New method for the decontamination of labyrinth seals of control rod drives (CRD) - 14167

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About Paks NPP

The Paks Nuclear Power Plant is located in the middle of Hungary, 115 km from Budapest at the bank of Danube. Four VVER-440/213 type units are operating here with a total nominal electrical power of 2000 MW, producing more than 40 % of the electrical energy generated in Hungary.

INTRODUCTION

The power output of the reactor is regulated by the movement of safety and control rods. During operation - as some areas are in direct contact with the primary side heat transfer medium that has a temperature of 296°C (565°F) - the temperature of the control rod drives (CRD) may reach 200°C (392°F). The temperature of the drive motor shall not exceed 100°C (212°F) therefore the space where the motor is located needs cooling. The labyrinth seals reduce the natural circulation forming between the upper cooled area and the lower hot environment, however the continuous extreme heat difference may cause thermic fatigue and cracks in them (Figure 1).

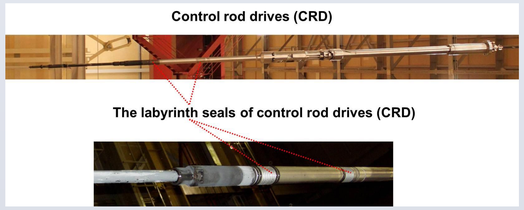

Figure 1. The control rod drives (CRD) and the labyrinth seals of CRD

The components of the CR drives that are in contact with the 296 °C water of the primary circuit are decontaminated by moving cathode electrochemical method before material testing and maintenance [1] (Figure 2). Following the material testing drives may only be reinstalled after a function test.

In the early 2000s modernized CRD-s were installed. Two years ago defects were detected in the labyrinth seals of these drives, therefore status inspection required for these modernized CR drives.

Due to the large number of CR drives, the shortness of the time available, and the relatively long time inspection required for each drive, a new method of inspection had to be developed.

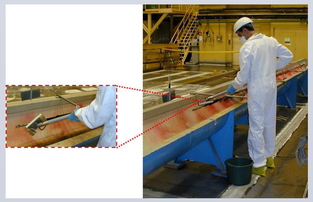

Figure 2. Manual electrochemical decontamination of CRD

DISCUSSION

Decontamination requirements for the labyrinth surfaces of CR drives

Using this new status inspection method the most time can be saved by performing decontamination in the vertical position of the drive, as in case of undamaged drives the time required for moving, laying and lifting, as well as the time for the function test can be saved (several hours) [2].

During planning the condition inspections of CR drives the following requirements for decontamination were defined:

- shortest possible time required for decontamination,
- decontamination in the vertical position of the drives,
- decontamination shall not have an effect on the integral structural elements of the drive,
- decontamination only of the sealing plane of the labyrinth seals, providing clear metal surface,
- dose received by staff during decontamination and material testing shall be reduced to the minimum.

As the current available methods [3, 4] for the required decontamination were not applicable, therefore we developed the following new method:

- a cell was constructed from two half-cylinders,
- the cell was securely and tightly installed onto the CRD preventing the leakage of electrolyte,
- auxiliary components assisting the operation of the cell were integrated into a complex device,
- the equipment was installed onto the 01-02TU10B001 decontamination bath,
- the CRD was hoisted by the reactor hall crane during decontamination.

The decontaminating equipment for the labyrinth seals of the CR drives

The main components of the equipment: base frame, moving frame, electrolytic tank (electrolyzing cell), electrical connections, and electrolyte-circulation (Figure 3).

The fixed frame is the base frame of the decontaminating equipment for the labyrinth seals of the CR drives made of acid-resistant stainless steel.

The moving frame contains the electrolytic tank and the connecting components. The moving frame is attached to the base frame with pneumatic cylinders (that act as bellows) and positioning bolts, the connection is not rigid. The task of the pneumatic cylinders is to reduce the effects of a possible vertical movement after the closing of the electrolyser cell.

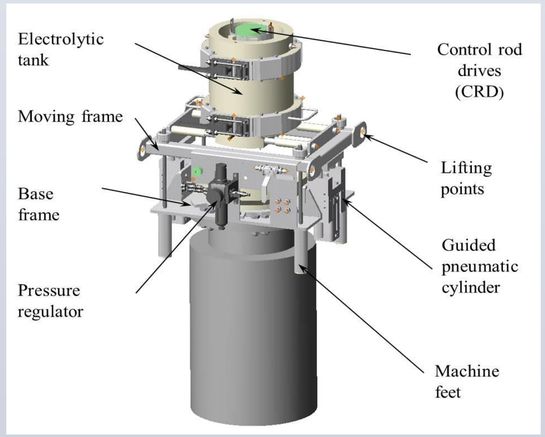

Figure 3. Schematic picture of the decontaminating equipment

The galvanic cleaning process takes place in the electrolyser cell (electrolytic tank) (Figure 4).

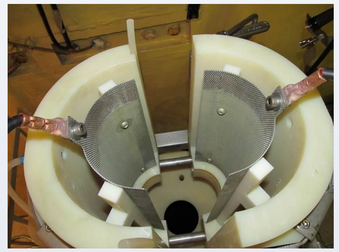

Figure 4. Electrolyser cell

Experience gained from the application of the new CRD labyrinth seal decontaminating equipment

The labyrinth decontaminating equipment operated in accordance with the plans, the effectiveness of decontamination was as required. The clean metal surface of the labyrinth groves was suitable for material testing (Figure 5 and 6).

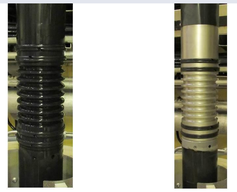

Figure 5. The effectiveness of decontamination

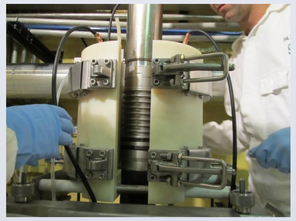

Figure 6. The CRD labyrinth thread after decontamination

Decontamination and material testing did not result in additional dose for the executing personnel (Figure 7) due to shielding of high dose areas and the relatively sparse and short manual labor. Those who spent the most time near the CR drives received about 30-40 μSv dose during an 8-hour shift.

Figure 7. Dose measurement during the decontamination of the labyrinth threads

CONCLUSIONS

In the beginning of the year 2012 failure was found of the lower threads of a number of CRD labyrinth cases. The arised failure required prompt inspection for all the CR drives, which demanded the development of a new decontamination technique for the CRD labyrinth seals necessary.

The new decontamination process had to fulfill special requirements. Decontamination had to be performed in the shortest time possible, in the vertical position of the drives without affecting the integral structure of the drives, and provide clean metal surface on the labyrinth seals for material testing.

The previously used decontamination methods had to be rejected as they did not fulfill the special requirements. According to the new method an electrolyser cell of two half-cylinders was installed around the section of the labyrinth seals; were the decontamination is carried out by immersion electrochemical method.

CRD was lifted and held between the two half-cylinders of the electrolyser cell by a crane during decontamination and material testing. There was no need to lay the CR drives into horizontal position; therefore the time required for laying, lifting and testing was saved.

During the decontamination on Unit 4 approximately 2 m^3 low level liquid radioactive waste was generated, but no high activity solid waste associated with the previous method (felt sheets from the manual moving cathode) was produced.

Decontamination and material testing did not result in significant dose for the executing personnel; the dose did not exceed 30-40 μSv/person/shift.

The new decontamination method reduced the time necessary for the condition inspection of CRD labyrinth seals by three quarters, which made possible the execution of inspections within the planned outage period of each unit.

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