SYSTEM DECONTAMINATION AS A TOOL TO CONTROL RADIATION FIELDS

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ABSTRACT

Since chemical decontamination of the Reactor Coolant Systems (RCS) and subsystems has the highest potential to reduce radiation fields in a short term this technology has gained an increasing importance. The available decontamination process at Siemens, i.e. the CORD process, will be described. It is characterized by using permanganic acid for preoxidation and diluted organic acid for the decontamination step. It is a regenerative process resulting in very low waste volumes. This technology has been used frequently in Europe and Japan in both RCS and subsystems. An overview will be given i.e. on the 1993 applications. This overview will include plant, scope, date of performance, system volume special feature of the process removed activities, decon factor time, waste volumes, and personnel dose during decontamination. This overview will be followed by an outlook on future developments in this area.

INTRODUCTION

The chemical decontamination process CORD (Chemical Oxidation Reduction Decontamination) of the Siemens Power Generation Group has successfully demonstrated in recent years its dose rate reduction capabilities during large scale technical applications. Table 1 for example summarizes the decontamination projects performed by Siemens in 1993 in Europe and in Japan. It is shown that in this calendar year 33 field applications at components and subsystems were performed. In addition, two major studies for Full System Decontamination (FSD) were awarded to Siemens.

A general experience related to decontamination is: the greater the surface of the system or subsystem , the greater the effect regarding

- Dose rate reduction, especially the area dose rate
- Recontamination.

This can be proven for example by the decontamination and recontamination results generated in the Wuergassen power station as shown in Figure 1.

Table 1. Siemens Decontamination Projects Performed in 1993

Plant	Type of Reactor	OEM	Component / System
Fukushima 2	BWR	GE/Toshiba	Regnerative Heat Exchangers
Fukushima 3	BWR	GE/Toshiba	Regenerative Heat Exchangers
Fukushima 5	BWR	MHI/Westingh.	Regenerative Heat Exchanger
Cofrentes	BWR	GE	Recirculation System Recirculation Pump Reactor Water Clean Up System
Oskarshamn 1	BWR	ASEA	Reactor Water Clean Up System Residual Heat Removal System Feed Water System
Grafenrheinfeld	PWR	KWU	Reactor Coolant Pump
Isar1	BWR	KWU	Reactor Water Clean Up System Bearing Water Supply System for Internal Axial Flow Pumps
Krümmel	BWR	KWU	Fuel Pool Cooling System Reactor Water Clean Up System
Krümmel	BWR	KWU	RPV-Nozzles
Philippsburg 1	BWR	KWU	Reactor Water Clean Up System Bearing Water Supply System for Internal Axial Flow Pumps
Isar 1	PWR	KWU	Reactor Coolant Pump
Biblis B	PWR	KWU	Reactor Coolant Pump
Hamaoka	BWR	GE/Toshiba	Recirculation Loops
Fukushima 6	BWR	GE/Toshiba	Reactor Water Clean Up Pumps
Trillo	PWR	KWU	Reactor Coolant Pumps
Kahl	BWR	KWU	Full System Decontamination
Brunsbüttel	BWR	KWU	Internal Axial Flow Pumps Reactor Water Clean Up System Bearing Water Supply System for Internal Axial Flow Pumps
Biblis A	PWR	KWU	Reactor Coolant Pump
Beznau 1	PWR	Westinghouse	Main Loop Sections
Doel 3	PWR	Westinghouse	Main Loop Sections
Mihama 2	PWR	MHI/Westingh.	Main Loop Sections
Oskarshamn 1	BWR	ASEA	Full System Decontamination Study
Loviisa	WWER	AEE	Full System Decontamination Study

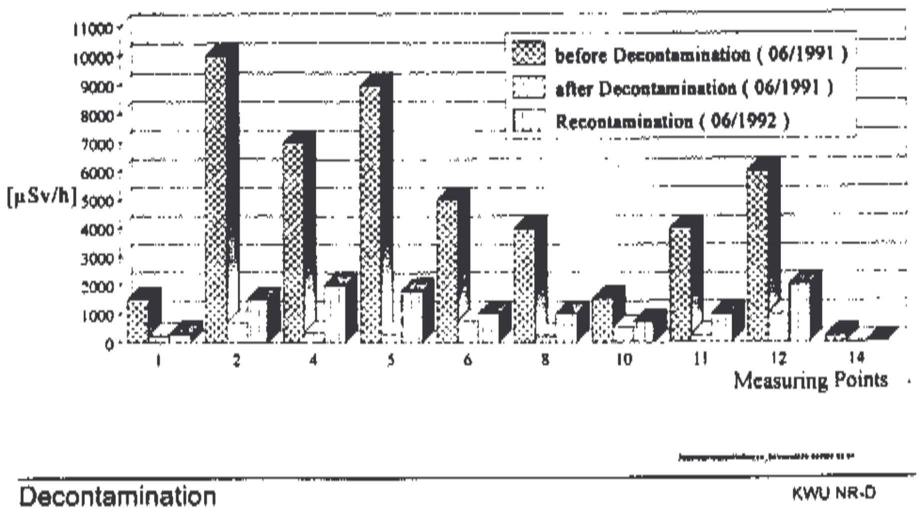
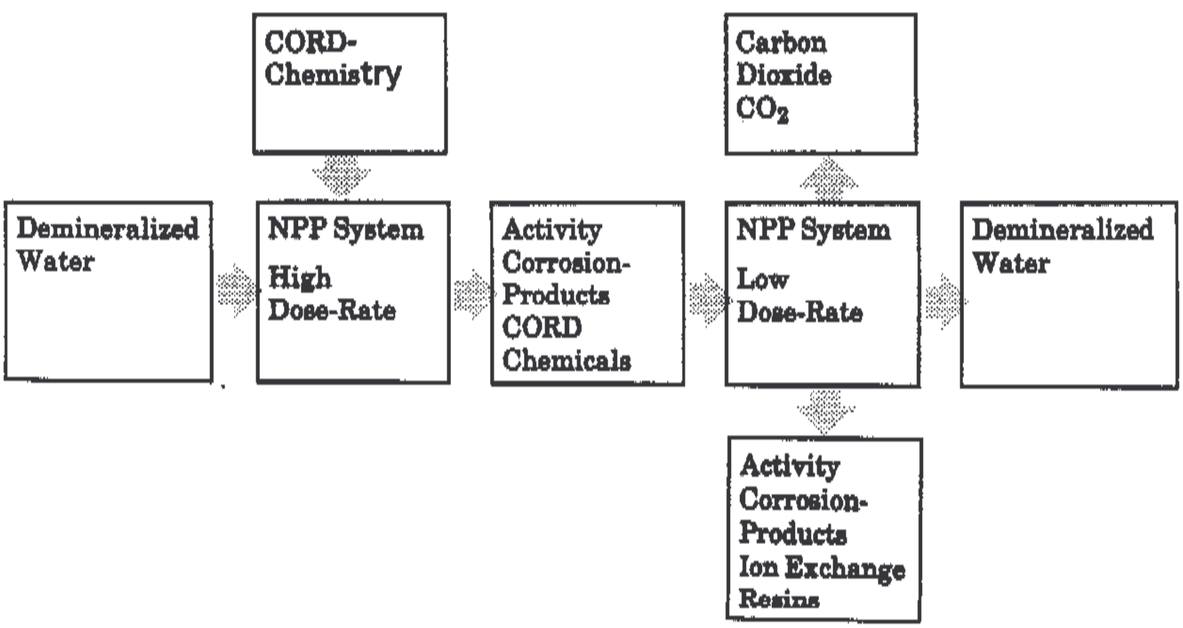


Figure 1. NPP-Würgassen
Recontamination of the Recirculation Loop No 2
after CORD-Decontamination

THE CORD/UV CONCEPT

A description of the CORD process is given in the attached paper of Wille and Sato [1] The present paper shall describe the most updated version of the CORD process and some application features. This combination of the chemistrry of the process and the application technology results in the CORD/UV-concept as described in the flow-chart as shown below

CORD/UV - Concept



The reactor system having high radiation field will be filled with demineralized water (one fill) and the CORD chemicals will be injected according to the work procedure. At the end of one CORD-phase (preoxidation + decontamination step) the fluid will contain the activated corrosion products, inactive corrosion products and the CORD chemicals. The next part of the overall concept is to decompose the CORD chemicals into water and carbon dioxide while removing the activity and the corrosion products via ion exchange resins. Through this procedure demineralized water will be left inside the decontaminated system having a water quality close to the make-up water that was filled originally into the system.

RECENT FIELD EXPERIENCE

Recent field experiences with the CORD/UV-concept are summarized in detail in Attachments 1 to 4. They describe the detailed results of

- Oskarshamn 1 — RWCU, RHR, Feedwater System
- VAK — FSD
- Hamaoka — RRL (both loops simultaneously)
- Oskarshamn 1 (OKG-1) — FSD.Because it is not possible to describe all these applications in all aspects, emphasize shall be given to the latest project, the FSD at OKG-1 (see also Reference).[2]

The decontamination measures at OKG 1 became necessary in order to permit extensive inspection and repair work in the reactor pressure vessel. Prior to the decision to decontaminate, the operator of OKG-1 as well as the Swedish Licensing Authorities requested extensive proof of qualification. This means in advance decontamination tests were done with original parts taken from the activated area of the reactor pressure vessel. Bent beam samples of these decontaminated parts (AISI 304 with a 316 weld) were placed into an autoclave and then again exposed to the operating conditions of a boiling water reactor. According to a previously agreed examination sequence, the samples were finallly microsectioned and metallographically examined for surface changes by Studsvik (Sweden).

Based on the positive findings, the CORD process was qualified for RPV decontamination by the licensing authority ands selected for application by OKG-1.

The total system volume amounted to approximately 160 m^3. The process was applied in such a way that the decontamination could be carried out with only one fill of demineralized water and also with plant internal equipment (pumps, heaters, ion exchangers) (see Figure 2).

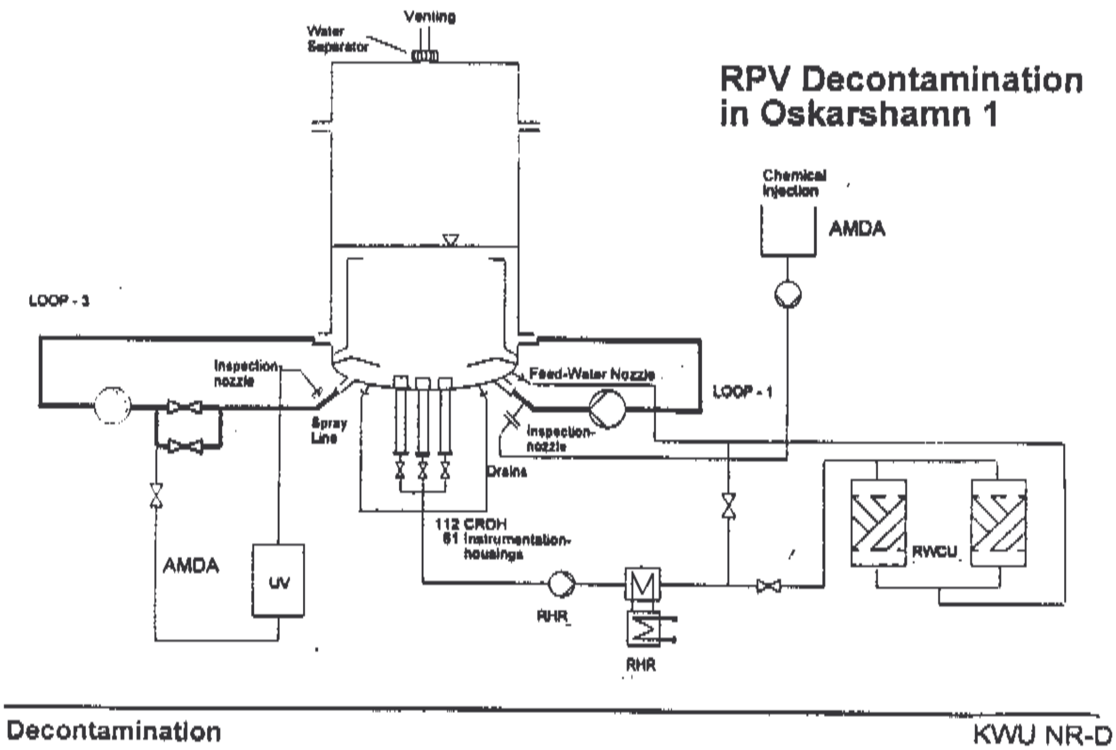
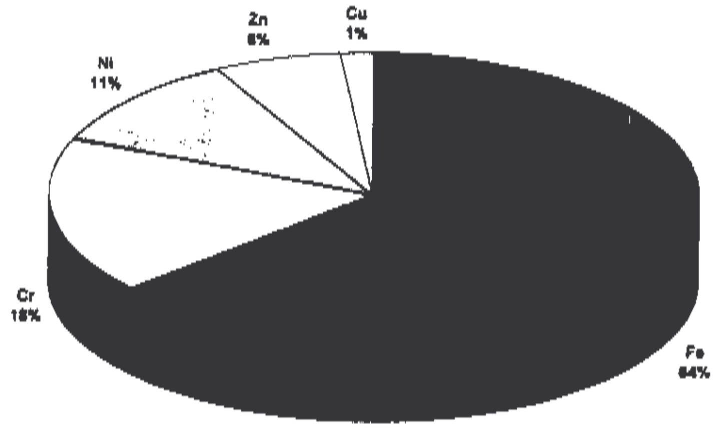


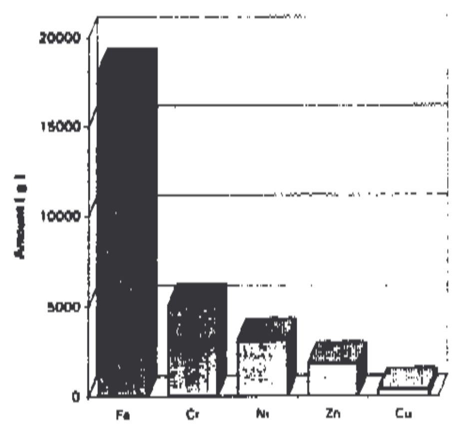
Figure 2. Full System Decontamination CORD/UV Technique

Additional external AMDA (Automated Mobile Decontamination Appliance) components were only supplied by Siemens for chemical injection and for the oxidative decomposition of the decontamination chemicals. The system water had again demineralized water quality (1.5 µS/cm) after completion of the decontamination process. 2.0 m^3 of ion exchange resin in the reactor water cleanup system adsorbed the removed activity (approx. 2.3 E12 Bq) and the dissolved metal ions (approx. 30 kg Fe, Cr, Ni). During decontamination, an oxidative treatment decomposed the decontamination chemicals completely to CO_2, i.e. no ion exchange resins were required for the removal of the decontamination chemicals (see Figures 3 to 6).



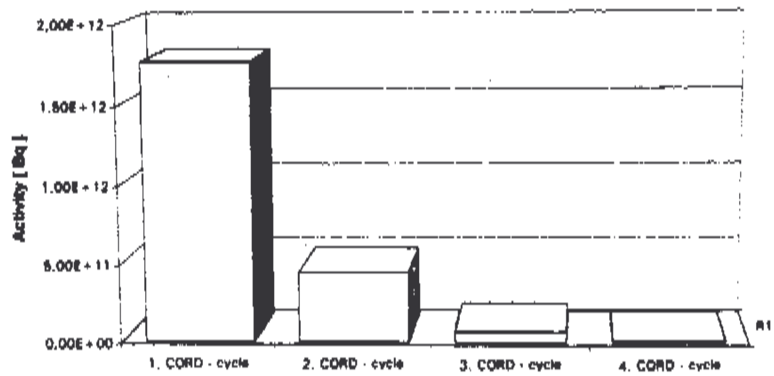
Decontamination KWU NR-D

Figure 3. NPP Oskarshamn 1 - 1994
Full-System Decontamination
Relation of removed Cations



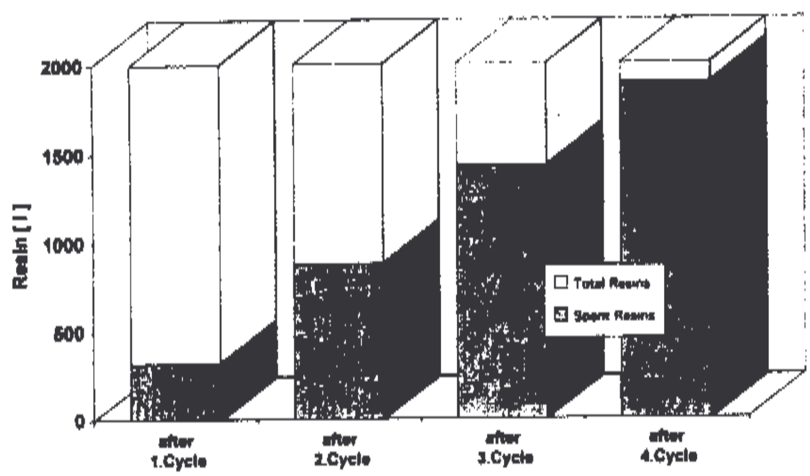
Decontamination KWU NR-D

Figure 4. NPP Oskarshamn 1 - 1994
Full-System Decontamination
Cation output after 4 CORD-cycles



Decontamination KWU NR-D

Figure 5. NPP Oskarshamn 1 - 1994
Full-System Decontamination
Activity Output depending on the CORD-Cycles

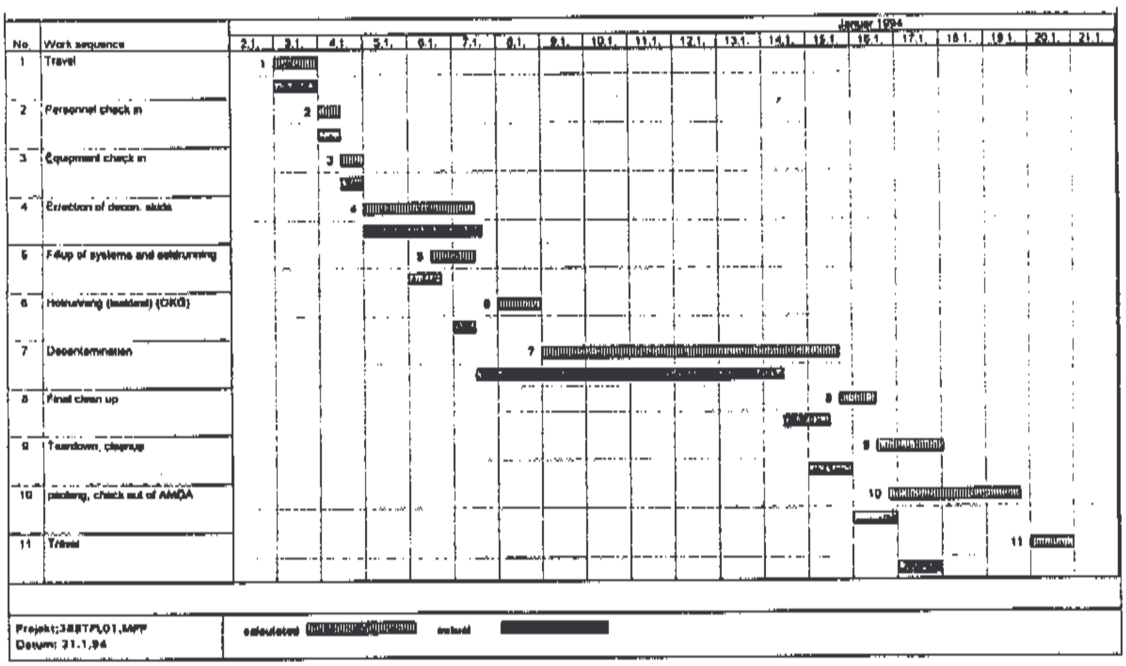


Decontamination KWU NR-D

Figure 6. NPP Oskarshamn 1 - 1994
Full-System Decontamination
Total Waste Generation

Approximately 20 OKG-1 employees and 9 Siemens employees were taking part during the decontamination. All interfacing and modification work in the power plant was done by OKG-1 personnel. A total of approx. 600 new temporary external interface points or flange connections were required. Siemens AG was responsible for installation of the AMDA components and for performance of the overall decontamination work. The excellent preparatory work done by OKG-1 and the very close and amicable team work between OKG-1 and Siemens personnel was a very important factor towards the excellent decontamination result. This contributed clearly towards the substantial shortening of the time frame scheduled (see Table 3).

Table 3. NPP Oskarshamn 1 Decontamination of the RPV and the 4 Loop's



After decontamination, the area of the RPV to be examined was again cleaned with high pressure water. First measurements taken after the decontamnation resulted in a smearable residual activity of approx. 4 Bq/cm^2 and a dose rate of only 15-20 µSv/h. This extreme low dose rate permits now inspection and repair work within the reactor pressure vessel of OKFG-1 without serious time limitations for the personnel.

Apart from decontaminations performed around the world, all full systrem decontaminations (MOL/Belgium, VAK/Germany, OKG/Sweden) done within the last 3 years were performed with the CORD technology.

In 1993, Siemens received also the contract for a full system decontaminatuion of the NPP Loviisa (Finland) with the CORD process. It is also planned for Loviisa to perform the decontainaition as far as possible with plant internal systems. At this time, the decontamination is scheduled to take place in August 1994. The total system volume is expected to be approx. 300 m^3 and approx. 17000 m^2 surface area will exposed to the decontamination solvent

REFERENCES

1. Wille, H. and Sato, Y., "Field Experience of Chemical Decontamination and Waste Reduction with the CORD Process," *Proceedings of the Conference Chemistry in Water Reactors, Nice, Volume 1*, pp. 179-186, 1994.

2. Lejon, J., Hermansson, A. and Bertholdt, H.P., "A Full System Decontamination of the Oskarshamn 1 BWR," *Proceedings of the Conference Chemistry in Water Reactors, Nice, Volume 1*, pp. 203-210, 1994.

Author Biography

Rolf Riess is Senior Director for the Power Plant Chemistry Division of Siemens AG KWU in Erlangen, Federal Republic of Germany. The division is responsible for all aspects of Power Plant Chemistry including research and development, and service activities like radiation control, decontamination and steam generator chemical cleaning. Before joining Siemens, Dr. Riess was a scientist for one year at the Institute of Nuclear Chemistry at the Technical University in Darmstadt, FRG. He received a Ph.D. degree in Chemical Engineering from the Technical University of Darmstadt, Federal Republic of Germany.

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PAPER 10-2
DISCUSSION

Egner: You touched on recontamination after the decontamination, which I think is very, very important. Have you, in your methods, some way of passivation, or what do you recommend for treatment?

Riess: We have no method of passivation, but the current thinking on our side is that it would be very useful to consider trace element injection, as an example, zinc injection, to further improve the situation in the plant to avoid that, but we have no special treatment as passivation method.