CONSIDERATIONS FOR THE DEVELOPMENT OF A DEVICE FOR THE DECOMMISSIONING OF THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR.

PART 10 - PRESENTATION OF THE DECOMMISSIONING DEVICE OPERATING

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ABSTRACT: This paper presents a solution proposed by the authors in order to achieve of a cutting and extracting device operating panel for the decommissioning of the horizontal fuel channels in the CANDU 6 nuclear reactor.

The Cutting and Extraction Device (CED) is fully automated, connected by wires to a Programmable Logic Controller (PLC) and controlled from a Human Machine Interface (HMI).

The Cutting and Extraction Device (CED) performs the dismantling, cutting and extraction of the fuel channel components, moving with variable speed, temperature monitoring and video surveillance inside the pipe, unblock and extract the channel closure plug (from End Fitting - EF), unblock and extract the channel shield plug (from Lattice Tube - LT), block and cut the middle of the pressure tube, block and cut the end of the pressure tube, block and extract the half of pressure tube. All operations can be monitored and controlled from an operating panel.

The PLC fully command the device in automatic or manually mode, to control the internal sensors, transducers, electrical motors, video surveillance and pyrometers for monitoring cutting place temperature.

The device controller has direct access to the measured values with these sensors, interprets and processes them, preparing the next action after confirming the action in progress.

The design of the Cutting and Extraction Device (CED) shall be achieved according to the particular features of the fuel channel components to be dismantled and to ensure radiation protection of workers.

Key words: Candu reactor, fuel channel, decommissioning device, dismantling, operator panel, cutting, extraction

1. INTRODUCTION

The CANDU reactor decommissioning activities involve the remote devices coordination to prevent the contact or some removed components proximity, of the operators, in compliance with the international basic safety standards on radiation protection.

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. Many of the decommissioning activities involve the remote devices coordination to prevent the contact of the operators with some removed components proximity.
2. GENERAL OPERATING PRESENTATION OF THE DEVICE

The decommissioning device is a electromechanical system with many freedom degrees, capable to perform the extraction of the internal components of the horizontal fuel channels. All operations are performed under the control of a system equipped with a Programmable Logic Controller (PLC) and monitored by an operator panel type Human Machine Interface (Touch Screen HMI). The system is automated, each operation step shall be confirmed by the operator after its finalization, to preparing the next operation step.

2.1 General considerations

The device assembly for the fuel channel components decommissioning is composed of the device itself and moving platform that contains the device support assembly for front alignment at the fuel channel. The platform support, for moving and positioning device front of the fuel channel, is an assembly that can be moved vertically and horizontally, in parallel plane front of calandria, to the fuel channel to be decommissioned. The platform support for moving and positioning device has 2 freedom degrees due to the X-axis movement (horizontal movement) and Z axis (vertical movement), shown in Figure 1.

![Figure 1. Schematic representation of the platform support degrees of freedom](image)

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, as exemplified in Figure 2.

![Figure 2. Schematic representation of the cutting and extraction device freedom degrees](image)

In conclusion, the decommissioning device assembly can be compared to an industrial robot capable to execute handling operations, autonomously and automatically, under a control system, which has 4 freedom degrees, three movements on the X, Y and Z axis, as well as a rotational movement around the Y axis.
2.2 Automation block diagram of the device

The automation block diagram of the decommissioning device is exemplified in Figure 3.

The main functional blocks of the fuel channels decommissioning device are:
- control unit for operation and parameters visualization (equipped with PLC and Touch Screen HMI );
- control unit of the moving platform (equipped with motors, encoders, limit switches);
- control unit of the access valve opening/closing (equipped with actuator, proximity switches);
- control unit of the storage tubes assembly rotating (equipped with motors, encoders, limit switches);
- control unit of the handling elements assembly movement (equipped with actuators, proximity switches);
- control unit for the connecting cable roller of the cutting and extracting device;
- control unit of the cutting and extracting device (equipped with motors, actuators, encoders, limit switches, position switches, video camera, pyrometers);
- control unit for the radiation level monitoring of the dismantled components (equipped with radiation sensor and parameters visualization operator panel);

2.3 Device hmi operator panel operating

The decommissioning device operations are performed under the control of a system equipped with a Programmable Logic Controller (PLC), monitored by an operator panel type Human Machine Interface (HMI) and for the radiation level monitoring by an specialized operator panel.

In the Touch Screen HMI operator panel are designed, using specialized software, viewing and operating screens of the decommissioning stages. The operating structure screens are designed on three operating levels.

2.3.1 Level 1 - startup screen

The Level 1 in the Touch Screen HMI operator panel are represented by main screen (Figure 4). In this page it is possible to turn to the level 2 screens operation, the calandria stage operations screen, the decommissioning device stage operations and the alarms screen.

![Figure 4. Schematic representation of the HMI startup homepage](image-url)
2.3.2 Level 2 screens

The Level 2 screens in consists of the following screens:

1. The calandria fuel channels plan screen.

   In this page the operator performs the following operations (Figure 5):
   - selection of the front or rear of the calandria;
   - selection of the fuel channel to be dismantled;
   - vertical and horizontal movement of the platform device to the fuel channel selected, movement monitored by encoder value;
   - confirmation of the performed operation to preparing the next operation step.

![Figure 5. Schematic representation of the calandria fuel channels plan screen](image)

2. The general decommissioning device screen.

   In this page the operator performs the following preliminary operations (Figure 6):
   - coupling and confirmation of the manual coupling operation finishing;
   - opening/closing of the device access valve;
   - tube selection by turning of storage tubes assembly in the working position;
   - execution element selection by movement of the handling elements assembly in the working position;
   - screen selection for working with one of the handling elements;
   - selection of the cutting and extraction device screen for plugs extraction and cutting operations and the extracting actuator screen for end fitting extraction extended channel closure plug mounting.
3. The general alarms screen.

In this screen the operator visualize and acknowledges the faults appearance when the fuel channel decommissioning operations are performed (Figure 7).

![Figure 6. Schematic representation of the general decommissioning device screen](image)

![Figure 7. Schematic representation of the general alarms screen](image)

The 5 classes of alarms, "Warnings", "Urgent", "High", "Medium" and "Low Errors" are exemplified in Figure 8.
2.3.3. Level 3 screens

The Level 3 screens in consists of the following screens:

1. The extraction and cutting device screen.

In this page the operator performs the following operations with the extraction and cutting device (Figure 9):
- selection of the operation step to be performed;
- moving of the extraction and cutting device to the set-point value position;
- blocking the extraction and cutting device in the working position;
- extraction of the channel closure plug from the fuel channel;
- extraction of the shield plug from the fuel channel;
- cutting of the pressure tube in the middle and at the end of the pressure tube at the joint with the end fitting;
- extraction of the pressure tube from the fuel channel and storage in the storage tubes assembly;
- confirmation of each finalization step in order to perform the next operation step.
2. The extracting actuator screen.

In this page the operator performs the following operations with the extracting actuator (Figure 10):
- selection of the operation step to be performed;
- moving of the extracting actuator to the set-point value position;
- extraction of the end fitting from the fuel channel;
- mounting / removal of the extended channel closure plug to / from the fuel channel;
- confirmation of each finalization step in order to perform the next operation step.

![Figure 10. Schematic representation of the extracting actuator screen](image)

2.3.4 Radiation level monitoring screen

The radiation level monitoring operator panel, mounted on the front of the control cabinet and connected to the radiation sensor, is necessary for the radiation level monitoring of the each extracted components from the fuel channel (Figure 11). It performs radiation level measurement, parameters calculating, reading and writing the parameters in the memory panel, achieving radiation levels tables for each fuel channel decommissioned component and PC coupling for data transmission, statistics achieving and them archiving.

![Figure 11. Schematic representation of the radiation level monitoring](image)
2.3.5 Video displays monitoring

For monitoring the decommissioning operations of the fuel channel components are required for video cameras for the dismantling steps surveillance performed by the cutting and extraction device, and the extraction actuator (Figure 12). The supervision of these operations need three cameras mounted in the following positions:
- a video camera in the cutting and extraction device, into the cutting module for monitoring the process of the pressure tube cutting;
- a video camera in the cutting and extraction device, into the extraction module for monitoring the extraction channel closure plug, shield plug and pressure tube;
- a video camera in the device for monitoring the extraction of the extended channel closure plug.

![Figure 12. Schematic representation of the video display monitoring](image)

3. CONCLUSIONS

The process of the fuel channels decommissioning requires piece by piece removal activities of the components, radiation protection of the operators during the dismantling, transport and storage in the dedicated facilities, records and specific documents preparation of the decommissioning operations.

The mechanical design, automation and software programs of the device 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, working procedures, ensuring a radiation protection of the operating personnel, environmental protection during the stages of decommissioning activities resulting from decommissioning plan developed.

4. REFERENCES

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