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ISOE INFORMATION SHEET

OVERVIEW OF THE FIRST THREE FULL SYSTEM DECONTAMINATION

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The purpose of this ISOE Information Sheet is to give an overview of the first three Full System Decontamination (FSD) performed the last two years in the world. These FSD have been performed:

- in Sweden, at Oskarshamn 1 (BWR), ended in January 4th-11th, 1994.
- in Finland, at Loviisa 2 (VVER), in August 10th-19th, 1994.
- in the United States, at Indian Point 2 (PWR), in March 1st-9th, 1995.

The results and performances of these experiences in FSD will be presented, remembering also the main characteristics of the processes of decontamination used (AP/CAN-DEREM™, and UV/CORD™).

THE MAIN RESULTS OF THE THREE FULL SYSTEM DECONTAMINATIONS

1. TWO PROCESSES UP TO NOW: CORD™/UV AND AP/CAN-DEREM™

1.1. CORD™/UV

The CORD™/UV (Chemical Oxidation Reduction Decontamination using in situ decomposition of the decontamination chemicals with ultra-violet light) uses permanganic acid and oxalic acid as the main decontamination chemicals.

Each CORD™-cycle consists of the following steps: preoxidation (addition of permanganic acid), reduction (addition of oxalic acid), decontamination (removal of released activity, corrosion products via cation exchange resins) and decomposition (using UV light to decompose the remaining oxalic acid and oxalates).

Both Oskarshamn 1 and Loviisa 2, where this process were used, applied four decontamination cycles.

1.2. AP/CAN-DEREM™

The AP / CAN-DEREM™ consists in succession of different steps: dissolution of iron oxide with organic acids using citric acid and EDTA (ethylenediaminetetraacetic) as chelating agent (CAN-DEREM™ step) and, oxidation and dissolution of the chromium with an oxidizing Alkaline Permanganate followed by a rinse step using dilute oxalic acid (AP step).

At Indian Point 2, a five steps process was used: CAN-DEREM / AP / CAN-DEREM / AP / CAN-DEREM.

2. SYSTEMS AND COMPONENTS DECONTAMINATED

At Oskarshamn 1, the systems decontaminated were:

- in the first phase (in June 1993), the residual heat removal system (RHR), the reactor water clean-up system (RWCU), pipe connections to the auxiliary condenser, a minor part of the final feedwater system, and
- in the second phase (in January 1994), all four recirculation loops including pumps and valves, the lower part of the reactor pressure vessel (RPV) without fuel and RPV internals but with control rod drives (CRD) and instrumentation housings.

At Loviisa 2, the systems decontaminated were: the complete primary circuit, the reactor pressure vessel (RPV) without fuel and control rod drives but with RPV internals, all 6 coolant loops (each with one steam generator, one reactor coolant pump and two isolation valves), the volume control and chemical injection system (corresponding to the volume control system in Western PWRs) and reactor water clean-up system (RWCU).

At Indian Point 2, the systems decontaminated were: the entire primary reactor coolant system (RCS) with fuel removed, residual heat removal system (RHR), chemical and volume control system (CVCS), portions of the primary sampling system.

3. DECONTAMINATION EFFICIENCY

3.1. Oxides and corresponding activities removed

Plant	**Corrosion products removed (kg)**					
	Fe	Cr	Ni	Cu	Zn	**Total**
Oskarshamn 1*	4.9	1.5	0.11	0.06	0.43	**7**
	16.9	5.1	3.1	0.4	1.8	**27**
Indian Point 2	37.2	42.2	46.7	n.a.	n.a.	**126**
Loviisa 2	n.a.	n.a.	n.a.	n.a.	n.a.	**291**

Plant	**Activity removed (TBq)**								
	Cr-51	Mn-54	Co-58	Co-60	Zn-65	Sb-124	Sb-125	Other	**Total**
Oskarshamn 1*	0.004	0.004	0.002	0.26	0.07		0.017		**0.4**
		0.01		2.1	0.11		0.034		**2.3**
Indian Point 2	10.3	2.4	52.2	66.6		11.7		1.3	**144.5**
Loviisa 2	24.1	1.3	1.7	9.2		3		2	**41.3**

* the first line corresponds to the decontamination of the primary system (RHR, RWCU, FW), the second line corresponds to the decontamination of RPV and main recirculation loops

3.2. Decontamination Factors (DF)

The Decontamination factors given below correspond to the following ratio:

$$DF = \frac{\text{Doserate(s) before decontamination}}{\text{Doserate(s) just after decontamination}}$$

Indian Point 2	DF
goal	*5*
at 55 locations (contact doserates)	7.8
at 28 locations (Steam Generators)	7.5
SG channel heads	5.9
Reactor coolant pump 21	9.2
Reactor coolant pump 22	6.0

Loviisa 2	DF
goal	*5*
near RCS (ambient doserates)	16
cold legs, average contact doserates on six legs	10
hot legs, average contact doserates on six legs	15
Two Heat Exchangers	7
on insulation of the loop piping	14
on RPV cover head, outside	33
on RPV cover head, inside	60
inside SG above tube bundles	153

Oskarshamn 1		DF
	goal	*10*
at 100 locations	**(first phase)**	**17**
	(second phase)	**22**
FFW piping		3
FFW manifold		4
auxiliary condenser		26
RHR/RWCU piping		32
RHR/RWCU components		11
lower part of RPV (near CRD housings)		200 to 1000
lower part of RPV (work areas)		50

3.3. Waste volumes

At Indian Point 2, a total of 50 m^3 of resins was used during the AP/CAN-DEREM™ process, including 1130 kg (3 wt%) of CAN-DEREM™ chemical solution and 321 kg (0.9 wt%) of oxalic acid.

At Oskarshamn 1, the total volume of the involved decontamination systems was approximately 166 m^3, and the surface about 1400 m^2. The total waste volume was calculated to 0.2 m^3 for the first decontamination and 1.9 m^3 for the second one. Due to the filter vessel design, the actual final waste volume was 1.2 m^3 for the first decontamination and 3.7 m^3 for the second one (3.4 m^3 cation resin and 0.3 m^3 anion resin).

At Loviisa 2, the volume of the decontaminated systems was 320 m^3, and the surface about 17000 m^2 (steam generator tubes representing 89% of this surface). The decontamination resulted in 8.5 m^3 of cationic and 22.5 m^3 of anionic resins. It has been estimated that 800 kg of oxalic acid was decomposed by UV-light, saving more than 9 m^3 of anionic resins.

4. DOSIMETRIC RESULTS AND ASSESSMENTS

The following Table presents the collective dose of the decontamination, the collective dose saved in the outage and the assessment of long-term collective dose saved.

Plant name	Collective exposure of decontamination (man.mSv)	Outage collective dose saved (man.mSv)	Long-term collective dose saved (assessed) (man.mSv)
Indian Point 2	117+84+284*	6500	> 30000
Loviisa 2	15**	8000	n.a.
Oskarshamn 1 (1st phase)	36***	3100	n.a.
Oskarshamn 1 (2nd phase)	40	n.a.	n.a.

* the collective dose is given for the following phases: pre-decon / decon / post-decon.
** this collective dose corresponds to the all the decontamination work (pre-decon to post-decon).
*** the decontamination phase equals to 4.5 man.mSv.

5. RECONTAMINATION

The success of the Full System Decontamination can be observed on the recontamination rates in the following refueling outage. The following Table gives the recontamination rates in Loviisa 2.

It should be noted that, according to analyses, most of the new contamination was short-lived nuclides. The dominated nuclides was Co-58 with a half life of only 72 days. The contribution of Co-60 in the new contamination was only 20%. The recontamination rate is supposed to be slower in the future, as short-lived nuclides do not cumulate.

Dose Rate Location	Dose Rates	Recontamination Rate [(3) / (1)]
cold legs, average contact doserates on six legs		
(1) before decontamination in 1994	1.75 mSv/h	
(2) after decontamination in 1994	0.19 mSv/h	
(3) one year later (1995 annual outage)	0.40 mSv/h	23%
hot legs, average contact doserates on six legs		
(1) before decontamination in 1994	0.74 mSv/h	
(2) after decontamination in 1994	0.05 mSv/h	
(3) one year later (1995 annual outage)	0.44 mSv/h	60%
two heat exchangers (average)		
(1) before decontamination in 1994	9.40 mSv/h	
(2) after decontamination in 1994	1.41 mSv/h	
(3) one year later (1995 annual outage)	3.60 mSv/h	38%
two steam generators (average)		
(1) before decontamination in 1994	5.25 mSv/h	
(2) after decontamination in 1994	0.03 mSv/h	
(3) one year later (1995 annual outage)	3.00 mSv/h	57%

These results can be compared with the recontamination rate for a generic PWR which has been established, as shown on the following Figure, to assess the long-term dose savings at Indian Point 2.

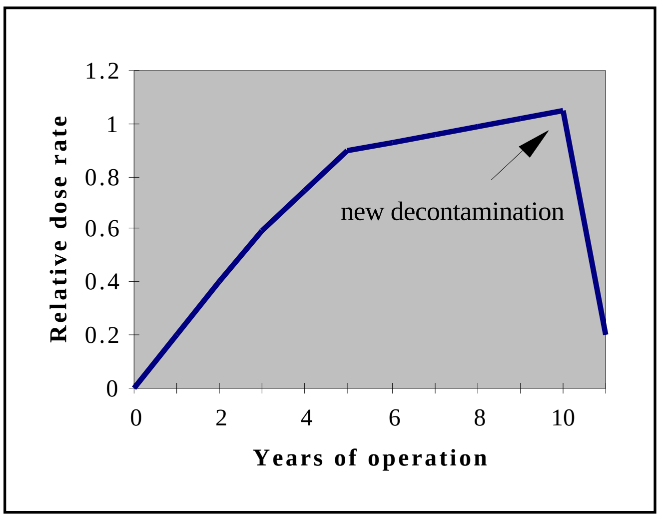

Figure 1. Recontamination Rate Assessment - Generic PWR

The recontamination rates are not available at that time for Oskarshamn 1 (no refueling outage since the FSD). Oskarshamn 1 will make measurements to evaluate the rate of recontamination during the next annual refueling outage which is scheduled for October 1996. The results will be provided into an NEA3 Questionnaire at the end of the year.

Additional information regarding the name of the contact-person in each nuclear power plant, his phone and fax numbers and references to reports are available in the NEA3 Questionnaires.