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RESEARCHES FOR THE CANDU NUCLEAR REACTOR FUEL CHANNELS DECOMMISSIONING. PART 1 - DECOMMISSIONING DEVICE AND FUEL CHANNEL DISMANTLING PRESENTATION

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Abstract: *The objective of this paper is to present a possible method for horizontal fuel channels dismantling from calandria vessel, based on the knowledge referring to assembly the fuel channel into calandria, and a solution for a device designing for the decommissioning of the horizontal fuel channels in the CANDU 6 nuclear reactor. In the final phase of the nuclear reactor dismantling, the most important operation is the decommissioning of fuel channels. The nuclear reactor fuel channels decommissioning consists in a planning phase and the implementation of all dismantling procedures and operations. 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 device shall be designed according to the radiation protection procedures. The fuel channel decommissioning device is an autonomous device designed for dismantling and extraction of the channel closure plug and shield plug, extraction of the end fitting, cutting and extraction of the pressure tube. The fuel channel decommissioning device consists of following major components: coupling and locking fuel channel module, assembly valve for access to the fuel channel, storage tubes assembly for extracted components, handling elements assembly, cutting and extraction device and housing device. The decommissioning device assembly of the fuel channel components is composed of the device itself and moving platform support for coupling of the selected channel to be dismantled and is achieved according to the particular features of the fuel channel components to be dismantled. 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, device, decommissioning, dismantling, radiation protection, fuel channel*

1. GENERAL CONSIDERATIONS

The CANDU reactor decommissioning activities are dismantling, demolition, controlled removal of equipment, components, conventional or hazardous waste (radioactive, toxic) in compliance with the international basic safety standards on radiation protection. The nuclear decommissioning includes two phases: a planning phase and an implementation phase of all procedures and operations.
The fuel channels decommissioning represents one of the last operation which is performed in the nuclear power decommissioning and is performed according to the detailed schematic documentation of a the CANDU nuclear reactors fuel channel.
Many of the decommissioning activities involve the remote devices coordination to prevent the contact or some removed components proximity, of the operators.

2. THE DECOMISIONING DEVICE PRESENTATION

The design of the dismantling device is achieved according to the particular features of the fuel channel components to be dismantled in the program of nuclear reactor decommissioning.
Many of the decommissioning activities involve the remote devices coordination to prevent the contact of the operators with some removed components proximity.

2.1. General considerations

Considering the fuel channel complexity, at the design of the channels fuel decommissioning device for shall be taken into account the detailed fuel channel description and its components, the installation documents history from the operation period of the dismantled fuel channel, the proposed program description of the fuel channel dismantling and its components, the description of the quality assurance program, the monitoring program, the equipments and methods used to verify the compliance with the decommissioning criteria and the planning of performing the final radiological assessment at the end of the fuel channel decommissioning.

2.2. Device assembly components general presentation

The device assembly for fuel channel components decommissioning is composed of the device itself (1) and moving platform (2) that contains the device support assembly (3) for front alignment at the fuel channel (Figure 1).

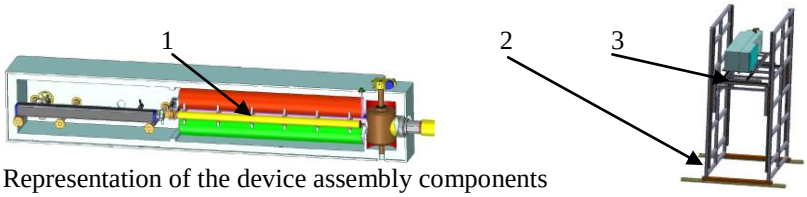

Figure 1: Representation of the device assembly components

The moving platform is necessary for moving in vertical and horizontal calandria plan and positioning in front of the fuel channel which shall be decommissioned.

The device support assembly is required for the positioning of the decommissioning device at the fuel channel which shall be dismantled, for coupling of the channel.

2.3. Decommissioning device components presentation

The decommissioning device for fuel channel components decommissioning is intended for the following operations performed at the fuel channel:

- the storage of the channel closure plug extracted from the end fitting;
- the storage of the channel shield plug extracted from the fitting end;
- the storage of the pressure tube extracted from the fuel channel;
- the storage of the end fitting.

The decommissioning device for fuel channel components decommissioning consists of the coupling and locking fuel channel module (1), the access valve assembly to the fuel channel (2), the storage tubes assembly for extracted components (3), the handling elements assembly (4) and the housing device (5), exemplified in Figure 2.

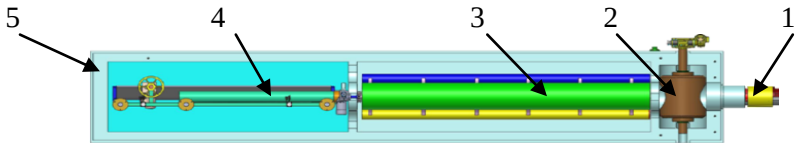

Figure 2: Representation of the fuel channel decommissioning device components

2.4. Coupling and locking module presentation

The coupling and locking module is a stand-alone device, for coupling and fixing the device at the fuel channel for performing the dismantling operations. The operation of the fuel channel coupling device is done manually by the operator. The coupling and locking module consists of the auxiliary closing piece (2), the locking cylinder (3), the safety seal (4) of the locking cylinder and is coupled to the fuel channel (1).

After fuel channel module coupling, is mounted a protective cylindrical screen, made of two semicircular pieces, closed with screws, covering the end fitting for the radiation protection of the operator, after extraction of the fuel channel end fitting, exemplified in Figure 3.

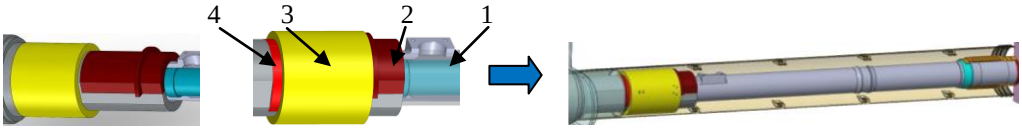

Figure 3: Representation of the coupling and locking module to the fuel channel

2.5. Access valve assembly presentation

The access valve is a structure which, by opening, enable the access of handling elements into the fuel channel to achieve the dismantling operations, and consist of the access valve itself (1), the valve actuator (2) and radiation detector (3), exemplified in Figure 4.

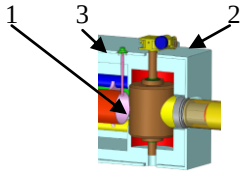

Figure 4: Representation of the access valve assembly

2.6. Handling elements assembly presentation

The handling elements assembly is composed of the sleigh assembly (1), the sleigh travel actuator (2), the stationary tube of the cutting and extraction device (3), connecting cable roller of the cutting and extraction device (4), the extracting actuator of the end fitting (5), exemplified in Figure 5.

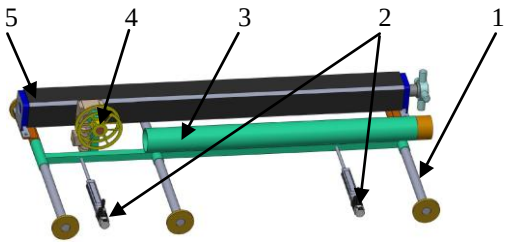

Figure 5: The handling elements assembly

The handling elements assembly can operate two positions in order to place one element front of the storage tube, one when the stationary tube it is in working and the second position is when the extracting actuator it is in working direction.

2.7. Cutting and extracting device presentation

The cutting and extraction device consists of the following modules: guiding-fixing module (1), traction modules (2), guiding-fixing module at cutting (3), cutting module (4), guiding-extracting module (5) articulated elements (6) for modules connecting and command cable (7), exemplified in Figure 6.

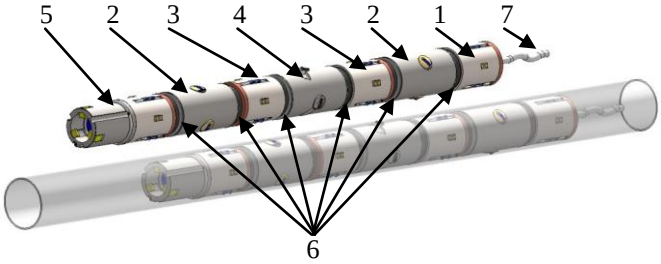

Figure 6: Representation of the cutting and extraction device components

The cutting and extraction device perform a forward/retreat movement along the Y axis and a rotational movement along the Y axis, so that it has two freedom degrees, exemplified in Figure 7.

Figure 7: Schematic representation of the cutting and extraction device degrees of freedom

2.8. Storage tubes assembly presentation

The storage tubes assembly is used to store the extracted components of the fuel channel, as a result of the dismantling operations. This assembly consists of the radiation detector (1), the Blue tube (2), the Red tube (3), the Yellow tube (4), the Green tube (5) and the gearmotor drive (6), exemplified in Figure 8.

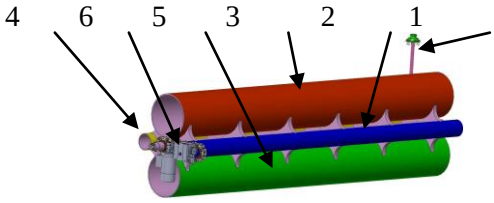

Figure 8: Representation of the storage tube assembly components

The storage tubes assembly is mounted on a shaft driven by a gearmotor to turning it in order to place a tube in front of the access valve for access to the fuel channel.
The storage tubes are used as follows, blue tube for storage of the pressure tube, red tube for the fitting end storage, yellow tube for storage of the channel closure plug and the channel shield plug and green tube for storage of the extended channel closure plug.

3. STEPS OF COMPONENTS DISMANTLING

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.
The fuel channels dismantling 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.

3.1. General considerations

Considering the fuel channel complexity at the design of the decommissioning device shall be taken into account the detailed fuel channel description and its components, the installation documents history of the fuel channel, adequate radiological criteria for decommissioning guidance, the proposed program description of the fuel channel decommissioning and its components, the equipments and methods used to verify the compliance with the decommissioning criteria.
The dismantling of fuel channel components is performed when the initial conditions are performed, no fuel bundles in the fuel channels, the cooling system should be power off and the facility dismantled and 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.
Dismantling of the fuel channel components is performed when the initial conditions are carrier out. 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 ').

3.2. Positioning Assembly dismantling

First step before start fuel of the channels decommissioning shall be the dismantling of the positioning assembly of all 380 fuel channels. The dismantling operation procedure of the fuel channel positioning assembly is manually performed by the operator, illustrated before and after removal in Figure 9.

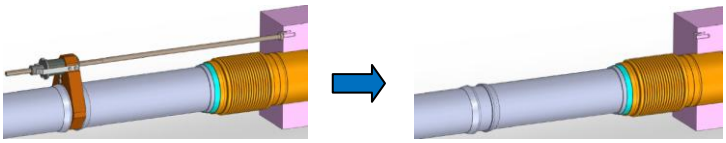

Figure 9: Representation of the positioning assembly before and after dismantling

The 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.

3.3. End Fitting components dismantling

The first operation is to mount a protective cylindrical screen which covering the end fitting for the radiation protection of the operator (see Figure 10).

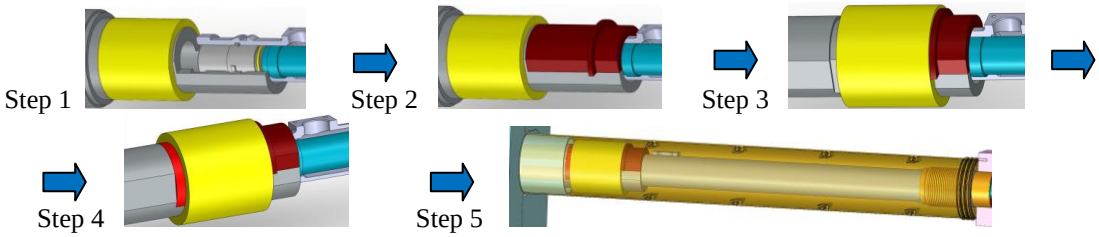

Figure 10: Representation of the device coupling steps and the protective cylindrical screen mounting

The operations procedure for end fitting components dismantling are the following:
- unlocking and extraction of the channel closure plug (1) and storage in the yellow tube (see Figure 11);

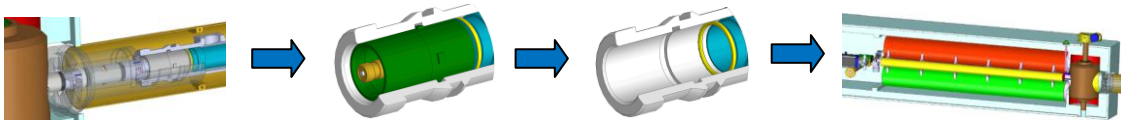

Figure 11: Representation of the channel closure removal

- unlocking and extraction of the shield plug (13) and storage in the yellow tube (see Figure 12);

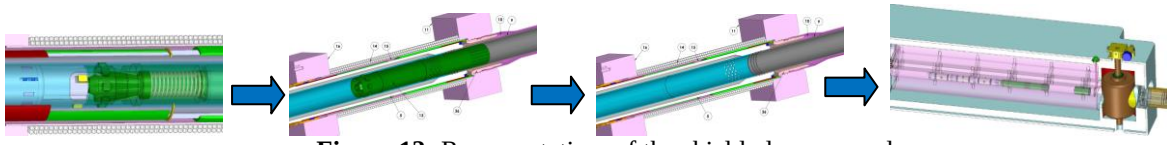

Figure 12: Representation of the shield plug removal

3.4. Pressure Tube cutting

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 Figure 13). The cutting operations are monitored by video camera and pyrometers for recording the temperature in the cutting rollers area.

Figure 13: Representation of cutting with rollers in the middle and to end of pressure tube

3.5. End Fitting extraction

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 Figure 14.

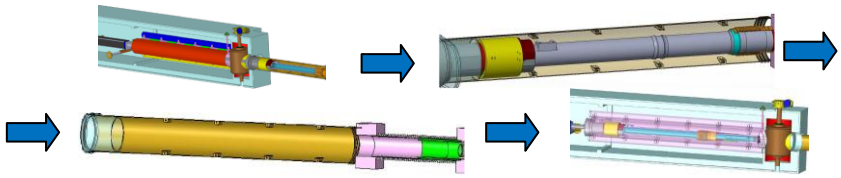

Figure 14: Representation of the channel state before and after end fitting extraction

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 Figure 15). After closing the access valve of the decommissioning device, the operator can prepare the pressure tube extraction stage.

Figure 15: Representation of the channel state after mounting of the extended channel closure plug

3.6. Pressure Tube extraction

This operation describes the procedure for the pressure tube (9) removing from fuel channel, performed by the working head (see Figure 16). The operation is monitored by video camera mounted on top of working head.

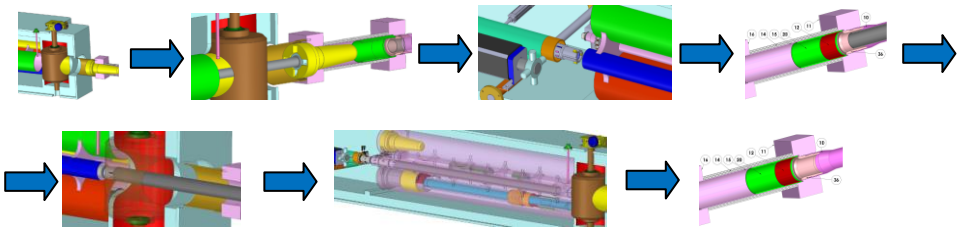

Figure 16: Representation of the channel before and after extraction of the pressure tube

After components extraction from the fuel channel, shall be inserted the extended channel closure plug into the channel and close the access valve of the decommissioning device. The closing operation of the fuel channel is necessary to ensure a radiation protection during the dismantling of the protective cylindrical sleeve. All operations are represented in Figure 17.

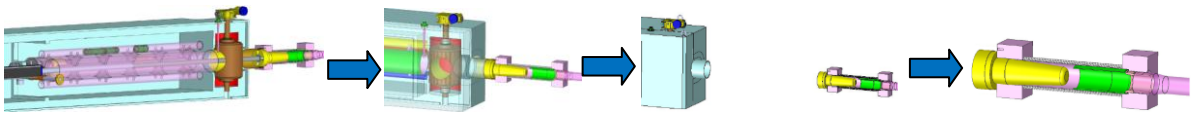

Figure 17: Representation of the fuel channel closing and final state

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. After dismantling of the fuel channel components, the charged decommissioning device is moved with the moving platform to the transfer position, at the transport container, for the decommissioned materials storage transfer.

4. CONCLUSIONS

The decommissioning of the fuel channels, which represent the final phase of nuclear facility decommissioning, 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 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 presented decommissioning device is a device that extracts the internal components of the horizontal fuel channels, ensuring a radiation protection during the stages of decommissioning.

The design of the device, moving platform and the device support assembly shall be achieved according to the particular features of the fuel channel components to be dismantled in the nuclear reactor decommissioning program, with respect of all security aspects, environmental protection during decommissioning activities and working procedures resulting from decommissioning plan developed.
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 final aim of nuclear reactor decommissioning is to recover the geographic site to its original condition.

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