We can't always find you. But you can always f nd us

For the latest on copper tube and fittings, visit www.copper.org

The Copper Development Association regularly publishes technical and application information on copper tube and fittings. To ensure you always have the latest updates, we've dedicated an entire section of our Web site to you.

Just go to ***www.copper.org*** and click on *Tube, Pipe & Fittings* under *Applications*. The *Technical References* section has the latest edition of **The Copper Tube Handbook**. And you'll find up-to-date information on all aspects of copper tube – including fuel gas distribution and fire sprinkler systems. Plus, a **Guide Specifications** section to make sure your specs are accurate and current. And if you want, we'll notify you whenever there's an update anywhere on the site that may affect you.

Have a specific question? Now you have direct e-mail access to the CDA regional manager covering your part of the country.

So log on to ***www.copper.org*** today. You'll find it's well worth it.

COPPER
The Smart Choice

Circle 11 on your reader response card for product information.

Plumbing Technology for the Mars Space Station

by Winston Huff, CPD, LEED AP

Photo: NASA

The activities of Christopher Columbus and other early explorers had very little effect on the average person's normal daily activities, but their discoveries sparked the imaginations of some people, especially when they looked across the ocean and knew that people lived on the previously unknown distant lands.

These explorations to "new" worlds eventually changed local economies, and new careers were created in areas such as construction, agriculture, travel, and trade. They even altered how people practiced religion and politics. In the same way, space travel is going to change the way humans live and work. It already has changed the plumbing engineering community; a small group of plumbing engineers and designers have spent their careers designing and building plumbing systems that are used in space. While most of this activity has little effect on our daily routines, we cannot help wondering how their work will influence future plumbing systems.

This article is the last in a four-part series looking at the future of plumbing technology. The first three articles covered new technologies that are now in service on Earth and in space. This article discusses current plans to travel to Mars and the plumbing systems that will accompany those journeys, as well as how these activities can open new fields in plumbing engineering.

Mars Mission

NASA and other organizations are trying to develop ways for humans to travel to Mars. In his January 2004 speech at NASA, President George W. Bush announced an ambitious space exploration plan that would return Americans to the moon by 2020. The moon will serve as a launching point for missions to Mars and beyond.

On the private side, Scaled Composites LLC, an aerospace and specialty composites development company, developed SpaceShipOne, the first non-government manned spacecraft. In October 2004, the craft won the Ansari X-Prize for being the first private manned craft to exceed an altitude of 328,000 feet twice within 14 days. The second flight broke a 40-year-old altitude record by traveling 69.6 miles above the Earth's surface. Other organizations such as the Mars Society consist of government and non-government entities promoting manned space flight to Mars. The Mars Society currently is conducting two simulated Mars missions: the Flashline Mars Arctic Research Station on Devon Island in the Canadian Arctic and the Mars Desert Research Station in southern Utah. The locations were chosen due to their environmental similarities to Mars.

At this point it is not known how humans will return to the moon or travel to Mars; however, a growing number of people is promoting the next step to human space flight, whether it be government or privately funded.

Challenges to a Mars Station. Research on developing systems for both lunar and Mars manned missions, stations, and colonies is now under way. Organizations agree on the basic steps that will need to be taken to realize manned missions to Mars. The first step includes a transport vehicle that takes people to Mars. The next step involves landing people on the planet and establishing a station. Over time the station will grow into a colony where people will live and work on Mars for extended periods.

One plan involves a series of crafts sent to the Martian surface to prepare the future human landing site. The initial unmanned trips would set up equipment that prepares fuel, water, and air. After several missions, inflatable structures would be brought to the surface to serve as habitats and a greenhouse that would provide food for the crew.

It is thought that the transport vehicles and first Mars station will use the next generation of the physical/chemical-type plumbing systems now in use on the shuttle and the International Space Station (ISS). These types of systems use physical or chemical methods to clean water from a waste stream to be used as safe potable water. These plumbing technologies were discussed in Part 3 of this series, "Plumbing Practices on the International Space Station" (*PSD* May/June 2005).

These physical/chemical systems will not be efficient when people live in space environments for long periods. As a result, research is being conducted on biological systems, sometimes called bioregenerative systems, that use plants that duplicate the Earth's biosphere to clean the crew's water and air.

Humans living on Mars will need water. The planet's atmosphere has trace quantities of water vapor, and the Martian poles have substantial amounts of ice. Water may be under the planet's surface, but the conditions on Mars forbid liquid water on the surface. In high altitudes, temperatures are 70-100°C below freezing; however, scientists hypothesize that liquid water may be present just below the surface. Boiling water on Mars is very different than on Earth. The Mars atmosphere is 100 times thinner than Earth's atmosphere. On Mars, water would boil at 10°C, whereas here on Earth water doesn't boil until it reaches 100°C.[1]

The Mars environment is harsh compared to Earth's environment. Mars receives 44 percent less sunlight because it is about 1½ times farther from the sun than Earth. Dramatic temperature changes occur during a typical Mars day, from 14°F in the afternoon to -105°F at night. The atmosphere warms from the ground up, so in the morning a person's feet can be 70 degrees warmer than their nose.[2]

The air pressure changes from day to night, resulting in windstorms every night. The length of the Mars day is 24 hours and 39 minutes; while only slightly longer than an Earth day, the variance can affect the human body. For instance, during the Mars Rover missions the people on Earth controlling the Rover started reporting to work 39 minutes later each day.[3] However, this may match the natural body clock. Some studies state that the body is set for a 25-hour cycle. A Harvard University study found that the natural body clock averages 24 hours and 11 minutes.[4]

Because of the thin atmosphere on Mars, the risk of exposure to high doses of radiation from the sun is a concern. Possible solutions include building structures using the Martian soil as building blocks or creating underground habitats several feet under the Martian surface to protect inhabitants from harmful radiation.

Bioregenerative Life Support

The plumbing systems for Mars must adapt to the planet's environmental and atmospheric conditions. Researchers are studying the way the Earth's biosphere recycles water and air to develop a type of space greenhouse that mimics the

Earth's efficient, economical, and safe advanced life support system.

An important element of a functioning greenhouse is light. Light in a greenhouse on Earth is obtained either by a clear glass roof that lets in the sun's natural light or artificial lighting. On crafts such as the ISS or the shuttle a large glass roof is not possible, but on Mars an inflatable greenhouse could have a clear roof to let in natural sunlight. The problems are the lack of sunlight on Mars, the frequent violent dust storms, and the exterior cold temperatures, which may make an inflatable greenhouse impractical.

One way to provide artificial light is the use of light-emitting diodes (LEDs). These low-energy lights can work for growing small quantities of plants, and they are planned for testing on the ISS. LEDs are energy efficient and do not produce large amounts of heat, so they can be installed near plants. Researchers also are trying to determine the light frequencies needed for photosynthesis and how the frequencies of the light spectrum can be altered to control possible crop damage such as disease or mold. Growth chambers for such experiments are unusual to observe because plants grow in one color such as red or blue.

Space systems require cooperation between electrical and plumbing engineers. For instance, researchers have developed a recirculation system that cools light fixtures and provides hot water for other uses. Water circulates around light fixtures encased in a sleeve, collecting the heat from the fixtures while letting the light shine through to the plants. The result is a light that radiates little heat and provides a way to heat water for other uses.[5]

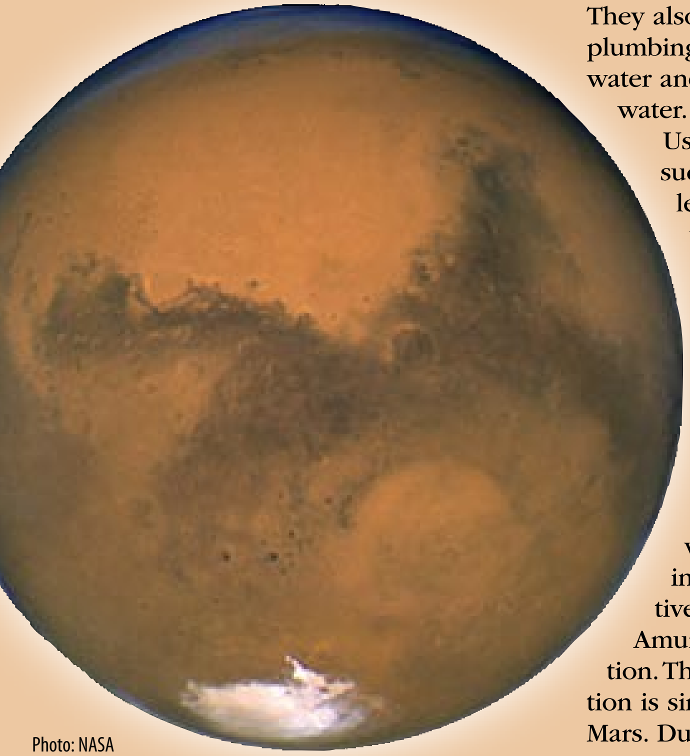


Photo: NASA

Another way to provide light is solar irradiance systems. This research is being conducted at the University of Arizona in a simulation of an underground growth chamber on Mars. These systems capture sunlight with solar collectors and transport the light via fiber optics to the plants. These systems can be used to supply natural light to underground greenhouses while protecting the plants and crew from harmful high doses of radiation.[6]

In addition to light, plants also require nutrients and water. On Earth plants receive the nutrients and water they need from the soil. Soil comprises decaying plants and animal waste, and it is heavy and hard to transport. To solve some of these problems, researchers are developing hydroponic techniques to grow plants in space. Hydroponics is a soil-less growing system that submerses the plants' roots in water.

Scientists at the Kennedy Space Center are developing methods to grow plants by circulating nutrient-rich water around the plants' roots.[7] These systems do not require the transportation of heavy soil to grow the plants. They also create the need for special plumbing systems to circulate the water and inject nutrients into the water.

Using this method, salad plants such as tomatoes, radishes, and lettuce have grown in test beds that simulate possible Martian stations. Other plants such as dwarf wheat have been grown in zero-gravity conditions. In zero gravity plants can be grown upside down or even sideways.

Supplementing a crew's diet with fresh food has many added benefits. This was demonstrated with the installation of a bioregenerative hydroponic system at the Amundsen-Scott South Pole Station. The South Pole Station's location is similar to the conditions on Mars. During the winter, the crew stays inside the remote station for months at a time because they cannot enter the harsh environment outside the station.

During this research project a Controlled Ecological Life Support System (CELSS) was installed that included a growth chamber for lettuce, tomatoes, and other salad vegetables. Crew members enjoyed supplementing their diet with fresh foods. They also appreciated the environmental conditions in the growth chamber, including the bright lights, garden vegetable smells, and the naturally oxygenated air. The crew also liked working with the plants in the station's otherwise sterile environment. NASA scientist realized that such systems would be important for a Mars crew.[8]

Bioregenerative systems can take many forms and are used in many different applications. Some systems use the hydroponics method to nourish plants. Some technologies use damp cloths around plant roots, while others circulate nutrient-enriched air around plant roots.

Future systems will include hydroponic systems that clean liquid waste from the crew's water systems such as washing water, condensate, and urine using similar methods as the Earth's biosphere. As these technologies develop, plumbing engineers will be tasked with designing systems to move liquid waste from the wastewater system to the hydroponic system. One of the by-products of such a system is clean water for the crew. The end result is a closed ecological system.

At this time these systems are small; however, they could expand in future Mars missions to support large communities. Plants will provide a means to remove carbon dioxide from the air and replace it with oxygen, as well as clean waste streams to make safe drinking water for the crew.

Plumbing Industry Opportunities

As a result of such space research, the field of plumbing engineering soon could include specialized areas such as developing hydroponic water systems on farms that provide nutrients for plants as well as clean water for plumbing systems. Another specialized area could be working with lighting systems that will provide light for plants while heating water for use in hot water systems.

The NIBCO® Advantage

Quality begins with Dale and his team – NIBCO associates and shareholders with 140 years experience. They charge the furnace at NIBCO's Stuarts Draft, Virginia copper fitting foundry and plant. If copper melts too fast; it hardens. If copper cools too fast; it breaks. Dale's team keeps the fires burning at a constant 2200° F. Dale comes to work on weekends and vacation to check his furnace. We have so much faith in Dale and his team, we back up their work with a 50 year warranty!

Look to the Leader... Look to NIBCO®

NIBCO® • AHEAD OF THE FLOW® • 1.800.234.0227 • www.nibco.com

Circle 15 on your reader response card for product information.

Aerospace Contractors/General Contractors. In the future it is predicted that the type of contractor used to design and build space stations will change. "Plumbing systems for space" is a foreign term in the space industry because the space industry is rooted in the aerospace industry, not the construction industry.

Yet a subtle shift is occurring in the space industry. Early space travelers were test pilots, but today's astronauts are not. They have backgrounds in many different fields. The spacecrafts also are changing. From Apollo to the shuttle program, the focus was on building crafts that transport people; in other words, spacecrafts were advanced airplanes. Now that the ISS is up and operating, the thinking for space vehicles has shifted. The ISS is a structure in which people live and work; it is a destination, not a craft for transportation.

Looking at the long-range future of the space program, a significant growth area will be in the structures that are made for habitation. Although aerospace contractors such as Boeing currently receive the largest share of the budget for constructing crafts for space, at some point a shift in funding will occur, and a general contractor such as Bechtel or Turner Construction could receive a contract to build a space station. When this happens general contractors will need to follow plans prepared by architects and engineers, not aerospace engineers. Plumbing engineers and designers will be needed to prepare documents for the plumbing systems. When people go to space they will be living and working in structures that plumbing engineers helped design.

Other future opportunities abound. Current plans will develop a station on the moon for research and from which to launch future Mars missions. The side of the moon that does not face the Earth could be used to study space because the moon blocks all electronic transmissions generated from human communications systems. As a result, it is a clean area in which to study electronic activity that may be generated in space. Raw materials possibly could be mined on the moon and used on Earth. Also, there are preliminary plans for tourism in space.

The end result is that structures will be built on the moon for many different purposes. When people live and work in these structures, they will need plumbing systems; thus, plumbing engineers will be needed to design these systems.

ASPE Data Books for Space. Plumbing engineers will need data books for plumbing systems in space. Designing a gravity waste system on Mars, which has less gravity than Earth, with Martian building materials will be different than designing a gravity system on Earth. Data books covering sanitary vent systems for Mars will describe when it is best to vent outside into the Martian environment and when to vent inside a structure.

People currently are designing plumbing systems for the ISS. As a result, data books could be prepared now for zero-gravity systems. In a strange way the future is now the past because many of the designers who worked on the Apollo and Sky Lab programs are retiring; if not written down, some of their knowledge could be lost.

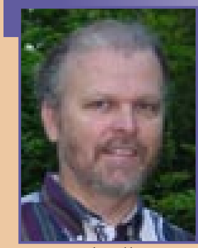
Looking to the Future

As I said in the first article of this series, my intent in writing these articles was to spark the imaginations of plumbing engineers and to open new worlds in the plumbing engineering industry. We live in a time that is similar to when early explorers were traveling to America. Their discoveries did not change the average person's routine, but they did change people's imaginations. I am sure that when they looked across the ocean, they would think about those distant lands. They would imagine what it would be like to travel to and live in those lands.

Current generations can look into the sky and see the far-off places to which people have traveled such as the moon. We wonder what our descendants will be doing. Years ago when I was the publisher for a scientific journal, I interviewed Alan Shepard Jr., the first American in space and lunar astronaut, and asked him if there would be a time when no one who had walked on the moon was alive. I could tell this thought had not crossed his mind. He was one of those rare people who think about the great things that could be done in the future. He had a hard time conceiving a time when people would not build on the accomplishments of the ones who went before them. I hope future generations maintain that spark of imagination. As a plumbing engineer, I can imagine what exciting systems plumbing engineers of the future will be building. ■

References

1. Phillips, Tony, "Making a Splash on Mars." Science@NASA, science.nasa.gov/headlines/y2000/ast29jun_1m.htm.
2. "The Temperature of Mars," Adler Planetarium, www.adlerplanetarium.org/learn/planets/mars/temperature.ssi.
3. "Watchmaker With Time to Lose." Jet Propulsion Laboratory, California Institute of Technology, marsrovers.jpl.nasa.gov/spotlight/spirit/a3_20040108.html.
4. Cromie, William J. "Human Biological Clock Set Back an Hour." *The Harvard University Gazette,* 15 July 1999.
5. Barry, Patrick L., "Leafy Green Astronauts." Science@NASA, science.nasa.gov/headlines/y2001/ast09apr_1.htm.
6. McGinley, Susan, "Solar Growth Chambers for NASA." University of Arizona, ag.arizona.edu/pubs/general/resrpt1998/nasa.html.
7. Heiney, Anna, "Farming for the Future." NASA, www.nasa.gov/vision/earth/livingthings/biofarming.html.
8. Staight, C.L., D.L. Bubenheim, M.E. Bates and M.T. Flynn. "The CELSS Antarctic Analog Project: an advanced life support testbed at the Amundsen-Scott South Pole Station, Antarctica." *Life Support and Biosphere Science,* Winter 1994.



Winston Huff, CPD, LEED AP, is a project manager, plumbing fire protection designer, and LEED facilitator with Smith Seckman Reid Consulting Engineers in Nashville, Tenn. He is the founding editor of Life Support and Biosphere Science academic journal and has served as its editor in chief. He also is president of Science Interactive, an organization promoting biosphere science. To comment on this article, or for more information, contact articles@psdmagazine.org.