NASA Fact Sheet

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Waste Managment In Space

For astronauts to live comfortably and safely in the closed environment of a spacecraft, the management of metabolic or biological wastes is among the life support functions which must be carried out efficiently. A spacecraft's waste management system must be reliable, sanitary, and psychologically acceptable to the crew. Systems to handle crewmembers' bodily wastes have evolved from simple assemblies used on Mercury flights to the present-day complicated equipment on board the Space Shuttle orbiters. With the increase in complexity the systems have become easily operated and more Earth-like, a feat difficult to accomplish in the zero gravity of space, where objects tend to float about in a state of "weightlessness."

MERCURY

When Mercury flights began to extend into hours-long duration, provisions were made for handling metabolic wastes. Astronauts wore a urination bag contained in their spacesuits. On the flight of Mercury-Atlas 9, which lasted more than 24 hours, astronauts used a waste-management system made up of two units — a urination bag and a storage bag with a syringe-pump and hose. The hose provided pressure to draw the urine from the in-suit bag to the storage bag.

Bags for defecation were not provided for any of the Mercury missions. Crewmen ate a low-residue diet for three days prior to launch so they would not have a bowel movement. They carried emergency containers for emesis, if vomiting should occur, on each of the Mercury missions.

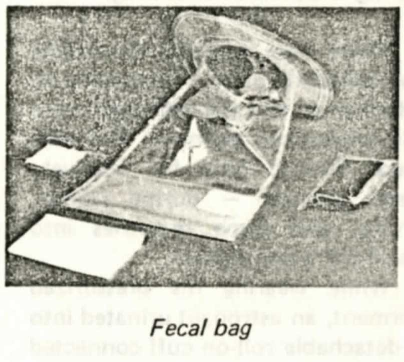
GEMINI

During the Gemini program, astronauts used a similar system which consisted of one urination bag for use during launch and another for use in-flight. The bag used during launch was y-shaped and made of neoprene-coated nylon. It fitted on the inside of the spacesuit around the pelvis. The bag had two openings, one with a fitted rubber sleeve that the astronaut attached to his body and another opening used for emptying the bag. For the astronaut to remove the bag, he unzipped his spacesuit and completely sealed off the bag with a hose clamp on the rubber sleeve. He emptied the bag into the spacecraft's overboard dump system through the other opening, then folded the bag for storage.

The other system was used after the astronauts attained orbit. It was a flexible bag with a roll-on rubber sheath. It used a double valve construction to prevent backflow of urine. The astronaut's bladder provided a pressure differential which caused the urine to fill the bag. The voided urine was then vented overboard.

Gemini missions 7 and 9 had a sampler valve which allowed the astronauts to draw off a specimen of urine for medical examination back on Earth. A radioactive tracer was added to the total quantity of urine. The amount of the tracer found in the sample allowed the total volume of urine to be determined.

The feces could not be flushed overboard like the liquid waste. On Gemini flights, the astronauts used a plastic bag with a 4-inch circular opening to collect the feces. First the astronaut placed a germicidal pouch in the bag to prevent or reduce gas and bacteria. Then he attached the bag to his buttocks using surgical-adhesive tape. After defecation, he removed the bag, placed soiled toilet tissues in it, and pressed the adhesive surfaces firmly together.



Fecal bag

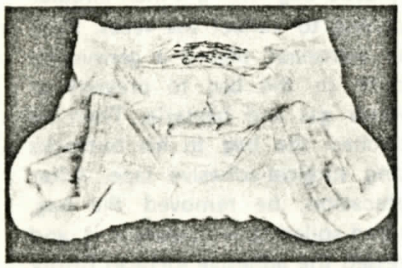
As in the Mercury program, Gemini astronauts ate low-residue foods prior to their flights and took emesis containers on the spacecraft.

APOLLO

For the manned missions to the moon in the Apollo program, provisions had to be made for collecting, inactivating, and stowing feces for 14-day periods. There were two fecal collection systems, one for the lunar module and one for the command module, which were identical.

The fecal collection assemblies consisted of an inner bag, germicide, and outer bag. The inner bag was nearly identical to and was used the same way as the bag in the Gemini program. After use the inner bag was placed in the outer bag, kneaded to rupture the germicide pouch, and stowed in a waste compartment. The compartment was vented to space to remove odors.

There was also a fecal containment system worn by the astronauts under their pressurized suits during extravehicular activities. The system functioned like a baby's diaper to allow for emergency defecation. It was an elastic underwear with an absorbent liner around the buttock area. Protective ointment was applied to the buttocks and perineal area to lessen skin irritation.



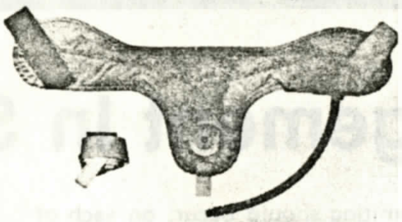
Fecal containment system for use during extravehicular activity

There were basically two modes for collecting urine — depending on whether or not the astronaut wore his pressurized garment. The suits were donned only for relatively short periods — during launch, EVAs, and some re-entries into the Earth's atmosphere.

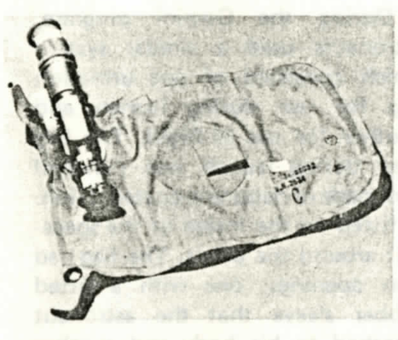
While wearing his pressurized garment, an astronaut urinated into a detachable roll-on cuff connected to a flexible rubber-coated fabric bag. The bag had a quick-disconnect fitting to a hose that drained the urine into stowage bags on the lunar module or overboard from the command module. The assembly featured an elastic harness to hold the device in place on the astronaut, and a relief valve to equalize pressure during urine transfer.

The urine collection systems of the command module and the lunar module had a basic difference. The system in the command module dumped the urine overboard; the system in the lunar module stored it to prevent contamination of the lunar surface.

In the command module, the astronauts used either a funnel or a roll-on cuff receiver with a bag and an outlet for attachment to the waste management system. Urine could be stored here temporarily or transferred to the waste-management system. Each Apollo crewman had his own cuff-and-bag device.



Apollo urine bag worn under space suit



Apollo urine bag used aboard command module

Several small bags were used to collect the urine on the initial lunar missions, but they proved inadequate for missions longer than two days. Apollo 15 and the two subsequent missions incorporated a large holding tank in the descent stage.

During the Apollo-Soyuz Test Project, the joint U.S.-Soviet space flight to test international rendezvous and docking techniques, American crewmen used the same waste management systems developed for the lunar program. This was because the same type of spacecraft, the Apollo command module, was used for this mission.

SKYLAB

Orbiting above the Earth, the Skylab space station provided a habitable environment for astronauts on long-duration space flights. Skylab's orbital workshop contained living quarters, crew provisions, and facilities for food preparation and waste disposal to support three-man crews on three missions (one for 28 days, one for 59 days, and the third for 84 days).

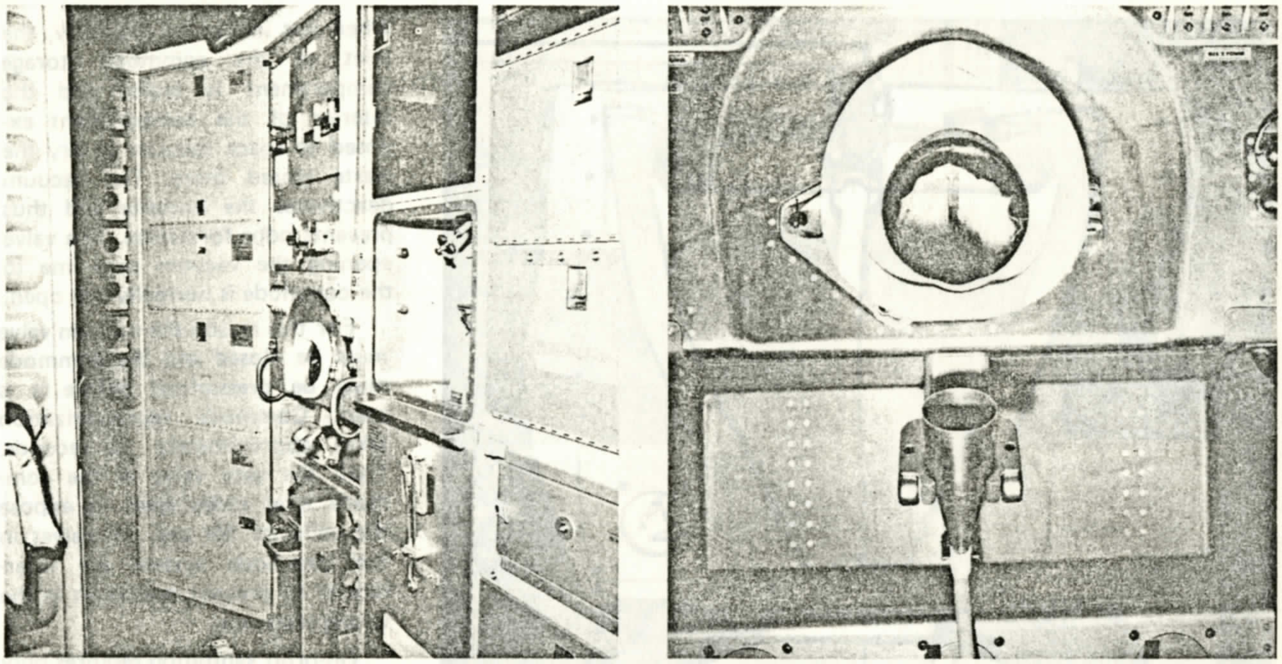
The waste management facilities were a challenge to spacecraft designers due to a set of extensive requirements for associated medical experiments. Samples of body wastes were required to assess the bone and muscle changes in astronauts exposed to weightlessness over a long period. All solid human waste products were to be dried, and the residue returned to Earth for examination and analysis. Daily urine samples had to be frozen for later analysis on the ground.

The fecal/urine collector, analogous to a toilet, was mounted on the wall. In the weightlessness of space, the user appeared to sit on the wall, facing the floor.

A crewman could defecate and urinate simultaneously while seated on the collector, using a lap belt and handholds to hold himself in place. The urine receptacle could also be used in a standing position, using foot restraints.

During defecation, feces were collected into a bag under the commode seat. The bag was permeable to air and impermeable to liquids and solids. An electric blower provided an airflow (suction) to aid in stool separation and draw the waste into the bag. The airflow was filtered to control odors and then recirculated back into the cabin. The bag was removed after each defecation, weighed with its contents, labeled, and vacuum-dried in a waste processor for 16 to 20 hours. Then the bag of fecal residue was removed from the processor and stowed for return to Earth.

Each crewman had his own urine drawer at the base of the fecal/urine collector. Each drawer housed a blower unit, a centrifugal fluid/gas separator, and a collection bag where the crewman's urine was pooled for 24 hours. Airflow from the blower drew urine into the centrifuge, which separated the urine from the air before it went into the bag. At the end of the 24-hour period, the crewman used a gauge to measure the thickness of the filled pooling bag, and thus estimated his daily urine output. The



Skylab fecal/urine collector, mounted to wall

output was later determined by the amount of lithium chloride (added to the bags prior to flight) found in the sample taken. Every 24 hours, a crewman would withdraw a 120 ml sample and place it into a freezer for return to Earth at the end of the mission.

SPACE SHUTTLE

The system for disposing of metabolic wastes is even more sophisticated on the Space Shuttle orbiter than it was on Skylab. However, medical samples will not be taken, a function which complicated the Skylab system. The new system was designed to be as routine and Earth-like as possible to conserve the valuable flight time of the orbiter crewmembers, who will be extremely busy deploying payloads into orbit, stationkeeping, and conducting experiments.

On the Space Shuttle, women will fly as astronauts for the first time in the American space program. Consequently, the orbiter was designed to collect and process biowastes from both male and female crewmembers.

The orbiter's waste collection system has a set of controls that are used to configure the system for various modes of operation, namely: urine collection only, combined urine and feces collection, emesis collection, and redundant capabilities. The system consists of a commode, or waste collector, to handle solid wastes, and a urinal assembly to handle fluids.

The waste collection system may be used in zero gravity and in a one-g (Earth) environment with the orbiter in the horizontal position. Twelve female and seven male subjects participated in a test of the system under normal gravity and simulated zero gravity. Zero gravity was achieved aboard a NASA KC-135 aircraft flying parabolic maneuvers. The study aimed at defining requirements for transport airflows, and as a result, airflows were increased eight-fold for the urinal and three-fold for the commode from those used on Skylab.

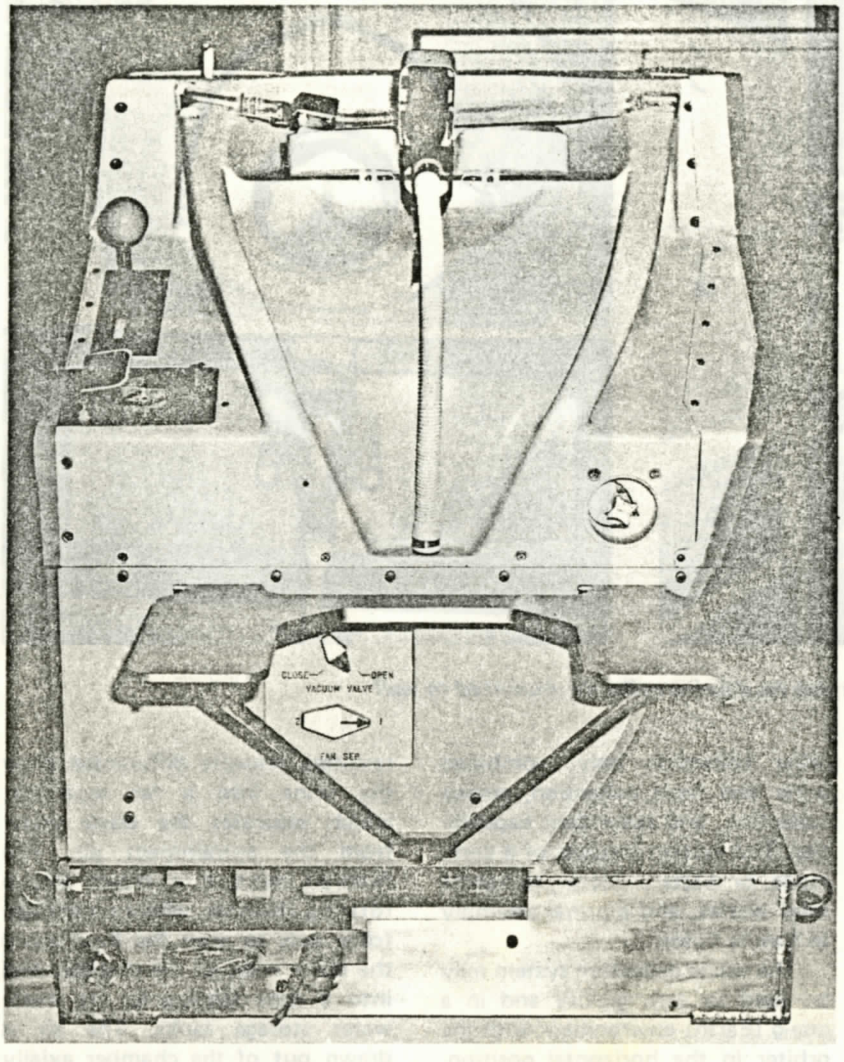
The urinal is used by both males and females, with the user either holding the urinal while standing, or sitting on the commode with the urinal mounted to the waste collection system. A contoured cup with a spring assembly, the urinal provides a good seal with the female crewmember's body. Its design normally precludes the need for females to wipe with tissues.

During urination, an airflow and resulting pressure differential draw the urine into a fan separator, which separates the waste water from the entrainment air. The fluid/air mixture is drawn into a rotating chamber, where centrifugal force acts to push the fluid along the outer walls of the chamber and into a tube leading to the waste water storage tanks. The air is drawn out of the chamber axially by a blower and returned to the orbiter cabin after being filtered to remove bacteria, dirt, and odor.

The commode is used for collecting both feces and emesis. It has a capacity for storing the equivalent of 210 person-days of vacuum-dried feces and toilet tissue. It may be used up to four times per hour, and may be used simultaneously with the urinal.

To operate the collector during defecation, the user positions self on the commode seat. Hand holds, foot restraints (used in conjunction with suction cup shoes), and waist restraints (similar to car seatbelts) help the user maintain a good seal with the seat. The crewmember uses the equipment like a normal toilet, including tissue wipes. The tissue is disposed of in the commode.

An airflow draws a solids/air



Space Shuttle commode and urinal (note foot restraints and "seatbelt" for zero-gravity use)

mixture into the commode. The tines of a rotating slinger shred the feces and fling it onto the commode inner wall, where it adheres in a thin layer. The tissue does not shred, but slides up and over the rotating tines and is stored with the feces. Air flows through the collector, out through a bacteria filter, and into the fan separator, the same one used for urine collection. Slinger tines in the filter area deflect debris and keep it from occluding the filter.

The commode is used in a slightly different manner for the disposal of used emesis collection bags. A bag containing vomitus is sealed with velcro, and deposited into the commode. The user changes the mode of operation so that the slinger rotates at a slower rate. The tines stay folded, and the bag has a clear passage. Air flow and the rotating slinger move it into the storage container.

The same type bag may be used as a backup to the waste collection system for fecal collection. The bag is attached below the commode seat and expands into the commode volume. After use, the bag is released into the commode opening. The bags are made of Nomex material with a porous teflon liner, which allows air to flow through the bag and move it into the storage area.

Everything stored in the waste collector — feces, tissues, and fecal and emesis bags — is subjected to vacuum drying in the collector. When not in use by the crew, the inlet to the commode storage compartment is sealed and the interior of the compartment exposed to space vacuum to dry the waste stored there. The vacuum deactivates the bacteria and thus prevents odor formation. The valve opening the vacuum vent line to the commode is normally left open.

For this reason the vacuum valve must be closed and the commode must be pressurized before it is used. Commode repressurization takes approximately 10 seconds. Then the gate valve at the commode inlet slides open to expose the collector for use. All valves in the commode system are interlocked to prevent operation in the wrong sequence.

On-orbit sanitation requires only that the astronauts periodically cleanse the urinal, commode seat, and other exposed areas with a sanitation agent and wipes. These wipes are disposed of in the wet trash storage compartment.

The wet trash stowage is a passive plastic-lined container in which used food bags, wet towels, wipes, tissues, soiled clothing, expended medical supplies, and personal hygiene items are disposed. It is vented to the waste collector system for odor control.

The waste water storage tanks not only receive biowaste fluids but also handle wash water and the condensate water from the airlock, portable life support system, and cabin air revitalization system.

The waste collector and the units for waste water and wet trash storage form an interrelated system for waste management on the Shuttle orbiter. Separating the storage areas and isolating levels of contamination prevent the highly contaminated wastes from spreading bacteria to everything else. This arrangement also makes it easier for spaceport ground crews to remove wastes from the orbiter and prepare the reusable spacecraft for its next mission.

Waste management, like many other areas of space flight, is on its way to becoming routine.