BREATHING AND PEEING IN SPACE

(1) Supporting human life inside of a spacecraft is challenging. A spacecraft is small and air and food need to be provided, waste needs to be removed and everything must stay clean. All of this is made more challenging due to the zero gravity or microgravity experienced within different spacecrafts.

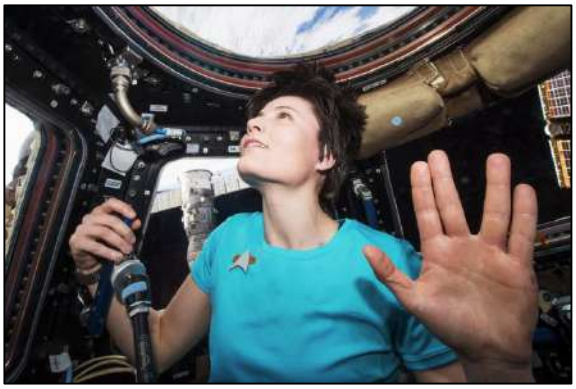
(2) Earth's air is made up of mostly 78% nitrogen gas and 21% oxygen gas. In a space station, there isn't a lot of room to store a large amount of air. The oxygen is quickly used up by the astronauts if no further oxygen is supplied. The International Space Station (ISS) was put into orbit around the Earth in 1998 and was designed for long-term missions. The original oxygen on board has long disappeared. In space crafts, there needs to be ways to generate oxygen and three main methods are used: 1) pressurized oxygen air tanks, 2) oxygen generators using electrolysis and 3) solid fuel oxygen generators (SFOG).

(3) The pressurized oxygen air tanks on board the ISS are constantly resupplied with oxygen when supply ships arrive from Earth. These supply ships also pump nitrogen gas into other tanks. The space station's atmosphere control system mixes the two gases together to imitate the mixture of air found on Earth. It then circulates this air mixture through the spacecraft.

(4) Oxygen generators can also use the process of electrolysis to make oxygen. During electrolysis, water molecules are broken down into oxygen gas and hydrogen gas. See the equation below:

$$2H_2O \rightarrow 2H_2 + O_2$$

When electricity is passed through water, two molecules of water will split apart and reform into two molecules of hydrogen gas and one molecule of oxygen gas. Both gases are collected separately. The oxygen is used to make the air mixture and the hydrogen gas is released into space. On the ISS, energy to make the electrical current for electrolysis comes from solar panels. Water is provided by supply ships from Earth and by space shuttles that dock with the ISS. As well, when astronauts breathe, they exhale water vapor into the air which is removed and collected in condensers.



Credit: NASA

This water, along with the water reclaimed from the astronauts' urine, can be used for electrolysis. The electrolysis of water is the main way that oxygen is provided on a spacecraft.

(5) The solid fuel oxygen generator (SFOG) is the backup method for making oxygen in case of emergencies. SFOG contains two powders: sodium chlorate ($NaClO_3$) powder and iron (Fe) powder. A chemical reaction happens between these two powders to form water. Take at look at the equation for this reaction:

$$NaClO_3 + Fe \rightarrow 3O_2 + NaCl + FeO$$

In addition to producing oxygen gas, salt (NaCl) and iron oxide (FeO) are also produced. Every kilogram of the SFOG powdered mixture can produce enough oxygen for 6.5 hours of breathing.

(6) Not only is oxygen strictly controlled on a spacecraft, so is waste production and waste storage. On Earth, water easily pours and flows due to gravity. In zero or microgravity conditions, water does not flow and instead forms into a ball. This is not useful when you need water to help flush a toilet. Since water can't be used and since urine and feces can't "fall" into the toilet, a special toilet must be designed to get rid of the waste and keep things sanitary.

(7) On a spacecraft, a zero gravity toilet is found in a 1m x 1m compartment. When sitting on the toilet, astronauts must strap themselves down with a seat belt so that they don't float away. Solid and liquid wastes are handled separately. For urine, female astronauts pee

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into a funnel attached to a tube, and for male astronauts there's just a tube. Air is sucked through the tube to drag the urine inside so that it doesn't float back out. In this way, liquid waste is easily managed on a spacecraft.

(8) Solid waste is a little trickier. When feces is produced a strong vacuum sucks air and poo into the toilet before it can float anywhere. The feces goes into a storage tank which is exposed to the vacuum of space outside. This exposure kills all the microorganisms in the feces and freeze dries the feces. Freeze drying is a process that uses cold temperatures, like those found in outer space, to freeze water until it sublimates which means the water turns a solid directly into a gas. This helps dehydrate the feces and shrinks its volume. When enough feces is collected from the crew, the feces is put into an unmanned supply ship which is released from the spacecraft. The supply ship is pulled towards the Earth and ends up travelling at extremely high speeds as it re-enters the Earth's atmosphere. As the particles of air rub against the supply ship like sand paper, the intense friction generated by the rubbing tears apart the ship and its contents until they burn away in the atmosphere. It will look like a streak of light in the night sky and an observer from Earth may mistake it for a shooting star when it's actually just a burning container of poo.

Article Questions

1) What does the typical mixture of air on Earth composed of?

2) Why is water needed to provide a spacecraft with oxygen?

3) What are three sources of water for a spacecraft?

4) Why can't water be used to flush toilets in space?

5) How are urine and feces removed in a zero gravity toilet?

6) What is freeze drying and why is this useful for treating solid waste?

7) Next time when you see a "shooting star" in the night sky, you'll realize it might not be as pretty as you used to think. Why?