2020 | 2021 | 2022 | 2023

MAJOR COMPONENT REPLACEMENT

UNIT 6 PROJECT OVERVIEW

1 DEFUEL

Defueling will take place in two phases. Workers begin with the "flow defuel" method for the first stage and then transition into using BRIMS, or the Bruce Reactor Inspection Maintenance System. This system enables shutdown of the heat transport pumps which are expensive to run. BRIMS will reduce the defuel timeline from 74 days to 65.5 days. Operational authority transfers from station to LIFEX.

Decay heat is too great to use BRIMS directly after shut down. This is why the flow defuel method is employed to start.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

2 BULKHEAD AND SHIELDING INSTALL

16 bulkheads; 7.2 tons each

EXECUTION PARTNER: Black & McDonald

Protective shielding and 16 bulkheads are installed to isolate Unit 6 from the operating units. By installing the shielding, workers can remain in the vault when the Fueling Machine Trolley performs spent fuel runs, which generally occurs one time every 24 hour.

Once the bulkheads are installed, vault pressure testing is completed to ensure Unit 6 has been fully isolated from the three remaining operating units.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

3 PHT DRAIN & DRY, CUT & CAP, MODERATOR DRAIN & DRY

Crews will drain and dry the Moderator and Primary Heat Transport (PHT) systems. These are the last key milestones before the major component replacement begins.

PHT Drain and Dry will be performed in parallel with the bulkheads installation. Moderator Drain and Dry will follow PHT drying and will overlap with beginning of feeder removal.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

4 STEAM GENERATOR REPLACEMENT

Each steam generator weighs approximately 160 tons.

EXECUTION PARTNER: SGRT Steam Generator Replacement Team

An 1,800-tonne capacity crane is used to remove the old steam generators and lower the new ones into place through ports in the roof of the reactor building.

Site Mobilization — Open Roof — Remove Interferences — Erect Crane — Remove and Replace Steam Generators — Close Roof — Replace Interferences — Remove Crane

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

5 VAULT WORK

960 feeder tubes, 480 fuel channels, and 480 calandria tubes are removed and replaced.

EXECUTION PARTNER: Shoreline Power Group

This phase of work is the heart of the project. It includes the removal and replacement of the pressure tubes, calandria tubes, as well as the lower and upper feeders.

This work is primarily completed by Shoreline Power Group.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

6 FUEL LOAD

The 480 fuel channels will get 12 fuel bundles each.

Fuel load marks the beginning of the end for the Unit 6 project. The main work is complete and the CNSC has signed off allowing Bruce Power to begin loading the fuel. This is the point that MCR starts to hand the unit back to Operations and the systems start to become live again.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

7 RETURN TO SERVICE

The Return to Service process ensures that all systems, structures, and components meet the design, performance, and licensing requirements to return the unit to full power following the Unit 6 outage. The process includes system window closeout, system readiness for service confirmations, hot commissioning, and unit start up.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

RETURN TO COMMERCIAL OPERATION

CRITICAL PATH

UNIT 6 SHUTDOWN (BREAKER OPEN) JAN.17, 2020

In 2020, Unit 6 will begin its power rundown. Station staff will disconnect the unit from the grid and begin the cooldown process while remaining pressurized. The main heat transport pumps are still running to facilitate the next phase of work: defuel.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

VAULT TURNOVER FOR MCR EXECUTION

Unit 6 vault conditions established to allow turnover to MCR.

MODERATOR REFILL

The Unit 6 moderator is filled with reactor-grade heavy water. This is the point of the MCR program where LIFEX recovers accountability for the radiological risk while MCR continues to remain accountable for vault work.

WORK ACCOUNTABILITY: LIFEX | OPERATIONAL AUTHORITY: LIFEX

CNSC APPROVAL FOR FUEL LOAD

This approval allows for the transition of operational authority from LIFEX back to the station.

PRESSURE TEST

A hydrostatic pressure test of the newly installed pressure tubes, feeder tubes, and boilers proves that we've met the requirements.

Prior to bulkhead removal, vault pressure testing is completed to ensure that containment for Unit 6 has been properly re-established.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

SYNC

All secondary steam and feedwater systems are tested and in full service allowing the generator to be synchronized to the provincial grid.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

AUXILIARY WINDOW (PROJECTS COMPLETED AS REQUIRED TO MINIMIZE IMPACT TO CRITICAL PATH)

PRIMARY HEAT TRANSPORT (PHT) 7 MONTHS

ELECTRICAL APPROX. 4.5 MONTHS

SAFETY SYSTEMS / MOD 4 MONTHS

CONVENTIONAL 6 MONTHS

CONVENTIONAL 6 MONTHS

COOLING WATER 6 MONTHS

BALANCE OF PLANT

Balance of Plant (BoP) refers to all systems in the station except steam generators, feeders and fuel channel assembly. During the Unit 6 MCR, targeted activities will be performed on BoP equipment to extend the life of key systems and ensure safe operation for decades to come. The primary Balance of Plant windows of work — including PHT, Cooling Water, Electrical, Safety Systems/ Moderator, and Conventional — will be executed in a systematic and efficient way to ensure necessary trades and resources are available. Bruce Power's Equipment Performance Division (EPD) will complete the MCR Maintenance scope of work and Project Management and Construction (PMC) will execute the Asset Management scope of work.

BRUCE POWER'S EXECUTION VENDOR PARTNERS

Nuvia Canada will supply qualified Radiation Protection Technicians. These technicians are essential to ensure safe operation, providing radiation protection assistance for workers, monitoring of radiation levels as well as providing direct technical support.

Shoreline Power Group will execute the full scope of Fuel Channel Feeder Replacement work.

Black & McDonald will provide construction services and project execution for 19 individual mechanical and electrical projects.

SGRT was awarded the contract to remove and replace all eight steam generators for the U6 MCR Program.

BrucePower
Innovation at work

STRENGTHENING OUR SITE

MAJOR COMPONENT REPLACEMENT PROGRAM

In December 2015, Bruce Power reached an agreement with the Independent Electricity System Operator (IESO) to advance a long-term investment program which would refurbish its nuclear fleet and help secure the site's operation until 2064.

Beginning in 2020 with Unit 6, Bruce Power will carry out its intensive Major Component Replacement (MCR) Program. This program focuses on the replacement of key reactor components in Units 3-8 and enables the completion of asset management and outage maintenance on a range of nuclear and non-nuclear systems during the shutdown period. The Life Extension (LIFEX) Division supports the completion of this program within the station. By identifying and prioritizing operational activities, LIFEX is able to minimize the impact of station work on MCR's critical path and Balance of Plant windows and vice versa.

Unit 6 MCR will not be a construction island as a result of lessons learned and OPEX from Restart. Consequently, the seamless integration between MCR and station will be achieved via the LIFEX link.

MCR BRUCE POWER MAJOR COMPONENT REPLACEMENT · Black & McDonald · NUVIA · SGRT STEAM GENERATOR REPLACEMENT TEAM · SHORELINE POWER GROUP

1

DEFUEL

Fuel bundles are in the reactor for about 1 1/2 years. Once removed, they spend approximately 10 years in the fuel bays and are then moved to dry storage facilities.

During the Unit 6 MCR, fuel handling crews will defuel 5,760 fuel bundles using a combination of the following methods: (1) flow defuel and (2) BRIMS defuel.

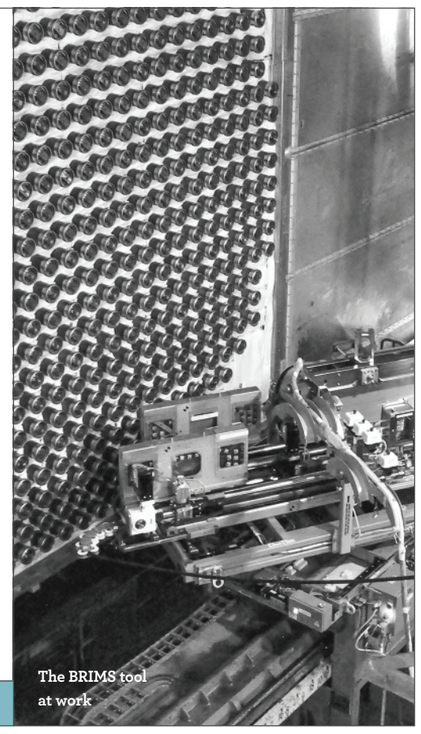
BRIMS, or the Bruce Reactor Inspection Maintenance System, is an innovative defuel method that was developed by Bruce Power engineers. This first-of-a-kind tool has historically been used for inspections and maintenance, but also allows for safe defueling.

BRIMS pushes fuel out of the fuel channel and into a fuel machine head. This is different from the traditional defuel method, flow defuel, which uses the flow of the main heat transport pumps to float the bundles into the fueling machine head on the other side.

The ability to use BRIMS means that the Primary Heat Transport (PHT) pumps can be shut down earlier than was possible during Units 1 and 2 Restart. These large motors are expensive to run making BRIMS a cost-saving opportunity. Shutting down the main pumps also opens up the opportunity to perform work, such as cobalt removal, earlier in the MCR campaign.

The BRIMS tool is remote controlled with the machine operator set up in the main control room working side-by-side with the fueling machine operator.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION


The BRIMS tool at work

2

EXECUTION PARTNER
Black & McDonald

BULKHEAD AND SHIELDING INSTALL

Protective shielding and 16 isolation bulkhead panels are installed over the fueling machine duct opening in the Unit 6 vault. To do this, a 10-ton capacity crane lifts the bulkheads into place. Qualified and tested pressure boundary welders install, fit and weld large carbon steel metal plates to complete the boundary enclosure. All welds are tested via non-destructive testing techniques. This welding is difficult to execute in a nuclear radiation environment due to the restricted mobility.

The most important stage in the bulkhead installation is the successful completion of the positive and negative pressure tests. This is a regulatory requirement of the Technical Safety and Standards Authority (TSSA) and Canadian Nuclear Safety Commission (CNSC). The purpose of these tests is to ensure that the bulkhead panels are completely sealed and will act as an alternate containment boundary.

After the reactor is refueled, the bulkheads will be removed prior to the PHT refill and hydrostatic pressure test.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX


Bulkheads being craned into place

3

The volume of water to be boiled represents approximately 1/4 of the total system volume of 100,000 litres.

PHT DRAIN & DRY, CUT & CAP, MODERATOR DRAIN & DRY

Three-quarters of the heavy water is drained from the PHT system. The remaining liquid, which cannot be removed through draining, is boiled off using heat and reduced pressure (i.e. vacuum drying).

The Moderator will also be drained of heavy water and then dried by circulation of nitrogen through a dehumidification dryer. Following this process, the system will be modified to maintain negative pressure in the calandria during MCR, which ensures tritium and ozone do not escape during the work phase.

The Removal of Energy Cut and Cap is being put in place to remove all credible sources of energy from the PHT and Moderator systems so work can proceed on the retube, feeder replacement and primary side of steam generator replacement without the need for clearance orders.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

VAULT TURNOVER TO MCR FOR EXECUTION

Unit 6 Vault Condition Checklist

- ☑ Defuel complete
- ☑ PHT and Moderator system Drain and Dry and Cut and Cap sequences are complete
- ☑ Bulkheads and shielding installed
- ☑ Vault pressure testing complete

4

EXECUTION PARTNER
SGRT STEAM GENERATOR REPLACEMENT TEAM

STEAM GENERATOR REPLACEMENT

The steam generator replacement portion of the project will involve the removal, replacement, and connection of eight new steam generators in Unit 6. Each of the eight steam generators are approximately four metres wide, 15 metres tall, and include a lower cartridge topped by a steam drum. An 1,800-tonne capacity crane is used to maneuver the steam generators over the building and into place through ports in the roof. The steam generators must be removed in an ordered sequence to maintain structural integrity of the Heat Transport System piping inside the reactor building. With the new steam generators in place, the inlet and outlet nozzles to the heat transport system are reconnected and the civil, electrical, and mechanical interferences are reinstalled prior to the roof ports being closed and sealed.

The majority of the steam generator replacement scope of work is off critical path. However, the removal, replacement and radiography of the steam generators are critical path activities due to the significance of the work. There will be 16 evolutions including eight removals and eight replacements.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX

5

The vendor partner work is executed and supported on a 24/7 timeline.

EXECUTION PARTNER
SHORELINE POWER GROUP

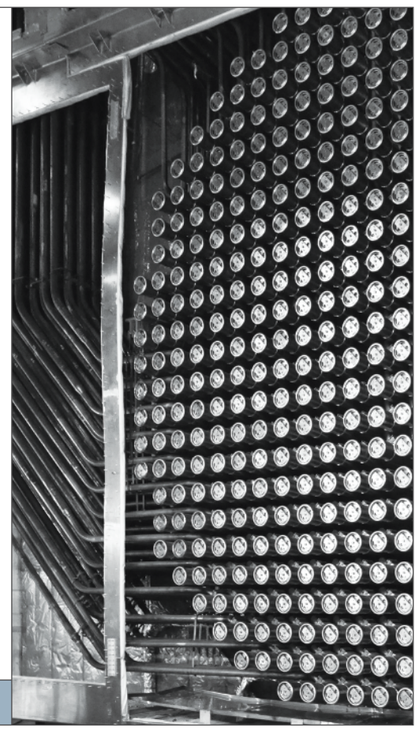
VAULT WORK

Each reactor has 480 fuel channels connected to 480 inlet feeders and 480 outlet feeders. The inlet feeder delivers cooled heavy water from the steam generators to the reactor fuel channel while the outlet feeder delivers heated heavy water to the steam generator in order to make steam.

As part of the Unit 6 MCR, the 960 feeders will be replaced from the Grayloc to the PHT header nozzle. While the feeder replacement is happening, the detube/retube work is also underway. During this scope of work, the calandria and pressure tubes will be removed, disposed of, and replaced.

While this window of work is occurring, the steam generator replacement program is executing the lift and placement of the eight steam generators.

WORK ACCOUNTABILITY: MCR | OPERATIONAL AUTHORITY: LIFEX



6

FUEL LOAD

The Unit 6 fuel load will be completed manually. A crew of Operations staff will work on both the east and west reactor faces at the same time while a ground support crew supplies them with the necessary closure plugs, shield plugs, channel strainers, and 12 new fuel bundles for each fuel channel.

Before crossing the plane into the reactor, an intensive Quality Control process ensures all the equipment and bundles are reactor grade with no defects. At the end of this process, Fuel and Physics will know the exact location of each of the 5,760 bundles in the reactor.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION

7

RETURN TO SERVICE

After a successful pressure test of the newly-installed pressure tubes, feeder tubes, and boilers, the reactor power-up process is started by releasing the Over-Poisoned Shutdown Guarantees.

Heat up of the Primary Heat Transport employs low levels of reactor power to bring heavy water and light water systems up to near-working temperatures. This allows for chemical conditioning of new pressure tubes, feeder tubes, and boilers. The auxiliary circuits are also being filtered to flush any impurities.

Successfully commissioning each system for Return to Service and turnover to Operations is a vital phase of the project.

WORK ACCOUNTABILITY: STATION | OPERATIONAL AUTHORITY: STATION