Box 9: Confined-Space Maintenance

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A confined space is typically defined as a volume which is large enough to enter and has restricted means of entry and exit. It is not designed for continuous human occupation and has the potential, if ventilation is insufficient, for containing a hazardous atmosphere. In addition, in the United States, the Occupational Safety and Health Administration (OSHA) has an additional clause describing a confined space within an internal configuration having inwardly converging walls or a floor which slopes downward and tapers to a smaller cross section. The Swedish Work Environment Authority, in its definition of a confined space, also includes a requirement that it is a temporary workplace. All of this certainly describes the pressure vessels for electrostatic accelerators.

Some of the hazards found inside the accelerator tank are immediately obvious. In the case of the large vertical tandems, maintenance is often performed at extreme heights. This can also be true for the large horizontal tandems, where the distance from the column to the tank is sufficient that falling from the column level would cause significant injury. There are also the obvious hazards from moving mechanical parts such as the charging belt or charging chain, and rotating power shafts. Work inside the high-voltage terminal also involves working with high-current or high-voltage power supplies. The use of various types of volatile solutions for degreasing or general cleaning can produce hazardous vapor concentrations. However, the potentially greatest hazard is the least obvious.

In the early days of accelerator development, the insulating gas was high-pressure air. It was found that the increased concentration of oxygen led to the occurrence of fires during a spark. The column damage was often substantial. Therefore, the insulating gas was changed to a nitrogen/carbon dioxide mixture. While this mixture is still used, a large number of modern electrostatic accelerators are now using 100% sulfur hexafluoride (SF_6). In both cases, these gases are often benignly described as biologically inert. It is this property that makes these insulating gases very dangerous.

The human breathing reflex is triggered by the buildup of carbon dioxide in the bloodstream. Therefore, walking into an oxygen-free volume, breathing normally, unconsciousness often results in about a minute with no warning. If some oxygen is present, hypoxia results. The major early symptoms of hypoxia include a feeling of euphoria combined with poor judgment or, more bluntly, stupidity.

Although this hazard can be avoided with adequate ventilation, extra care must be taken with sulfur hexafluoride. While the nitrogen/carbon dioxide mixture has about the same density as ambient air, sulfur hexafluoride is 5 times more dense and will tend to pool in low areas. There have been cases where even though the tank has two open hatches at each end with a fan in one of them, the SF_6 has remained undisturbed enough that personnel near the bottom of the tank have been in an SF_6/air mixture. This is immediately made apparent by the deepening of the person's voice. Just as breathing helium will cause a voice to increase in pitch, breathing SF_6 will cause the voice to lower in pitch. As soon as this is noticed, it is extremely important the personnel leave the area.

Many countries have government agencies that issue strict guidelines for working in confined spaces. In the United States, these rules are issued by the Occupational Safety and Health Administration, as mentioned above. Their rules focus on the proper preparation before entering a confined space, with adequate communication and ventilation while inside a confined space. These rules require adequate training of personnel with access to the confined space, as well as the availability of emergency equipment and crew. A brief look at rules and regulations for other countries indicates similar priorities. For example, the Swedish Work Environmental Authority has recommendations but no specific rules about work in confined spaces. These recommendations (AFS 1993:3) point out the importance of having good communication between employer and employee, so that the planning and realization of the work can be done in agreement.

The details for the preparation to enter a confined space vary from country to country, and from laboratory to laboratory depending upon the size and configuration of the accelerator tank. In general, before entry can be allowed into the pressure vessel, the gas transfer system must be secured or "locked out" to prevent insulating gas from reaching the pressure vessel while open. In addition, the charging system, power inside the tank and, in some cases, the complete control system are also locked out. This may change during maintenance as the testing of various column components is done. There may be other requirements, such as grounding the accelerator column to prevent charge buildup.

In all cases, it is necessary that the pressure vessel be thoroughly vented with ambient air. For many large machines, the venting process continues for 12 hours or more before personnel are allowed access. Then, before any entry, the oxygen level is monitored. In the case of the large, vertical tandems the oxygen monitor is lowered to the interior base of the tank.

At this point, some organizations require the safety department to issue a Confined Space Entry Permit. Oftentimes, this permit takes the form of a checklist to assure that all safety precautions have been taken and the necessary safety equipment is present. Then, only trained staff are allowed entry to prepare the interior of the accelerator tank for maintenance. Oftentimes, this requires at least one trained person outside the tank in constant communication with trained personnel inside the tank. This preparation consists of assembling floorboards in the case of horizontal accelerators or securing the service platform in the case of vertical accelerators. Then the necessary safety equipment, such as communication devices and oxygen monitors, is installed in the tank. At this time, the necessary tools and lights are also brought in.

Once the interior of the accelerator tank is ready for accelerator maintenance, often the requirements are relaxed to where constant communication is no longer required. However, most organizations will require at least two people in close proximity in case an emergency develops. In some cases, there is a sign-in/sign-out procedure whenever entering or exiting the pressure vessel. In all cases, it is expected that only persons thoroughly familiar with the accelerator be allowed entry. All guests must be carefully escorted.

Many accelerator laboratories have other confined spaces, such as the insulating-gas storage tanks. Often, the procedures for working inside these tanks are more rigorous. In the case of the very large liquid storage vessels at the Holifield Radioactive Ion Beam Facility, there is always one person outside who is in constant communication with the person inside the storage vessel. In addition, the person working inside wears a safety harness to allow remote retrieval by the person outside unless the harness interferes with the safe performance of the job at hand.

In order to maintain a competent safety staff, many laboratories have annual refresher courses to train the safety personnel in the use of respirators and other safety equipment and procedures. This assures that all proper care is taken at each accelerator opening.