs of reactive sorbent powder and two wash mitt applicators that eliminated the need for water and decreased the time for chemical decontamination. The reactive sorbent powder was both non-toxic and non-corrosive, unlike DS2, and did not interfere with chemical agent detectors. It could also be used at greater temperature ranges than DS2. The SDS weighed less than the M11 and was designed to fit in the M11's mounting bracket.[73]

THE FUTURE

Decontaminating Equipment

Joint Service Sensitive Equipment Decontamination (JSSED)

The continued need for a decontamination capability for sensitive equipment, aircraft/vehicle interiors, and shipboard equipment, while on the move, led to the Joint Service Sensitive Equipment Decontamination (JSSED) project. The project is divided into three unique capabilities. The first capability (Block I) is to decontaminate sensitive equipment such as avionics, electronics, and life-support systems, without affecting operational readiness. This requirement will probably use a re-circulating solvent system. Block II will concentrate on the decontamination of large interior storage spaces requiring a high-output air heating system and a periodic decontamination process. Block III will concentrate on spot decontamination while on the move. This requirement will probably be met by a solvent wash or sorbent decontamination. The overall project should take about four years to develop.[74]

Joint Service Family Of Decontamination Systems (JSFDS)

The Joint Service Family of Decontamination Systems (JSFDS) will consist of a family of decontaminants and a family of applicator systems intended to enhance force protection through personnel, equipment, facility and area decontamination. The JSFDS will provide the Armed Services with an ability to decontaminate fixed sites, ports of entry, airfields, ships, logistics support bases, and key command and control centers, facilities, personnel and equipment which have been exposed to the damaging effects of nuclear, biological, and chemical warfare agents, contaminants or toxic industrial materials. To achieve these objectives, the JSFDS program was subdivided into four phase blocks. The Block I objective is to acquire and field a family of commercial ("off the shelf") and/or non-developmental item decontaminants. This family of decontaminants will initially be used with existing fielded military applicators or, if necessary, with commercial integral applicators. The integral applicator, if required, is an interim solution. The Block I integral applicator will compete in the JSFDS Block II applicator procurement to become part of the Block II solution. The focus of Block II is to field and if necessary develop a family of applicators capable of dispensing the entire family of decontaminants regardless of form (e.g. non-aqueous, aqueous, non-liquid). If required, containment systems will capture, store and if possible reuse hazardous runoff or residue. The focus of Block III is to identify and field a personnel skin decontamination capability for use on personnel, with and without open wounds. This decontaminant will require Food and Drug Administration approval. The Block III acquisition is being conducted by the U.S. Army Medical Research Acquisition Activity, Frederick, Maryland. The focus of Block IV is to address requirements that will be traded-off during Blocks I, II, and III. It will also address requirements that are currently undefined by inserting technology as it matures to the point of being cost effective.[75]

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