Chemical System Decontamination at PWR Power Stations Biblis A and B by Advanced System Decontamination by Oxidizing Chemistry (ASDOC_D) Process Technology - 13081

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ABSTRACT

For chemical decontamination of PWR primary systems the so called ASDOC_D process has been developed and qualified at the German PWR power station Biblis.

In comparison to other chemical decontamination processes ASDOC_D offers a number of advantages:

- ASDOC_D does not require separate process equipment but is completely operated and controlled by the nuclear site installations. Feeding of chemical concentrates into the primary system is done by means of the site´s dosing systems. Process control is performed by standard site instrumentation and analytics
- ASDOC_D safely prevents any formation and precipitation of insoluble constituents
- Since ASDOC_D is operated without external equipment there is no need for installation of such equipment in high radioactive radiation surrounding. The radioactive exposure rate during process implementation and process performance may therefore be neglected in comparison to other chemical decontamination processes
- ASDOC_D does not require auxiliary hose connections which usually bear high leakage risk

The above mentioned technical advantages of ASDOC_D together with its cost-effectiveness gave rise to Biblis Power station to agree on testing ASDOC_D at the volume control system of PWR Biblis unit A. By involving the licensing authorities as well as expert examiners into this test ASDOC_D received the official qualification for primary system decontamination in German PWR. As a main outcome of the achieved results NIS received contracts for full primary system decontamination of both units Biblis A and B (each 1.200 MW) by end of 2012.

INTRODUCTION

NIS together with NCT has developed the advanced chemical process ASDOC_D for decontamination of reactor primary systems. The target for this development was to develop chemical process logistics which avoid known disadvantages of standard decontamination technologies like e.g. formation and precipitation of oxalates and manganese dioxide including generation of oxide particles from existing oxide layers as well as precipitation in dead legs which can produce high dose rates especially in the NPP auxiliary systems.

The developed process logistics also eliminate all external decontamination equipment and therefore any organic hose connections between external equipment and the nuclear system.

The outcome of this development is the ASDOC_D process which utilizes the power station´s systems and controls to perform the decontamination process. With ASDOC_D the process chemicals are injected into the reactor primary system via the site´s dosing installations. The process solutions are circulated through the primary system by normal reactor system operation. Dissolved ions and nuclides from the primary system´s oxide layers are removed by means of the site´s ion exchange water clean - up system.

During all phases of development, ASDOC_D was consequently benchmarked against worldwide known chemical decontamination processes (more than 50).

ASDOC_D offers a convincing and safe execution of the decontamination process because the process is non-susceptible to temperature, pressure and flow fluctuations. The process may be interrupted and restarted at any arbitrary moment.

The oxide layer and therefore all contamination inside the primary system are removed by distinctly controllable and well defined steps. The process can precisely be terminated at the interface between oxide layer and bulk material. Therefore there is no risk to dissolve material from below the oxide layer (e.g. activated metal).

In a co-operation between RWE and NIS the ASDOC_D process was qualified at the 1200 MW PWR Biblis A unit by a test-decontamination of the volume control system.

Decontamination of the volume control system started in early March 2012 and was terminated in June 2012.

During testing the process underwent all required licensing procedures like long term material testing, safety analyses and post examination of the system after decontamination.

DESCRIPTION

The main components of the volume control system which were exposed to the chemical decontamination were:

- The recuperative heat exchanger
- The high pressure coolers

- The high pressure circulation pump
- The volume control tank

The flow chart of the decontamination circuit is shown in fig.1.

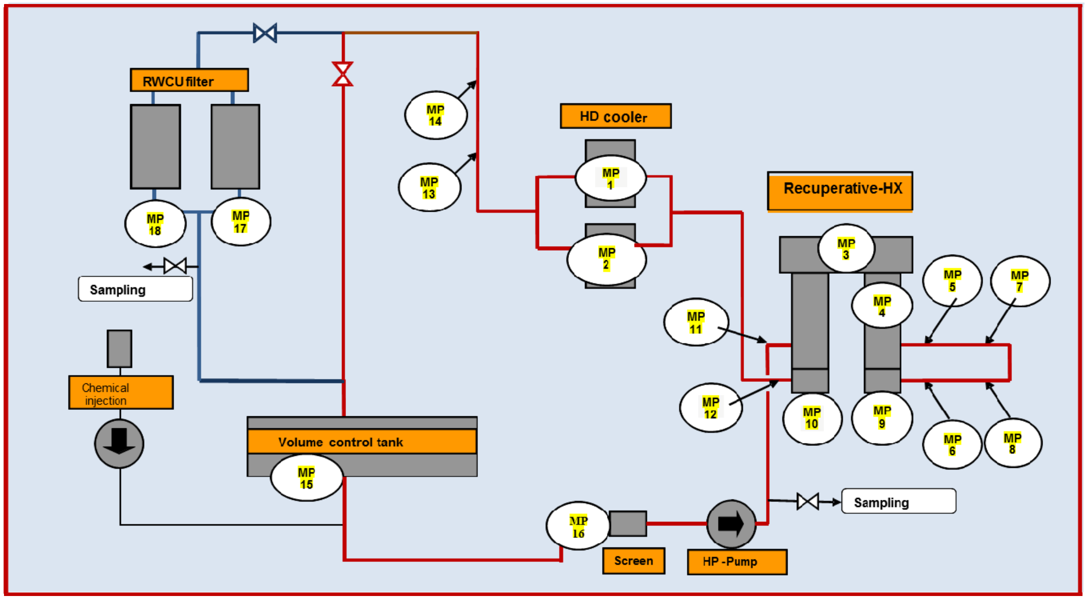

Fig. 1 Flow chart of the volume control system PWR Biblis unit A

Connected to the volume control system were the ion exchange columns of the RWCU filter (**R**eactor **W**ater **C**lean-up **U**nit) and the chemicals make up and injection system (represented by the injection pump in fig.1). During decontamination the volume control system was separated from the primary system by closing the isolating valves. The chemical process solution was then circulated through the volume control system and periodically passed through the ion exchange filters in order to remove ions chemically dissolved within the volume control system.

The decontamination procedure was divided into a certain number of separate process steps consisting of chemicals injection, dissolution of oxides, and cleaning by ion exchange.

The test target was demonstration of the general ASDOC_D performance. It was not intended to achieve an optimum decontamination factor (this was left to the later on intended full system decontamination into which the volume control system will be included again). It was agreed to terminate the test decontamination after arrival at a decontamination factor of about 10).

The volume control system of Biblis unit A had been decontaminated several times before by standard chemical decontamination as well as by high pressure water jet cleaning. Some isolated hot spots as well as a general contamination level equivalent to some mSv/h characterized the radiological situation at the beginning of the ASDOC_D test decontamination.

The decontamination progress was controlled by 16 dose rate meters installed along the volume control system. Most of the dose meters were attached to the recuperative heat exchanger.

For process control the outlet line of the ion exchange columns was also equipped with dose rate meters. Between high pressure circulation pump and inlet of the recuperative heat exchanger water sampling was provided for control of chemical parameters.

Results

12 separate ASDOC_D process steps were performed within 20 days including final cleaning of the system.

A maximum decontamination factor (ratio of initial dose rate to final dose rate) of 23 could be achieved at the upper bend of the recuperative heat exchanger. At other measuring points (starting with dose rates << 1 mSv/h) the dose rate leveled off into the general background radiation level.

Besides this obvious successful decontamination performance the precise dissolution of the system´s oxide layer could be demonstrated. In contrast to standard chemical decontamination technologies ASDOC_D operates with very small amounts of chemicals which are consumed during the chemical reactions on a stoichiometric basis, leaving no excess chemicals in the system. Fig. 2 shows the dissolution of the oxide layer during the course of the separate process steps. The figure demonstrates the regular amount of oxide removal and the continuous increase of total dissolved oxide.

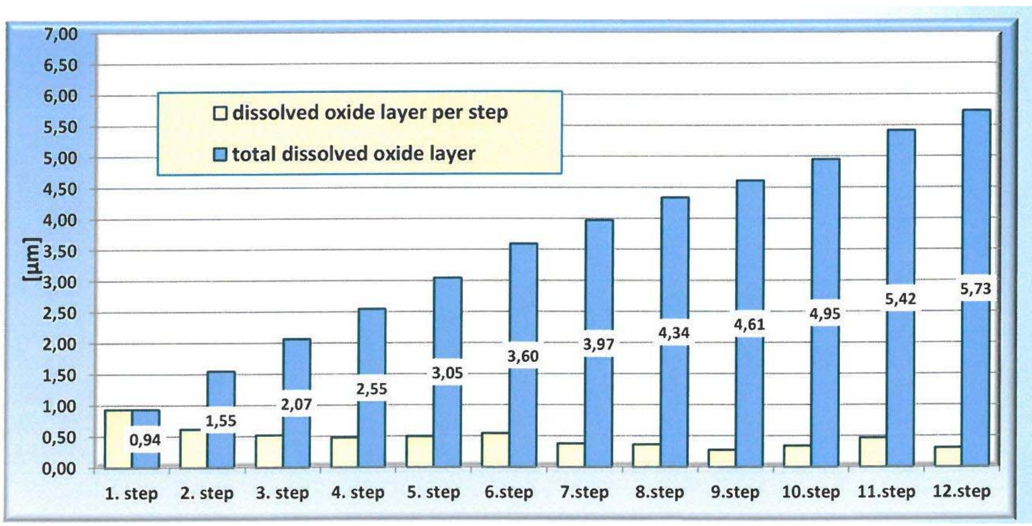

Fig.2 Dissolution of the oxide layer in the course of ASDOC_D process steps

Particle generation during decontamination was observed by analyses of water samples during the process as well as by control of the inlet particle filter of the high pressure circulation pump. No particle release could be observed.

The achieved dose for the test decontamination campaign was roughly 3 mSv. 2.5 mSv of these were achieved during the final inspection program while the decontamination itself only consumed 0.5 mSv.

After final cleaning of the system by flushing with demineralized water, the system was opened for inspection. Inspection was performed under observation of the licensing authority and technical experts. The inner system surfaces (recuperative heat exchanger and e.g. valves) looked shiny represented by fig. 3.

Smear samples were taken for evaluation of the residual contamination.

Fig.3 Interior surface condition (metallically clean) of a valve housing after ASDOC_D decontamination

No shift in the ratio of gamma contamination to alpha contamination could be found.

The results of the test decontamination were summarized in a final report which was analyzed by the licensing authority and the technical experts. Approval of the ASDOC_D qualification for PWR primary system decontamination has been declared.

CONCLUSIONS

The chemical decontamination of PWR Biblis unit A volume control system by means of the ASDOC_D process has demonstrated the capabilities of this process. All its advantages described above could be proved without restrictions.

As a consequence of this result NIS has meanwhile been contracted with the decontamination of PWR Biblis unit A and unit B primary system by means of ASDOC_D. All licensing documents required for this task have been prepared and forwarded to the licensing authority. Decontamination of Biblis unit A will start in April 2013 while decontamination of unit B will follow in September 2013.