

A Look Back...

“Mae Wests and Electric Suits”:

Outfitting *The Masters of the Air* with Aviator Clothing and Survival Equipment



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“High altitude aerial combat subjected bomber crews to emotional and physical stresses that human beings had never confronted before. Strange things happened to the human body when it entered the earth’s upper atmosphere. This new kind of warfare demanded a new kind of medicine – for the mind as well as the body. Aviation medicine, then in its infancy, had yet to address the problems flight surgeons encountered in England.”

Donald Miller, Masters of the Air

“They had been instructed and drilled in every emergency, life saving and self-defense method known, to the point of being thrown, fully clothed in heavy flying equipment, in a swimming pool with a packed rubber life raft to simulate ditching in the North Sea. They had been taught the use of hand weapons and survival kits in case they should be downed in enemy territory.”

Martin Caidin, Flying Forts

“They passed their officers as they hurried toward the trucks going down to the flightline. At the hardstand, *Flak Shak III* waited, a dull sheen on her silvery body, and in a heap near her were the crew’s flying suits, parachutes, Mae Wests, oxygen masks, flak suits and helmets... The navigator passed out escape kits containing silk maps, small compasses, and fifty dollars in fives and tens. When the time for start engines drew near the crew donned their heavy gear and began boarding.”

Steve Birdsall, Log of The Liberators

“Some of our equipment bothered us as much as the Germans. Our planes were open at the waist position, so the temperatures at 30,000 to 32,000 feet were forty to seventy degrees below zero. We had to dress heavily – I wore long underwear, a uniform shirt and pants, an electric suit over that plus a fur-lined flying suit on top of it. On my feet I wore silk stockings, wool stockings, electric shoes and fur-lined flying boots. My hands had silk gloves, wool gloves, electric gloves and then fur-lined flying mitts. You could barely move a finger and you always left one free to work the trigger of the machine gun. We didn’t dare unplug the electric suits which were connected to the battery system. Without heat you would freeze to death in a matter of minutes.”

B-17 gunner, 303rd Bomb Group

The Immediate Need for Aviator Clothing

In 1941, the pre-war Army Air Corps had a little over 152,000 members. By 1944, that number had grown to 2.3 million and included 389,000 pilots, navigators, bombardiers and gunners. Outfitting that many flight crews with required equipment in such a short time for them to go into action was a challenge for the wartime Army Air Forces (AAF.) The dedicated AAF personnel determined to provide for the aircrews faced the same conditions familiar to all acquisition programs – develop technical solutions that meet the requirements of the warfighters, but, also ensure that the production and delivery of the articles themselves can be achieved by industry. The highly specialized nature of the flight clothing and equipment and the great variety of articles required, along with the very rapid increase in procurement needs imposed a huge burden on both development and production facilities. This production often required scarce materials such as rubber or brass. During the war, the AAF had as many as thirty different manufacturers making the same items of clothing, which then had to be delivered to units around the world. One of the first priorities was to equip AAF units conducting the strategic bombing campaign against the Third Reich. To implement and sustain a long-term strategic bombing operation required not just sufficient aircraft, but prepared and outfitted aircrews.

Through the late 1930s “open cockpit” era of flying, the main requirement had been for a useful, durable, winter flying suit. The AAF had yet to experience sustained combat operations, so air officers had little experience to draw on when planning for other types of combat clothing and equipment. As the war drew near to the US, it was clear that considerable effort needed to be devoted to other items such as radio sets, oxygen and goggle equipment as well as heated flying suits for sustained high-altitude flight. In the early part of the war, the AAF relied on the resources from the Army Quartermaster Corps for clothing and personal equipment. Eventually the AAF set up its own laboratories and project offices within the Materiel Division, the Air Materiel Command, the Air Services Command and the Air Technical Services Command for developing more specialized clothing and equipment to

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respond to the unique needs of aircrews, particularly those such as bomber, transport, reconnaissance, and patrol plane crews. These aviators would be regularly assigned to high-altitude, long-duration missions. There was also much information sharing between the US and the United Kingdom (UK), whose aircrews were also engaged in the same regions and missions.

During the entire wartime period of flying clothing development, the details of pattern, style, fit, and comfort made the process extremely complex. Regulations and requirements had to be met in pattern and color, and the number of types acquired kept to a minimum. In the design process for flying suits, decision to use one or two pieces, ease of donning and removal, fitting to seated airmen, size, position and number of openings, use of zippers (known as slide fasteners in the day), the number, position, size and shape of pockets all had to be considered. As with any other feature of aircraft design, weight is also a consideration, especially for single-seat fighters. Space was also at a premium – B-17s and B-24s each had crews of 10 – some of whom were wedged into confined spaces in the nose and gun turrets. Also factored into the design was the best type of material, either cloth or natural animal hides, for durability, wearability, weight and thermal insulation, as well as their commercial availability. Access to the body for treatment of wounds, particularly during a bombing mission, was a requirement, but did not receive much attention during this period. The overall extensive requirements of the AAF resulted in the production of a suite of clothing and equipment, tailored to summer, intermediate and winter environmental conditions. The most immediate and crucial need was outfitting the crews for the ongoing bombing campaign in Europe. Unbelievably, an officer from the Aero Medical Laboratory at Wright Field found out through investigation in the UK that in the winter of 1943-44, the number of bombers going out on a combat mission was determined by more by the amount of clothing available than any other factor.

The Physiology of High Altitude Flight

As the strategic offensive of the Eighth Air Force got underway in 1942, flight surgeons encountered five problems in aviation medicine which remained concerns until the end of the war. They were: anoxia (lack of oxygen), frostbite, aero-otitis (inner ear problems), battle wounds, and stress. These afflictions were all especially severe given the long duration of the bombing missions and the length of time airmen were exposed to them. Three of these conditions - anoxia, frostbite and battle wounds - could be directly addressed by improved flight clothing and equipment. The problem of temperature and frostbite at high altitude was particularly acute. In the aviation world, a “Standard Day” means a temperature of 59 °F at Sea Level. As you go up in altitude, the temperature decreases by about 3.5 °F per 1000 feet, up to 36,000 feet where it is considered to be -65 °F. Above this point, the temperature is considered constant to 80,000 feet. By WWII, aeronautical engineers had solved the problem of engine design to permit flight at 50,000 feet or higher before aviation medical researchers worked out the human equation to permit sustained operations at those altitudes. Because the bombers and fighters used in the first half of the war were “unpressurized,” crews were exposed to the elements inside and out. Waist gunners in early model B-17s had to basically fire their hand-held machine guns through open windows – directly exposed to the cold and wind blast. The typical mission altitude for unpressurized B-17s and B-24s over Germany was 20-25,000 feet so crews could expect to endure temperatures as low as 40 below zero for most of the duration of the missions, which could last as long as eight or nine hours. Under those conditions, protection from frostbite was as important as protection from enemy fire. In early 1943, the percentage of combat casualties for airmen from frostbite was 70%. With better training, clothing and equipment, by the end of 1943 that percentage had been reduced to less than 20%.



Waist gunners in early model B-17s were exposed to the elements. *Left:* SSgt Tony Nastal of *The Memphis Belle* at the open hatch. *Right:* Gunner stations were back to back. Oxygen was supplied from an onboard system to each crewman’s mask.



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The first cold-weather flying suits used by bomber crews were lined shearling leather jackets, trousers and gloves. The leather was treated with a process known as Korsseal - a brown polyacrylate leather dye and a lacquer top finish. This made the shearling more resistant to moisture, fuel, oil and dirt and gave the garments their distinctive dark brown color. On their own, however, the shearling garments were found to be inadequate for the temperature extremes encountered on missions over Europe, so additional electrically-heated garments were the next solution. These had been available in limited use before the war, but the earlier designs were unreliable, and the internal wiring was easily broken. The first type, a one-piece suit in bright blue wool was worn under the cloth or leather outerwear and plugged into the electrical system of the aircraft itself.



Above and Left: Examples of early-war dark brown two-piece shearling flying suits and A-6 boots.



The Type F-1 one-piece “Electric Suit”

Left: Made in bright blue wool (Credit: National Museum of the USAF)

Center: With heated glove and shoe inserts.

Below: F-1 as worn by B-17 crewman, top left.



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The personnel of the Clothing Branch of the Aero Medical Laboratory (under Air Materiel Command) pursued the design and testing of more effective and suitable “electric suits” which consisted of separate jackets, trousers, gloves and boot inserts that were made available to aircrews. Special sewing equipment even had to be developed to attach the electrical components securely to the fabric. One gunner in a bomber crew described the suits in this way: “There were two types of electric suits, the English and the American. The English model was a quilted type with resistance wire in the body of it, down to the back of the silk gloves and across the top of the feet. The gloves and the boots were plugged into the suit proper. The American model, made of blue wool felt was wired the same. I found that if I wore the right boot on my left foot and vice versa, my feet would stay warmer.” The new designs fielded by the middle of the war were big improvements, although they still required a certain amount of careful handling. After a few missions the wiring tended to short out or fail, because the men were not told how to take proper care of them. After a mission, exhausted men sometimes wrapped them in a ball with their other flying clothing and stuffed them into lockers or barracks bags, which damaged the fragile heating elements.

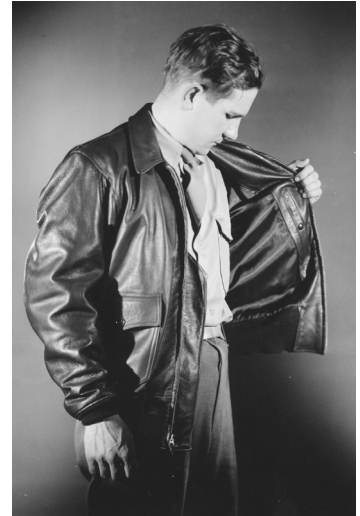


Above: Views of the late-war, two-piece Type F-3 Electric Suit

The As and Bs of Flying Clothing

A full range of flying suits and outerwear were eventually perfected during the war. These articles needed to be provided to flyers operating in both hot and cold environments. Cotton twill suits were developed for warmer and summer environments, and wool gabardine suits for colder or winter conditions. Summer flying clothing was originally given type numbers in the “A” series, and winter garments were assigned “B” series numbers. The Type A-2 unlined leather summer flying jacket and the bulkier, lined B-3 winter jackets are two common examples. The A-2 jacket is worthy of particular mention. It replaced long and short leather flying coats and became a standard item in 1931, and, along with the “50-Mission-Crush” service cap, became one of the iconic symbols of AAF aviators in WWII. It was made at various points from horsehide, steerhide or goatskin by several manufacturers. Aircrew members decorated their A-2s with a range of colorful unit insignia, artwork and mission symbols, and although it was a popular and practical item, it was one of the items of leather flying clothing that Air Corps Chief General Hap Arnold ordered replaced by a substitute or improved garment. Although the replacement, the AN-J-3 flying jacket was officially adopted for both AAF and US Navy aviators, the A-2 remained a favorite with aircrews and served throughout the war in all theaters.

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Clockwise from upper left: A-2 jacket with summer-weight flying suit and helmet; Summer-weight flying suit and standard service shoes; The improved AN-J-3 flying jacket; B-17 crew in A-2 jackets; B-24 crew, Pacific. Pacific flyers in tropical environments often flew only in summer-weight flight suits or even just regular uniform items.

Various versions of lined and unlined leather flying helmets were also introduced, all equipped with radio receivers, but some airmen, particularly fighter pilots, preferred British versions they had been issued when they arrived in the UK. Suitable gloves were also a major concern – airmen could not remove their gloves at altitude to accomplish fine tasks lest they be exposed almost immediately to frostbite. A range of gloves with electrical heat and various finger combinations were developed, both for pilots and gunners. A second pair of silk or rayon gloves was added under the top layer of leather glove to further protect the skin from direct contact with frozen metal surfaces.



Left and Center: Gunner's heavy shearing “one finger” gloves. *Right:* Navigator wearing only rayon glove inserts.

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Durable, insulated boots were also required that were compatible with the electric inserts. The standard version, the shearling A-6 boot, was used throughout most of the war. (The “A” designation in this case was because there were no summer equivalents.) It was designed primarily for warmth and protection at high altitudes, not for walking long distances. As a result, many fliers carried a separate pair of regular leather service shoes along with them on missions, sometimes tied to their parachute harness in the event of a bailout. The AAF even experimented with “escape shoes” – flying boots that were made in two pieces, so the top could be removed after bailout and the bottom shoe used as a typical, inconspicuous civilian style when worn with local civilian clothes.



AAF Flying Boots (*Clockwise from upper left*): Shearling A-6 insulated boots were worn for most of the war; Additional inserts were available for extra warmth; P-47 aces Robert Johnson (l) and Walker Mahurin (r), Mahurin is wearing standard GI service shoes, but Johnson sports a pair of two-piece “escape shoes”; Early-war wool electrically-heated boot inserts; Late-war insulated cloth versions.

In mid-1943, the AAF contracted for 15 million square feet of shearling (sheep) hides necessary for flying clothing. After that, AAF shifted the outerwear clothing fabric from natural leather to cotton or wool for introduction in 1944, but many fliers held on to their leather coats and jackets more for status than protection. The shearling and leather garments gave way to multi-piece garments with improved linings, features and functionality. They were illustrative of the amount of research and development on aircrew protection conducted during the war.



By the end of the war, the AAF had phased out leather garments and substituted cotton and wool-lined versions.

Left and Center: The cloth garments were more practical and had features for oxygen and radio equipment that were better suited to modern cockpits.

Right: Samples of the types of fabrics evaluated by the AAF during the war.



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Left and Right: By 1945, cloth garments for aircrew had almost completely replaced earlier leather articles. The B-17“G” model on the right shows the improved/enclosed waist gunner station which reduced the gunners’ exposure to the elements. The aircraft were still unpressurized and oxygen was required for high-altitude flight.

Coupled with the temperature extremes was the fact that above 10,000 feet supplemental oxygen was necessary to keep the airmen alive. At 25,000 feet without oxygen, a crewman’s useful consciousness may only be five minutes or less. The aircraft had an internal oxygen distributions system but a wounded crewman who could not stay at his station had to be given one of several emergency “walkaround” oxygen bottles to attach to their mask to stay alive. These were stowed around the aircraft for just such situations. The AAF used a wide array of oxygen masks during the war, in an attempt to arrive at a satisfactory design that would stay tight against the wearer’s face and also stay free of frozen condensation at altitude.



Left: Early-war Type A8 Oxygen Mask.

Center: Improved, late-war Type A14 Mask.

Right: Maintenance technician servicing the oxygen bottle system in a B-24.

Protection from Enemy Fire

“Those flak suits are a healthy thing to be wearing when the Jerries put up a barrage. They are heavy has heck, but they feel like feathers when the flak starts bursting around you.”

B-17 Pilot, 303rd Bomb Group

The Eighth Air Force determined that 70 percent of wounds sustained by combat fliers were due to low-velocity impacts of flak fragments or spent rounds from German fighters that had entered through the aircraft skin. (*Flak* is a shortened version of the German word, *Flugabwehrkanone*, which means basically, “air defense artillery.”) Brigadier General Malcolm Grow, then Surgeon of the Eighth Air Force, concluded that some form of light armor

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over the chest and abdomen would avert numerous injuries and save a considerable number of lives among combat crews. The USAAF then went to work developing and fielding a system of light, wearable armor for aircrews, building on prior British experience. The War Department contracted with the Wilkinson Sword Company of the UK for an armored vest made out of overlapping plates of light manganese steel, supported by a covering of nylon and canvas fabric. Altogether, the armor weighed close to 30 pounds. Special multi-piece steel helmets were also designed and produced that would fit over standard flying helmets and earphones. The helmets and so-called “flak vests” were issued to bomber crews, particularly gunners, and the results were immediately positive – the aircrew wound rate was reduced by 42% and the fatality rate of those struck was reduced by 62%. This led to the estimation that by the end of the war, the armor protection had saved over 2500 airmen from being wounded or killed. Beyond the physical protection, the wearable armor gave a crews a slight psychological lift, as a study of morale in the AAF documented after the war, “The protection that the newly-developed body armor, for example, gave to the bomber crews of the Eighth Air Force in December 1942 yielded benefits that were mental as well as material and lead to wholesale adoption of the new life-saving equipment. There was no hiding place in a B-17, and any gadget or garb that lessened a crewman’s feeling of naked vulnerability to all missiles was bound to have a comforting effect.”



Above and Top Right: Aircrew armor. Aprons could be detached and the vest worn alone for seated airmen.

Right: B-24 crewmen don steel helmets for protection.

Survival, Evasion, and Rescue Equipment

Flying clothing and equipment were all required regardless if the mission was successful or not. But additional planning and development was required for emergency equipment needed for survival, evasion of enemy forces, or rescue if the aircraft was downed by enemy fire or mechanical problems. The Personal Equipment Laboratory of the Air Technical Services Command spent considerable effort designing and acquiring equipment for an extraordinarily wide range of these contingencies for aircrew that were operating across the globe – including for the first time, extended flights over jungles, deserts, and open ocean. In terms of surviving a water landing, pre-war thinking was only focused on making the airplane itself buoyant, rather than providing for the crew, and this work was limited to aircraft operating out of Hawaii.

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Water Survival

Long-range operations over the Pacific and the English Channel resulted in many situations where crews had to bail out or ditch their aircraft and take to small rafts and await rescue. In the case of Pacific flyers, this might mean several days before they could make it to shore or be picked up by friendly forces. This pointed to the need for the AAF to develop water survival equipment for individual aviators as well as larger rafts for aircrew and passengers aboard bomber or transport aircraft.

Life Vests and Life Rafts

Aircrew of other nations had been wearing individual life vests along with their parachute harnesses for some time. The vests were either made of kapok or cork, or were inflated by either a small CO₂ bottle, or a mouth tube and they served to keep a fully equipped individual afloat for several hours. For Naval Aviators, this was a normal part of their equipment ensemble. In the early days of the war, USAAF fliers in the UK adopted a British version until a standardized USAAF model was available. Kapok or cork vests were unsuitable due to bulk, so inflatable models were perfected. Aircrew were also issued, or acquired, whistles which they clipped to their flying jackets to be used to help rescue forces find them when bobbing about on the surface of the sea. The bright yellow vest, models B-3 and B-4, were universally issued to Army, Navy and Marine aviators throughout the war and worn uninflated under the parachute harness, although the vests were seldom referred to by their official nomenclature. Instead, aircrew universally referred to the B-4, and subsequent models as simply the “Mae West,” because when fully inflated, the wearer resembled the 1930s movie star of the same name!



The B-4 individual life vest. *Left:* Showing the CO₂ inflation system and the dye marker packet.

Center Left: Vest is worn over the flying clothing and under the parachute harness.

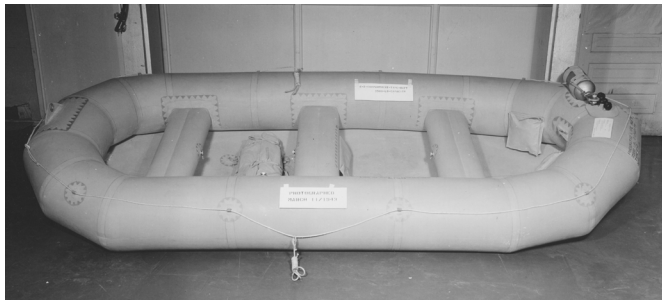
Center Right: Vest when fully inflated. *Right:* Actress Mae West (Credit: NY Public Library)

By 1943, the AAF recognized that some provision for raft equipment was necessary for all combat aircraft. Prior to that, the AAF carried out experiments on a number of different raft designs and concepts but requirements for aircrew rafts were complex and ambitious. They involved materials, size, weight, temperature extremes, inflation time and methods, durability, and stability in the water. The wartime shortage of rubber, which followed the loss of the East Indies and Malaya rubber plantations, forced changes in specifications, materials and construction. Interestingly, during this period there was much internal competition between the Army and the Navy for the critical components and materials needed for life vests and rafts. There were also trade offs from providing one big raft per aircraft versus several smaller models. Eventually the provision of rations in the raft itself was also accommodated. The AAF shared raft development experience and ideas with the US Navy, the British Air Commission and even civilian airline companies.

Air Materiel Command developed individual rafts for single-place aircraft. In parallel, larger versions that would hold several airmen were also acquired and fitted into dedicated spaces in the upper fuselage of multi-engine aircraft so they could be accessed quickly and easily in the event of a water landing. A one-man raft attached to the parachute harness, the AN-R-2, was standardized in mid-1942. It was designed to be used in aircraft that had

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a crew of three or less. (The Eighth AF in the UK also distributed similar British models until sufficient stocks of US rafts were available.) A five-man raft, model A-3, was eventually fielded in 1943. This was modified, after extensive operational experience, into the A-3A version. The E-1, a larger, seven-man raft was developed that could be air-dropped to stranded crews and was used on B-29s in the Pacific. The larger life rafts were equipped with extensive survival provisions including rations. Both the life vests and rafts had attached packets of colored dye markers that could be dispensed into the sea water around the airman to make him more visible to rescue aircraft and surface vessels. By the end of the war, complete air-droppable, motorized lifeboats were developed that could be launched from specialized B-17s. These new lifeboats were first successfully used in April 1945.



AAF Life Rafts

Upper left: C-2 one-man raft with sea anchor extended.

Center: Early A-3 five-man raft.

Right: Improved A-3A model.

Lower Left: E-1 seven-man raft.

Left: Air-droppable Higgins Lifeboat under a specially-modified B-17.

Right: Lifeboat fully deployed and underway.



Based on feedback from aircrew and crash survivors, other accessories were eventually designed for inclusion with the rafts, such as patching supplies, sails, sea anchors, first aid kits, flares and signaling devices, fishing kits, rainwater containers, bailing buckets, water distillation devices, desalting kits, and even portable radios. Higgins Industries of New Orleans, famous builder of the landing craft used in Allied amphibious landings, was given the contract for the special airborne life boats and even submitted a design for a solar still for emergency water purification. Many of the rafts themselves and products destined for use in raft kits were evaluated for suitability by Air Proving Ground Command in the waters off of Eglin Field, Florida. In parallel with water survival equipment, specialized, packaged food rations were also produced during the war.

Land Survival and Rations

Survival rations were of particular interest to both the Army Ground Forces (AGF) and the AAF. The AGF was investigating their usefulness for issue to Airborne troops, and the AAF wanted to procure them for convenient use by aircrew on long missions or in the event of forced landings. Again, this was a field not researched to any extent before the war. Eventually a range of aircrew and survival rations was developed, from single bars of concentrated chocolate to full meals suitable for use by multi-person crews on long range patrol missions.

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Survival Equipment and Emergency Rations



Left: Accessories and rations included with the A-3 and E-1 life rafts.

Right: Life raft ration container. Charms candies were popular items in survival kits and ration packs.



Left: Emergency rations contained in parachute kits. Cigarettes were included in most survival kits in the 1940s.

Right: Emergency Sustenance Kit E-1 for large aircraft. Includes mess kits and utensils.



Left: The Aircrew Lunch in 1944. Its contents consisted mostly of sugar.

Right: Parachute Emergency Kit, type B-4. It was attached to the individual's parachute pack and included a fold-out machete, a bar of condensed chocolate, and fire-starting materials.

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Above, Left to Right: The AAF developed a full range of specialized clothing for flight nurses and female aviators, from flight suits to jackets, boots, and parkas.



Above, Right Upper and Lower: The ubiquitous Type D-1 shearling jacket was worn by maintenance and ground personnel for most of the war, as shown by these mechanics repairing a P-47 in France, late 1944, and a B-17 in the UK.



Right: By 1945, an improved Mechanics' Type D-2 Pile-Lined Suit was available for issue.

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Above: Air Materiel Command and Air Service Command technicians and specialists worked tirelessly to inspect and test a wide range of fabrics and materials to ensure they were durable, suitable, and effective for clothing airmen operating around the world.

The task of developing equipment and outfitting airmen during WWII was a monumental one, given the urgency of wartime operations, the number and type of industries involved, and the scarcity of many critical materials. The AAF materiel commands did the best they could to provide for air and ground crews now operating around the world. The development of specialized aircrew and life support equipment did not stop with the end of WWII and continues to this day. Every effort is made to try to ensure American air crews can complete their missions and return home safely.

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