



Advanced Crew Escape Suit

The **Advanced Crew Escape Suit**, or ACES, is a full pressure suit currently worn by all Space Shuttle crews for the ascent and entry portions of flight. The suit is a direct descendant of the U.S. Air Force high-altitude pressure suits worn by the two-man crews of the SR-71 Blackbird, pilots of the U-2 and X-15, and Gemini pilot-astronauts, and the Launch-Entry Suits worn by NASA astronauts starting on the STS-26 flight, the first flight after the Challenger Disaster. The suit is manufactured by the David Clark Company of Worcester, Massachusetts.

History

The ACES was first worn by U.S. Air Force pilots in the mid-1970s, replacing a similar suit worn by SR-71 and U-2 pilots, and was identical to the suits worn by X-15 pilots and Gemini astronauts. Unlike the ACES suit, which is a full-pressure suit, the high-altitude suits were partial pressure suits, thus requiring a rubber diaphragm around the wearer's face. With the development of the Space Shuttle, and the inclusion of ejection seats on the Space Shuttle *Columbia* on the first four flights (STS-1 to STS-4), NASA decided to adopt modified versions of the suit; the modifications being the attachments to the parachute harness, and the adoption of inflatable bladders in the legs to prevent the crew from passing out during reentry. One other modification, a mount for prescription glasses, was incorporated for astronaut John W. Young, who wore modified bifocal reading glasses (resembling aviator sunglasses, but with the top portion, usually for distance seeing, being of regular glass, and the bottom, for reading, of the wearer's prescription) during the flight.

The four test flights, between April 1981 and July 1982, went without incident, and the pressure suits performed without any problems. With the termination of the test flight program, all flights from STS-5 to *Challenger* (STS-51-L) saw the crew wearing one-piece light blue flight suits, escape harnesses, and helmets similar to the pressure suit helmets, but fitted around the head with a clamshell-like closure. After *Challenger*, NASA, in need of an escape system, also required the reintroduction of the wearing of pressure suits during the launch and landing portions of the flight.

For the first "Return to Flight" STS-26, the five-man astronaut crew wore, for the first time, new Launch & Entry Pressure Suits (LES). Resembling the Gemini spacesuit in appearance, but identical in function to the SR-71 partial-pressure suits, the new LES suits featured a one-piece torso-limb suit with a Nomex outer layer (which NASA was able to use on the Shuttle due to the mixed nitrogen/oxygen sea-level atmosphere), closed with a rear-entry zipper, and featuring a full-pressure helmet with a polycarbonate clear faceplate, mechanical seal, and black sunshade, zippered-on gloves (resembling the gloves used by astronaut Alan Shepard on his Mercury 3 suit), heavy black "paratrooper" style safety boots, and a survival backpack, which is donned prior to entering the Orbiter and contains a parachute, life raft, survival gear, and a 30-minute supply of breathing oxygen.

Because of the helmet design, which rested on the astronaut's shoulders and allowed them to freely move their head around, astronauts were now required to wear a communications cap similar to those worn by Apollo astronauts, and because they were white (later changed to brown), the suit resembled the Vostok pressure suit worn by Yuri Gagarin. The suits were designed to withstand pressures up to 40,000 feet (12 kilometers), and submersion in the ocean for up to 24 hours at 40 degrees Fahrenheit (5 degrees Celsius).

Because of the limitations of protection the LES could offer, NASA and the David Clark Company introduced the current ACES design in 1995, and is currently the only suit used for Shuttle missions. Based on the LES, but being a full-pressure suit, the ACES suit now incorporates gloves on disconnecting lock rings on the wrists, liquid cooling and improved ventilation, and an extra layer of insulation. The ACES suit is analogous to the Sokol suits used for Soyuz missions and its functions are virtually the same — the only differences being the ACES suit having a detachable helmet and survival backpack, while the Russian suit has an integrated helmet and no backpack (due to the limitations in space aboard the

Soyuz, and that the spacecraft is an entry capsule, not a winged spacecraft or lifting body).

On June 11, 2008, NASA announced that the new Constellation Space Suit, which will be worn on Orion flights to the International Space Station and the Moon, will be built, using a modified version of the ACES suit for launch, landings, in-flight emergencies, and EVA, with the latter using the ACES-based suit and Hamilton Sundstrand/ILC Dover-developed Mark III suit components.

Current specifications

The ACES used by Shuttle astronauts is similar in design to the Gemini spacesuit worn by astronauts between 1965-1966 and by the three Apollo 1 astronauts in 1967. The components of the ACES consists of the following:

A one-piece pressure garment assembly with integrated pressure bladders and ventilation system. Oxygen is fed through a connector at the wearer's left thigh and is transmitted to the helmet, via a special connector at the base of the neckring. The helmet and gloves are connected to the suit, via locking rings, a metallic gray in color (Gemini suits featured a gray neck ring and red and blue anodized glove rings). The suit has a Nomex cover layer in international orange color, instead of silver or white as in previous David Clark suits. The orange color allows rescue units to easily spot the astronauts in the case of an Orbiter bailout over the ocean. Underneath the suits, astronauts wear "Maximum Absorbency Garment" (MAGs) urine-containment trunks (resembling "Depends" incontinence shorts) and blue-colored thermal underwear, which has plastic tubing woven into the garments allowing for liquid cooling and ventilation, the latter being handled by a connector located on the astronaut's left waist.

A full pressure helmet with a locking clear visor and a black sunshade worn to reduce any glare from reflected sunlight, especially during the approach and landing phases of the mission. A communications cap (originally white, but since changed to dark brown and identical to those worn by the Russian cosmonauts with the Sokol space suits worn aboard Soyuz missions), is worn underneath the helmet, and connected to a special plug inside the helmet, which is then connected to the intercom system in the Orbiter, via a white-colored plug similar in appearance to the communications "pigtail" on the old Mercury helmets. An anti-suffocation valve at the back of the helmet allows for the passing of carbon dioxide from the helmet. The helmet's clear pressure faceplate is locked into

place with a mechanical seal with a prominent "lockdown" bar which can be easily reached with gloved hands.

The gloves are also attached via a locking ring and are likewise in international orange color. When the suit is pressurized, the gloves are also pressurized. The palm of the gloves is textured to allow crews to throw switches, push buttons, turn knobs (especially the "ABORT MODE" knob on the commander's panel), and, for the Commander and Pilot, to operate the flight control stick during the final approach during landing.

Heavy black leather "paratrooper" boots with zippers instead of laces. These help prevent foot and ankle injuries and reduce swelling of the feet when the suit is pressurized. No cloth is used on the boot, as a way to prevent injuries in the event of a flash fire (something encountered during the Vietnam War in which aircraft crews wearing jungle boots, with their nylon uppers, were injured when the material literally melted onto the person's skin when an aircraft caught fire). Survival backpack, which includes a personal life raft, that is donned before entering the orbiter.

Light sticks, which are tucked into the shoulder pockets on both upper arms. The light sticks are intended as an aid in case of an emergency, and are colored orange to identify the astronaut crew, while technicians in the close-out crew carry green ones.

Each suit weighs a total, with survival gear, of 80 lb (35 kg), and is sized individually, although most suits can be worn by astronauts of different heights. No ACES has failed during normal flight operations, although a report released by the Columbia Accident Investigation Board (CAIB) said that the suits worn by the astronaut crew would not have protected the astronauts at the altitude and velocity of the *Columbia* break-up in 2003.