LESSONS LEARNED: THE EFFECT OF INCREASED PRODUCTION RATE ON OPERATION AND MAINTENANCE OF OPG'S WESTERN USED FUEL DRY STORAGE FACILITY

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ABSTRACT

In 2010, the Western Used Fuel Dry Storage Facility (WUFDSF) located at Ontario Power Generation's (OPG's) Western Waste Management Facility in Tiverton, ON, transferred, processed and stored a record-high number of Dry Storage Containers (DSC's) from Bruce Power's nuclear generating stations.

The WUFDSF has been in operation since 2002. The facility transfers, processes, and stores the used fuel from the Bruce Power generating stations located in Tiverton, Ontario. As per a contractual agreement between OPG and Bruce Power, an annual DSC production and transfer schedule is agreed to between the two parties.

In 2010, an increased annual production rate of 130 DSC's was agreed to between OPG and Bruce Power.

Throughout 2007, 2008 and 2009, several facility modifications had been completed in anticipation of the increased production rate. These modifications included:

- Installation and commissioning of a second set of welding consoles
- Addition of a second vacuum drying system
- Procurement of a second transfer vehicle
- Installation of a bulk gas system for welding cover gas

In 2010, the increased production rate of 130 DSC's/year came into effect. Throughout 2010, significant lessons learned were gained related to the impact of such a high production rate on the operation and maintenance of the facility.

This paper presents the challenges and successes of that operation.

The facility successfully achieved its production target with no safety incidents. This high rate of production is planned to continue for several years at the facility. Some challenges continue and these are being assessed and incorporated into the facility's business plan. In order to continue being successful, the facility must look to the future for opportunities for improvement and efficiencies to be gained.

1. INTRODUCTION

1.1 Description of the Process

In 2010, the Western Used Fuel Dry Storage Facility (WUFDSF) located at Ontario Power Generation’s (OPG’s) Western Waste Management Facility in Tiverton, ON, transferred, processed and stored a record-high number of Dry Storage Containers (DSC’s) from Bruce Power’s generating stations.

The purpose of this paper is to provide lessons learned related to the impact of such a high production rate on the operation and maintenance of the facility.

The WUFDSF has been in operation since 2002. The facility transfers, processes and stores the used fuel from the Bruce Power generating stations (Figure 1). New empty DSCs are received from the manufacturer and unloaded at the facility. There, the empty DSCs are prepared and transferred to the station for subsequent loading. Bruce Power completes the loading of fuel, from its wet bays, into the DSC. The DSC is loaded while submerged in water in the loading bay. The DSC is lifted out of the bay, drained of water, and then the DSC exterior is decontaminated. A transfer clamp is placed on the DSC in preparation for the on-site transfer to the WUFDSF.

Using one of two transfer vehicles, OPG then picks up the loaded DSC and transfers it across the site to the WUFDSF. At the WUFDSF, the DSC lid is seal welded. The integrity of each weld is inspected using Phased Array Ultrasonics Technology (PAUT). Final vacuum drying and helium backfilling of the DSC cavity is performed, followed by installation of the drain port plug. The drain port plug is then also welded and inspected. The DSC is then placed in a vacuum chamber and helium leak tested. On successful completion of this leak test, the DSC then undergoes minor paint touchups and an International Atomic Energy Agency seal is then applied. The DSC is then transferred to the on-site Storage Buildings.

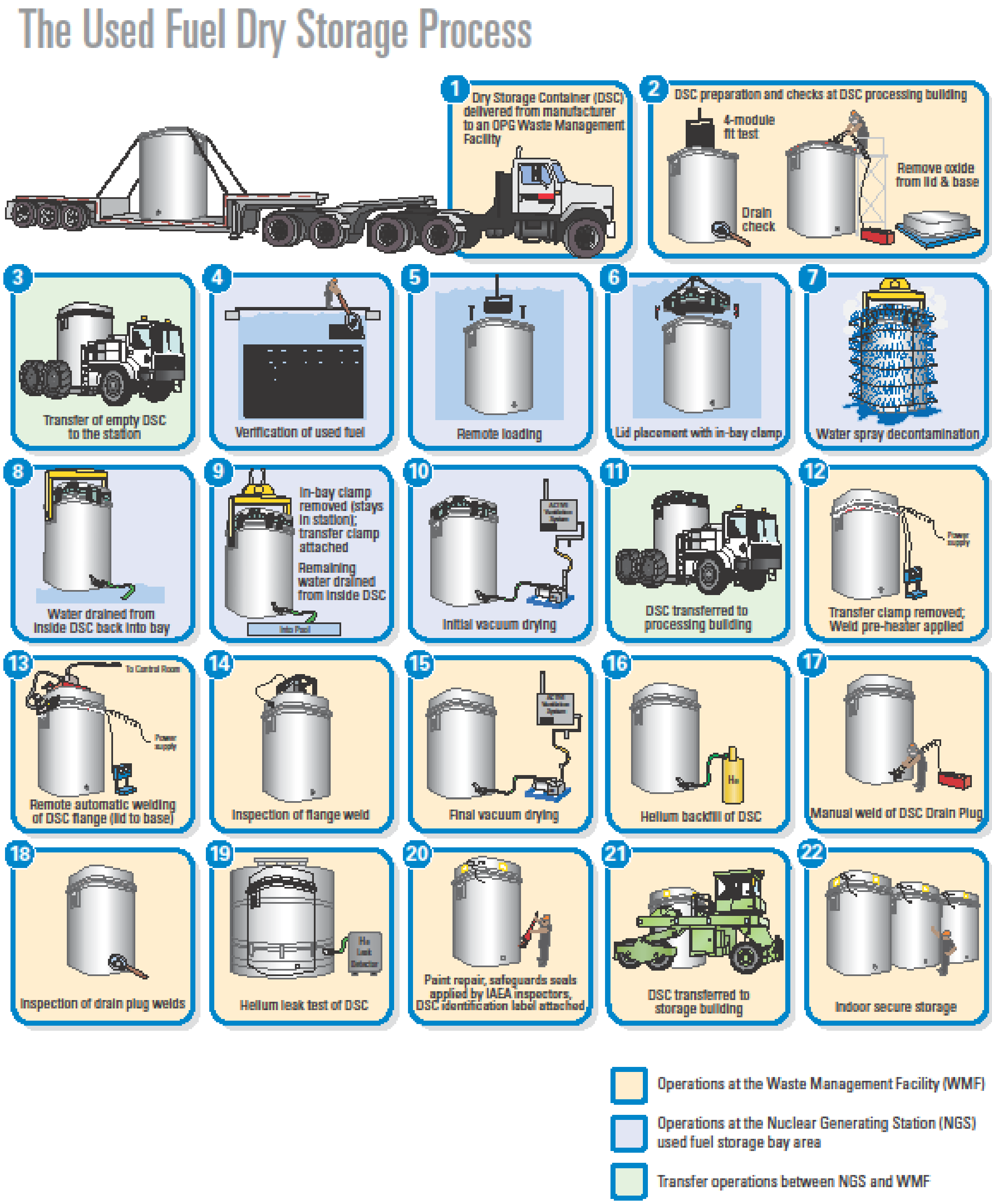

Figure 1. Used Fuel Dry Storage Process [1].

1.2 Contractual Obligation

As per a contractual agreement between OPG and Bruce Power, an annual DSC production and transfer schedule is agreed to between the two parties.

The production rate was approximately 65 DSC's per year from 2004 to 2006. Production rates then increased slightly from 2007 to 2009 as Bruce A fuel was transferred as well. However, an increased production schedule was required in order to accommodate fuel from both Bruce A, Bruce B generating stations, and to maintain adequate fuel bay space in the Bruce Power wet bays. An increased annual production rate of 130 DSC's was agreed to between OPG and Bruce Power.

In 2010, the increased production rate of 130 DSC's/year came into effect. Throughout 2010, significant lessons learned were gained related to the impact of such a high production rate on the operation and maintenance of the WUFDSF.

In total, 130 DSC's were transferred and processed at the facility over the course of the year. This equated to a delivery schedule of approximately three or four DSCs being transferred every week for ten months of the year. No other used fuel facility in Canada had ever faced such a challenge. This high production rate posed some significant challenges for staff performing operation and maintenance activities. There are valuable lessons learned that can be exchanged with other utilities.

2. THE EFFECT OF THE INCREASED PRODUCTION RATE

2.1 Modifications made in preparation of 130DSC's/Year

Throughout 2007, 2008 and 2009, several facility modifications had been completed in anticipation of the increased production rate. These modifications included:

- Installation and commissioning of a second set of welding consoles
- Implementation and usage of a second weld assembly
- Addition of a second vacuum drying system
- Procurement of a second transfer vehicle
- Installation of a bulk gas system for welding cover gas

Each modification was completed in order to prevent certain areas of the process from becoming the bottlenecks. Since the used fuel process is mostly a sequential series of steps, delays in one step could cascade throughout the process and lead to delays throughout. The addition of redundancy in several key steps of the process was critical in these preparatory years. Redundancy was required in order to increase reliability of the process and enable the execution of preventative maintenance on key components.

2.1.1 <u>Installation and commissioning of a second set of welding consoles</u>

In 2008, a second set of welding consoles was procured, installed and commissioned (Figure 2). The used fuel dry storage process utilizes a Gas Metal Arc Welding semi-automatic welding system. The closure weld, which seals the DSC lid to the base, is a full penetration, multi-pass groove weld. The welding system is fitted with two metal inert gas shielded weld heads. Each weld head has its own remote camera system and separate monitoring and control console. The weld head assembly is hoisted by the overhead crane and rests on the DSC lid during the weld cycle.

The system is remotely operated from the control room. [1]

There are three welding bays at WUFDSF. Prior to 2008, with only one welding console and weld head in service, it was only possible to weld one DSC at a time. The installation and commissioning of a second set of welding consoles enabled two DSC's to be welded simultaneously. In practice, it was not always practical to do so due to the time delays in receiving and preparing loaded DSC's for welding. However, the increased production rate often led to one DSC being prepared for welding (through the application of pre-heaters) in one weld bay, while another DSC was being welded in the other weld bay.

The addition of the welding consoles provided increased flexibility in the process and ensured that the welding stations did not become the bottleneck in the process.

Figure 2. Welding Control Room, showing two pairs of welding consoles.

2.1.2 Addition of a second vacuum drying system

The DSC vacuum drying system evacuates and dries the DSC internal cavity through the drain connection, after lid-to-base seal welding and weld inspection. The DSC cavity is then backfilled with helium gas. The helium gas facilitates leak detection for the seal-welded DSC and creates an inert atmosphere for the stored used fuel.

It is essentially the same equipment or tool, which performs all of these, functions i.e. vacuum drying, helium backfilling and helium leak detection. Therefore, in order to ensure that the vacuum drying station did not become the bottleneck in the process, a second vacuum drying system was procured.

In practice, throughout 2010, it became apparent that even with one vacuum drying system in service, this equipment did not become the bottleneck in the process. However, the redundancy provided by a second vacuum drying system increases the overall reliability of the process.

2.1.3 Procurement of a second transfer vehicle

In 2007, a second transfer vehicle was procured. Until that point, there had been reliance on one vehicle for both on-site transfers and for movement of DSC's within the facility. The increased production rate would lead to increases in both of these areas. Therefore, the reliance on one vehicle increased the risk of downtime and the inability to meet the production targets should that vehicle be taken out of service for corrective or preventative maintenance.

After extensive modifications to the vehicle to address several deficiencies, the new upgraded vehicle was placed in service in time for the increased production rate of 2010. The new vehicle is a different style, designed specifically for transfer between the stations only. The new vehicle purchased was capable of slightly higher speeds, still within the limits set in the facility's Safety Report. However, this marginal increase in speed dramatically reduced the transfer time in particular to Bruce A – the more distant generating station from the waste management facility.

Figure 3. DSC Transporter Vehicle.

2.1.4 Installation of a bulk gas system for welding cover gas delivery

In 2009, a bulk gas system was installed and commissioned for welding cover gas delivery. The welding system uses a gas mixture, which are 92% argon and 8 % carbon dioxide. In the original facility design, the weld cover gas was provided via individual cylinders, which were stored in a room internal to the facility.

Anticipating the increased production rate, it was speculated that an increase in weld cover gas usage would occur resulting in a significant increase in the amount of individual cylinders being required on a daily and weekly basis. This would increase the manual handling of the cylinders by personnel thereby increasing the potential for personnel injury due to the ergonomic concerns with handling these cylinders in that particular location.

Therefore a bulk gas system was installed which consists of two 16-cylinder packs with automatic switchover capability between the two systems (Figure 4). In practice, it has been determined that one 16-cylinder pack is capable of completing the welding of approximately six DSC's. Therefore the entire cylinder pack is replaced every two weeks.

Since the cylinder pack is moved using a forklift, the manual handling has all but disappeared.

Figure 4. Two 16-cylinder packs containing Welding Cover Gas.

2.2 Challenges Faced

Despite the facility modifications made in advance of the increased production rate, other challenges became more apparent during the actual 2010 execution.

Some of these challenges included:

- increased congestion on the Processing Building floor,
- high service hours placed on the facility crane and significant increase in craning activities,

- any interruptions or delays cascaded through the entire process. For example, the need to incorporate weld repairs into the process or any delay in completing PAUT analysis had a significant impact on the schedule;
- increased wear and tear on equipment and therefore the need for more frequent maintenance cycles; and
- increased usage of consumables and the required increased in procurement and stock-keeping.

2.2.1 Increased congestion on the processing building floor

The high production rates translate to receiving a loaded DSC from the generating station at a rate of typically three to four DSC's per week. In addition, in order to sustain the high production rate, an equal amount of empty DSC's must be received from the manufacturer.

At various times during 2010, the processing building floor was significantly congested with both loaded DSC's (waiting processing or at various stages of the process) and empty DSCs (awaiting preparation or delivery to the stations). (Figure 5). Significant effort was expended by the staff in order to ensure optimum usage of the floor space within that area.

One innovative and easy solution for the facility was to reverse the delivery method for the DSC's from the manufacturer. Until then, DSC deliveries occurred as follows: one transport would first deliver one DSC body, and then a second transport would deliver a second DSC body. A third shipment would then follow with the two lids that matched the previously shipped bodies.

The DSC bodies, awaiting delivery of the lids, would then have to remain in the Processing Building and therefore took up valuable floor space. A simple suggestion was to modify the delivery pattern. By delivering the lids and a body on one day, this would enable the lid to be installed onto its corresponding DSC body and moved out of the Processing Building immediately.

Figure 5. Picture of Processing Building floor with several DSCs waiting further processing.

2.2.2 High service hours placed on crane

Throughout any day, the 90-tonne overhead crane in the facility is moving DSC's around the various stages of the process. With the number of loaded DSC's increasing to three or four transfers per week plus the accompanying delivery of empty DSC's, this results in many crane movements each day. It has been estimated that in order to fully process one DSC from start to finish within the process, then over 20 crane movements are required.

Due to the critical nature of the crane to the operations, an aggressive preventative maintenance program was put in place. A semi-annual maintenance inspection is completed compared to the manufacturer-recommended annual frequency. A service contract exists with the crane manufacture both for on-going inspection and maintenance and for emergency breakdown response. In addition, a critical parts review was conducted to ensure that all critical spares were identified, stocked as required or capable of being obtained off-the-shelf.

Throughout 2010, no significant issues occurred related to the crane and this can be attributed in large part to the maintenance regime described above.

2.2.3 Interruptions or delays in the process cause cascading effect

The DSC lid-to-base seal weld is inspected using one of two Non-Destructive Examination (NDE) techniques. Up to January 2010, the weld had been inspected using X-ray radiography. Starting in 2010, an approved modification had been completed and there had been a transition to the use of PAUT. PAUT offers the following advantages:

- It does not produce the radiation hazard associated with X-ray radiography
- It can be performed in any location within the facility that has a suitable AC power supply
- It creates an electronic file that allows new options for records retention and the provision of interpretive services.

The initial usage of PAUT however, did cause some delays in the process. This was because the interpretation of the PAUT scan – in order to confirm that the weld had met the acceptance criteria – took, initially, longer than a similar X-ray film analysis had taken. The need to ensure accuracy of the analysis resulted in longer analyses times. This meant that the particular DSC could not progress in the process until the analysis had confirmed that the weld met the acceptance criteria. Initially, this led to increased congestion on the floor as well.

As 2010 progressed and the knowledge of the analysis techniques increased, the time required to complete the analysis became shorter and enabled faster turnaround of the processed DSC's.

A simultaneous challenge that arose was related to the quality of the welding wire. Starting in approximately 2009, there had been some welding difficulties encountered at all of OPG's Used Fuel Facilities. The typical difficulties related to erratic arc and fouling of the weld head contact tips. The quality of the weld remained acceptable however; the suspect weld wire quality increased the time required for welders to complete the weld. Throughout 2010, the weld wire difficulties continued in particular at Western site, with the increased throughput.

Several discussions were held with the weld wire manufacturer who provided assistance in further investigating their internal processes. Eventually it was confirmed that a change in the manufacturer's process had resulted in a different coating application to the wire. The wire still met its required technical specification; however, the different coating resulted in difficulties as described above.

This was eventually resolved and weld wire quality returned to previous conditions.

However, both of these issues (the delay in PAUT analysis results and the increased welding time due to weld wire issues) slowed down the process. At the increased production rate, it soon became apparent that such delays were difficult to recover from as the delay cascaded throughout the process and led to bottlenecks elsewhere.

In order to accommodate these cumulative delays in the process, it was necessary in 2010 to institute short-term alternate shift arrangements to increase welding time in the facility.

2.2.4 Increased wear and tear on equipment

It is inevitable that increased usage of equipment will lead to increased wear and tear. This was anticipated prior to the increase in production rate and therefore maintenance cycles on critical equipment was increased in many cases. For example, weld head calibrations and rebuilds were increased in frequency. As previously mentioned, the crane inspection frequency was increased.

Critical Parts were also reviewed for the key processing systems. A systematic review of the system's components and parts was completed to ensure that the appropriate mitigation strategy was in place – for example, critical parts may be stocked, or lead times may be confirmed to be adequately short with the manufacturers or preventative maintenance programs may be initiated to increase reliability.

2.2.5 Increased usage of consumables

It is also inevitable that increased production rates will lead to increased usage of consumables. The most evident example of that, throughout 2010, was the increased usage of welding wire and welding cover gas. Supply contracts and inventory reorder points were reviewed and adjusted accordingly

2.3 Lessons Learned

Throughout 2010, there were valuable lessons learned. These were shared among the OPG Used Fuel Facilities and many opportunities for transfer of lessons learned among the three facilities were sought. Peer Teams were set up in areas such as welding to ensure consistency among the three facilities. There was some sharing of staff resources as well to gain lessons from the increased production rate.

Some of the valuable lessons learned included:

- A surveillance area with IAEA cameras was installed and commissioned in the Storage Building. This enabled DSC's which were fully processed, but awaiting the application of IAEA seals, to be moved to the Storage Building, thus alleviating congestion in the Processing Building.
- Opportunities were sought to alleviate congestion due to the management of empty DSC's in the Processing Building. For example, the delivery schedule of empty Dry Storage

Containers from the manufacturer was changed to ensure efficiency and minimize the impact on floor space

- Off-site storage of empty DSC's was established at the manufacturer's location. This reduced the inventory of empty DSC's needed to be stored on site in the Storage Building.

3. CONCLUSIONS

The facility was able to successfully achieve its production target with no safety incidents. This high rate of production is planned to continue for several years at the facility. Some challenges continue and these are being assessed and incorporated into the facility's business plan. In order to continue being successful, the facility must look to the future for opportunities for improvement and efficiencies to be gained.

4. REFERENCES

[1.] OPG, "Western Waste Management Facility Safety Report W-SR-01320-00001", September 2009.