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CONTRIBUTIONS FOR THE DECOMMISSIONING OF THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR.
PART 1 - MAIN STEPS OF THE FUEL CHANNEL DECOMMISSIONING

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Abstract:, *The purpose of this study is to achieve a possible method for decommissioning of the horizontal fuel channels of calandria vessel, based on the knowledge referring to assembly the fuel channel into calandria of CANDU 6 nuclear reactor. Nuclear reactor decommissioning consists in a planning phase and the implementation of all procedures and operations. The decommissioning of fuel channels represents one of the last operation which is performed in the nuclear power decommissioning and it is the most important operation in the nuclear reactor dismantling. The decommissioning of fuel channels, one of the most important operation in the nuclear reactor dismantling, represents the final phase of nuclear facility decommissioning and refers to the technical operations taken to extract the components from inside of the nuclear reactor channel. The decommissioning is a complex process and requires activities such as disassembly decommissioning device, locking/unlocking the channel closure and the shield plug, pressure tube cutting, extracting of each component from the channel, as well as radioactive waste management. The dismantling operation stages of the fuel channel components should be repeated for each of all 380 channels of the reactor, starting from the front of calandria side and continuing with the rear side. The radiological safety analyses should be made by certified experts for protection assessment to radiation exposure of workers in time of fuel channel dismantling.*
Keywords: *Candu reactor, calandria tube, fuel channel, pressure tube, fuel bundle, end fitting, annulus spacer*

1. INTRODUCTION

The decommissioning activity refers to all activities required to be deployed at a nuclear power plant permanently discontinued and these are administrative, technical, and include the preparation, endorsement and approval of documents, obtaining permits and authorizations, providing financial resources, decontamination, dismantling, demolition, controlled removal of equipment, components, conventional or hazardous waste (radioactive, toxic), demonstrating the fulfillment of the radiological conditional or unconditional release of the facility and the ground, included in the decommissioning project.
Nuclear decommissioning includes two phases: a planning phase and an implementation phase of all procedures and operations.
The decommissioning of fuel channels represents one of the last operation which is performed in the nuclear power decommissioning, as the most important operation in the nuclear reactor dismantling.
For the fuel channels decommissioning should be taken into account the detailed description of the fuel channel and its components, the installation documents history, adequate radiological criteria for decommissioning guidance, safety and environmental impact assessment, including radiological and non-radiological analysis of the risks that can occur for workers, public and environment, the description of the proposed program for decommissioning the fuel channel and its components, the description of the quality assurance program and of the monitoring program, the equipments and methods used to verify the compliance with the decommissioning criteria, the planning of performing the final radiological assessment at the end of the fuel channel decommissioning. These will include also, a description of the proposed radiation protection procedures to be used during decommissioning.
The dismantling of the fuel channel components is performed according to the detailed schematic documentation of a the CANDU nuclear reactors fuel channel.

2. FUEL CHANNEL COMPONENTS DISMANTLING STEPS

The dismantling of the fuel channels is a complex process and requires activities such as locking/unlocking the channel closure plug and the shield plug, pressure tube cutting, extracting of the components from inside of the nuclear reactor channel, as well as radioactive waste management.
The operations of the fuel channel dismantling in the CANDU nuclear reactor calandria, shall satisfy the general decommissioning requirements which are described in the documents specified by AECL.

2.1. General considerations

Dismantling of the fuel channel components is performed when the initial conditions are performed.
The initial conditions for the fuel channels decommissioning starting are the following:
- there are no fuel bundles in the fuel channels;
- the cooling system should be power off and the facility dismantled;
- the feeders coupling of each feed pipes through which the cooling agent passes, located on the outside of each end fitting to be disassembled and the connection to be covered with a blind flange with four fastening screws and metallic safety lock against unscrewing;
- the platform shall be in maintenance position for installation of the dismantling device.
The components of the fuel channel design are illustrated in Figure 1.

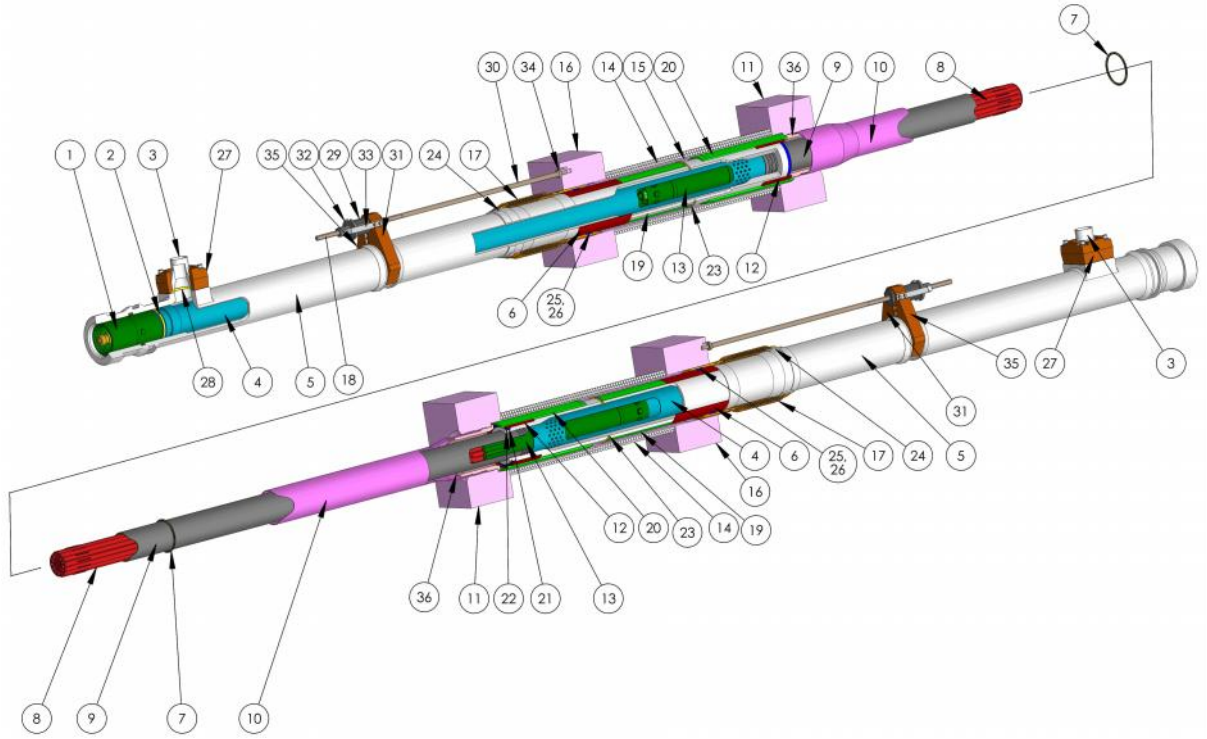

Figure 1: Representation of a CANDU fuel channel component parts

1. Channel closure; 2. Closure seal insert; 3. Feeder coupling; 4. Liner tube; 5. End fitting body; 6. Outboard bearings; 7. Annulus spacer; 8. Fuel bundle; 9. Pressure tube; 10. Calandria tube; 11. Calandria tubesheet; 12. Inboard bearings; 13. Shield plug; 14. Endshield shielding balls; 15. Endshield lattice tube; 16. Fuelling tubesheet; 17. Channel annulus bellows; 18. Positioning assembly; 19. End fitting shielding sleeve; 20. Lattice tube shielding sleeve; 21. End fitting inner ring seal; 22. Elastic safety lock for end fitting inner ring seal; 23. Elastic safety lock for end fitting shielding sleeve; 24. Support ring for annulus bellows; 25. Annulus bellows outer ring seal; 26. Elastic safety lock for Annulus bellows outer ring seal; 27. Feeder coupling attachment; 28. Feeder gasket; 29. Rod positioning threaded part; 30. Rod positioning; 31. Right fastening piece for rod positioning; 32. Counter nut locking; 33. Safety lock for counter nut; 34. Lock pin for rod positioning; 35. Left fastening piece for rod positioning; 36. Crimping ring for calandria tube;

The decommissioning operations of a 380 fuel channels of the nuclear reactor shall be repeated for all the channels, from the front of calandria side (plane R), as well as the rear side (plane R ').

2.2. Dismantling of the Positioning Assembly

Before start fuel of the channels decommissioning shall be dismantled the positioning assembly of all 380 fuel channels.
The dismantling operation procedure of the fuel channel positioning assembly is manually performed, illustrated before and after removal in Fig.2. The notations of the components are from Fig. 1.

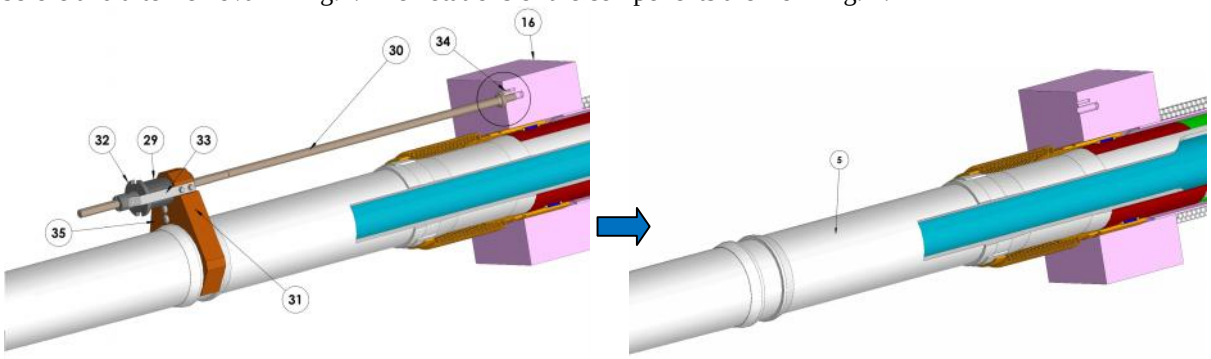

Figure 2: Representation of the positioning assembly before and after dismantling

- dismantling operation stages of the positioning assembly shall be repeated for all the channels, from the front of calandria side (plane R), as well as the rear side (plane R ').
- all removed components are placed in a special container for storage;

2.3. Dismantling of the End Fitting components

The first operation is to mount a protective cylindrical screen which covering the end fitting for the radiation protection of the operator (see Fig. 3).

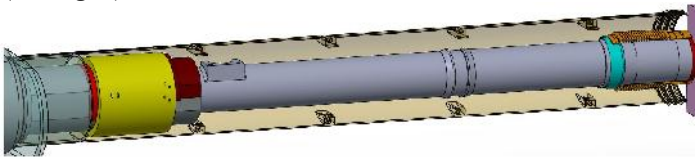

Figure 3: Representation of the protective cylindrical screen mounting

The operations procedure for end fitting components dismantling are the following:
- unlocking and extraction of the channel closure plug (1) (see Fig. 4);

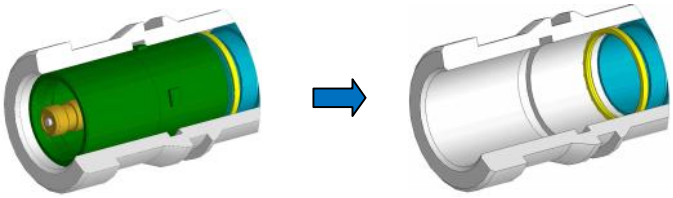

Figure 4: Representation of the channel closure removal

- unlocking and extraction of the shield plug (13) (see Fig. 5);

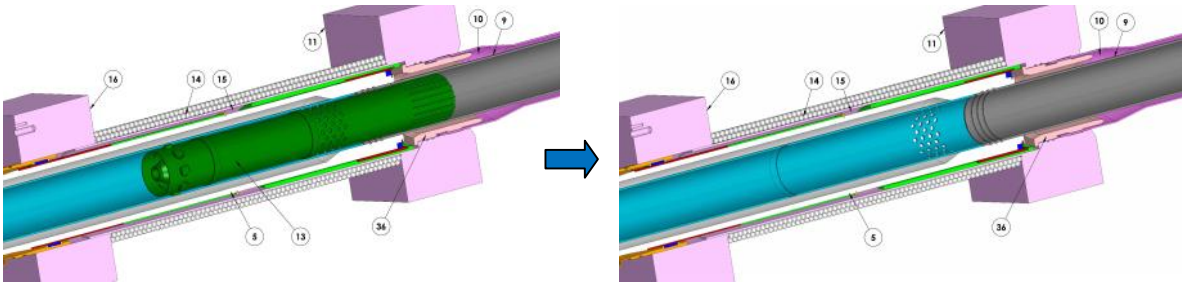

Figure 5: Representation of the shield plug removal

2.4. Cutting of the Pressure Tube

The cutting procedure facilitates the pressure tube removal and of the fitting end for each fuel channel on each side of the calandria. The operation procedure of pressure tube cutting at middle, as well as the end from of end fitting (see Fig. 6).

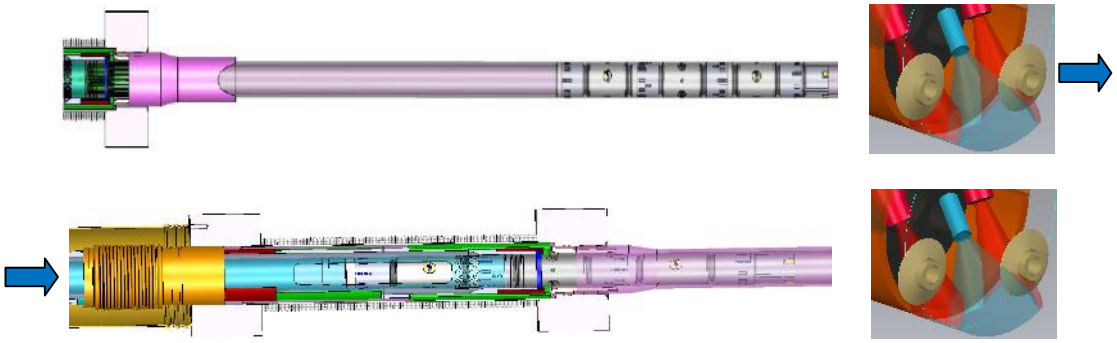

Figure 6: Representation of cutting with rollers in the middle and to end of pressure tube

The cutting operations are monitored by video camera and pyrometers for recording the temperature in the cutting rollers area.

2.5. Extraction of the End Fitting

The operation for end fitting dismantling is performed by extraction working head. After extraction of the end fitting from the fuel channel, the final state of the channel is represented in Fig. 7.

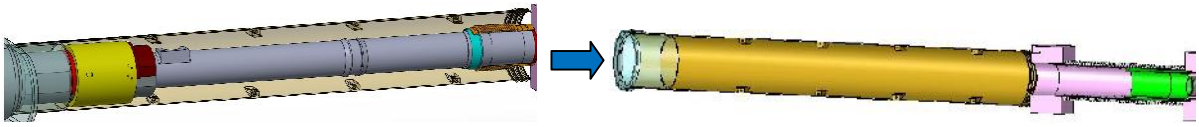

Figure 7: Representation of the channel state before and after end fitting extraction

After extraction operation of the end fitting from the fuel channel, shall be inserted the extended channel closure plug into the channel and now it is possible to remove the protective cylindrical screen (see Fig. 8).

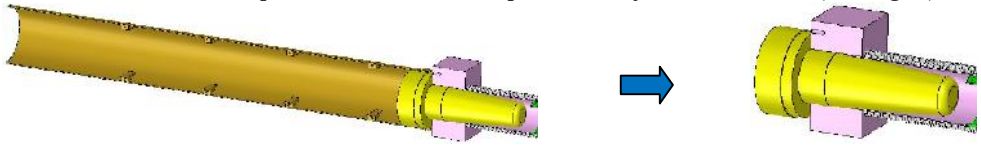

Figure 8: Representation of the channel state after mounting of the extended channel closure plug

2.6. Extraction of the Pressure Tube

This operation describes the procedure for the pressure tube (9) removing from fuel channel, performed by the working head (see Fig. 9). The operation is monitored by video camera mounted on top of working head.

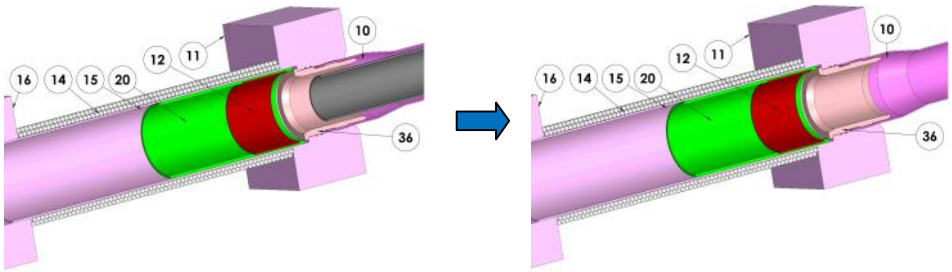

Figure 9: Representation of the channel before and after extraction of the pressure tube

After components extraction from the fuel channel, shall be inserted the extended channel closure plug into the channel and the final state of the channel is represented in Fig. 10.

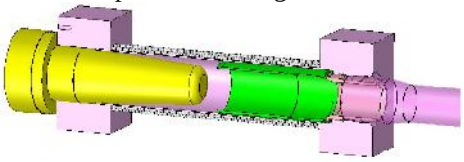

Figure 10: Representation of the fuel channel final state

The piece by piece dismantling of fuel channels components, shall be performed for all 380's fuel channels of the nuclear reactor. All dismantling operations shall be performed by a remote controlled decommissioning device.

3. CONCLUSIONS

The decommissioning of the fuel channels, which represent the final phase of nuclear facility decommissioning, refer to the administrative and technical actions taken to eliminate the facility from the nuclear field regulations.
The decommissioning of the fuel channels is a complex process that requires piece by piece removal activities of components, transport and storage in dedicated facilities, preparation of records and documents specific decommissioning operations.
The radiological safety analyses should be made by certified experts for protection assessment to radiation exposure of workers in time of fuel channel dismantling.
The dismantling operation stages of the fuel channel components are repeated for all the 380 channels of the reactor, from the front of calandria side (plane R) as well as the rear side (plane R').
The final aim of decommissioning is to recover the geographic site to its original condition.

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