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PRESSURE SUITS FOR PROJECT MERCURY ASTRONAUTS

Pressure suits for the Nation's first space men, the seven NASA Project Mercury astronauts, were designed to provide an artificial environment similar to the atmosphere of earth in the event of failure in the Mercury pressurization system. The life-support garment is a modified version of the U.S. Navy pressurized flight suit developed by the B.F. Goodrich Company and the Navy.

The B.F. Goodrich suit was selected by scientists and engineers of the NASA Manned Spacecraft Center for use by the first Americans in space. The 20-pound outfit is an aluminum-coated nylon-rubber creation. It incorporates oxygen-cooling and respiratory systems, automatic warning gauges and pick-ups for medical telemetering systems to record temperature and respiration, electrocardiographs for recording heart action, and other scientific apparatus.

A pressure-tight garment of this type is vital for the protection of any human above 45,000 feet where air pressure is extremely low. The astronaut is protected primarily by the pressure system of his spacecraft, but should this pressure fail he is encased in a suit simulating his natural environment. The suit was also designed to provide flotation for water landing.

Early in the Mercury program the seven astronauts made trips to B.F. Goodrich for suit fittings and then to a subcontractor for helmet fittings. Each astronaut has three suits -- two flight suits and one work suit for normal training purposes.

The suit is light and flexible, yet is capable of providing artifically pressurized environment so that even in an almost total vacuum the pilot can be comfortable as a person in a conventional pressurized aircraft at 35,000 feet.

The full-pressure suit consists of four basic parts -- torso, helmet, gloves, and boots. Each element was modified hundreds of times before the present design was selected.

The torso is a closely fitted coverall shielding the entire body with the exception of head and hands. The helmet is attached by a neck ring and contains anti-buffeting protection and a complete communications system. Gloves form a continuous assembly when attached to the sleeves. Custom-made boots complete the attire.

The gloves are curved with elaborately ribbed material -- with the

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exception of the left middle finger, which is pressurized so that the astronaut is able to push instrument buttons. On the first two fingers of each hand are small red lights to help him see his instrument panel in the event of electrical failure.

Oxygen is pumped into the suit through a waist connection. One hundred per cent oxygen flows throughout the suit to cool it, then circulates in the helmet for breathing. Exhaled air escapes through a special vent in the helmet. Temperature inside the suit can be controlled at 80-degrees F. even in the intense heat encountered during reentry into the earth's atmosphere.

Ventilation is conducted through the "trilok ducting," a three-dimensional material in the suit, to the wrists, ankles and periphery of the neck ring. Beneath the suit the astronaut wears long underwear with waffle-weave ventilating patches in areas where his body will be pressed too tightly against the suit -- elbows, back, knees, etc. -- to permit ventilation. The patches raise the suit fabric enough to allow free passage of air.

The astronaut enters the suit by means of a pressure-sealing zipper located diagonally across the chest. He is able to move his shoulders, arms, legs by means of a series of pleats and bellows tailored into the suit. A nylon adjustment strap in these sections "sizes" the suit to the astronaut's body. Sock endings for the legs are made of nylon stretch fabric with a thin ply of neoprene gum added. These "feet" are permanently attached to the inner layer of the suit.

The plastic helmet provides visibility, comfort, mobility and windblast protection.

The astronaut wears a mirror on each wrist to enable him to see and work on instruments placed in positions difficult for him to see while lying in his contour couch. He wears a "parabolic" mirror on his chest to enable the onboard camera to record instrument readings, decks of lights and switch positions while photographing his facial expressions.

The following procedures are used for donning and checking the Mercury pressure suit before a manned mission:

1. Prior to astronaut suit donning, suit technicians will have completed inspection and checkout of the suit assembly.

2. When the astronaut's flight surgeon has attached the astronaut's biosensors, and the astronaut has put on his undergarments, the suit technicians assist in pressure suit donning, following definite guidelines.

(a) Assist astronaut's legs into legs of the suit
(b) Lock biosensor harness connector to bioinstrumentation receptacle located near astronaut's knee
(c) Insure entrance zipper reinforcement is snapped
(d) Pull suit torso over astronaut's hips

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(e) Assist astronaut's armsinto arms of the suit
(f) Open waist zipper and adjust inner ply material and ventilation tubes
(g) Place helmet tiedown buckle at front of the suit
(h) Assist astronaut in putting his head through the neck ring of the suit
(i) Smooth the inner suit ply material and close waist zipper
(j) Start suit ventilation with dressing room air source
(k) Close neck zippers and snap neck straps in place
(l) Connect distal end of blood-pressure cuff hose to internal suit fitting and check the cuff inflation system for leakage
(m) Close entrance zipper and snap zipper reinforcement into place over the zipper slide
(n) Fasten underarm straps, fasten and adjust shoulder-to-side straps and fasten shoulder-to-shoulder strap
(o) Fasten helmet tiedown strap
(p) Fasten ankle closure zippers
(q) Assist astronaut in donning of boots and in donning of plastic boot protectors
(r) Assist in donning of helmet
(s) Remove respiration thermistor placement tape from anterior neck surface and attach and adjust respiration thermistor to microphone
(t) Center, attach and lock the helmet to the suit neck ring
(u) Assist the astronaut while donning pressure suit gloves, and secure and lock the helmet to the suit neck ring
(v) Fasten and adjust the glove restraint straps

3. After the astronaut is completely suited, he is inserted into the checkout couch for suit pressure and leakage tests. The following are pressurization precautions:

(a) Prior to suit pressurization, the suit technicians check the oxygen supply and set the ventilation pressures at the suit test console.
(b) A technician checks the control pressurization valve to insure that it is in the open.
(c) Suit zippers are not to be opened, and the visor seal is not deflated while the suit is pressurized.
(d) The flight surgeon watches the astronaut closely during pressure leak tests. During these tests, communications are maintained between the astronaut and the Flight Surgeon and suit technician operating the test console.

4. Following insertion of the suited astronaut into the checkout couch, suit technicians perform the following suit pressure and leakage tests:

(a) Disconnect dressing room ventilation and start oxygen ventilation using the suit test console
(b) Connect astronaut helmet communications plug to communication test console
(c) Adjust underarm and shoulder-to-shoulder tiedown straps

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(d) Fasten and adjust the life vest and mirror to the helmet tie-down assembly
(e) Attach visor seal bottle hose to helmet fitting
(f) Close and open the helmet visor several times to check inflation and deflation of the visor seal bladder
(g) Instruct astronaut to close helmet visor
(h) Secure and tighten couch restraint straps

5. The following suit checkouts are then performed:

(a) Helmet communications
(b) Respiration sensor amplifier adjustment
(c) Comfort

6. The suit technician operating the test console pressurizes the astronaut's suit to 5.0 psi by slowly closing the pressurization valve.

7. Suit integrity and pilot comfort are checked at this point -- pressure points, helmet rise, etc. Suit pressure is reduced for adjustments if necessary.

8. The astronaut remains pressurized and ventilated for five minutes. During this time, the suit technician works quickly to perform suit leakage tests; his check list consists of the following:

(a) Close test console ventilation valve
(b) Switch leak-test valve from NORMAL to LEAK TEST
(c) Open flow through appropriate flowmeter
(d) Record leakage rate on suit data form
(e) Slowly switch valve from LEAK TEST position to NORMAL position
(f) Open ventilation valve
(g) Slowly depressurize suit; when suit pressure is at zero, advise astronaut that he may open his helmet visor

9. At the completion of suit leakage tests the astronaut performs the following:

(a) Release support couch restraint straps
(b) Disconnect communication lead
(c) Disconnect visor seal bottle hose
(d) Disconnect ventilation hose

10. The suit technician again connects the portable ventilator unit.

After the above pressure suit checkout is completed, the spacecraft-launch vehicle countdown status is ascertained. At the proper point during countdown -- at about T-185 minutes, the astronaut enters the transfer van with his insertion team and awaits the call to pad 14, the Mercury-Atlas launch area. Suit ventilation continues at this time, and transfer van biosensor read-outs begin.

From the transfer van to the spacecraft, the astronaut's suit is ventilated

by means of the portable suit unit which he carries in his hand. After his insertion into the spacecraft, suit ventilation is continued throughout the remaining countdown.

Following liftoff of the Mercury-Atlas system, the astronaut is protected primarily by his cabin pressure system. But should this pressure fail, he is encased in a suit capable of providing an artificial environment similar to cabin atmosphere.

This suit was adequate for the tasks performed by Astronauts Shepard, Grissom, Glenn, and Carpenter in their flights, but more and more elaborate suits must be designed for journeys into deep space. The present suit cannot ward off cosmic radiation which later flight astronauts will meet. Nor can the suit withstand extreme temperatures found on such distant goals as the moon and many of the planets.

The B.F. Goodrich Company's experience in high-altitude garments dates back to 1934 and includes the Navy Mark IV light-weight full-pressure suit. The products of that company's combined engineering efforts back in the 1930's turned out to be a rigid affair of heavy rubberized cloth, surmounted by a diver's helmet. The problem that plagued the early space suit tailors and one that still exists to a certain degree is the tremendous rigidity of the fabric under pressure. Even three pounds of air per square inch pumped into a suit gives the material the character of sheet metal.

Over a period of some 20 years, most of the problems of maneuverability were solved. The real breakthrough was a 1952 development of a swivel joint of airtight rotating bearings and fluted joints; this suit resembled a construction of what looked like small rubber tires glued together.

The Navy Mark IV suit thus evolved and is still worn by operational Navy pilots on missions at extreme altitudes. This was the model on which the present suit was patterned.