Frozen-Plug Technique for Liquid-Oxygen Plumbing

An established plumbing technique is extended to systems other than water pipes.

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A frozen-plug technique has been conceived as a means of temporarily blocking the flow of liquid oxygen or its vapor through a tube or pipe. The technique makes it possible to perform maintenance, repair, or other work on downstream parts of the cryogenic system in which the oxygen is used, without having to empty an upstream liquid-oxygen reservoir and, hence, without wasting the stored liquid oxygen and without subjecting the reservoir to the stresses of thermal cycling.

The present frozen-plug technique was inspired by an older frozen-plug technique used by plumbers on water pipes in situations in which the expansion of water ice can be tolerated. In a typical application of the older technique, the affected section of pipe is cooled by use of carbon dioxide or liquid nitrogen, causing the water in the affected section of pipe to freeze.

In the present frozen-plug technique, the section of pipe to be plugged is wrapped with a tube or vessel that can be filled with a suitable cryogen. A secondary fluid that is compatible with oxygen and that has a freezing temperature higher than that of oxygen is pumped into the pipe under pressure, completely filling the affected section. The higher freezing temperature of the secondary fluid makes it easier and safer to use the secondary fluid than to fill the pipe with liquid oxygen. In the initial application for which the technique was conceived, an oxygen-compatible cleaning solvent was chosen as secondary fluid because of an application-specific requirement to maintain cleanliness in the cryogenic system. Other secondary fluids may be suitable in other applications.

The cryogen is pumped into the tube or vessel wrapped around the pipe. The cryogen (typically, liquid nitrogen) is chosen to have a temperature lower than the freezing temperature of the secondary fluid. Therefore, the pipe and its contents become chilled below the freezing temperature of the secondary fluid, so that a plug of frozen secondary fluid forms in the pipe. The plug can withstand the upstream and downstream pressures and the differential pressure between them.

The present frozen-plug technique is adaptable to systems containing fluids other than the liquid oxygen of its original application, and to the use of secondary fluids that are not cleaning solvents. Moreover, the choice of cryogen in this technique is not limited to liquid nitrogen. The technique can also be adapted to non-cryogenic systems. In systems in which freezing of the commodity fluids (perhaps some food products, for example) can be tolerated, there may be no need to use secondary fluids. In cases of some commodities, it may be necessary to perform research to identify any potential hazards posed by freezing.

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