A giant step for wate

The moment that Atlas V rocket took off on 6 December 2015 for the Internationa Space Station was the moment when the fire extinguishing agent of choice for space travel and exploration became water mist. Jose Sanchez de Muniain interviewed Dr Angel Abbud-Madrid, director of the Center for Space Resources, Colorado School of Mines, US about the 18-year journey to get portable water mist fire extinguishers in space.

Why water mist?

Back in 1997 we were looking at how the industry was changing after the Montreal Protocol had banned halons for fire suppression. We started researching possible replacements and water mist seemed like a great technology to put out fires, particularly fires in space where there were several issues to deal with.

Which technologies did you look at?

Back then the Space Shuttle had halon extinguishers. For the International Space Station NASA opted for CO_2, which we thought could be a better alternative. But the problem with putting out fires in spacecraft is that if you use any chemical agent or carbon dioxide, you have the problem of increased levels of toxicity in a fully enclosed space. The protocol from NASA was that if you discharged a halon extinguisher in the Space Shuttle you would have to come back to Earth almost immediately. We wanted to propose a suppression agent that was non-toxic, non-corrosive, and that if you were on a long trip – not just on orbit around Earth but to the Moon or Mars – you could actually refill it onboard instead of coming back to Earth. And water mist was perfect for this.

Two portable water mist extinguishers have now arrived at the International Space Station and more will be arriving later this year (above, commander Scott Kelly on a December 21, 2015 spacewalk).

Credit: National Aeronautics and Space Administration.

Portable water mist fire extinguisher flight unit at NASA Johnson Space Centre.

What experiments did you carry out?

We started looking at how water mist interacts with propagating flames such as propane-air mixtures in a cylindrical tube. Our basic questions were: what are the optimum droplet size and water amount necessary to put out the fire? For a controlled experiment, we conducted tests in microgravity, because it is the only way to create a homogeneous mist without settling after a few seconds. It just stays floating until the flame propagates through it. We ran different tests with flames interacting with this mist, changing either the droplet size or adding more water until we finally extinguished the flame. In that way, we determined that the optimum droplet size was around 20 to 30 microns in diameter. If you go below that size you start evaporating the water way ahead of the flame. And above that, you waste water as large droplets begin to go through the flame without fully evaporating.

How does water mist behave in zero gravity? Does it coalesce?

That was one of the first questions we had, so we started with experiments in a parabolic-flight airplane capable of giving us 30 seconds of microgravity. This wasn't long enough to giv us a clear idea of what was really happening, so we went to the Space Shuttle where you get unlimited time of steady microgravity. There we discharged the mist into a cylindrical tube and what we saw is that after moving around for a few seconds and occupying the entire volume, the mist would then just stay quiescent. I mean, these droplets wouldn't go anywhere, they would just float there for minutes. It was beautiful to see it! We did not detect any effect on the droplet size; the mist stayed homogenous all the way until the flame passed through it.

Did you test conductivity on that mist?

There was an initial concern regarding the effect of using water on electrical components. The way we addressed it wa by using de-ionized water. In addition, the size of the droplets is so small that they evaporate very quickly, with little water accumulation left behind.

Why did it take 18 years to develop?

From the initial concept to flying on the Space Shuttle it took

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us five years, because once you are scheduled on a flight you have to wait your turn, and our mission kept being delayed. After the Shuttle flight we realized water mist was a great choice for a fire suppressant for spacecraft, so we proposed its use to NASA. But by then the Space Shuttle had only a few years before its retirement and NASA had settled for CO_2 as the fire suppression agent for the Space Station. A large investment had gone to develop these extinguishers. But then in 2011 NASA decided to extend the life of the Space Station and conducted a review of all its subsystems. For fire suppression, NASA realized that while CO_2 was effective, its discharge could lead to high toxicity levels. Besides, the breathing masks required to be used by astronauts filtered fire by-products, but not CO_2, nor provided oxygen. It was only then that NASA recommended the use of non-toxic water-mist fire extinguishers to mitigate this risk.

How does the extinguisher work?

A terrestrial water extinguisher has a dip tube that pulls the water from the bottom of the extinguisher, but in microgravity water clings to the walls and so this technique does not work. The space-rated extinguishers have to work in any configuration – up, down, and in any gravity field. The main tank has a metal bellows inside where water is contained, while outside the bellows nitrogen is kept at a high pressure. When the handle is squeezed, the water mixes with the nitrogen at the nozzle, where the atomisation takes place.

In the film Gravity Sandra Bullock uses a CO_2 fire extinguisher to propel herself from the Soyuz to the Tiangon capsule. Would a water mist extinguisher have also saved her life?

I always get that! And actually that was one of the questions we had to answer in a test, to measure the kickback force on an astronaut and keep it to a minimum. The force is low enough that it's not going to violently propel astronauts against the wall. They will definetely feel a small force, but a very managable one, not Sandra-Bullock type, not as dramatic!

Will the new extinguishers be used on future space missions?

Absolutely, yes. After water mist became the fire suppression agent of choice for the space station, we and our industrial partner ADA Technologies have been talking to companies which are building human-rated spacecraft. In fact, for the Orion spacecraft being planned for trips to the Moon, NASA* is considering the use of a modified version of the portable fire extinguisher for the capsule. Hopefully, water mist will be used on the Moon, Mars, and any other future mission.

Together with ADA Technologies, we are also actively looking into terrestrial applications for portable water-mist fire extinguishers.

**The Orion Multi-Purpose Crew Vehicle is NASA's first spacecraft designed for long-duration, human-rated deep space exploration.*

Four more portable fire extinguishers are scheduled to take off 22 March on Orbital's OA-6 mission in a United Launch Alliance Atlas V rocket and two more payloads will be carried by Space X later in the Spring.

Angel Abbud-Madrid, director of the Centre for Space Resources, will be speaking at the 16th International Water Mist Conference in Vienna, Austria, 21-22 September 2016.