NASA Facts

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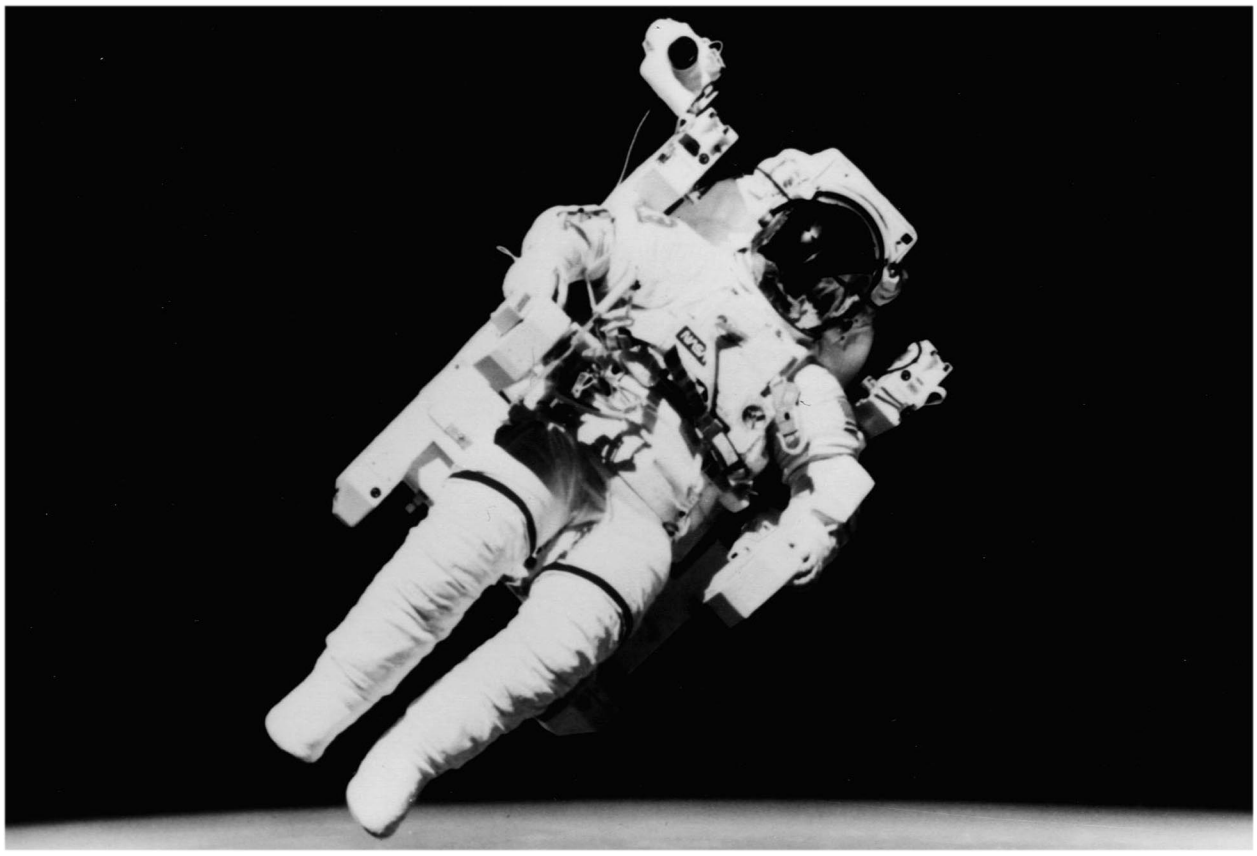
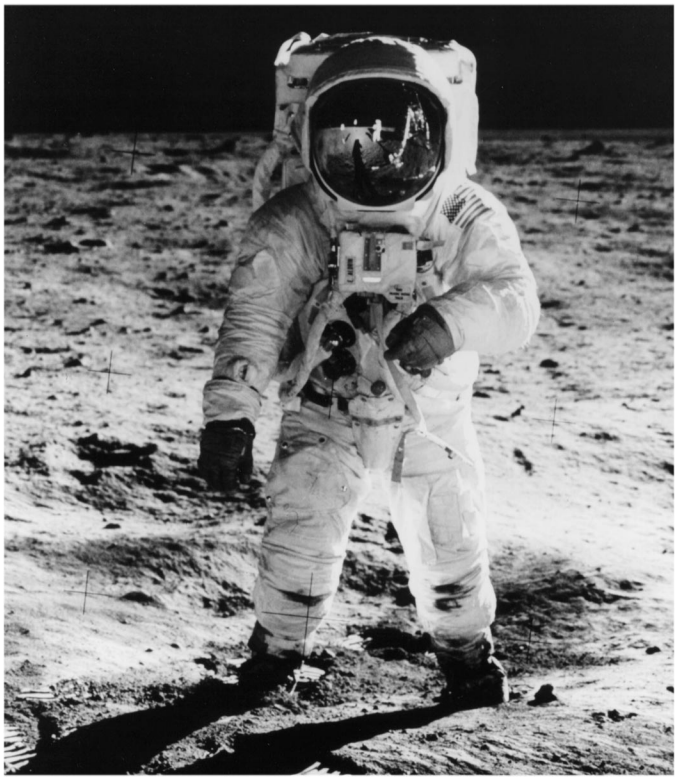
SPACESUITS FOR ASTRONAUTS

As astronauts soar into space, they face many challenges to their survival. One of the most critical is the loss of atmospheric pressure. Pressurized flight suits provide a protected artificial atmosphere for pilots and astronauts.

An important component of the atmosphere for humans is oxygen. At altitudes above 50,000 feet, the air is so thin and the amount of oxygen is so small that spacesuits containing pressurized oxygen are needed. An oxygen shortage is not the only problem experienced at high altitudes, however. As air pressure surrounding the body rapidly decreases, gases can bubble out of the body tissues into the blood. This creates a painful and life-threatening condition called the “bends.”



The current space shuttle suit offers both protection and freedom to work outside the shuttle.



The Apollo missions to the moon presented new challenges to spacesuit design. Apollo spacesuits had to shield the astronauts from the hazards of the hostile lunar environment as well as supply life support for moon walks of up to eight hours

The pressurized spacesuit currently used by space shuttle astronauts creates a pressure around the body of about 4.3 pounds per square inch (psi). Since this is about one-third normal atmospheric pressure, an astronaut must pre-breathe 100 percent oxygen for four hours before donning the lower-pressure suit to prevent the bends.

Alternatively, astronauts can lower the pressure inside the shuttle to 10.2 psi and acclimate to this intermediate pressure for 24 hours before putting on he suit. The new psi suits now being developed will eliminate these time-consuming procedures and will be usable on short notice.

Spacesuits also must protect against additional hazards of space, such as bombardment by micrometeoroids and extreme climatic conditions. The side of the suit facing the sun may get as hot as 250 degrees Fahrenheit, while the side exposed to deep space may get as cold as minus 250 degrees Fahrenheit.

History

Spacesuits have become increasingly flexible and independent of spacecraft life-support. The Project Mercury suit was design for astronauts confined to a small capsule. The Project Gemini suit allowed astronauts to explore space while tethered to their spacedoncraft by a life-support umbilical. Apollo suits were designed for unconstrained exploration of the harsh lunar surface. Suits for the space shuttle, based on the Apollo design, have interchangeable parts.

The Space Shuttle Suit

From the initial Mercury project through the Skylab program in the 1970's, spacesuits were custom-made for individual astronauts. Beginning with the space shuttle, the suits have been made in several standard sizes and are fitted "off the rack."

When assembled, the new spacesuit is similar to the Apollo suit except for the torso, which is now made of fiberglass instead of rubber and fabric. It also has a permanently attached life-support backpack.

The suit gives astronauts the freedom to perform a wide range of tasks outside the shuttle without being tethered. Many satellites and payloads like the Hubble Space Telescope are designed for maintenance and repair in space by astronauts using

Hard Spacesuits

these self-sufficient suits.
A series of “hard” spacesuits has been under development for more than two decades at NASA Ames Research Center. Except for soft gloves, these suits were constructed only of hard materials such as aluminum and carbon-impregnated fiber.

The hard suits had many advantages, including exceptional mobility. The astronaut could move any joint —shoulder, hip, or knee- without straining the suit. Designed to operate continuously at high internal pressures, the hard suits eliminated the time consuming pre-breathing of oxygen before leaving the spacecraft. The hard materials used to make the suits also block dangerous cosmic radiation.

Current Advanced Spacesuits

1990, NASA evaluated two versions of the spacesuit astronauts may wear in extravehicular activities (EVAs) at Space Station Freedom and eventually en route to the moon and Mars. These suits would serve astronauts working in the hostile environment of space for longer periods than ever before.

One suit is the AX-5 the latest version of NASA Ames’ all-hard, metal suit. The other suit, the Zero Pre-breathe Suit (ZPS Mark 3), uses both hard and soft elements, and was developed at Johnson Space Center in Houston, Texas.

Hard suit designers believe hard suits like the AX-5 are more durable and easier to make and maintain than soft suits. They consider it “revolutionary” in providing for prolonged and repeated use. Soft suit proponents say suits like the ZPS Mark 3 are more mobile and comfortable, factors of major importance to the user.
While either the AX-5 or the ZPS Mark 3 could be selected as the next generation spacesuit, a hybrid model, drawing some elements from each, also could result. The two prototype spacesuits share such features as ring-bearing system at joints and an actuator mechanism. In both suits, astronauts use a rear-entry hatch, stepping feet-first into a suit latched to a don/doff stand.

Both the AX-5 and the ZPS Mark 3 can operate at 8.3 psi internal pressure. At the same time, the new suits are more mobile than current shuttle suits. The AX-5 can be operated at up to normal atmospheric pressure, 14.7 psi. These higher inside pressures eliminate the need for lengthy pre-breathing of oxygen to prevent the bends.

Extravehicular Activity

For routine chores and maintenance outside the space station or Mars ship, new spacesuits must be designed to withstand up to eight continuous hours of extravehicular activity (EVA). This makes it necessary to have a tough, “blue collar” type of system, according to Hubert “Vic” Vykukal, NASA Ames research scientist and designer of the AX series of hard suits.

These spacesuits should fit both male and female astronauts, be easy to get into and out of, and be comfortable to wear, allowing good mobility and range of motion. They should also protect from radiation, micrometeoroids and man-made debris.

The suit must be easily maintained and services on board the space station or spacecraft because it will stay up for a year or much longer before being brought back to Earth for maintenance. By contrast, current shuttle suits require a major and

The AX-5 hard suit can be sized to fit astronauts from four feet ten inches to seven feet tall by adjusting sizing rings in the sections between joints.

The ZPS Mark 3 spacesiut has a metal upper torso and a hard metal brief connected with a rolling waist joint. The waist joint has sizing rings so torso length can be adjusted to fit different size crew members.

AX-5

Ames Research Center's AX-5 hard suit is built of aluminum alloy and stainless steel. Sizing rings in the sections between joints, such as ankle to knee and knee to hip, can be adjusted to fit astronauts from four feet ten inches to seven feet tall.

Each section is mated to free moving rotary joints. Minimal effort for movement in the suit is required with this design because the suit maintains a constant volume, and hence a constant internal pressure, no matter how it is flexed.

The AX-5 is put together with wire and groove joints and sealed with O-rings. The suit is not penetrated by fasteners and requires no welding. It has a 13-inch diameter, fixed "fish-bowl"—type helmet, allowing unrestricted head movement.

The all-metallic design is durable and is easy to build and maintain. The suit's dense material and double-hulled structure shields astronauts from radiation, micrometeoroids and debris. Thermal coatings, protecting against temperatures in space ranging from broiling to super-cold, can be applied directly to the structure. This eliminates the bulky thermal overgarment.

The AX-5 can operate for several years with little maintenance. Its modular design can be built by standard aircraft techniques and has only 15 major parts that are easily replaced.

ZPS Mark 3

The Johnson Space Center's ZPS Mark 3 space suit has a metal upper torso and a hard metal brief, both made of aluminum and connected with a rolling waist

joint. The waist joint has sizing rings so torso length can be adjusted to fit different size crew members. The suit has a metal multiple-bearing hip joint below the hard-metal brief. Like the AX-5, the Mark 3 uses wire and groove couplings between suit segments.

The Mark 3's legs and arms are polyester fabric with sizing inserts, and the boot is also fabric. The suit has compound shoulders — fabric-covered metal blades — which provide a rolling action of the fabric. The fabric joint elements in the elbow, arm, leg, and ankle areas are similar to the current shuttle suit.

The Mark 3 has the same fiberglass torso now used in the shuttle suits. The Mark 3 differs from past suits by having a hard brief, and other added hardware.

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