# The Evolution of the Protective Mask for Military Purposes:

# 1919 to Present

MAJ Humberto E. Galarraga and Anthony R. Maranto, Ph.D.

U.S. Army Environmental Center

Aberdeen Proving Ground, Maryland

## ABSTRACT

This paper is the second in a two part series outlining the evolution of the science and technology connected to military protective masks. The information presented in this paper details the design and application of protective masks developed in the military sector and traces the evolution of the military science of chemical and biological protection from the end of World War I to present day.

(Key Words: gas mask, chemical biological warfare, NBC, CBW, technology evolution, science history, military science)

## INTRODUCTION

Developments in the science and technology of warfare commonly arise from concepts advanced in the civilian section. Such was the case for the military protective mask. As detailed in the first paper in this series, the military protective mask owes much of it's early development to its civilian forerunners developed largely to offer protection for medical, industrial, and fire rescue operations.

Following the initial development, however, military pressures (namely the development of field-expedient chemical gas attacks by German forces in World War I) soon prompted the rapid and distinctly military evolution of protective mask technologies. As we shall see in this paper, the multi-faceted technical maturation of protective masks did not slow after the end of World War I, rather as the adaptations of chemical and biological warfare became more sophisticated, refined, and widespread, protective masks developed to equal the new forms of offensive technologies.

Through the examination of the historical developments of the technologies of warfare, we can gain a clearer understanding of how such evolutionary processes are impacted by developments outside of the battlefield, and how they influence developments in other civil and military arenas. By examining the historic development of the protective mask, a clear picture may be gained of the progression of chemical and biological warfare and how defensive technologies may be able to adapt to the offensive strategies and developments of the 21st century.

**BETWEEN THE WORLD WARS: RE-ASSESSMENT AND RE-DESIGN**

The rapid developments and counter-developments of the chemical warfare programs of the Germans and Allies from 1915-1918, saw the military protective mask evolve from plain un-treated cotton mouth-pads to fairly sophisticated small-box respirators with fitted rubber face-pieces and effective canister filters. Although Fritz Haber, the German chemist who sired and directed the German chemical warfare program, was devastated by Germany's defeat and feared that he would be tried as a war criminal for his activities, he was instead awarded the Nobel Prize in chemistry. Indeed, in his acceptance speech, Haber addressed the issue of gas warfare by stating, "In no future war will the military be able to ignore poison gas. It is a higher form of killing" (Goebel 2000).

Even though Germany was banned from producing gas weapons under the Treaty of Versailles in 1919 (Addington 1994), Haber continued his work under the cover of creating pest control compounds. One of his discoveries during this period was a fumigant known as Zyklon B. While this gas did have insecticidal properties, it was also deadly to humans in enclosed spaces. As events unfolded, the Nazis would in turn use this gas some 20 years later for their extermination camps.

There are sketchy reports of intermittent use of gas warfare in the years immediately following WWI. Gas shells of various compositions were reportedly used by both the White and Red armies in the Russian Civil War and by British, French, and Portuguese troops in the maintenance of colonial rule (Goebel 2000).

The small-scale use of gas warfare, however, proceeded in the face of an international movement to ban such combat. In 1925 the Geneva Protocol made the use of gas warfare illegal. While, 38 countries signed the protocol, it was not ratified by the U.S. or Japan and it contained numerous loopholes such as the lack of verification and enforcement clauses. Despite the protocol, the major powers, even among the signatures, continued to develop their chemical warfare programs in secret. During the 1920s the Soviets and Japanese began their own gas warfare programs, aided in part with assistance from Germany.

As with the development of most military technologies, the continuous development and experimentation in offensive technologies is mirrored by similar progress in defensive technologies, in this case, the protective mask. By the signing of the armistice on November 11, 1918, what was arguably the most highly developed mask on either side of the conflict was the Kops Tissot Monro (KTM Mask). The KTM Mask composed of a stockinet-covered rubber face-piece that was one was one of the most comfortable of the World War I designs. It used a small canister filter that included a felt pre-filter to capture toxic smoke particulates. The KTM was also one of the last masks produced during the conflict and only about 2,000 were produced prior to the signing of the armistice, so while effective, they saw relatively little action on the battlefield (Smart 2000).

Following the end of World War I, the KTM mask continued in production and became known as the Model 1919. In 1921 the 1919 Model was standardized as The Service Gas Mask, M1. Minor changes were introduced to the M1 mask in 1928 including the addition of Triplex glass eyepieces and screw-threaded rims (making replacement in the field easier).

These changes marked the introduction of the M1A1 mask, as well as a new nomenclature system for U.S. military protective masks (Carey 1998).

During the 1920s and 30s, the U.S. military adopted a standard identification system to keep track of the various face-piece, filters, and carrier models developed and employed during this period. Model numbers for each of these three components were linked together, separated by a hyphen. So a mask system composed of an M1A1 face-piece, an MIV canister, and an MIII carrier would be designated as M1A1-IV-III (Walk 2001).

In 1934, MIA2 mask introduced the 'Universal' size, which was designed to fit 95% of users. This standardization meant that fewer sizes of masks need to be manufactured so the logistics and re-supply of masks in the field became more streamlined. The MI, MIA1 and MIA2 masks remained in reserve stocks until late 1944 when enough newer masks were available to declare the M1s obsolete (Smart 2000).

By the late 1930's, the political leaders across Europe, Asia, and the Americas could sense that war was on the horizon. In preparation of the eventuality of a war in Europe the US Chemical Warfare Service (CWS) began earnest work on a revised respirator face-piece. In 1938 the U.S. Army developed a lightweight mask consisting of a fully molded natural rubber face-piece. The design proved to be very popular with soldiers and was ultimately standardized as the M2 series mask in 1941. The M2 was the first to eliminate the need for stockinet coverings due to the improved nature of the chemical and age-resistant rubber used in its manufacture. Molded around the underside of the mask harness attachment was what was termed as a 'rifle skid.' This raised edge was designed to prevent the butt of a weapon from catching on the harness and inadvertently knocking the mask off of the face (Smart 2000; Hibbs 1998).

When the Nazis came to power in 1933, the military complex had keen interest in revitalizing the gas warfare program of WWI. While Adolf Hitler's combat injuries left him with a distinct personal distaste for gas warfare, he understood its capabilities. Hitler took Germany out of the League of Nations and the World Disarmament Conference and began re-building its military might (Addington 1994). Given that Fritz Haber still represented an invaluable resource to the Germans, they allowed him to continue his research, despite his Jewish heritage. After seeing the persecution of his fellow Jewish scientists, however, Haber decided to resign and move to Switzerland in late 1933 (Goebel 2000). He died a year later, leaving his legacy in the hands of the Nazis.

Another German chemist named Gerhard Schrader eventually resumed Haber's work. Schrader was earnestly working on the development of insecticides in 1936 when he and his team developed a lethal organophosphate compound named Tabun. Tabun was the first synthesized compound in a new class of poison gases, the "nerve agents". These compounds act by interfering with the propagation and transmission of the electro-chemical impulses across nerve synapses. Victims quickly lose control of autonomic bodily functions like breathing and death rapidly ensues from very minuet dosages. Additionally, early research showed that protective masks were of little protection against Tabun and similar agents since the compounds could be absorbed through the skin (Goebel 2000).

Even though Schrader had not been looking for a weapon, he quickly realized the military potential of the compound and turned his discover over to the authorities (as was required under Nazi law). While he was not enthusiastic about devoting his research to chemical weapons, Schrader was pressed into service and in 1938 he discovered an even more lethal analog to Tabun, which he named Sarin.

Around the mid 1930s, chemical warfare began to re-surface from its quite development phase. In the spring of 1935, Benito Mussolini sent his Italian troops to invade Abyssinia (Ethiopia). Mussolini added a new page to the gas warfare textbook by dropping mustard gas from airplanes in the form of gas bombs. World leaders criticized the Italians use of chemical warfare and in response to the furor Italy withdrew from the League of Nations and allied itself with Germany (Addington 1994).

Japanese use of chemical warfare also became public during its 1937 attack on China. While reports from China were sketchy, owing to a lack of unified reporting within China, it is widely believed that the Japanese used mustard gas on both Chinese soldiers and civilians (Goebel 2000).

The revival of chemical warfare in the mid to late 1930s sparked a panic in Western Europe. England, in particular, had vivid memories of the air raids of WWI and the British government realized the threat of chemical weapons being dropped from airplanes onto large population centers. To this end, the British rushed to produce over 38 million gas masks for civilian use (and eventually produced over 70 million). The respirator termed simply, the Civilian Respirator, was a very simple; a thin rubber face-piece with single plastic window and a filter canister held on by a large rubber band (Hibbs 1998). Through this effort, England became the first country to attempt to completely protect its civilian population from chemical attacks.

Somewhat more quietly, another non-conventional military weapon was beginning to take shape in the 1930s. While, the use of disease as a weapon of war has it's origins back to the early 14th century when Tartar invaders hurled the corpses of plague victims into the besieged city of Kaffa, the methodical development of biological warfare had not truly begun until after the first World War. Although the basic scientific knowledge and technology did exist to manufacture biological weapons during WWI, there is no compelling evidence that any country undertook such development. The possibility, however, was widely realized and the Geneva Protocol of 1925 included language that expressly forbade biological warfare (Goebel 2000 and OTSG 2000).

It was not until Japan took the lead in the 1930s, that biological toxins began to be seriously explored as a military weapon. Paralleling the development of poison gas in Germany, the development of biological weapons in Japan, was largely the brainchild of a single man, an Imperial Army Officer and doctor by the name of Shiro Ishii (Goebel 2000).

After the Japanese invasion of Manchuria, China in 1932, it set up a Japanese puppet government in the region. In 1935 Dr. Ishii had convinced the Imperial government of Japan to allow him to set up a research hospital in the town of Harbin, Manchuria in order to undertake small-scale experiments with pathogens of potential military value. By 1937, the Japanese War Ministry established a full-scale bio-weapons research complex in a small town named Pingfan about 40 miles south of Harbin (Goebel 2000; TA 1995).

The Pingfan Institute was completed in 1939 and Emperor Hirohito signed the founding order for a special unit to operate the military and medical research at Pingfan. The unit was known simply as Unit 731 and its mission was to develop biological weapons using Chinese (and latter Russian and American) POWs as test subjects (TA 1995).

Unit 731 studied almost every major type of biological pathogen for its potential as a military weapon. Included in the scientific logs was research on anthrax, Yersina pestis (the bacterium responsible for bubonic, pneumonic, and septicemic plague), gas gangrene, brucellosis, Glanders disease, Salmonella, Clostridium botulinum, typhus, typhoid, cholera, small pox, tuberculosis, tetanus, and encephalitis (Goebel 2000). Most of the early work of the Japanese biological warfare research program went unnoticed by the western powers. As a result, the protective masks available at the beginning of WWII were not in any way designed to protect soldiers from this type of weapon.

## WORLD WAR II: UNREALIZED THREATS OF CHEMICAL WARFARE

When war broke out in Europe in September 1939, the German chemical Corps had not yet developed an operational dispersal system for Tabun. The strategy of the German war machine was that of "blitzkrieg" and rapid attack and mobility was key to that tactic. Gas warfare was more of a siege weapon than one of lighting attack, so the German Army refrained from the early introduction of gas, since widespread use on the front would just as likely bog down the German offensive as it would inflict damage on its enemies. Nonetheless, the German Chemical Corps continued to stockpile gas weapons, in massive amounts. In 1940, they had begun the construction of a huge Tabun and Sarin plant in Silesia, Poland. Fortunately for the Allies, a series of production complications kept the plant out of service until around April 1942 (Goebel 2000).

During the early stages of the war, the Allies continued to develop their existing masks, making moderate changes to aid the functionality, however all of the developmental work undertaken by the Americans and British was done without any knowledge of the threat of the German nerve gas or the Japanese biological agents, or the ineffectiveness of the existing mask systems against them.

By 1939, the British had decided that the number of variants of their Mk.IV Respirator were too much for their logistics system to effectively support. The Royal Armed Forces moved to standardize a single rubber face-piece the similar to the American model. The Mk.V was issued in 1939 as a hose/canister mask similar in overall design to the Mk.IV. The various sizes of the Mk.IV were ultimately combined into three sizes with the Mk.V. This later variation contained a microphone molding as part of the face-piece. This advent was a key component in allowing orders and communications to be effectively transmitted on the battlefield while in protective gear (Hibbs 1998).

By 1940, the U.S. had developed the Diaphragm Gas Mask designated the M3-series. The M-3, also a hose/canister mask system, was much lighter than the M2 series. It also allowed for speech to be transmitted more efficiently than with the M2. In 1942, the M3A1 Diaphragm mask was designed to incorporate a different way of replacing the diaphragm in the field. Later that same year, another variant of the M3 was produced. The M3 Lightweight, weighed only 3 1/2 pounds and used the same face-piece as the M2, but without the rifle skids. The M3 was fitted with a M10 filter, which had a shorter life than the MIVA1 but was considerably lighter. Over 13 million of the M3 series masks were produced during WWII and they (along with all masks using the M10 filter) were made obsolete in 1949 (Walk 2001; Smart 2000).

A small run of 250,000 masks of the M4 series was also developed in 1942. The M4 was a hose/canister mask that employed a modification to the M2Ae face-piece that allowed a more rapid production time. The M4 also included a nose cup, which allowed a more comfortable fit. Like the M3 series, the M4 was declared obsolete in 1949 (Smart 2000; Carey 1998).

One of the few significant developments in WWII era Allied protective mask designs arose in the U.S. M5 Combat Mask and the British Light Anti-Gas Respirator. These two protective masks were designed to be lightweight and accommodate assault operations. The masks eliminated the hose and canister assembly that was present in all of the other US and British designs of the period. Instead, the canister of the M5 and the Light Anti-Gas Respirator attached directly to the side of the face-piece, in a similar manner to the German WWI design. The canister was lightweight but still provided equivalent protection to the heavier canisters of the M2 and equivalent masks. The M5 used a new M11 canister (was based on the German FE42 filter) which could be interchangeably used with its British counterpart. This represents the first serious attempt by Allied Forces to standardize protective equipment (Walk 2001; Carey 1998).

Over 500,000 M5s were produced in 1944. American troops involved in amphibious assaults, including the D-Day invasion of Normandy, were issued the light and compact M5 masks and while they were very popular with the soldiers, the M5s had a serious design issue that could have lead to a potential disaster on the battlefield. The masks were constructed, largely of synthetic neoprene, which proved in earlier M3 designs to be ineffective in cold weather, since the material tends to deform ("cold set") as the temperature drops. This cold set, in turn, can result in an incomplete seal around the face of the user making the mask ineffective against chemical agents. M5s were declared obsolete in 1947 and were replaced by the M8 Snout Mask (Smart 2000; Carey 1998).

As the cold set problems of the neoprene-based face-pieces became more widely known, the U.S. rushed to introduce the M8 Snout-Type Service Gas Mask as a replacement. The face-piece for the M8 was taken from existing stocks of M2/M4 masks and the M11 canister was fitted directly onto the front of the face-piece. There were only about 300,000 of the M8s produced prior to the end of the war, however they remained in use until they were declared obsolete in 1958 (Smart 2000; Carey 1998).

As with the Allies, the Axis Forces also continued to improve upon the basic designs of their WWI protective masks. In 1930, the Germans moved to the Gasmaske 30 (GM30) as a standardized military protective mask. The GM30 was made of natural rubber, covered with a gray stockinet, and employed a standardized 40mm screw-thread filter that fitted all German military and civilian masks. The mask was well-constructed and contained leather padding to cushion blows to the head and replicable eyepieces to facilitate repairs. The GM30 was remained the German standard at the beginning of the war, even though a replacement was being manufactured by 1938 (Hibbs 1998).

As the Germans began their invasions, the German military had redesigned the GM30 for mass-production. It is speculated that the new GM38 may have incorporated design elements based on the Czech Fatra 38 mask, as a result of German occupation of Bohemia-Moravia in September 1938. The GM38 incorporated a filter, which protruded from the face-piece at a semi-horizontal angle, as opposed the semi-vertical angle used in earlier designs. This mask also introduced the use of synthetic rubber (known as 'buna'). While the German buna masks also displayed some cold-set properties, they seem to have been less problematic than those experienced by the US neoprene masks (Hibbs 1998).

The Italians, who had used the British Small Box Respirator at the end of WWI, also began to design their own protective masks. When they entered WWII in 1940, they had standardized their chemical protection gear into two designs, the T33 and the T35 protective masks. The T33 was a hose/cylindrical configuration designed in 1933. Despite being quite effective against the standard gas-warfare compounds, it was not poplar with Italian troops due to its weight and bulk. In 1935, the Italians reconfigured their mask with a similar face-piece made out of natural molded rubber and a face-mounted filter canister similar to the German model (Hibbs 1998).

Despite an active involvement in the pre-war development of chemical weapons, the Imperial Japanese military made few contributions to the development of military protective masks. The Japanese Model 99 gas mask was the most commonly found Japanese military mask from the W.W.II era. The 99 came in both a hosed (for Imperial Navy operations) and face-mounted canister version. Much of the design and development elements of Japanese masks appear to have been borrowed from their Axis allies or from earlier WWI masks (NFP 2000; Hibbs 1998). Given the Japanese development of biological weapons by Unit 731, it is surprising that they did not advance protective mask technology to defend against such weapons. Rather, they relied on the development of vaccines and antidotes as a counter to the biological weapons they were designing.

Despite their lack of innovation in military masks, however, the Japanese seemed to be quite concerned with the possibility of gas attacks on their civilian population. The Japanese developed at least 5 different variations of a face-mounted filter type mask for civilian use or civil defense operations (NFP 2000).

This fact marks an interesting development in the evolution of protective mask technologies. While the initial use of protective masks initially developed in the civilian sector and then transferred to the military with the development of chemical warfare agents, World War II represents a cross-over point where the technology, designed with military applications in mind, is filtered back to the civilian population for war-time protection. We have already discussed the British attempts to equip their entire population with some measure of gas protection. In addition to the efforts of Japan, the governments of the U.S., Germany, Czechoslovakia, France, Hungary, Belgium, Denmark, Holland, and the Soviet Union also attempted in some degree, to provide protective masks to their civilian populations.

While, the exploration of the multiple variations in civilian protective masks is beyond the scope of this paper, it should be noted that some of the more interesting and innovative designs were implemented in the protection of children. Two of the most well known of these masks arose in the US. Following the attack on Pearl Harbor, the US issued a lightweight hood type device that could be used by children. The hood was made of treated muslin and to make it less threatening to the child; two padded "ears" were sewn onto the top. About 38,000 units of the mask, which aptly became know as the "Bunny Mask", were manufactured and issued to each child in the Hawaiian Islands.

Another example of this type of protective mask was the "Mickey Mouse" mask. The mask was designed as a replacement to the Bunny mask and was produced in cooperation with

Walt Disney. Although, it was never mass-produced, about 1,000 of these masks were manufactured prior to the end of the war (Smart 2000).

Given that the masks on both sides of the conflict did not evolve significantly beyond the box respirators of WWI, and given that both Axis and Allied Forces had massive stockpiles of chemical weapons (and biological weapons on the part of the Japanese), numerous scholars have questioned why there wasn't a single major chemical battle throughout the entire course of WWII.

Even as the war was slipping away from Germany, and even at Normandy where the Allied Forces were almost completely unprotected from nerve gas attack, Hitler resisted the temptation to use his stockpile. Part of the reason for this may lie in Hitler's personal experience with chemical warfare in the trenches of WWI, but another perhaps more pressing reason was an ironic duel-sided failure of military intelligence. Despite an impressive intelligence operation, the Allied side was completely unaware of the capacity and reserves of Hitler's nerve-gas compounds. Likewise, the Nazis knew that research on organophosphate toxins had been published in the civilian scientific literature for numerous years prior to the war, so they just assumed (falsely) that the US and Britain had their own stockpiles of nerve agents similar to Tabun. Actually, the British had stumbled across toxins similar to Tabun and Serin in the process of their work on the insecticide DDT; however, they failed to realize the potential military applications of these compounds (Goebel 2000).

What transpired in the failure of either side to employ chemical weapons was most likely the first application of the principles of Mutually Assured Destruction. Winston Churchill emphasized to Germany that should gas weapons be used on the battlefield, Britain would saturate German cities in poison gas (a very real threat). A similar threat and understanding was stated between the Americans and Japanese. What both sides failed to realize was that the parity of chemical might that everyone assumed, was false. With the destructive power of Tabun and Serin taken along with the vulnerability of Allied protective systems, the Germans clearly held the advantage.

Potentially, the closest that WWII came to seeing serious chemical battles came after the summer of 1944 when Germany began firing their V-1 and V-2 flying bombs. Churchill was so enraged by the attacks on civilians, that he considered a chemical bombardment of German cities in retaliation. His military staff eventually talked him out of it by convincing him that they could do more damage with conventional bombs than with phosgene gas (Goebel 2000).

One major development in the propagation of chemical weapons capacity game in August 1944. When the Soviets marched on the Tabun gas plant in Dyenfurth, the Germans attempted to destroy the factor with demolition charges. The Soviets got there, before the Germans could destroy the plant, however, and they proceeded to dismantle it and transport the entire facility to Russia to begin production of nerve agents for Stalin (Goebel 2000).

The same situation existed for biological warfare, while the Japanese continued to use bio-weapons on the Chinese until about 1941 (including the spraying of plague invested fleas over the Nationalist Chinese city of Ningpo), they were never employed in battles against the Allied Forces. Similarly, the Allies, who by 1941 had developed their own anthrax bombs at facilities at Camp Detrick, Maryland; Alberta, Canada; and Proton Down, England, never really employed them for fear of escalating the use of such weapons. The only minor exceptions to this, while unconfirmed, lie in the assassination of General Werner Heydrich by what is believed to have been a botulism toxin grenade, and the possible use of Colorado beetles as an anti-crop weapon on German potato crops in 1944 (Goebel 2000). Propagation of the threat of biological war also came at the end of WWII, when the US took General Ishii into custody and he cooperated in divulging the research of the Pingfan Institute and Unit 731.

In the end however, the Americans unleashed a weapon of mass destruction that unseated chemical and biological weapons as the"500 pound gorilla" of the battlefield. The detonation of two atomic bombs over Japan, ushered out the age of Chemical and Biological as the sole weapons of unconventional warfare, and ushered in the new era of Nuclear, Chemical, and Biological threat.

## PROTECTIVE MASKS IN THE MODERN ERA

Even though the Post WWII period saw some genuine reductions take place in the production and development of offensive chemical and biological weapons, Armies on both sides of the Iron-Curtain continued to keep strategic stockpiles of the weapons and continued to devote serious effort into the development of defensive technologies, including protective masks.

After the 1940s almost every major military force had developed standardized protective masks based in large part on the fundamental design elements of the British, Americans, and/or the Germans. From the 1950s on, the protective mask became a fundamental component of military equipment in most of the world's Armies. In an effort to focus on the major developments in protective masks, rather than the hundreds of minor variations applied across various national Armies, this paper will now examine the development of masks within the US military. Since the Americans continued to be the principal developers of new designs and innovations, the development of the US military protective mask serves as a good parallel for development of masks by other governments as well. Most effective designs and innovations have proved to be rapidly incorporated by other militaries within 2 to 5 years after initial development.

After the end of WWII, the most current mask design was the M8, which was by all accounts a functional, stop-gap design rushed into production to deal with the limitations of the M5 Combat Mask. Improvements in the general design of the M5 series lead to the development of the M9 Gas Mask in 1947. The face-piece of the M9 was made of synthetic molded rubber compositions that reduced the cold set problems of neoprene. The face-piece could be used with either a right or left side canister to accommodate both right handed and left handed shooters. Over 3 million of the M9 series were mass produced between 1957 and 1959 (Smart 2000).

During this time period a specialized tanker mask was also produced. By 1953 the need for a collective protection system for tank crews was realized, and the M14 Tank Mask was developed. A hose connected the mask to an air purifier system within the tank and a cable connected a microphone to the tank's communication system. A standard canister could be attached to the M14 when the mask was disconnected for the three-man collective protection system (Smart 2000).

During the late 50s the Chemical Corps initiated a research and replacement program to better standardize the wide variety of masks that the Army had at its disposal. The search of the ultimate mask included work with masks without any conventional filters, ones attached directly to the helmet, hood-type masks, and even inexpensive disposable masks. The research into masks without conventional filters showed considerable promise, and by 1959, the initial prototypes had evolved into the M17 series mask (Walk 2001).

The M17 represented the first real departure from the canister masks of WWII. The mask eliminated the need for a canister by placing the filtering material in cheek pockets. This fundamental design change also eliminated the need to produce right and left handed masks. The M17 also contained a voicemitter to improve speech transmission on the battlefield. In 1966, a drinking tube and a resuscitation tube were added to the newly named M17A1. The latter was later drooped in subsequent designs (Smart 2000).

The M17 was not a perfect design, but the standard addition of the drinking tube and the voicemitter made it a significant improvement over previous models. While soldiers felt that the mask configuration made it difficult to shoot accurately, its other advantages lead the army to quickly phase out masks form its inventory (Walk 2001). The M17 represented the state of the art in infantry masks during the 1960s and no other significant developments were witnessed during this time.

There were, however new advances in two areas of specialized masks. While the need for a protective masks for air-crews was initially established in 1933, there had been few developments in that area except for some minor advances by the Germans during WWII. In 1962, however, the Army standardized a modified version of the M14 Tank Mask as the M24 Aircraft Mask. Like the M14, the M24 hooked into a vehicle air purification system, but could also accommodate an external filter. It included a hood for over the helmet use, antiglare lens adapters, and an oxygen adapter. The M14 was also upgraded in the Tank environment. In 1963, the mask was updated as the M25 Tank Mask. A new microphone system was included as well as minor improvements to the face-piece (Smart 2000).

During the 1970s, the US experimented with a series of masks that was never standardized. The XM29 series mask was developed in 4 variations: combat, armor, aviation, and special purpose. The masks used a single large uni-molded flexible lens constructed of transparent silicone rubber with a special protective coating. Difficulties with the lens coating, however lead to redevelopment of the mask as the XM30 in 1979 (Smart 2000)..

The XM30 also employed a large flexible silicone lens, which gave it improved visibility over he M17. The XM30 also incorporated front and side voicemitters, a drinking type, and rapid donning ability. The canister for the XM30 was actually developed by the Canadian military and was standardized with NATO threads. The XM33 Aircraft Mask and the XM34 Combat Vehicle Masks were direct progeny designs. The XM series masks all suffered from marring issues with the front lens and resulted in the US Army dropping the XM series masks in the early 1980s after an investment of over $60 million (Walk 2001; Smart 2000).

While the Army reopened M17-series production in 1983, the US Air Force and Navy liked the XM30 design. Development work was completed by the Air Force and the mask was produced as the MCU-2/P. Both services used the mask to replace the M17 series and the MCU-2/P was used heavily until after the Persian Gulf War (Smart 2000).

In 1987, the Army implemented a "Minimum Change-Minimum Risk" program during the development of the M40 mask. The M40, designed as a direct replacement to the M17, employed a face-piece made of silicone rubber and an off-center mounted canister with NATO threads. In 1992, the M40A1 was developed with a "Quick-Doff Hood" and an improved nose-cup design that made the mask faster to use and more comfortable to wear (Walk 2001). The M40 series also was developed for armor and aircraft applications as the M42 Combat Vehicle Mask and the M43 Aircraft Mask (Smart 2000).

The requirements for a better aviators mask has also resulted in the development of the M45 Chemical and Biological Mask and the M48 Apache Aviator Mask. The M45 was developed in 1996 and provides protection without requiring forced air ventilation. The mask was designed to be compatible with night vision devices and sighting systems for rotary-wing aircraft and can be used by both aviation and infantry troops. The M48 was developed to eliminate the need for aircraft mounted blower systems. The mask contains a small, shoulder-mounted blower and provides some of the highest levels of chemical and biological survivability currently available in a military mask.

In response to the changing battlefield, the US military is currently developing the next, and most advanced class of military protective masks. The XM50 Joint Service General Purpose Mask (JSGPM) is a revolutionary advancement in protective mask design and technology. The cheek-pocket filter mask was designed to meet the requirements of all armed services (Army, Navy, Air Force, and Marines), reduce breathing resistance, and increase protection against toxic chemical and biological materials. The JSGPM is currently being developed to replace all M40, M42, and MCU-2/P masks presently in service. The objective of the program is to provide better protection, lower breathing resistance, increased visibility, and reduced weight. Distribution of the mask is expected to take place around 2002 and design elements will likely be incorporated into the protective masks of other NATO allies.

## CONCLUSIONS

In the post-World War I era, protective masks have gone through numerous stages of evolution. Despite Allied and Axis development of nerve agents and biological weapons which far outstripped the defensive capability of the protective masks of the day, both sides focused more on the development of offensive technologies than defensive ones. It was not until the resolution of hostilities from World War II, that all nations got a full view of the breadth and depth of the threat from non-conventional weapons.

As with the development of other military technologies, offensive developments precede the mass development and refinement of defensive technologies. Assessments of the inadequacies of the protective masks of WWII lead to rapid re-development and refinement of both mask and filter technologies. This development is best illustrated through the mask technologies employed by the United States, but are mirrored in the development and standardization of protective mask equipment employed by nearly every national military on the planet. The awareness of threats associated with chemical and biological weapons has integrated itself in the minds of military strategists and civil defense planers alike. Owing to both the threat, and the practical integration and standardization of features like voicemitters, drinking tubes, and weapons accommodations, protective masks are now standard equipment for soldiers, sailors, and airmen of all nations. The level of protection offered by these devices will only improve as technology advances and new threats (either from military or criminal sectors) emerge.

## REFERENCES


Addington, L.H. 1994. *The Patterns of War Since the Eighteenth Century*. Indiana University Press: Bloomington, IN.

Carey, C.T. 1998. *U.S. Chemical and Biological Defense Respirators: An Illustrated History*. Schiffer Publishing, Ltd.: New York, NY.

Goebel, G. 2000. A History of Chemical Warfare. In: *Chemical and Biological Warfare*. Wysiwyg://147/http://vectorsite.tripod.com/twgas0.htm

Hibbs, P. 1999. Gas! Gas! Gas!: A virtual museum of military and civilian respirators. Published by the World Wide War Zone. http://www2.prestel.co.uk/history/gas!/index.htm

No Future Productions (NFP). 2000. "La Masque a Gaz: History". NFP: Chicago, IL. http://www.nofuture.com/lemasque.htm

Office of The Surgeon General (OTSG). 2000. "History of Chemical Warfare and Current Threats". OTSG, NBC Defense Staff: Falls Church, VA. http://www.nbc-med.org/SiteContent/MedRef/OnlineRef/FieldManuals/medman/history.htm

Smart, J.K. 2000. *History of the Army's Protective Mask*. U.S. Army Soldier and Biological Chemical Command: Aberdeen Proving Ground, MD.

Technology Artist (TA). 1995. "Unit 731: A Half Century of Denial". Technology Artist: New York, NY. http://www.technologyartist.com/unit_731/index.html

Walk, R.D. 2001. "Mask History: Infantry or General Purpose Mask." *Army Chemical Review*. February 2001. V3, N1.


## About the Author:


**Humberto E. Galarraga, M.S.** earned his masters degree in Environmental Chemistry from the University of Maryland. He serves as a Program Manager and Team Leader at the U.S. Army Environmental Center at the Aberdeen Proving Grounds. Mr. Galarraga also holds the rank of Major in the U.S. Army Reserve, Chemical Corps. He has over 18 years of experience and expertise in environmental chemistry, military smoke and obscurants, and protective masks.

**Anthony R. Maranto, Ph.D.** earned his doctorate in Environmental Chemistry from the Union Institute School of Graduate Studies. He serves as a Project Manager at the U.S. Army Environmental Center at the Aberdeen Proving Grounds. Dr. Maranto has over 10 years of experience in environmental chemistry, biochemistry, and radiation protection.

**Cite As:** Galarraga, H.E. and A.R. Maranto. 2001. The Evolution of the Protective Mask for Military Purposes: 1919 to Present. *Greenwich Journal of Science and Technology*. 2(2):76-87.

View Related Article: Galarraga, H.E. and A.R. Maranto. 2001. The Evolution of the Protective Mask for Military Purposes: Inception to World War I. Greenwich Journal of Science and Technology. 2(1):37-48.

Return to GJST Home Page