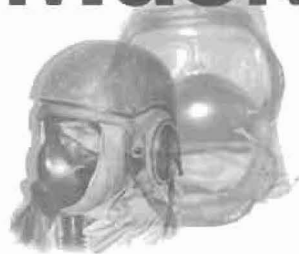




The Armored-Vehicle Protective-Mask History



By Major Robert D. Walk

In addition to the modern use of chemical agents in war, armored vehicles (tanks) were used first in World War I. The crewmen who operated these armored vehicles required protection. Initially, these soldiers were masked with the same mask as the infantry, but proper use of the sights required the use of special masks. Since operating in a tank is like operating in a confined space, air had to be supplied. After extensive research, air suppliers or "collective protectors" were developed and issued to tankers. They required special masks or adapters for the standard mask to work properly. This is their story.

Early Efforts

The Chemical Warfare Service developed a gas mask for use with optical instruments for the U.S. Navy in the 1920s. This was the experimental Navy Diaphragm Optical (NDO) Mark I. The Army recognized the need for the same capability and adopted the NDO as its optical gas mask, M1. This mask had a filter mounted behind the head and a diaphragm to allow better speech transmission. Although the theory was great, it was not successful for Army use. The optical lenses were good, but were small, which considerably narrowed the soldier's field of view. The filter mounted behind the head caused problems in the cramped confines of a tank turret. It was still on the armored-battalion equipment lists in 1943, but it was not truly acceptable to the armored force.

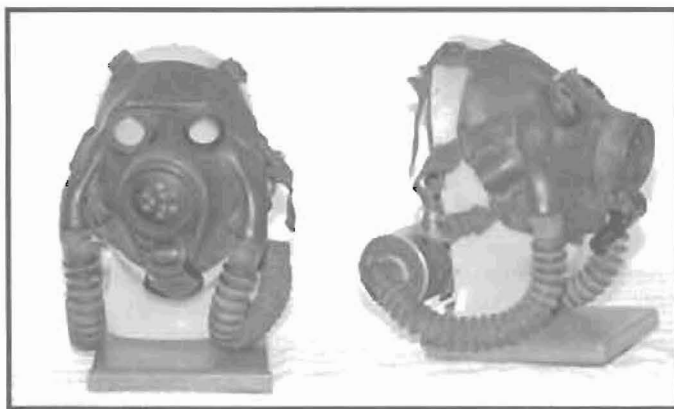
The M2 optical gas mask replaced the M1 optical gas mask. The M2, sort of an NDO and lightweight gas-mask hybrid, had an NDO derivative facepiece with a lightweight gas-mask hose and M10 filter. This mask was produced in World War II with an M8 outlet valve and during the Korean conflict with a C15 outlet valve. The M2 optical gas mask provided improvements over the standard M1 optical mask by mounting the filter on the soldier's side instead of behind the head. This improved the soldier's ability to maneuver inside the tank, but the soldier still suffered reduced visibility inside the tank turret.

Development of a proper armored-vehicle crewman's mask continued, but further work included a centralized filter system to provide air for the vehicle crew.

Collective Protection

Much consideration was given to protecting the soldiers manning the tanks. Soldiers operating in the cramped, stuffy confines of a tank could use a blast of fresh air across the face. A formal requirement in 1943 established CWS D4.1-11, *Collective Protectors for Tanks*. Two areas of research were initiated—positive pressure for a sealed-crew compartment (fully overpressurized)—and supplied air to ventilated facepieces for already existing tanks. The first (overpressure) system was installed during manufacture, while the second (ventilated facepiece) system was a retrofit for current vehicles.

Beginning with the T23 tank project, the idea of an incorporated collective protector was included in the basic tank-design requirements. Because it was difficult to seal tanks completely, particularly during firing the main gun, the ventilated-facepiece program was more successful than the overpressurized system. It is interesting to note that captured German research revealed a planned overpressure system for their Tiger and Panther tanks. The American ventilated-facepiece-system program resulted in the E21-series collective protector.



Early efforts included the M1 (left) and the M2 (right). The lenses greatly restricted the soldier's field of vision.

The E21, designed by engineers at the Massachusetts Institute of Technology, used the concept of the ventilated facepiece for the soldier. A central filter unit provided air to two to three permanently connected facepieces. Efficient and effective, it provided overpressurized-filtered air to the soldier's facepieces. Each mask had no outlet valve, so the air was constantly flowing around the periphery of the mask. When the soldier inhaled, the mask, made of thin rubber, instantly sealed against his/her face. The facepieces were not detachable, so the soldiers carried standard masks with them at all times so they could quickly dismount from the tank while protected.

Units that were produced included the E21R2 with one filter unit that protected one to three soldiers; the E21R3 with two filter units that protected two to six soldiers; and the E21R4, which was an E21R3 with a different filter unit. An M4A3 Sherman tank required two E21R2 units or one E21R3 or E21R4 unit. In 1945, the E21R2 unit was considered satisfactory for use in the Pacific for the impending invasion of Japan, but the Army ground forces did not adopt it because of the lack of detachable masks. The mask was also deficient when used with optical devices.



World War II E21 tank mask.



A limited procurement (1,000 sets) of the E21-protector series was authorized in World War II. One hundred-fifty E21R2s and 350 E21R3s were produced. ElectroluxTM manufactured all units in 24 volt, while a 12-volt conversion set was authorized, but cancelled after VJ-day.

After the war, research and development continued. Recognizing the need for adequate protection for tank crews, work continued and the specifications changed to include a removable mask for use by the tank crew outside of the tank. Postwar research resulted in the E25-series protector with two filter units and six masks. The blower used the tank's 24-volt system and delivered 3 1/2 cubic feet per minute of filtered air to each tank crewman. Each mask could be easily disconnected by the operator and used outside of the tank, eliminating the need for the soldier to carry a standard service mask.

While the E25 system worked, it did not fit into standard armored vehicles. Improvements and revisions resulted in the E26. Where the E25 was built for six masks, the E26 was built for up to three masks. Most tanks at that time required two E26s to protect the entire crew. Ultimately, the first revision of the experimental model 26 (E26R1) was adopted in 1954 as the M8 three-man-tank collective protector.

The M8 three-man-tank collective protector included an M2 air purifier, a 9-foot M6 tank protector hose, two 6-foot M7 tank protector hoses, and three M14 (E56) tank protective masks. The air purifier first cleans the air in a cyclone precleaner, filters the remaining particulates with a paper filter, and removes the chemical agents with a charcoal filter. The purifier can be used in or out of a chemical environment. The hoses were placed close to crew stations, and the M14 masks were plugged into the hoses when needed.

Improvements to the basic system in 1955 resulted in the M8A1 filter unit. Installation of the M8A1 in tanks required the M20 installation kit. In 1959, after logistics problems were identified in getting the M20 installation kit and the M8A1 gas-particulate filter unit

(GPFU) to the appropriate locations for installation, the two were combined to become the M8A2 filter unit—gas-particulate, tank, three-man, 12 cubic feet per minute. At the same time, the M14 masks were removed from a component of the end item and made separate end items. In 1963, the M8A3 became the final adopted version. These GPFUs were issued and mounted in M41 tanks, M48 tanks, and M113 armored personnel carriers (APCs). This unit is still a standard system in the M113-series APCs.

The M8 collective protector was acceptable as long as no more than three soldiers used the protector in one location. Certain experimental tanks had more than three soldiers in one location so, in 1952, experimental work began on a larger version. As an example, the M103A1 tank had four soldiers in the turret, which required two M8 protectors. This was not acceptable. Thus the Chemical Corps developed a more powerful version—the E37-series tank collective protector. In addition to the more powerful filter, this version included an airline heater to provide heated, filtered air to the soldier. No storage space was required in the vehicle because the unit was attached to ventilating ducts or placed under the floor for access to the individual plug-in stations.

The E37 unit consisted of five M14 masks, the M1 precleaner, five M1 canister couplings, and one E38 20-cubic-feet-per-minute gas filter. The E37R1 was a modification to adapt the kit to any heater or cooling system in the tank. This assembly, however, required storage space within the tank. When the M60 tank was in development, the E37R2 filter unit (adopted as the M13 collective protector) was developed especially for it. This consisted of an M1A1 precleaner, E45 20 particulate filter, two E44 10 gas filters, four E39 heaters, and the filter-unit hose. The M1A1 precleaner and E45 particulate filters were installed in a metal housing. The air then flowed to the two E44 gas filters so that purified air was conveyed through hose sections through a heater to the driver and through a modified slip ring and then through heaters to sockets for each crewmember. The crews attached their M14-series masks to self-locking quick-release couplings when they needed them. The improved M13A1 is used on the M60-series and M1-series tanks. After developing good filtration systems, the Army concentrated on improving the armored-vehicle crewman's mask.

Masks for the Collective Protector

The M14 protective mask has a gray, 85 percent natural-rubber faceblank with a large plastic, flexible lens designed so that air enters the chin and deflects over the lens to prevent fogging. An air deflector was used and not a true nosecup. The inner surface is stippled (rough) to allow a better grip on the face and, thus, a better seal. A 2-foot hose supplied air to an M10A2 filter. The M10A2 filter was an M10A1 filter with an M1 canister coupling. The M1 canister coupling was an adapter that attached the filter to the M6 or M7 hose. The only reference to the M10A2 is the early 1950s; thereafter, it was the M10A1 canister with M1 canister coupling.

An M51/UR microphone mounted in front of the mouth inside the mask enabled communications. A wire passed from the microphone through the facepiece to a connector to plug into the intercom system. The M1 antidim kit was included to reduce fogging in the mask. The operator carried the mask in the M13 tank mask carrier. For long-term storage, the M6 faceform was used to prevent distortion of the mask.

Tests found the M14 mask was acceptable, but not as good as the standard M9A1 protective mask. Other deficiencies noted in the mask included the following:

- A soldier could not wear glasses with the mask.
- The outlet airflow was bad.
- The eye lens scratched easily.
- The eye lens had a distracting glare.
- The mask had a tendency to fog up.

The Chemical Corps worked to correct the problems.

The M14A1 (E56R2) (1960) mask included a nosecup capability; was constructed of black rubber (for low-temperature flexibility); and had smooth inner surfaces, better eye-lens adhesion, and improved eye-lens design. In 1961, atomic, biological, and chemical (ABC) protection was added to the nomenclature to make it ABC-M14A1.

The M14A2 (E56R4), adopted in 1961, improved the mask by adding a permanent C11 nosecup, eyeglass capability, M9 harness, and the E34 hood. This mask was retained until the AN/ARC-44-series radio sets were deleted from

the inventory. This mask was standardized with Canada and Australia in 1967. To modify this mask for the new radio sets, the M51/R microphone was replaced with the M116G microphone and the mask became the M25.



M14 mask, ca. 1962.

The initial M25 was only a remicrophoned M14A2 for use with the AN/VRC-12-series radios. The M25A1 (E56R5) (1963) was an improved M25 by adding an eyelens outsert for arctic use and improving the fit. The M25A1 mask took the U.S. Army into the 1990s. This mask was effectively an M24 with a different microphone, simplifying logistics and procurement. Problems with lens scratching from use with a tank's sighting systems never went away; therefore, research for a better mask continued.

Continuing Research

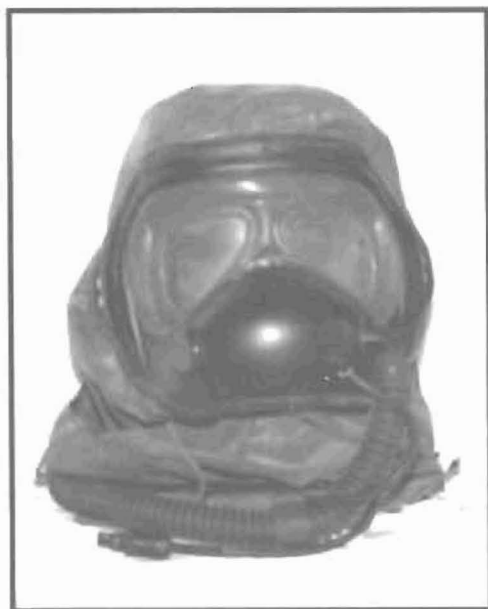
Other work in the 1960s involved adding an overpressure system for the MBT-70. The idea of overpressure, rejected during World War II, resurfaced in the 1960s. In an overpressure environment, soldiers working in the tank can be in relative comfort while operating the tank in a contaminated area. Every time the tank is fired, though, the overpressure can be lost when reloading the cannon, and overpressure doesn't help the soldier when rapid egress is required in a contaminated environment.

A common-mask system would simplify logistics and save money. Thus, the Army sought to develop a common-mask system—the XM29. This one mask would use a common facepiece for all variations and would be of one-piece, injection-molded, transparent, silicone rubber. The use of this revolutionary materiel was a tremendous leap forward. Silicone provides an excellent sealing to the face in a wide range of temperatures and has no adverse skin toxicity. The mask used a screw-mounted-filter canister that either mounted on the mask cheek (right or left side) or on a hose. The side opposite the filter or hose attachment had a voicemitter and a front voicemitter as well.

The tanker version of the mask had the appropriate microphone installed and had a permanently attached hose to a separate filter mounted on the belt or chest of the soldier. Unfortunately, the silicone itself did not provide adequate protection against CB agents or the decontamination chemical and required special coatings. In addition, the XM29 eye lens had a tendency to "frost," but this could be corrected by scrubbing it with a mild cleanser. The technology did not exist to coat the silicone properly and allow it to remain transparent. Problems with the lens coating led to the Army's development of the XM30 series, which was effectively an XM29 with a separate, glued-on lens.

1980s

The XM30-series masks continued the developmental work of the XM29-series and even had designations attached. The XM34 was combat-vehicle-crewman mask designation. The XM30-series mask was based on the earlier work of the XM29 mask. The XM30 was a hybrid approach that retained the silicone faceblank materiel, but



Experimental mask from the early 1980s that combined the mask with the combat-vehicle crewman's helmet.

mechanically bonded a transparent, urethane-materiel lens to the faceblank. There were some initial manufacturing problems with securing the lens adequately to the silicone facepiece, which were not resolved within the program schedule. The manufacturing bonding process to bond the urethane lens mechanically to the silicone faceblank was eventually solved, and the U.S. Air Force adopted the XM30, now redesignated the MCU-2/P, as their standard mask.

Both the U.S. Air Force and U.S. Navy have reliably used the inherent advantages of a flexible, full-windshield lens in a flexible, silicone faceblank for more than 18 years. Unfortunately for the Army's part of the program, in 1981 after an investment of more than \$60 million dollars, it received a Senator William Proxmire "Golden Fleece Award" for a perceived waste of the taxpayers' money. Shortly afterwards, the Army's portion of the program was dropped and a minimum-change, minimum-risk program was initiated for the M40 series.

The M40 program was initiated to modernize the Army mask as quickly as possible. The objective of the M40 program was to combine the best elements of the mechanically attached, rigid lenses of the M17 and the silicone faceblank and replaceable filter canister of the XM30 program into a new mask for the military. Several versions were called for, including a tank mask. Scott Aviation®, ILC Dover, Inc., and Avon submitted masks for the program. The M42 mask was the armored-vehicle-crewman version of the M40 series.

This mask was adopted in 1987. It came in three sizes and included a microphone and air-hose connections to the vehicle's collective-protection system. The M42 had a permanently attached air hose. The M42A1 (1992) had most of the M40A1 mask improvements, including a better nosecup and quick-doff hood. The M42A1 also allowed the hose to be removed by incorporating a swivel connection on the hose. The hose then became a repair part. By including the standard M40 facepiece and an

external detachable microphone, it became the M42A2 mask in 1995 and is the Army's present standard armored-vehicle-crewman mask.

Collective protection improved during the 1980s. The M1 tank was fielded with the M13A1 system. In the M1A1, this became a total protection system because the overpressure system provided heated or cooled filtered air to the soldiers manning the tank. Presently, most U.S. armored vehicles include collective protection for the crew either using the ventilated facepiece system (for example, M113 armored personnel carrier and the Bradley fighting vehicle) or an overpressure system (for example, Abrams tank).

The 1990s

The follow-on mask was scheduled to be the XM46, but was cancelled in 1995. This was a hybrid of the XM45 aviator mask. Comparative testing in the combat vehicle between the XM46 and XM42 did not demonstrate a significant improvement over the M42, so it was abandoned.

The RESPO-21 project was a technological leap, which has evolved into the joint-service general-purpose mask (JSGPM) program. As initially demonstrated, a prototype technology demonstrator proved to be a lightweight and compact mask issued to each soldier, sailor, marine, and airman. Comfortable to wear with minimal peripheral vision loss and low breathing resistance, this was the Cadillac among masks. The program's objective is to lower total ownership cost for the military. Since this mask will be used by all services, the initial unit cost and spare and repair parts will benefit from an economy of scale. In essence, the more the military buys, the less each mask will cost.

Sustainment will be considered throughout the design and testing phases of the program. It is the DoD's hope to



The ILC Dover and the Scott Aviation versions of the XM42. The Scott Aviation version was ultimately accepted.

replace the mask. The idea is to consider and simplify logistics.

The NBC-defense project manager will also work closely with other PMs that are developing other components of the NBC ensemble (such as overgarment, helmet, and gloves) to ensure that they meet the new joint-service sustainment initiatives like "Vision 2010" to create the best cost-effective, low-logistic-footprint protective

mask for the twenty-first century. This would help ease logistics in the future battlefield (remember a good theater commander is always concerned about logistics). Reduction in overall weight and bulk are also critical, and the JSGPM mask must occupy less space than a replacement M40 facepiece. The armored-vehicle version of the JSGPM is the XM51. It includes the capability to attach to the vehicle's collective protection system and is compatible with vehicle-communication systems.

The XM51 is a technological leap forward, but it still has a long way to go. As of February 2000, a benchmark "cradle-to-grave"



JSGPM mask.

developmental, production, and sustainment request for quotation has been released. The JSGPM is in its final source selection, and the initial program-definition, risk-reduction phase will start later in FY00. Only with the continued dedication of an extensive, joint-service integrated-product team will the XM51 JSGPM be a

success. If you have spent time eating tanker dust or have a good idea or a bad experience, don't hesitate to write the PM. You can contact the system manager for the JSGPM at his Web site (SBCCOMs). He wants to develop the best mask for the soldiers, so he will review all ideas submitted.

Conclusion

The search for the best protection for our armored vehicle continues. Choosing the mask that performs best while logistically supportable is difficult. During the years, the Army has examined and procured masks to protect soldiers while continuing the search for the best mask. The current standard mask, the M42A2, has an excellent protection factor. Meanwhile, there is an ongoing search for a better mask in the JSGPM program. In addition to masks, from no collective protection system available in World Wars I and II, the Army has procured systems that filter and heat the air as needed to reduce the stress to the soldier in the tank. Future ideas in collective protection include the possibility of using catalysts to destroy chemicals drawn into the tank—eliminating the need for carbon filters that must be replaced. What will be next? Only the PM knows for sure...

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Training Notes

The 4/100th Chemical Battalion, based in Huntsville, Alabama, and commanded by Lieutenant Colonel Don A. Chiri, completed its annual-training rotation at Fort Leonard Wood. The unit trained 23 students in the 54B10 MOS and 63 students in the 54B20/30 MOS.

The students experienced live-agent training at Leonard Wood's newly established Chemical Defense Training Facility. They also conducted decontamination, physical, smoke operations, and field training. On 1 June 00, the 4/100th graduated 89 students.