Compressed Gas Safety for Experimental Fusion Facilities

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Experimental fusion facilities present a variety of hazards to the operators and staff. There are unique or specialized hazards, including magnetic fields, cryogens, radio frequency emissions, and vacuum reservoirs. There are also more general industrial hazards, such as a wide variety of electrical power distributed throughout the facility, instrument air, cooling water, crane and hoist loads, working at height, and handling compressed gas cylinders. This paper outlines the hazards associated with compressed gas cylinders and methods of treatment to provide for compressed gas safety. This information should be of interest to personnel at both magnetic and inertial fusion experiments.

A variety of gases are used in fusion research. Nitrogen is used as a fill gas in vacuum vessels and in gloveboxes to reduce intrusion of humid room air, hydrogen and deuterium gases are used as fuel sources, and P-10 gas (10% by volume methane and 90% argon) is used for a cover gas in radiation counters such as ionization chambers and portal-type contamination monitors. Sometimes halon gas or carbon dioxide gas is used for fire suppression. Other gases may be used to cool diagnostic devices or as lasing gases for laser diagnostics, including nitrogen, carbon dioxide, neon, argon, and others. A typical 140 cm tall by 23 cm diameter gas cylinder from a gas supply company is pressurized to ~13 MPa (2,000 psia) and generally weighs about 59 kg (130 pounds). In the press of experiment activity, proper treatment of gas cylinders can be overlooked.

The US Department of Energy (DOE) Occurrence Reporting and Processing System off-normal events database has been searched to identify incidents from 1990 and on, across the DOE complex, that are pertinent to compressed gas safety in fusion research. The findings are summarized in this paper; they include system parts such as metal parts and gauges that have been expelled under gas pressure, incorrect gases being plumbed to an experiment, cylinder isolation valve leaks, gas cylinder “missiles”, cylinder through-wall ‘pinhole’ leaks, and other events. Preliminary estimation of the frequency range of several of these types of events is given; the frequencies are low but these are nonetheless credible events. Thus far, no US fusion experiment facilities have reported any gas cylinder events to the DOE. However, in some DOE-funded facilities the treatment and handling of these cylinders is not safety conservative. Other safety-related events with compressed gas cylinders are also summarized in this paper, including US Nuclear Regulatory Commission event descriptions and a few chemical process industry case histories.

A calculation of the thrust force available from gas exiting the bore of a sheared valve, assuming a typical gas cylinder, has been performed and results are given for a variety of gases that are often used at fusion facilities. These calculations, and the historical event accounts, show that there is ample force available to penetrate sheet metal and cinder block walls, gouge concrete floors, or to send a cylinder aloft. Treating gas cylinders with respect and keeping cylinders well restrained while in use is a prudent course of action for all fusion researchers.

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