Rapid Characterization and Removal of Hazardous Gas Cylinders

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Abstract: A combination of INEEL developed field instrumentation was used to characterize a CERCLA site containing buried gas cylinders suspected of containing hydrofluoric acid (HF). Remedial action was accelerated due to increased risk posed by wildfires and the site's proximity to an occupied nuclear facility. The fast, accurate characterization obtained using the rapid geophysical surveyor (RGS) and portable ionization neutron spectrometer (PINS) made possible a safe, cost-effective, and quick remediation of this acutely hazardous site. The RGS is a high-resolution wheeled magnetometer that collects and stores closely spaced magnetic field data. Data stored on the RGS was downloaded to produce maps indicating the spatial distribution and extent of the buried gas cylinders. The PINS assesses the chemical contents of an enclosed cylinder using gamma radiation and a spectrometer. The relative ratio of the elements clearly identifies the specific chemical compounds in the cylinder. The PINS instrumentation confirmed the presence of HF. Once located, the cylinders were hand-excavated, ultrasonically examined and remotely handled. The valves were tested using a manifold system purged with argon gas. Cylinders were depressurized, sampled for HF, and removed and readied for safe disposal at an approved treatment facility.

Compressed gas cylinders generally pose two types of hazards: the chemical hazard associated with cylinder contents (corrosive, toxic, flammable, etc.), and the acute physical hazard presented by a pressurized vessel (rupture, fragmentation). In a controlled and maintained environment (such as a laboratory), these hazards are easily mitigated and controlled. However, abandoned compressed gas cylinders pose additional health and environmental risks because the contents may be unknown, the cylinder and valve assembly integrity may be uncertain, or the lack of control or isolation from potentially damaging conditions (shock, fire, weathering) can deteriorate the cylinders. These were the conditions encountered at an abandoned gas cylinder site at the Idaho National Engineering and Environmental Laboratory (INEEL)

The site, referred to as CPP-94, is located at the INEEL in an off-road desert scrubland area, about one-mile from an active nuclear facility. Located in an area measuring about 20 x 60 ft, one cylinder was fully exposed at the surface and three cylinders were partially exposed. It was not known how many additional buried cylinders were present. The limited background information available indicated the cylinders were abandoned sometime in the 1950's for reasons unknown. Physical evidence included four small aluminum tags labeled "Hydrofluoric Acid" (HF) found near the site. HF is extremely corrosive and poisonous can has severe acute effects upon external contact, inhalation, or ingestion. In the form of gas, HF is also extremely reactive and poisonous.

During the summer field season of 2000, wide ranging wildfires at the INEEL came precariously close to the CPP-94 site. A fire at the CPP-94 site would increase the potential for cylinder rupture and HF release and pose an immediate threat to facilities, field workers, security personnel, and fire-fighting personnel. The decision was made to accelerate the characterization and remediate the site rather than risk exposing the cylinders to another fire season.

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The objectives of the characterization effort were to (a) provide a better delineation of the spatial extent and distribution of the cylinders and, (b) verify the cylinder contents for treatment and disposal planning. Characterizing cylinder locations and distributions was conducted using the Rapid Geophysical Surveyor (RGS), a Sage Earth Science proprietary system jointly developed with the INEEL. The RGS is a wheeled system that allows for the automated and cost effective collection of closely spaced magnetic data (6 in. x 20 in.). The data is used to produce a detailed high-resolution map showing the locations of buried and surface ferrous objects. The survey area measured approximately 250 ft x 250 ft and extended well beyond the CPP-94 borders to ensure that other unknown buried cylinders were not missed. The magnetic field survey at CPP-94 produced significant magnetic signatures consistent with the cylinders already identified. The survey also indicated that other cylinders may be buried near or under the visible cylinders. Other detects were associated with sign posts and metallic debris.

A second INEEL developed technology (portable ionization neutron spectrometer or PINS) was used to assess the contents of the one fully exposed cylinder at the site. Using a radioisotopic source, PINS directs a beam of neutrons into the cylinder that collide with the elements within the cylinder. The collisions produce a gamma ray signature that has the unique characteristics of the elements present. The gamma rays are detected by a high-purity germanium spectrometer which allows identification of the elements (and consequently the compounds) contained within the cylinder. A hydrogen gamma-ray peak at 2223 keV and fluorine peaks were observed at 197, 1348, and 1356 keV (Figure 1). The hydrogen and fluorine peaks (and the absence of other key elements) closely matched the spectra observed from a known HF cylinder previously assessed using PINS. Using the information gained from the RGS and PINS, a strategy was developed to address the health and safety requirements, the excavation and removal process, and the treatment and disposal options.

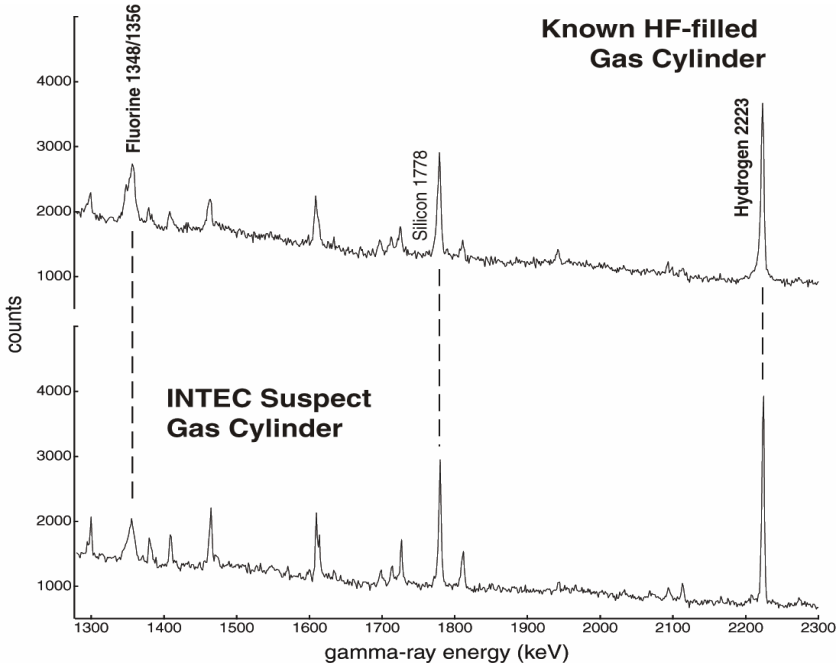

Figure 1. PINS spectra of HF cylinder.

To expedite CPP-94 field activities and implement all appropriate safety precautions, the remedial action was planned and executed using the INEEL Integrated Safety Management System (ISMS). ISMS was used in place of a traditional RD/RA work plan and placed a strong emphasis on field safety. In addition, the CPP-94 Health & Safety Plan and Hazard Classification were integrated into the ISMS project work control package.

Due to the possibility of hydrogen production through a chemical reaction of HF with the carbon steel container, a series of safety controls were established to assure that no reasonable potential for a fire or explosion existed during the excavation, evaluation, and pressure check process. The first measure taken to prevent personnel exposure was continuous ambient air-temperature and cylinder-temperature monitoring along with calculated control points including constant HF monitoring. The second mitigation process was electrical grounding of the cylinder. The third mitigation process included an inert gas (argon) purge of the manifold system. Gas flow was monitored to ensure oxygen and combustible gas concentrations remain below or above the LEL/UEL, respectively. The final mitigation measure included extensive use of personal protective equipment (PPE). Field personnel working in the exclusion zone used supplied-air, fire-resistant Nomex suits, ballistic shielding, and Level B PPE. Emergency services (fire department and ambulance) were also mobilized to the job site during high-risk operations.

A combination of mechanical and hand operations were used to perform a surgical excavation of the compressed HF cylinders. A small track-hoe equipped with ballistic shielding was used to excavate soil to within 12 inches of the buried cylinders. Hand excavation was then conducted using non-sparking tools. Prior to lifting the cylinders a graded approach was used to evaluate the cylinder and valve integrity based on standards identified by the Compressed Gas Association (CGA).

With a cylinder excavated and secured in place, it was necessary to determine its pressure and valve integrity using a manifold test system. After connecting the cylinder to the manifold, the system was purged with argon gas. The cylinder valve was then opened and the contents bled to a nalgene scrubber. After the cylinder was completely depressurized, the valve was closed. A cylinder containing HF was placed in an over-pack container and sent to an off site facility for neutralization. If the cylinder was not pressurized the valve was removed and the cylinder evaluated for hazardous materials. If the cylinder was deemed to be RCRA-empty, the cylinder was destroyed and sent to the INEEL landfill for disposal.

Results of the CERCLA accelerated remedial action at CPP-94 are considered highly successful. The combination of the innovative characterization technologies, non-traditional RD/RA work plan development, and rigorous hazard mitigation practices, provided the Department of Energy a 10% cost saving and allowed the project to be completed nine months ahead of schedule in a safe and compliant manner.