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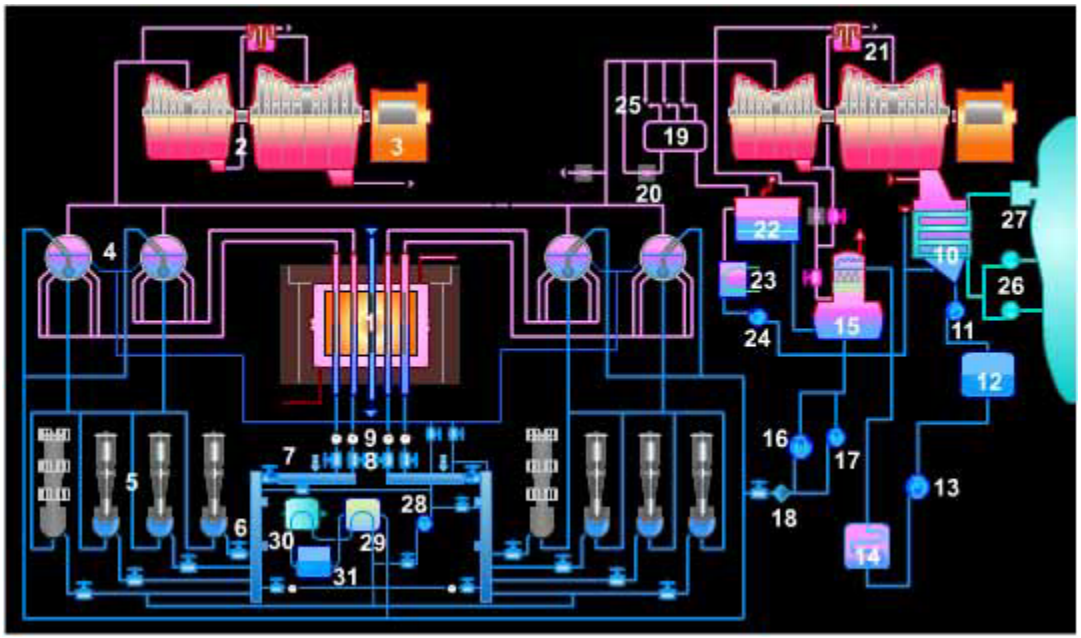
Decontamination techniques

Experience and perspectives for Russian NPP units

RMBK-1000



1. Reactor RBMK-1000
2. Turbine K-500-65
3. Generator
4. Drum-type steam separator
5. Main circulating pump
6. Header
7. Distributing group collector
8. Shutoff-and-regulation valve
9. Flowmeter "STORM"
10. Condenser
11. Condensate pump, 1 stage
12. Condensate purification
13. Condensate pump, 2 stage
14. Low pressure heater
15. Deaerator
16. Feedwater pump
17. Small feedwater pump
18. Mechanical filter
19. High pressure annular space
20. Fart-acting reducing station
21. Moisture separator/reheater
22. Pressurized relief quench tank
23. Operating condenser
24. Condensate pump
25. Main safety valve
26. Circulating pump
27. Siphon drain well
28. Coolant pump
29. Regenerative heat exchanger
30. Aftercooler
31. Bypass purification of forced circulation coolant circuit

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Use of previous experience

- No experience on decontamination of RBMK in decommissioning phase

- From an analysis of the experience accumulated in radioactive decontamination of the circuits of multiple forced circulation, it is concluded that this experience and appropriate technologies can be used in decommissioning power unit no. 1 at the Leningrad nuclear power station and other power units at nuclear power stations with RBMK reactors.
(ref *Teploenergetika*)

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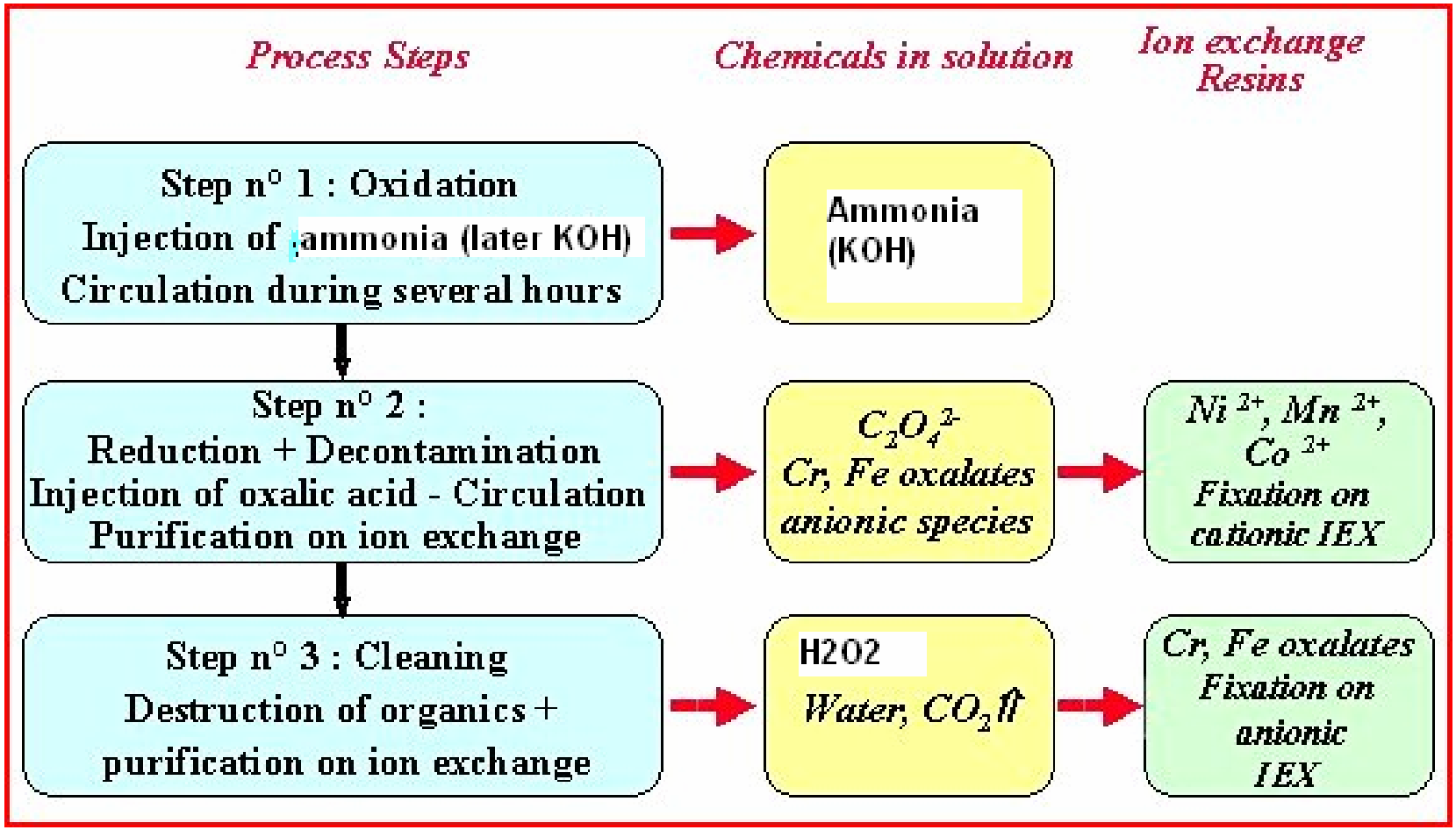
Decontamination of CMCC

- Volume of the loop: 1200 m^3
- Presence of “impasses” (stagnant zone)
- Overall amount of cruds: 1000-1300kg
- Composition (influenced by presence of O_2 in water)
  - Fe_2O_3, α and γ-Fe_2O_3, $[Fe,Ni]O.[Fe,Cr]_2O_3$,….
- Radiological data
  - ^{51}Cr, $^{58\text{ and }60}Co$, ^{96}Zr, ^{95}Nb
  - 500-1000 Ci
- Dose exposure after shut-down
  - Under-control room: up to 3600-14000 mR/h

Oxalic acid Process



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NITROX Process

- Base: Oxalic process acid
- Main difference: KNO_3 is added to the solution
- Advantage: reduction of the liberation of
  - Iodine (present in the crud)
  - Reaction gases (CO_2, O_2, H_2)

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Oxalic Acid
Some parameters and results (during exploitation)

Unit	Data	Composition of solutions	Premises	K_d on	removed		Time h
				dose rate	Activity, Ci	Fe, kg	
LAES-1	1976	$H_2C_2O_4$+ NH_4OH+H_2O_2	Under-control rooms GCN	2,1 2,7-3,2	10000	936	~ 100
LAES-2	1977	The same	Under-control rooms GCN Drum-separators	2-3,6 2,2-9,5 5,7-4,4 (av. 4,6)	6000-7000 (LRAW - 4300 m^3)	1300	95

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NITREX
Parameters and performances (during exploitation)

Unit	Data	Composition of solution	Premises	K_d on dose rate	removed		Duration (h)
					Activity, Ci	Fe, kg	
LAES -1	1989	$H_2C_2O_4$+ KNO_3+H_2O_2 ("nitrox") 2 cycles	Under-control rooms GCN Premises NVC Drum-separator	18-32 2,9 2,1 10,1 (av. 6,3)	5000	1000	118
LAES-3	1995	The same 2 cycles	Premises. NVC Boxes GCN Boxes GCN (connector NC-VC) Downcomer- pipe-lines Drum-separators Under-control rooms	1,0) 1,4 52 1,0-3,6 (av. 1,8) 1,0-11 (av. 5,75) 12-24 (av. 18)	1430	900	160

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Non Reagent and Carbon dioxide process (during exploitation)

Unit	Date	Dose rate, μR/s				Removed		Duration (h)
		Premises	Before decont	After decont.	K_d	Activity Ci	Fe, kg	
LAES-2	04. 1984	Under-control rooms	350; 420; 350; 650	180;230; 160;180	2,4	670	-	69
		NVK	88; 146; 56; 186	70; 140; 30; 48	2,0			
		Boxes GCN	53; 30; 146; 127; 47; 29; 103	43; 47; 42; 28; 20; 23; 28	2,46			
		Drum-separators	24; 18	18; 19	1,14			
		Downcomer-pipelines	7,3; 6,3	6; 0; 2,6	1,82			
					av.2,0			

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Un-reagent vs. Chemical decontamination

The title of premises or equipment	Initial dose rate Doses, μR/s	Coefficient of decontamination (Kd)	
		Un-reagent decontamination	Chemical decontamination
Control-rooms (016/1,2)	335 - 970	4,2	18-32
Premises of low	36 - 119	3,1	2,1
water communications (033/3,4)	166 - 240		
Boxes GCN (08/9-16)	25 - 125	3,9	2,9
Down-comer pipe-lines, suction collector GCN (115/3,4)	7 - 20	1,5	10,1
Drum-separators (505/3,4)	21 - 140	1,3	6,5
Average Kd	-	2,0 - 4,1	1-st cycle - 2,6 2 cycle - 6,1
Reduction of dose rate	-	in 2,0 - 4,1 times	in 5,2 times
Removed: Gamma-activity, Ci Iron, kg	-	 142 - 670 2,3 - 2,6	 5000 580 + 390
Volume of Liquid RAW , m^3	-	1200 - 1800	4000 - 5000
Prolongation of the process, h	-	60 - 70	1-st cycle - 62 2-d cycle - 56

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Further decontamination of decontamination solutions by means of sorbent

Termoxid				HCF			
Volume, mL	Bed volumes	Specific activity of filtrate, Bq/L	Df	Volume, mL	Bed volumes	Specific activity of filtrate, Bq/L	Df
400	25	32.4	$4.0*10^5$	750	47	$8.7*10^2$	$1.5*10^4$
1080	68	$6.7*10^2$	$1.9*10^4$	990	62	$1.1*10^3$	$1.2*10^4$
1790	112	14	$9.3*10^5$	1620	101	$2.0*10^3$	$6.5*10^3$
2070	129	$2.0*10^2$	$6.7*10^4$	1880	118	$4.3*10^3$	$3.0*10^3$
2740	171	$1.3*10^2$	$1.0*10^5$	2640	165	$6.7*10^3$	$1.9*10^3$
2960	185	$1.6*10^2$	$8.1*10^4$	2930	183	$6.9*10^3$	$1.9*10^3$
3170	198	$2.2*10^2$	$1.4*10^5$				
3720	233	$3.0*10^2$	$9.9*10^4$	3630	227	$1.0*10^4$	$1.3*10^3$
3980	249	$1.3*10^2$	$2.2*10^5$	3870	242	$1.1*10^4$	$1.2*10^3$
4630	289	$3.5*10^2$	$8.6*10^4$	4090	256	$1.2*10^4$	$1.1*10^3$
4820	301	$3.4*10^2$	$5.0*10^4$	4750	297	$2.4*10^4$	542
5480	343	$1.7*10^2$	$1.0*10^5$	5040	315	$2.1*10^4$	619
5750	359	$2.1*10^2$	$8.6*10^4$				
5940	371	$2.1*10^2$	$8.6*10^4$	5940	371	$2.5*10^4$	520
6170	386	$1.0*10^2$	$1.8*10^5$				
6840	428	$1.2*10^2$	$1.5*10^5$				
7100	444	$3.1*10^2$	$5.8*10^4$				

Decontamination and material management