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STRATEGIES FOR ACCELERATING THE SLARette PROCESS

ABSTRACT

The SLARette (Spacer Location and Repositioning) process is continuing on several CANDU reactors, where loose fitting garter springs (spacers) were used, to prevent contact between the calandria tube and the pressure tube for the target life. With time, the sag in the fuel channel is increasing and consequently increasing the potential for contact between the pressure tube and the calandria tube. Also, due to increasing sag in the pressure tubes and increasing magnitude of the fuel channel constrictions on the eddy current detection system, the Spacer Location And Repositioning activities are becoming more time consuming and difficult. For CANDU owners, during the SLARette campaigns, station outage time is the most expensive item. Therefore, it is beneficial to complete the SLARette process as early as possible and as fast as possible. New SLARette strategies can substantially accelerate the overall SLARette process and thus minimize the outage time. There are several strategies to perform the SLARette process. These strategies include :

- Using the SLARette Mark II Delivery System,
- Using SLARette Advanced Delivery System,
- Implement creative fuel handling technique,
- Operate from both sides of the reactor using Mark II Delivery Systems,
- Operate from both sides using Advanced Delivery Systems.

Each strategy offers different benefits, rate of fuel channel processing (SLARette Activity), and schedule constraints. This paper provides the details of each strategy and compare them in terms of outage time, man-rem consumption, and constraints.

STRATEGIES FOR ACCELERATING THE SLARette PROCESS

1.0 INTRODUCTION:

Pressure tubes and calandria tubes in CANDU Reactors are separated by four Annular Spacers (Garter Springs). In the mid 1980s, it was found that for the CANDU stations, where loose spacers are installed, the spacers may have moved from their original design locations. Due to this random movement of the spacers, the pressure tube may not have adequate support or annular separation from the calandria tube. Consequently, due to increasing creep and sag, pressure tubes may either be in contact with or are anticipated to contact the calandria tubes.

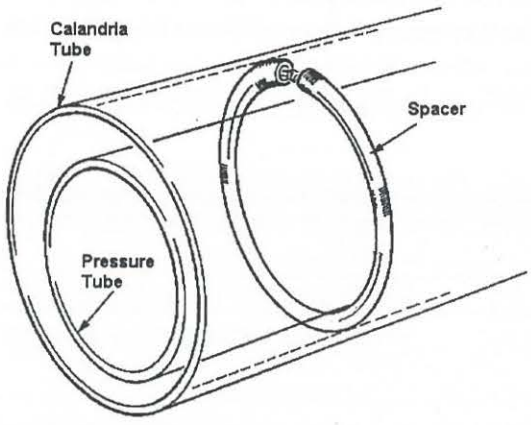
To prevent the hydrogen equivalent level being equal to or higher than the blister formation threshold, the contact between the pressure tube and the calandria tube is not desirable. To ensure the contact free target life of fuel channels, SLAR System, an acronym for **S**pacer **L**ocation **A**nd **R**epositioning, was developed to locate and to reposition the spacers to the new locations. A SLAR system applicable for a small scale Spacer Location And Repositioning process is called SLARette. This paper discusses the possible strategies to accelerate SLARette system.

The SLARette system using the SLARette Tool, locates the annular spacers by means of Eddy Current and Ultrasonic probes and then repositions them using Linear Induction Motors to the new locations. The Spacer Location And Repositioning process is currently in progress for the CANDU 6 Nuclear Generating Stations with loose Spacers.

As the reactor ages, the pressure tube sag increases due to thermal and radiation creep. Consequently, the increasing sag pinches the spacer against the calandria tube with increasing force making the spacers more difficult to move. In addition, severely crept pressure tubes can also limit the performance of a SLARette Tool. Aging of the reactors makes the SLARette process more time consuming and expensive. Therefore, it is beneficial for the utilities to complete the SLARette process as soon as possible. SLARette activity is performed during station outages. Outages are very expensive for the utilities, so there is always a push to complete as many channels as possible in that given time slot.

The SLARette campaign is generally carried out by using the "Base-Line SLARette System", i.e., the Mark II Delivery System installed on one side of the reactor. In 1995, the Mark II Delivery System was up-graded to the Advanced Delivery System at Gentilly 2 to enhance the SLARette performance.

This paper discusses all the possible ways to speed up the SLARette Process. This paper compares all the SLARette strategies with the base line SLARette process in terms of cost, schedule, man-rem consumption rate, training, man-power requirements, and channel processing rate.



2.0 CREATIVE FUEL HANDLING TECHNIQUE:

Fuel handling is one of the major time consuming activities during a SLARette campaign. It consumes approximately 10% of the overall time when the SLARette process is performed using a base-line SLARette System. This strategy is to implement a creative fuel handling technique to reduce fuel handling time substantially.

In the beginning of a SLARette campaign, the total targeted fuel channels are divided usually into batches of nine channels. In this paper, a scenario of nine channel batch is considered for discussion. The fuel and the shield plugs are removed from the fuel channel before the delivery machine can be latched on for the SLARette process. Fuel from all channels of the first batch is discharged into the spent fuel bay. The shield plugs however are not discharged but are stored in the fueling machine and the rehearsal facility. During the fuel handling operations, shield plugs from three channels are stored in two fueling machines and the remaining shield plugs from the other six channels are put back into these channels. At the end of de-fueling of each batch, the three fuel channels with no shield plugs are ready for SLARette. Upon completing the SLARette activities on the first three channels, the stored shield plugs are reinstalled into these channels and the shield plugs from the next three channels are removed to continue SLARette process. As a result, for each batch of nine channels, the SLARette process is interrupted at least two times for shield plug shuffling. Shield plug shuffling takes a minimum of 1.5 hours per channel. Therefore, about 9 hours are spent for shield plug shuffling for each batch of nine channels.

The time for shield plug shuffling can be greatly reduced if 12 shield plugs from six channels are discharged to the spent fuel bay and the six shield plugs from the remaining 3 channels are stored in the fueling machines. Then the SLARette activities can proceed uninterrupted for all nine channels from the first batch. Upon completion of the first batch, 12 shield plugs from the 2^{nd} batch channels are removed and installed in the six channels of the first batch. The shield plugs from remaining three channels of 2^{nd} batch can be stored in the fueling machines. Similarly, SLARette process for the entire 2^{nd} batch can proceed uninterrupted. And so forth this process can be carried on throughout the SLARette campaign. Therefore, by sacrificing 12 shield plugs, about 1.5 hours per channel can be saved. At the end of the SLARette campaign, 12 new shield plugs would be installed.

For an outage planned to SLARette 100 fuel channels, about 100 hours (4 Days) can be saved at a cost of 200K. The cost of 12 shield plugs is insignificant when compared with the cost of saved outage time. More over it may be possible to retrieve the discharged shield plugs from the spent fuel bay and re-use them.

The implementation of this fuel handling technique may cause higher radiation fields in the vault due to the lack of shield plugs in six additional fuel channels. Therefore, it is recommended for the SLARette campaign with Advanced SLARette System where the vault work is significantly reduced.

2.1 CREATIVE FUEL HANDLING TECHNIQUE:

SUMMARY:

BENEFITS:	**ABOUT 10% INCREASE IN CHANNEL PROCESSING RATE**
CONSEQUENCES:	**LOSS OF 12 SHIELD PLUGS**

3.0 MARK II DELIVERY MACHINE UP-GRADED/REPLACED WITH ADVANCED DELIVERY MCHINE:

The SLARette Tool is positioned in the fuel channel by the SLARette delivery machine. This is a mechanism which advances, retracts, and rotates the SLARette Tool in the fuel channel and the calibration facility. There are two models of SLARette delivery machine: MARK II SLARette Delivery Machine and Advanced SLARette Delivery Machine. This strategy is to replace the Mark II Delivery System with the Advanced Delivery System to accelerate the channel processing rate and to reduce the man-rem consumption.

In the case of the Mark II Delivery Machine, the SLARette Tool is positioned axially and rotationally by an assembly of five push tubes and rotary and axial drives. During the SLARette operation, a team of trained SLARette personnel must be available to connect or to disconnect the push tubes to provide adequate length of push-tube assembly. A significant amount of time and man-rem dose are consumed for the manipulation of the push tubes. To limit individual man-rem consumption, several teams of SLARette operators are trained and used for this task.

The Advanced SLARette Delivery Machine was designed to minimize the man-rem consumption and to enhance the performance of the SLARette System. The Advanced Delivery Machine replaces the push tubes with a 3 STAGE telescoping ram which positions the tool in the fuel channel with a remote control in the SLARette control room. No operators are required in the vault once the Delivery Machine is latched onto the fuel channel. Therefore, by reducing the number of operators required for the vault work, man-rem consumption is reduced. The Delivery Machine latching and unlatching mechanism for the Advanced Delivery Machine has also been modified to simplify the process. For a Mark II Delivery Machine, latching and unlatching process takes about one to two hours for two persons. The modifications made for the Advanced Delivery Machine reduced this time to only 30 minutes for one person. The Advanced Delivery Machine incorporates most of the Mark II Delivery Machine design while adding and replacing some systems. The Advanced Delivery System had been successfully used for Gentilly-2 SLARette outages 1995, 1996, and 1997 with a total of 134 channels completed.

The overall benefits of using the Advanced Delivery Machine over the Mark II Delivery Machine is about 15% savings in time per fuel channel processed and 70% savings in men-rem consumption. In addition, due to lower Man-Rem consumption, a smaller team of operators is required for the vault work. Since the channel processing is faster, the SLARette tool spends less time in the reactor per channel. This has a favorable effect on the SLARette Tool life. These benefits are mainly due to reduction of vault work, faster latch-on and latch-off operation, and faster positioning of the SLARette Tool during SLARette operations.

3.1 MARK II DELIVERY MACHINE UP-GRADED/REPLACED WITH ADVANCED DELIVERY MCHINE:

SUMMARY:

Consequences:

- **Additional Training**
- **Additional Cost**

Benefits:

- **Over-all channel processing time improved by 15%,**
- **70% Reduction in Man-Rem consumption**
- **Smaller team for the Vault work.**
- **Increased SLARette Tool Life**

4.0 Dual SLARette System using Mark II SLARette Delivery Machines:

Conventionally, the SLARette process has been performed using one SLARette system installed on each side of the reactor. Both sides of CANDU reactors are identical for SLARette purposes. Therefore, it is possible to install and operate a SLARette System on each side of the reactor, simultaneously. With two SLARette systems installed and operated on opposite sides of the reactor, two channels can be accessed and processed simultaneously.

The implementation of this strategy requires two Inspection systems, two Mark II delivery machines, two cable penetration systems, two LIM Power Supplies, two Tool Valve Stations, two Delivery Machine Valve Stations, two control rooms, and two operating crews.

Because of large capital and man-power commitment, this strategy will require higher job priority from the station than most other jobs in progress during the outage. It puts more pressure on the fuel handling system and crew to work at higher efficiency level. To maximize the productivity, it demands good coordination between the both SLARette crews, the fuel handling crew, and the other supporting teams. To minimize the idle time, it will be beneficial to implement creative channel de-fueling techniques to some what synchronize on-channel activities for both SLARette crews.

With two SLARette systems working simultaneously, the SLARette productivity can be increased by at least 50% over a single base line SLARette system. The overall typical rate for channel processing is 1.5 channels per day. With dual SLARette systems, more than two to three channels can be completed per day. For 100 channels, 16 to 33 days of outage time can be saved by having an additional base line SLARette system.

4.1 Dual SLARette System using Mark II SLARette Delivery Machines:

SUMMARY:

BENEFITS:

- **Overall Channel processing Rate At Least 50% faster.**

CONSEQUENCES:

- **Additional Personnel require for operation and maintenance.**
- **Additional Cost.**
- **Additional penetration and control room requirement.**
- **Higher accumulated Man-Rem Consumption**
- **Higher Pressure on Fuel Handling crew and System**
- **Require higher priority**

5.0 DUAL SLARette SYSTEMS USING ADVANCED SLARette DELIVERY MACHINES:

Dual SLARette System using Advanced SLARette Delivery Machines would provide the largest increase in the productivity. This strategy is to install and operate SLARette system on both sides of the reactor. This approach is identical to the approach discussed in the previous section but using the Advanced Delivery Systems instead of Mark II Delivery Systems.

This strategy requires two SLARette teams, two Advanced SLARette Delivery Systems, two control rooms, two inspection and control systems compatible with the Advanced SLARette Delivery Machine, two LIM Power Supplies, and two Cable Penetrations.

To maximize the use of equipment and the crews and to minimize the idle time, the station owner must provide special attention and highest priority to SLARette campaign during the outage. It will also require very efficient and well planned and organized fuel handling crews and systems. It also requires a larger supporting team from the utility.

By performing the Advanced SLARette process simultaneously on two fuel channels, the channel processing productivity can be increased by 100% of the time over the single base line SLARette system. It means that on average basis, more than three channels can be processed in a single day of operation. This scheme not only saves the overall SLARette times but also saves a substantial Man-Rem consumption. For a 100 channel SLARette campaign, more than 33 days of outage can be saved when compared to single Base line SLARette system.

5.1 DUAL SLARette SYSTEMS USING ADVANCED DELIVERY MACHINES:

SUMMARY:

BENEFITS:

- **Overall Channel processing time 100% faster**

CONSEQUENCES:

- **Additional Personnel require for operation and maintenance.**
- **Additional penetration and control room requirement.**
- **Higher accumulated Man-Rem Consumption**
- **Higher Pressure on Fuel Handling crew and System**
- **Require higher priority**
- **Additional Cost**

COMPARISON OF SLARette STRATEGIES FOR 100 CHANNEL OUTAGE				
Section	***STRATEGY***	***TIME(DAYS)***	***Man-Rem Reduction***	***Consequences***
	Base-Line SLARette using Mark II D/M	65	0%	N/A
3.0	Single SLARette using Advanced D/M	55	70%	Extra Training Extra Cost
2.0 & 3.0	Creative Fuel Handling Techniques coupled with Single Advanced SLARette	51	70%	Extra Cost Extra Training Loss of 12 Shield Plugs
5.0	Dual Base-Line using Mark II D/M	44	0%	Higher Priority Larger Team Add'nl Penetration & Control Room Higher Accumulated Man-Rem Consumption Extra Cost
5.0	Dual SLARette using Advanced SLARette System	33	70%	Highest Priority Extra Training Add'nl Penetration & Control Room Extra Cost Larger Team
2.0 & 5.0	Creative Fuel Handling Techniques coupled Dual Advanced SLARette	29	70%	Loss of 12 Shield Plugs Highest Priority Larger Team Add'nl Penetration & Control Room Extra Cost Extra Training
* Men-Rem Consumption Rate when compared with Single Base-Line SLARette Operations				