Tools Developed to Prepare and Stabilize Reactor Spent Fuel for Retrieval from Tile Holes – 12251

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ABSTRACT

Spent fuel from the Chalk River Laboratories (CRL) nuclear reactors is stored in the waste management areas on site. This fuel is contained within carbon steel spent fuel cans that are stored inside vertical carbon steel lined concrete pipes in the ground known as tile holes. The fuel cans have been stored in the tile holes for greater than 30 years. Some of the fuel cans have experienced corrosion which may have affected their structural integrity as well as the potential to form hydrogen gas. In addition to these potential hazards, there was a need to clean contaminated surfaces inside of and around the exposed upper surface of the tile holes. As part of the site waste management remediation plan spent fuel will be retrieved from degraded tile holes, dried, and relocated to a new purpose built above ground storage facility. There have been a number of tools that are required to be developed to ensure spent fuel cans are in a safe condition prior to retrieval and re-location. A series of special purpose tools have been designed and constructed to stabilize the contents of the tile holes, to determine the integrity of the fuel containers and to decontaminate inside and around the tile holes. Described herein are the methods and types of tools used.

INTRODUCTION

Spent fuel from the nuclear reactors at the CRL is stored in the waste management areas on site. The fuel comes from the National Research Universal and the National Research Experimental reactors. Once the spent fuel rods are removed from the reactor they are stored under water for a number of years and then loaded into steel cans, known as fuel cans that are placed into tile holes.

Figure 1 shows the cross section of an open Irradiated Fuel Element Tile Hole. Each tile hole is comprised of a vertical carbon steel-lined concrete pipe approximately 15 ft in length buried in the ground on top of a concrete base. The fuel cans have been stored in the tile holes for more than 30 years. Each of the tile holes that protrude from the ground is exposed to the environment. Not shown in Figure 1 are the features that close off the tile hole which is a steel flange and gasket that are fastened to the top face of the tile hole.

There are a number of different designs of fuel cans. Some of the different configurations of fuel cans are shown in Figure 2. Figure 3 shows an example of the top of a fuel can, showing signs of corrosion, inside a tile hole.

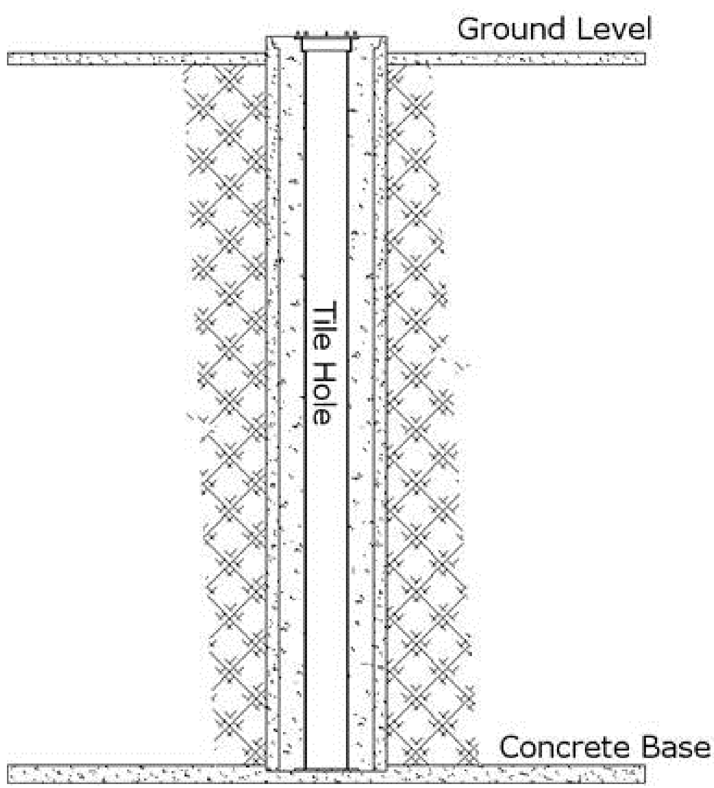


Figure 1 Cross Section of a Tile Hole

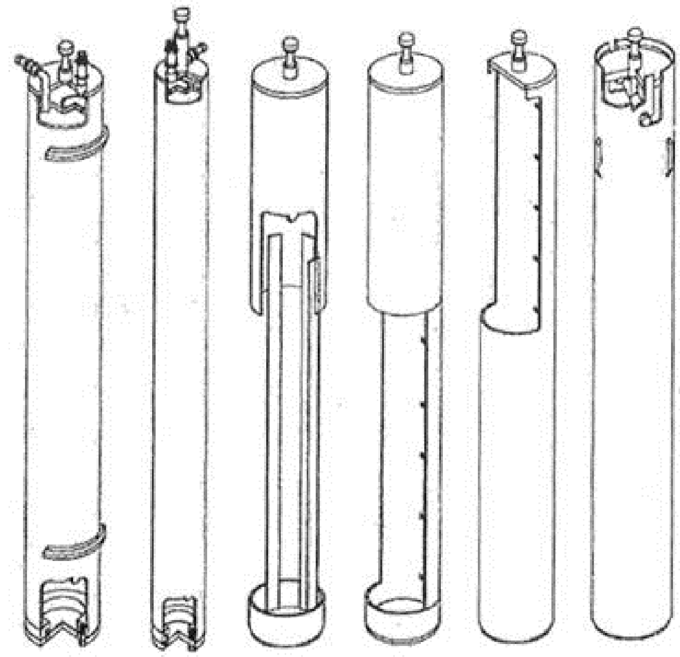


Figure 2 Schematic of the Different Fuel Can Designs used at CRL

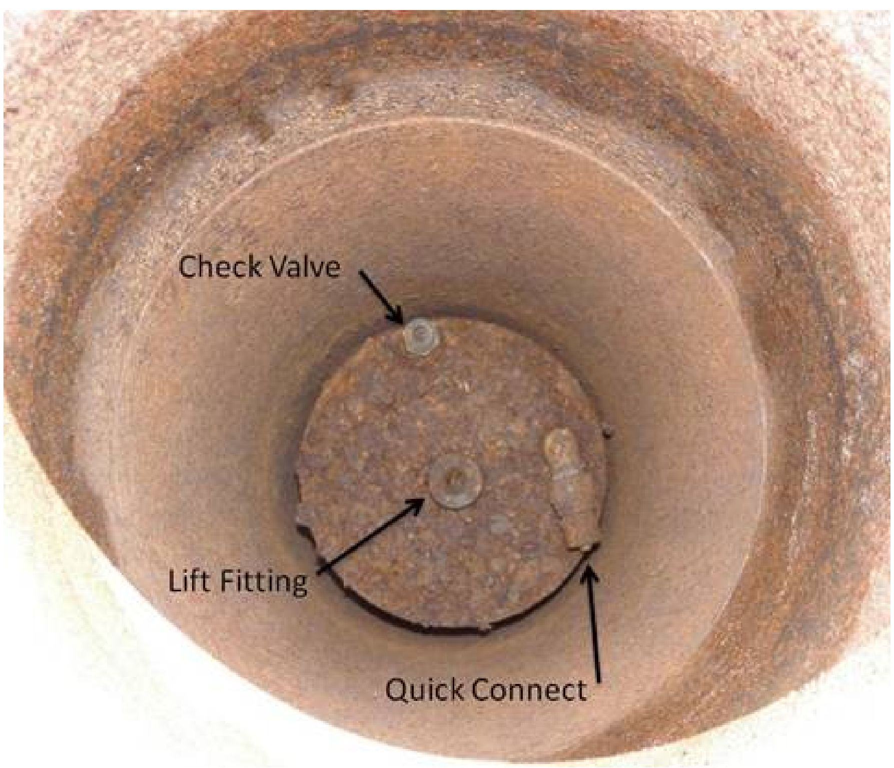


Figure 3 Presence of Corrosion Shown on Top of a Fuel Can

During storage in the tile holes some of the fuel cans have degraded over time. This has resulted in visual evidence of significant corrosion to some of the fuel cans, which may have affected their structural integrity. Some of the fuel cans are sealed and due to the degradation of the contents there is potential that hydrogen gas or uranium hydrides, (which react vigorously with water or oxygen releasing hydrogen gas), have formed inside. In addition, there was a need to clean up surfaces around the fuel cans and the tile holes.

As part of the site waste management remediation plan the spent fuel will be retrieved from the tile holes, dried, and relocated in a new purpose built Fuel Packaging and Storage (FPS) Facility. To assist in stabilizing and evaluating the state of the fuel cans, a series of tools have been developed to meet the following objectives:

1. To safely stabilize the inside of the tile holes and the fuel cans.
2. To provide a means of assessing the integrity of the fuel cans.
3. To clean up contamination inside and around the top surfaces of the tile holes.

Each of these tools was required to be operated on fuel cans within tile holes that were located in a designated and controlled waste management area on site. The design and testing of these tools was carried out, or is in the process of being completed, within the R&D Division in collaboration with Waste Management Operations at CRL.

Each of the above objectives was met by developing equipment as follows:

1. To vent the fuel cans, flush out any hazardous gasses and oxidize any uranium hydrides in a controlled fashion.
2. To partially raise the fuel cans, measure the weight of each can to ensure the weight matches the expected weight.
3. To design and implement a dry ice “blasting” device.

The tools used to meet each objective are provided in the following sections.

SPENT FUEL CAN CONTENT STABILIZATION

The fuel was originally loaded underwater into the cans through an open aperture (at the bottom of the can) and then the can was capped. Air was then pumped into the can via a fitting on the top of the fuel can forcing water out through a check valve that was also located on the top of the fuel can. This process removed the majority of water from inside of the fuel can although it did leave some residual water behind. These cans were then transported to the waste management area and placed vertically inside a tile hole. During storage radiolysis of the water in the fuel can and oxidation of the fuel and fuel can, resulted in two possible hazards within the fuel cans. It was possible the fuel cans could be pressurized with hydrogen gas, or the uranium metal may have reacted with H_2 to form uranium hydride. Two tools were developed to safely vent the contents of the fuel cans and then oxygen was introduced to the fuel cans to oxidize uranium hydrides that may have been present.

There were two tools developed to stabilize the contents of the tile holes and the fuel cans. These were:

a) A bung removal tool to remove temporary stoppers that were inserted into holes in the top of a number of fuel cans.
b) A check valve removal tool to remove check valves from the tops of the fuel cans.

Bung Removal

A number of the closed fuel cans had rubber stoppers inserted into holes in the top of the can. It was decided that the safest way to vent these cans was to remove these bungs. A tool was developed to remove these bungs from the fuel cans while the tile hole was flooded with an inert gas. This tool consisted of an enclosure that clamped to the top of the tile hole and was vented to atmosphere through a HEPA filter. The bung removal tool consisted of an inner shaft with a corkscrew tip. The inner shaft was manually screwed into the rubber bung and a hydraulic cylinder was attached. This cylinder was then actuated remotely to create a vertical lifting motion to pull out the bung, and vent any pressure in the fuel can into the tile hole and out through the HEPA filtered ventilation system.

An inert gas consisting of argon with 2% oxygen was then repeatedly introduced to the fuel to react with uranium hydrides. Once completed, air was reintroduced to the tile hole and fuel can. This equipment was successful in removing all rubber bungs fitted to fuel cans in tile holes.

Check Valve Removal

A tool, shown schematically in Figure 4 was developed to unscrew check valves from the tops of some of the closed spent fuel cans to remove any hazardous constituents from within the fuel cans. This tool also required the introduction of gases and remote operation similar to that used in bung removals. The tool consisted of a four foot long inner shaft with an integral hexagonal socket to mate with a hexagonal external feature on the check valves. The shaft was rotated via a torque driver that had sufficient strength to shear the check valve in case the thread was seized. Although the preferred removal method was to unscrew the check valve, shearing it off was acceptable since a gas passageway into the fuel can would result in both cases. The tool was designed, built and tested on a mock-up prior to successful removal of check valves in the field.

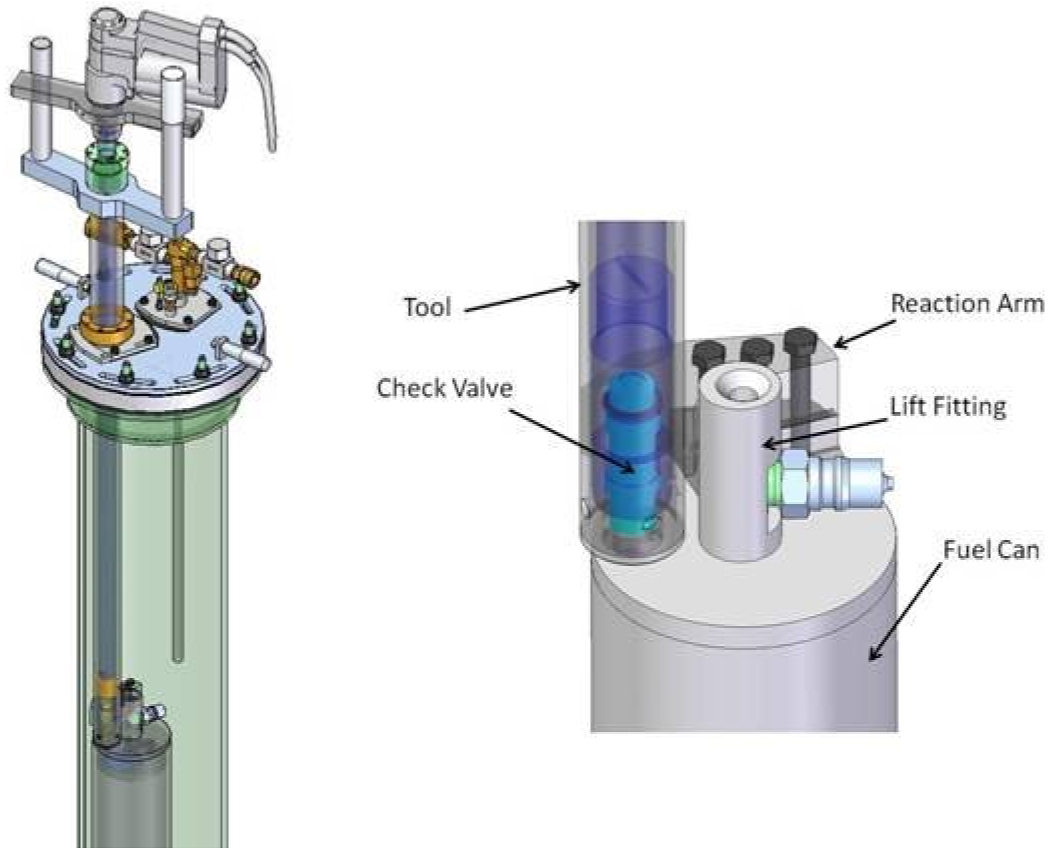


Figure 4 Schematic of Check Valve Removal Equipment

INTEGRITY CHECK OF FUEL CANS

Since the tile holes and the spent fuel cans are fabricated from carbon steel and have been exposed to the environment over 30 years the gaskets have degraded allowing moisture inside the tile holes causing corrosion of the fuel cans. Tools have been developed to determine if the fuel cans are able to be safely lifted before being transferred to an above ground facility. Tools have been specifically developed to test the integrity of the lifting points of the fuel cans, refurbish them if required, and to partially lift each fuel can to measure its weight.

On the tops of the spent fuel cans there is a threaded fitting that was originally used for lifting. A new tool was developed that applies tension to this connection to simulate expected lifting forces. It consists of an outer tube that rests on the top of the fuel can with an inner threaded rod that screw into the lift-fitting. The operation of this tool is performed by tightening a threaded feature at the top of the rod. The outer tube then becomes compressed and the threaded rod is put in tension simulating the lifting force on the lift-fitting. If the threads in the lift-fitting were stripped during testing a back-up tool was developed to drill and tap new threads in the fuel cans.

Once the integrity of the lift-fittings was confirmed, another tool was used to remotely raise the fuel cans within the tile hole and at the same time measure the weight of the can during the lifting process. A cross-section and photograph of this tool applied in the field are shown in Figure 5. Weight measurements provided information as to whether the fuel cans were still intact. If corrosion was sufficient there was the potential that the bottom part of the cans could have come apart and thus the measured weight would be below that expected. Also if the weight measurement was greater than expected it would indicate the fuel can was stuck inside the tile hole.

The tool that was developed consisted of a pipe, housing equipment within it that fitted over and was sealed to the top of the tile hole. Inside the pipe is a hydraulic cylinder that is connected to the fuel can. This hydraulic cylinder was used to lift the fuel can. During operation the tool and the tile hole were purged with inert gas (N_2) to remove oxygen from the tile hole to prevent potential reactions with the contents of the fuel cans. Fuel cans were able to be successfully lifted a few inches and held for a short period of time. By monitoring the hydraulic pressure required to lift the fuel cans it was possible to correlate this with the weight of the fuel can. This tool has been used to test lift a number of fuel cans and provided information that confirmed that all cans were intact and in one case the fuel can could not be lifted as it was stuck inside the hole.

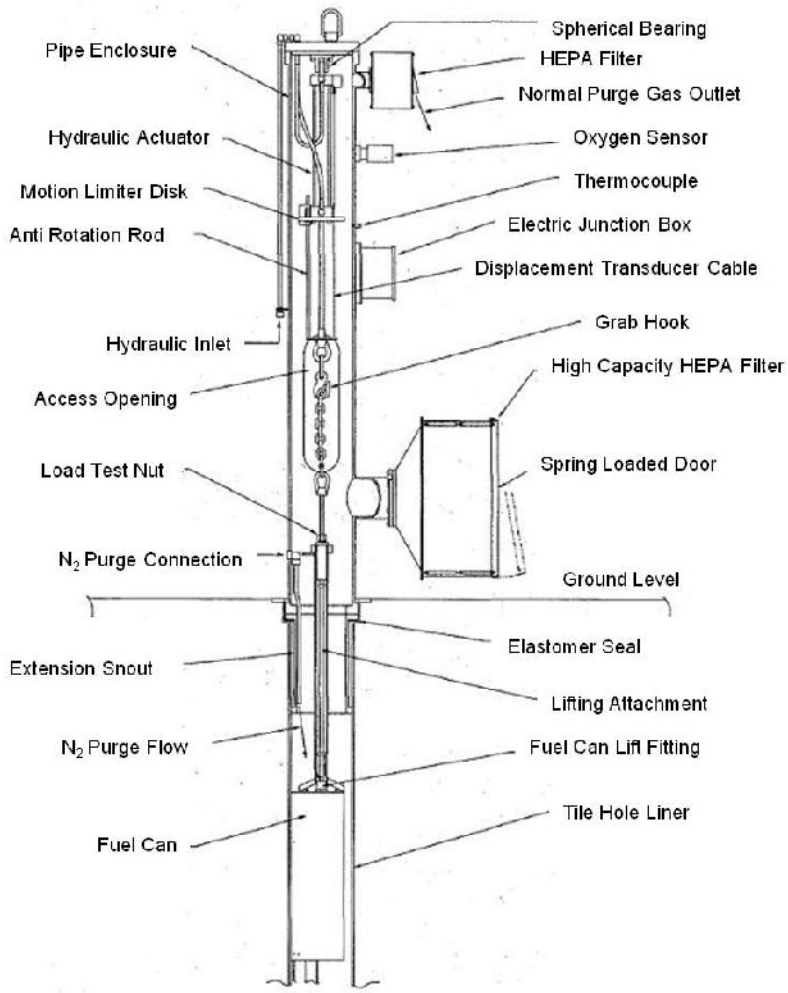


Figure 5 Upper: Section Through Lifting Tool. Lower: Tool Applied in Field

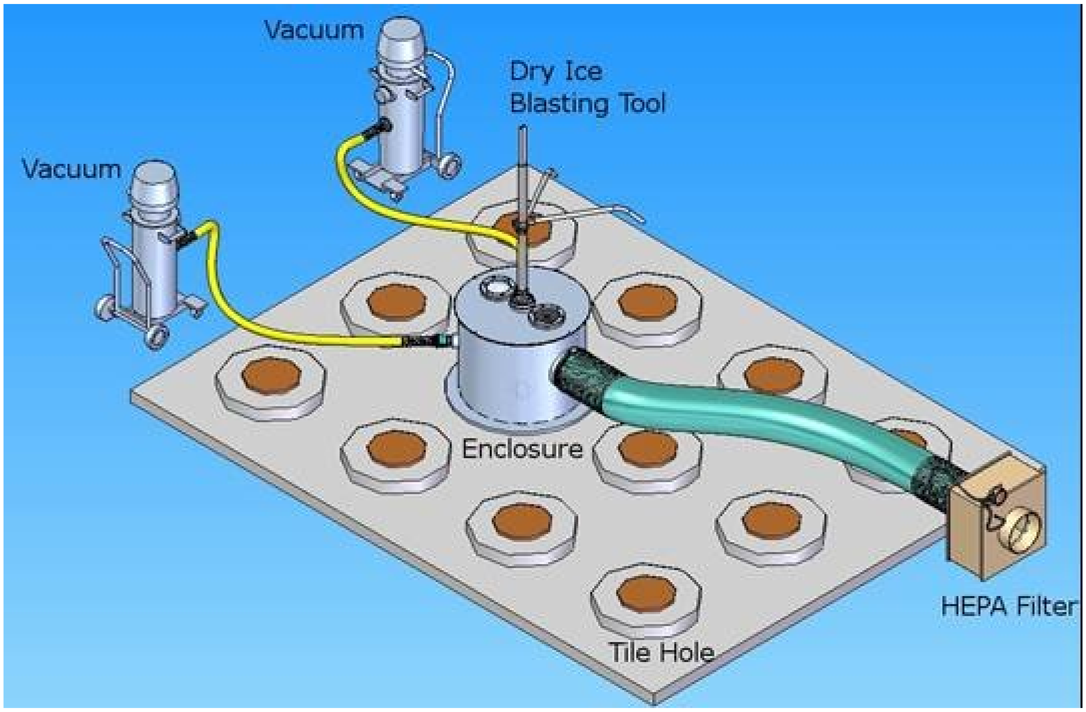
DECONTAMINATION TOOL

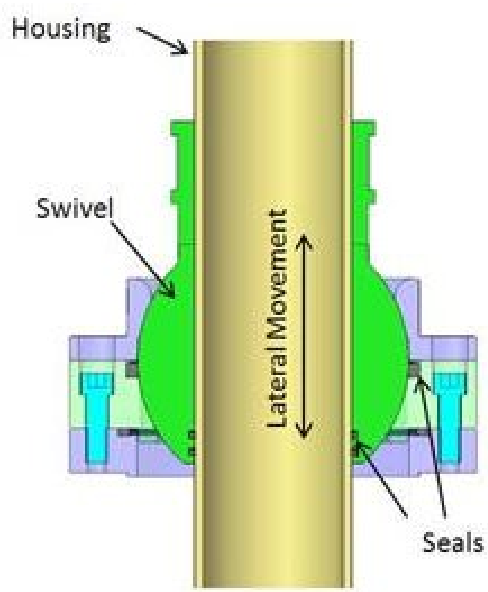
Over the decades the seal on top of the tile holes has degraded and allowed water into some of the tile holes. In some cases this has caused contamination to the top portion of the tile hole and high radiation fields around tile hole arrays. Equipment has been developed to reduce this hazard. A commercial dry ice blaster was purchased and was adapted to work inside and outside of the tile holes.

An enclosure was designed to fit over the tile hole to prevent the spread of contamination during operation. The dry ice blaster enclosure has been designed to fit to the top of the tile hole and consists of a large cylinder that provides containment to the tile hole, attachment of the dry ice blaster equipment and allows movement of the tool. The dry ice blaster system, shown in the upper view of Figure 6 comprises of the enclosure, a ventilation system and supply of dry ice and compressed air. The adaptor is ventilated at a rate higher than the supply rate of the dry ice blaster. This ensures the space connected to the inside of the tile hole is maintained at a lower pressure than atmospheric to prevent leakage of contaminants to the environment.

The additional equipment connecting to the dry ice blaster was sealed through the top of the enclosure. The originally supplied gun-portion of the dry ice blaster was replaced with a long narrow tool through which the cleaning medium was supplied. The long narrow tool was required to be sealed to the adaptor and also allow both vertical and rotational movement. The sealing and movement requirements were met by incorporating a spherical joint shown in the lower left view of Figure 6 that enabled the ice blaster nozzle to direct dry ice to all required areas.

The cross section of the nozzle is shown in the lower right hand view of Figure 6. This tool has been designed and built and will shortly be ready for mock-up trials. After the tile hole has been dry ice blasted any loose debris will be removed through a HEPA filtered vacuum before being disposed of.





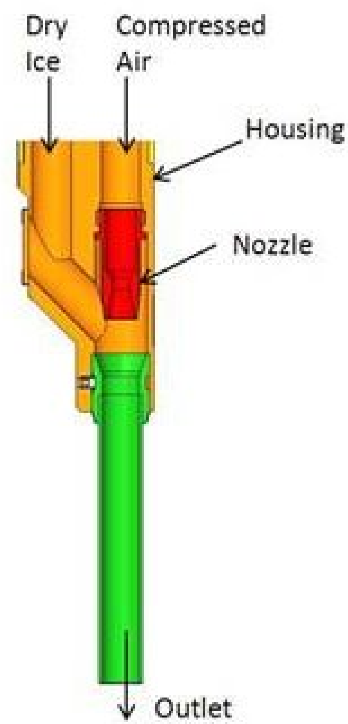


Figure 6 Upper: Dry Ice Blaster System
Left: Spherical Joint for Dry Ice Blaster
Right: Cross Section of Dry Ice Blaster Nozzle

Tab Can Bolt Removal

A number of fuel cans have a pair of rectangular features (tabs) welded to their top. These cans are known as Tab Cans. A nut and bolt arrangement was originally used to provide a location for lifting the cans. Due to the amount of visual corrosion it was decided to remove the original nut and bolt. A tool was designed to cut these bolts so that they can be taken out of the tabs. This tool consisted of a simple hand grinder mounted to a shaft to allow vertical and swinging motion and allow operation from outside of the tile hole through a sealed interface. There were penetrations through the interface that were necessary to a) facilitate mechanical and electrical functions that were needed to be sealed for containment purposes and b) to allow cover gas and HEPA filtration during operation. The equipment has been successfully proven on a mock-up and is planned to be applied to the field in the summer of 2012.

CONCLUSION

Tools that have been presented here have been used, or will be used in the near future, in the waste management areas of the CRL Site in preparation for storage of spent fuel in a new above ground facility.

The stabilization tools have been demonstrated on mock-up facilities prior to successful use in the field to remove hydrogen gas and uranium hydrides from the fuel cans.

A lifting tool has been developed and used successfully in the field to confirm the integrity of the fuel cans for future relocation.

A tool using a commercial dry ice blaster has been developed and is ready to start mock-up trials and is scheduled to be used in the field during the summer of 2012.

ACKNOWLEDGEMENTS

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