Closed Fuel Can Venting and Hydride Passivation - 14305

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ABSTRACT

Atomic Energy of Canada Ltd. (AECL) Chalk River Laboratories (CRL) site has been storing intact and defective fuel rods from the NRX and NRU Reactors since 1963. The fuel rods are stored in open or closed carbon steel fuel storage cans in below-grade vertical cylindrical concrete structures called “tile holes” with carbon steel liners. The closed fuel storage cans incorporate a check valve and a quick-disconnect coupling. Monitoring and inspection of the used fuel stored in the tile holes has shown that some of the fuel storage cans and fuels are corroding.

The tile holes contain a wide variety of fuels, of various shapes and sizes, fabricated from different materials such as uranium metal, uranium oxide and uranium carbide. It is known that small volumes of water remained in the closed fuel storage cans at the time of transfer from the rod bays to the tile holes. Thus, even if the original atmosphere did not contain oxygen, radiolysis of the water could result in the production of oxygen and hydrogen in the fuel storage can. Corrosion of carbon steel, aluminum or uranium metal in the fuel storage can could also result in a hydrogen-rich atmosphere, which promotes uranium hydride formation.

A buildup of hydrogen within the closed fuel storage can could lead to an explosion. Similarly, uranium hydride could react exothermically with air or water, which could lead to fire or explosion. The need to vent and passivate the closed fuel cans was necessary to ensure the continued safe storage of the fuel.

Two diverse sets of remotely operated tools were developed to interface with the tile hole and closed fuel storage can to vent any gasses that have built up, including hydrogen. A commonly employed method was to inert the tile hole and to passivate any hydrides present in the fuel storage can through the controlled introduction of oxygen. The atmosphere inside the fuel storage cans was then returned to normal atmospheric conditions. Finally, the fuel storage cans were permanently vented to prevent re-pressurization of the fuel can.

The venting and passivation process was completed on 21 closed fuel storage cans. All pressurized gasses, including hydrogen and hydrocarbons were successfully vented. In addition, uranium hydrides present in several fuel storage cans were passivated to a safe level and the internal atmosphere of all fuel storage cans were returned to normal levels.

INTRODUCTION

Atomic Energy of Canada Ltd. (AECL) Chalk River Laboratories (CRL) site has been storing intact and defective irradiated fuel rods from the NRX and NRU research reactors since 1963. These fuel rods are in carbon steel storage cans and stored in vertical cylindrical concrete structures called “tile holes” with carbon steel liners. The fuel consists of three main types: uranium oxide, uranium or thorium metal, and uranium-aluminium alloy. Fuel sheath materials are either aluminium or Zircaloy.

Monitoring and inspection of used fuel stored in tile holes has shown that some fuel cans and fuels are corroding. Continued corrosion of this fuel will increase the future costs and hazards of handling the fuel and decommissioning the CRL waste storage structures. It has therefore become necessary to remove, dry and repackage this fuel. To this end, a new Fuel Packaging and Storage (FPS) facility [1] has been designed and constructed at the Chalk River site. Once the fuel has been dried and repackaged in the FPS facility, fuel corrosion and deterioration will be reduced such that potential future increases in hazards and costs associated with handling the fuel are minimized.

To facilitate safe transfer of the fuel storage cans to the FPS facility, a number of preparatory activities must be completed, including the venting and removal of combustible gases within the fuel storage cans.

DESCRIPTION OF CURRENT STORAGE

Tile Hole

The tile holes associated with the can puncturing project (constructed between 1960 and early 1980) are made from sections of 61 cm (24 in) ID concrete drainpipes set vertically at 1.23 m (4 ft) centers on a poured concrete base located at the bottom of a trench approximately 4.6 m (15 ft) deep. A 25.4 cm (10 in) diameter mild steel pipe with a welded base plate was set central within the concrete pipe and the annulus between the two backfilled with concrete.

The tile hole arrays are backfilled with sand and concrete pads are laid to carry the weight of the equipment used for loading. Fig. 1 shows a schematic of a typical tile hole and Fig. 2 shows the construction of a tile array.

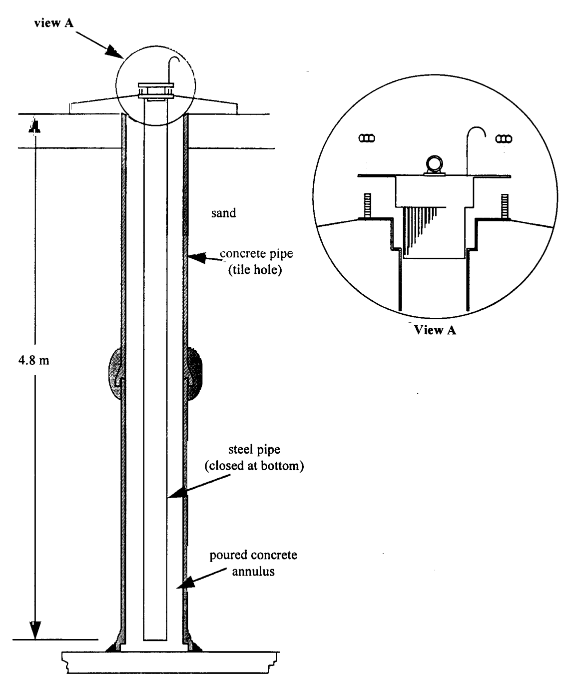


Fig. 1: Typical tile hole design from 1960's to early 1980's

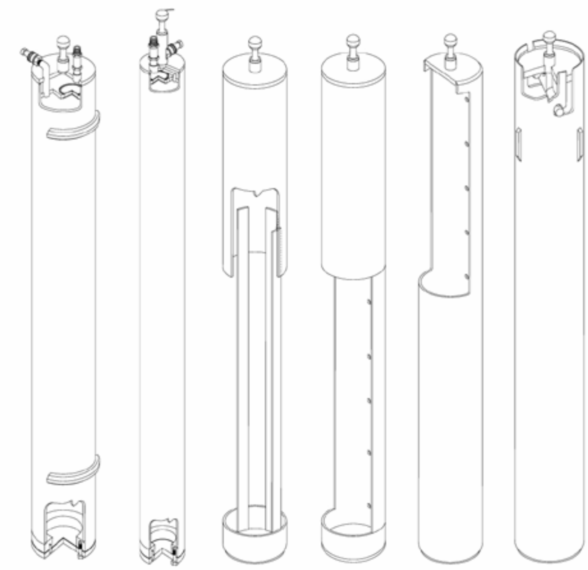
Fig. 2: Tile Array under Construction

Fuel Storage Cans

Fuel storage cans were used to store long, irradiated research reactor prototype fuels rods that powered the NRX and NRU reactors, and experimental fuel and breeder rods. The fuel rods were loaded into storage cans in the rod storage bays.

Fuel has been stored in either "open" or "closed" fuel cans. The majority of fuel is stored in various open cans (See Fig. 3 below), referred to as strap cans, canoe cans or NRU cans. The open cans pose no explosion risk as they are open to the tile hole atmosphere. Closed fuel cans were used for known defective fuel rods. The closed fuel cans could pose an explosion risk due to the potential for buildup of hydrogen and/or uranium hydride within the closed can. As a result, the focus of this work was only on the closed fuel cans.

Historic Storage Containers (HSCs)



	Closed Can	Closed Can	Strap Can	Canoe Can	NRU Can	Recan
Material (Carbon Steel)	8" Sch 40	5" Sch 40	8" Sch 40	8" Sch 40	8" Sch 40	9" Tube
ID, mm	202.7	128.2	202.7	202.7	202.7	228.6
OD, mm	219.1	141.3	219.1	219.1	219.1	241.3
Length, mm	3,759.2	3,711.6	3,860.8	3,860.8	3,800.5	4,133.9
Tare Weight, kg	180	90	60	90	124	160
Max. Gross Weight,kg	924	152	804	834	869	994
ID, in	7.981	5.047	7.981	7.981	7.981	9
OD, in	8.625	5.563	8.625	8.625	8.625	9.5
Length, in	146.125	146.125	152	152	149.625	162.75
Tare Weight, lb	396	198	132	198	273	352
Max. Gross Weight,lb	2,033	335	1,769	1,835	1,912	2,187

Fig. 3: Description of Various Fuel Storage Cans

There are two types of closed fuel storage cans; “small” and “large”. Small cans are fabricated from 5 in carbon steel pipe, while large closed cans are fabricated from 20.3 cm (8 in) carbon steel pipe. Both fuel cans are ~ 3.8 m (147 in) long.

The bottom of the can is closed by a 1.3 cm (0.5 in) thick steel plate attached by bolts, and sealed by a neoprene gasket. The top of the can is closed by a 1.3 cm (0.5 in) thick steel plate welded to the pipe. This top plate incorporates a central lifting adapter. Approximately 3.8 cm (1.5 in) below the top plate, a second 1.3 cm (0.5 in) thick steel divider plate is welded into the pipe. A check valve mounted in a 1.3 cm (0.5 in) NPT half-coupling welded to the top plate vents the cavity between the two upper plates. An L-shaped, 1.3 cm (0.5 in) pipe nipple penetrates both plates and is capped outside the can with a female Hansen connector.

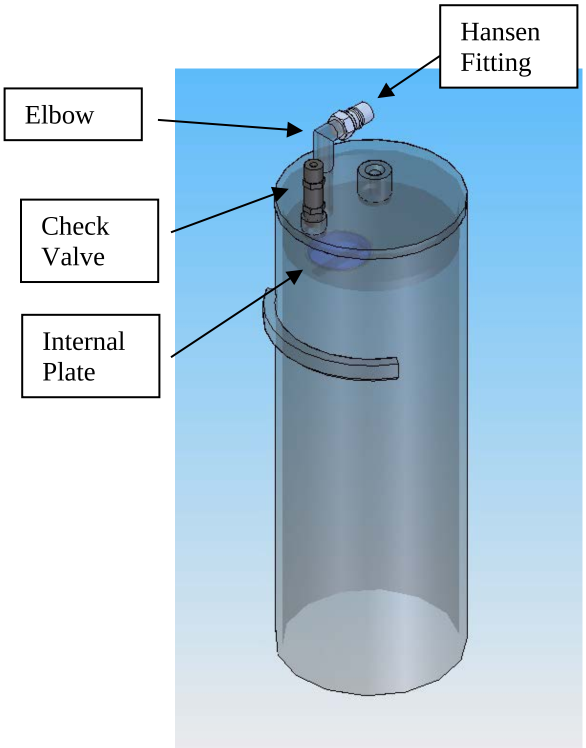


Fig. 4: Top Portion of Large Closed Can showing Elbow, Hansen Fitting, Check Valve, and Second Plate

The design intent of the closed fuel can check valve was to allow the purging of rod bay water from the fuel can following the initial underwater loading of the fuel rods in the rod bay. Loading was done from the bottom open end. The can was placed in the loading bay, the bolted end plate removed, the can tilted slightly, and the fuel rods pushed inside. Once the storage can had been loaded, the end plate was bolted back on and an air hose fitted to the Hansen connector. Air was then pumped into the can until the water was forced out through the check valve and bubbles were observed. There was no further drying of the fuel, and some residual water was expected to be retained in the can.

In storage, the check valve provided a low pressure < 103.5 kPa (15 psig) relief for the can. The check valve and the Hansen connector may not be functional. If they failed, it is not known whether they ceased to function in an open (vented) or closed (sealed) state. If the valve failed in a closed state, the cans could be under significant positive internal pressure.

HAZARD IDENTIFICATION

Hydrogen and Hydride Formation

In addition to the fuel, water may be present in the fuel cans, either from when the fuel was initially loaded into the storage cans or due to migration from the environment. If water is present, there is the potential for either a hydrogen rich atmosphere or combustible hydrogen-oxygen atmosphere. These gases could potentially be at high pressure if the check valve has failed closed. In some tile holes that experienced flooding, bubbles were observed coming from the check valves; analysis of gases in several tile holes indicated the presence of hydrogen.

Depending on whether a wet or a hydrogen-rich atmosphere is present in the can, either oxidation or hydriding of uranium (and corrosion of steel) could result. The extent of oxidation or hydriding that has occurred in these cans over the years is not known.

Corrosion has the potential to produce hydrogen and hydrides which may pose fire and explosion hazards. The safety concern with hydrides is their pyrophoricity [2]. Hydrides that are exposed to air or water may combust since these reactions are highly exothermic. When reacted with water in a low oxygen environment, the hydride reaction releases hydrogen that may build to flammable levels in a closed volume.

Uranium hydride can potentially form during anoxic corrosion of uranium metal, uranium alloy and thorium fuels within the closed tile hole cans. Only when oxygen levels drop below 100 parts per million (100 mg/kg) is the reaction sequence altered to produce hydrogen and uranium hydride in addition to the oxide [2]. This change in the reaction mechanisms for uranium is of particular interest for the failed or defective metal fuels stored in the closed tile hole cans that may be devoid of oxygen. In this case, with the system depleted of oxygen, water can freely adsorb on the oxide surface and hydrogen ions formed can proceed to form hydrogen and hydride.

The aluminum sheathing and flow tubes, the carbon steel storage can and exposed uranium will corrode under suitable conditions. These oxidation reactions liberate hydrogen that will increase the pressure in the cans. The installed check valve could release some of this pressure, thus mitigating the buildup of hydrogen and reducing the hazard. However, reliable function of the check valve cannot be assumed. In addition, some of the water will undergo radiolysis; the oxygen will quickly react with any of the metallic surfaces to maintain a reducing environment. This anaerobic corrosion environment in the closed tile hole cans is conducive to the formation of oxides and hydrides.

VENTING EQUIPMENT DESCRIPTION

The main priority was to ensure that the above hazards are eliminated, and that the closed cans do not contain any residual significant pressure. Two sets of tools were developed to vent the closed fuel storage cans: the first generated a small hole in the closed fuel can, while the second removed a check valve. Both tools operated in an inert atmosphere, and have provisions for introducing inert gas into the closed fuel can. Once vented, passivation of the contents of the closed fuel cans was achieved via the controlled introduction of oxygen using a pressurize and purge sequence.

The general sequence of operations is as follows:

- Installation of the tile hole adapter plate and cover plate;
- Purging the atmosphere within the Tile Hole using argon gas;
- Installation and operation of the Can Puncturing Tool / Check Valve Removal Tool;
- Puncture can / remove the check valve;
- Passivation of the can contents by pressurizing and purging the closed fuel can with a 2% oxygen in argon mixture, followed by the introduction of dry compressed air to the closed can to achieve an oxygen level of >19%;
- Enlargement of the punctured hole; and

- Removal of the equipment.

Description of Can Puncturing and Drilling system

A contract was awarded to Marathon Engineering of Brockville in Canada to design a tool that would be able to puncture the steel without producing heat or a spark of any kind; allow for the diversion of pressurized gasses to an analysis system and to flush the residual gasses after penetration. In addition, an interface system to the tile hole was requested and finally a mechanical drilling head which would allow a larger 9.5 mm (3/8 in) hole to be drilled to ensure the can was permanently vented. Marathon supplied most of the equipment and AECL Mechanical Equipment Design completed any outstanding items. The following equipment was used for the can puncturing and drilling system:

- An adapter plate and cover plate to mate to the current tile hole flange.
- A Mobile Integrated Cutting and Radiological Detection System (MICRADS), grit delivery and gas flow system.
- A mechanical drill.
- A computer-controlled, remote operating system.
- A HD remote camera system
- A work shelter to protect the equipment.

Adapter Plate and Cover Plate

The cover plate is the interface between the tile hole and the MICRADS system. The cover plate has gas inlet attachments, sample port, and exhaust port connected to a High Efficiency Particulate Air (HEPA) filter. An argon cylinder was connected to the adapter plate to inert the tile hole. A lower explosive limit (LEL) meter capable of detecting the presence of hydrogen gas up to the lower explosive limit was connected to the sample port. The lower explosive limit for hydrogen in air is 4%. The instrument reads as a percentage of this lower explosive limit; a reading of 100% on the LEL meter indicates 4% hydrogen in air.

The adapter plate has been specifically designed to be secured to the tile hole regardless of the condition of the tile hole, geometry, and number of studs. The adapter plate is capable of withstanding pressures in excess of 1.24 Mpa (180 psi).

MICRADS System

The MICRADS system incorporates an abrasive jet machining system that is specifically designed to generate a small hole in the steel elbow. The system uses a high velocity inert gas (helium) jet laden with silicon carbide (Grade F 50 micron); the technology is known as Abrasive Cutting Technology. The technology does not cause vibration, create sparks or high temperatures, minimizing or eliminating the ignition source. Extensive testing was performed on the system at varying Hydrogen concentrations to ensure that the technology was safe.

Two concentric tubes pass through the cover plate and extend down to the top of the closed can. The outer tube seals on the Hansen Fitting Elbow and the inner tube or probe, delivers the abrasive particles in a high velocity inert gas stream. Erosion of the steel results in a small hole being generated. Spent gas and abrasive particles return via the annulus between the inner and outer tubes, and exhaust through a nuclear grade HEPA filter. The exhaust is monitored for hydrogen (as a percentage of the LEL), oxygen, pressure, and radioactivity.

For large fuel cans, the high velocity jet was directed onto the Hansen Fitting Elbow. The size of the pierced hole is approximately 0.635 mm (0.025”) in diameter.

Fig. 5: Pierced hole in mockup fitting

Once the initial can puncture has been completed, the passivation system was connected and delivered argon with 2% oxygen mixture to passivate the contents of the fuel can.

Mechanical Drill

Once the storage can was pierced with the MICRADS tool and passivation of any hydride in the can has been performed and hydrogen purged, the grit piercing tool was replaced with a mechanical drill.

The mechanical drill assembly was used to drill a 9.5 mm (3/8 in) hole in the location of the grit piercing, enlarging the hole. This hole ensures venting of the interior of the can with continued exposure to air and provides access for video camera inspection.

The mechanical drill tool is a custom-designed, remotely operated drilling machine. Drilling is done without a cutting fluid, to prevent reaction with uranium hydride. Argon gas continually floods the tile hole above the can to displace air.

Computer-Controlled Operating System

A laptop computer was used by personnel to start, stop, and monitor the operation. Real-time data from the grit piercing operation was passed to the computer and automatically used to terminate the operation when penetration is achieved. The parameter used to determine penetration was the characteristics of the pressure of the gas returning from the grit piercing operation. Changes in pressure were monitored and used to determine if penetration was achieved. Before gas was released to the atmosphere it passed through a HEPA filter.

The computer was located a minimum distance of 30 m (100 feet) from the tile hole, with remote communication established through a radio modem link.

Description of Check Valve Removal System

Similar to can puncturing, the objective of the Check Valve Removal (CVR) tool was to safely vent the closed fuel cans. The CVR tool was designed in Chalk River by the Mechanical Equipment Development Branch to remove the check valve from both the small and large fuel cans. This design flexibility was chosen as the can puncturing tool was not designed for the small cans, and interface issues were identified on at least one large fuel can during field inspections.

The CVR tool physically removes the check valve which is threaded into the fuel can. Once the check valve is removed, a purging tool is inserted into the tile hole. This created a seal over the lip of the welded boss where the check valve was installed in order to pressurize the fuel can during passivation.

The following equipment is collectively referred to as the Check Valve Removal Tool:

- An adapter plate and cover plate that mates to the current tile hole flange.
- The reaction pipe.
- The torque tool assembly.
- The purge tool assembly.
- A HD remote camera system
- A work shelter to protect the equipment.

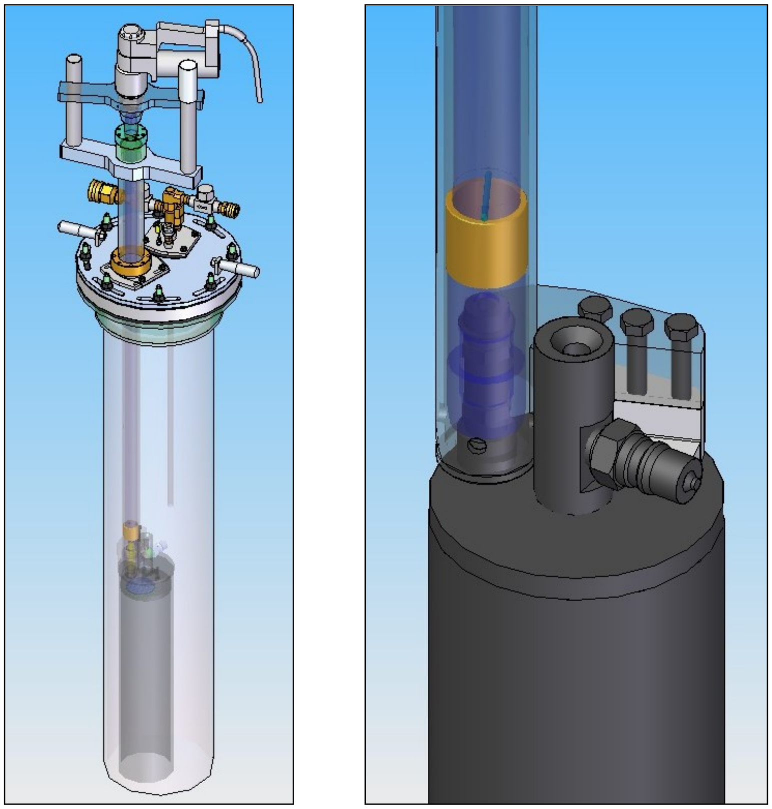


Fig. 5: Check Valve Removal Tool

Adapter Plate and Cover Plate

The cover plate and adapter plate are similar in design and function as that for the can puncturing tool.

Reaction Pipe

The reaction pipe provided a means to insert the check valve removal tool through the cover plate, and also provided a reaction point with the fuel can which enabled the removal of the check valve. The reaction pipe consisted of a length of pipe that passed through the cover plate and located over the check valve and half-coupling on the closed fuel can. A reaction plate was welded to the lower end of the reaction pipe. This plate contacted the threaded lifting adapter boss on the top of the closed fuel can, which provided the reaction point with the torque tool during check valve removal. The reaction pipe remained in position for both the check valve removal using the torque tool assembly and the passivation phase using the purge tool assembly.

The lower portion of the reaction pipe had four equally spaced holes to allow venting of gasses to the tile hole during check valve removal. The cross-sectional area of the four holes was equal to the cross-sectional area of the 1.3 cm (0.5 in) NPT half-coupling, which prevented any pressure build-up in the reaction pipe during check valve removal.

The upper portion of the reaction pipe body was machined to a tight tolerance to allow sealing of the reaction pipe to the cover plate using a gland nut and o-ring arrangement. A hexagon head nut was machined into the top portion of the reaction pipe, which allowed the installation of a double-handled wrench. This wrench contacted the reaction arms of the torque tool during check valve removal.

Torque Tool Assembly

The torque tool assembly consists of the torque shaft, reaction arms, and electric torque tool. The torque shaft consists of a commercial socket welded to an extension shaft. The end of the shaft has a hex that interfaces with the electric torque tool. The torque shaft was inserted into the reaction pipe, and was seated over the check valve. The hex socket of the torque shaft engaged the lower hexagon head nut on the check valve. Following the installation of the torque shaft, the gland nut and o-ring were installed onto the reaction pipe and tightened, to seal the torque shaft to the reaction pipe and tile hole. This resulted in a completely sealed assembly.

Next, the torque tool with reaction arms was installed onto the hex head on the torque shaft. The torque shaft and reaction pipe together support the torque tool. The torque tool was hard-wire connected to a remote control box. The control box consists of an on/off switch and an ammeter. The ammeter reading provided indication of the maximum force applied by the torque tool, and when the check valve had been loosened off. The control box is connected to 110V Class 4 power.

Purge Tool Assembly

The purge tool assembly created the interface between the gas delivery system and the fuel storage can, which enabled the pressurization and purge operations. It consisted of the purge tool, o-ring, and gas passivation system. The purge tool was essentially a hollow cylinder with a Hansen quick-disconnect coupling on one end. Following removal of the torque tool assembly, an o-ring was inserted onto the half-coupling, followed by the purge tool. A gland nut and o-ring was installed over the purge tool, and tightened onto the reaction pipe. This forced the purge tool down inside the reaction pipe and compressed the o-ring between the half-coupling and the purge tool as the end of the purge tool and the reaction pipe were forced together. This created a seal between the bottom of the purge tool and the closed can, and a seal between the top of the purge tool and the reaction pipe.

There is one inlet with a Hansen quick-disconnect coupler located at the top of the purge tool. The gas delivery system was connected at this point. Gas was delivered through the purge tool to pressurize the closed fuel can to ~ 43.5 kPa (5 psi), and was vented through the purge tool to the atmosphere via a HEPA filtered exhaust line.

OPERATIONAL PROTOCOL

Preparations

Extensive testing was initially performed off-site after receipt of the tooling on steel containers in which various explosive concentrations of hydrogen gas was placed and then sealed. The tool performed very well and was available for mockup work in 2007. During this time from 2007 to 2010, refinements were made, procedures written and approvals obtained to begin the work. As a uranium fire was also a possibility due to the explosive nature of uranium hydrides, enough Metal-X powder was purchased to completely fill a tile hole. Training was provided to the on-site Fire Department to ensure all shifts were aware of the work and the unique hazards involved.

Mockup work on the Check Valve Removal tool was also performed, however, this tool was simpler in design and operation, the scope was less and less modifications were needed. In addition, field personnel completed all can puncturing work before check valve removal work began.

Many similar activities were performed operationally in order to ensure the work was performed safely. A communication protocol was followed ensuring that all interested and/or affected groups were notified as to when the work was to be performed. Work was performed outside, so a shelter was needed. A worse-case safety analysis for an explosion scenario was completed and an exclusion zone of 30 m from the tile hole for personal was recommended.

Setup

Field personnel dressed in Personnel Protective Clothing and Equipment (PPE&C). Using a mobile crane, the shield plug on the designated tile hole was removed. Personnel performed monitoring for airborne radioactive contamination, explosive concentrations of gasses as well as oxygen and carbon monoxide levels. Once it was deemed safe to approach the tile hole, surface contamination levels and radiation dose rates were measured. The shield plug was placed safely away from the work area and the adapter plate was then put in place. A cover was placed over the tile hole and the temporary shelter was then erected.

The tile hole and storage can was inspected. Water levels inside the tile hole were measured and a pump-out line was inserted if water above 61 cm (24”) was measured. The top of the storage can was cleaned where the tooling would attach. The cover plate was installed, and the can puncturing or check valve removal tooling was put in place. A laser pointer was used as a guide for the can puncturing equipment, but a regular flashlight was good enough for the positioning of the CVR tool. Gas connections and exhaust filtration equipment were connected and a monitor for explosive gasses, oxygen and CO levels was attached so that those parameters could be measured. The oxygen level in the tile hole was reduced to < 1% using argon gas. Argon gas in heavier than air and is an asphyxiant. Ambient work area atmosphere was constantly monitored and the exhaust location was cordoned off preventing entry. If there was water in the tile hole, it was then removed. The HD remote camera was installed focusing on the tooling. Personnel then left the immediate area and key groups contacted.

Operation

Can Puncturing

The drilling equipment was activated using the computer-controlled system. The tile hole remained at < 1% oxygen and a helium-driven silicon carbide grit was delivered to the elbow. Drilling typically took from about 2 to 14 minutes to complete. Pressures and gas concentrations were monitored throughout the process and once drilling into the can was completed, the can contents were allowed to enter into the gas stream. HEPA filtration trapped radioactive particulates while other non-radioactive gasses passed through the system with the argon and helium gas stream. Once excess pressures and elevated combustible gasses subsided, the piercing bit was changed out and the hydride passivation gas connection was installed. After passivation was complete and the hazards minimized, the passivation gas connection was removed and the 9.5 mm (3/8”) mechanical drill was installed. Oxygen levels remained at < 1% while the 9.5 mm (3/8”) hole was drilled in the elbow.

Fig. 6: Before and After Photos of Can Puncturing

Check Valve Removal

Once the CVR Reaction Pipe and Torque Tool Assembly were connected, personnel left the immediate area. The concentration of oxygen in the tile hole remained at < 1% and the torque tool was remotely actuated. This process only took a few seconds and the check valve was removed allowing the can contents to enter the argon stream. HEPA filtration was also in place while other non-radioactive gasses exited the tile hole. The exhaust stream exited to an exclusion area with warning signs due to the high levels of argon and possibly hydrogen. Once excess pressure and elevated combustible gasses subsided, the torque tool assembly was removed and the purge tool assembly connected.

Figure 7: Before and After Photos of Check Valve Removal

Hydride Passivation

Hydrides violently react with both air and/or water and can be safely passivated only when they are allowed to slowly react with air. For this reason, a specialized Argon-2% oxygen gas was used utilizing a pressurized/purge system. The storage can was pressurized to 34.5 kPa (5 psi) and left for the night. In the morning, any residual gasses in the storage can was released and the fuel storage can was re-pressurized to 34.5 kPa (5 psi). The process was repeated at the end of the day.

RESULTS

Over the course of 6 months, 21 closed fuel cans were vented and passivated-15 using the Can Puncturing tooling and 8 using the Check Valve Removal tool. In most cases, hydrogen gas was detected upon venting of the closed cans. The design and operation of the tooling proved successful in managing the combustible atmospheres found within the closed cans. No incidents or upset conditions occurred during the operation.

Table 1 presents a summary of the observations from can puncturing and check valve removal. In most instances, the measurement of LEL in the fuel storage can was >100%, which indicates that the concentration of hydrogen within the fuel storage can was above the lower explosive limit for hydrogen in air (>4% hydrogen in air).

TABLE 1: SUMMARY OF OBSERVATIONS DURING PASSIVATION

Tile Hole	LEL (%)		Oxygen (%)		Days to Complete
	Initial	Final	Initial	Final	
1	>100	0.0	0.8	3.1	6
2	>100	0.0	1.8	1.3	11
3	>100	0.0	0.8	1.5	3
4	>100	0.0	1.5	1.6	5
5	0.0	0.0	8.7	4.1	3
6	>100	0.0	1.8	1.5	6
7	>100	0.0	1.5	2.5	10
8	>100	0.0	1.9	2.8	7
9	14	0.0	1.6	2.0	2
10	>100	0.0	0.5	0.8	17
11	>100	0.0	8.2	2.5	2
12	>100	0.0	0.3	1.2	29
13	0.0	0.0	2.3	13	4
14	42	0.0	2.1	2.3	4
15	>100	0.0	0.3	1.0	17
16	>100	0.0	13.7	2.6	26
17	>100	0.0	3.6	2.5	4
18	0.0	0.0	3.4	4.0	3
19	>100	0.0	1.2	1.0	11
20	0.0	0.0	1.8	3.5	3
21	0.0	0.0	12.4	8.5	3

CONCLUSION

Intact and defective fuel rods from the NRX and NRU Reactors are stored at Chalk River Laboratories since 1963 in open or closed carbon steel fuel storage cans in below-grade vertical cylindrical concrete structures called “tile holes” with carbon steel liners. These old fuels are to be relocated to a new location, the Fuel Packaging and Storage Facility. The closed fuel storage cans are suspected to contain hydrogen and uranium hydrides which must be removed prior to safely moving the fuels.

Two different types of tooling were developed to remove any hydrogen and to passivate any hydrides. Due to the hazardous nature of the work proposed, extensive testing and approvals were needed to address this Health, Safety and Environmental concern. Hazards included elevated radiation fields, surface and airborne contamination, oxygen deficient atmospheres and elevated hydrogen levels with potential for fire and/or explosion.

Careful job planning and execution was necessary in this complex field work. No personal contamination events occurred and radiation exposures were well within expected parameters. There were no radioactive releases to the environment and no exothermic events. Subsequent monitoring of the tile holes have been performed and no elevated explosive gasses are detected.

As a result of the success of this project, the stored fuels are one step closer to becoming ready for transfer to the new storage facility.

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