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Decontamination of the 4 steam generators, the pressurizer and loop piping at the French NPP Chooz A

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Content

The Chooz A dismantlement project: Pioneering D&D in France

- **First PWR built in France (1963)**
- **Located near the Belgian border in the French Ardennes**
- **4 Loops Westinghouse reactor**
- **Power output 305 MWe**
- **Final shutdown in 1993**
- **Since then in Safe Enclosure (SAFSTOR)**
- **Dismantling decree: Sept. 2007**

Picture: EdF

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Decontamination objective & process selection

- **Decontamination activities as decisive work package of dismantlement project**
- **Large components to be re-classified as VLLW after decon** ***(fr. TFA, < 100 Bq/g)***
- **Chemical decon selected for the treatment**
  - **High effectivity**
  - **Low radiation exposure of involved personnel**
  - **Low risk of uncontrolled spreading of contamination**

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  - Decon equipment
  - Implementation (Pictures)
- Results obtained
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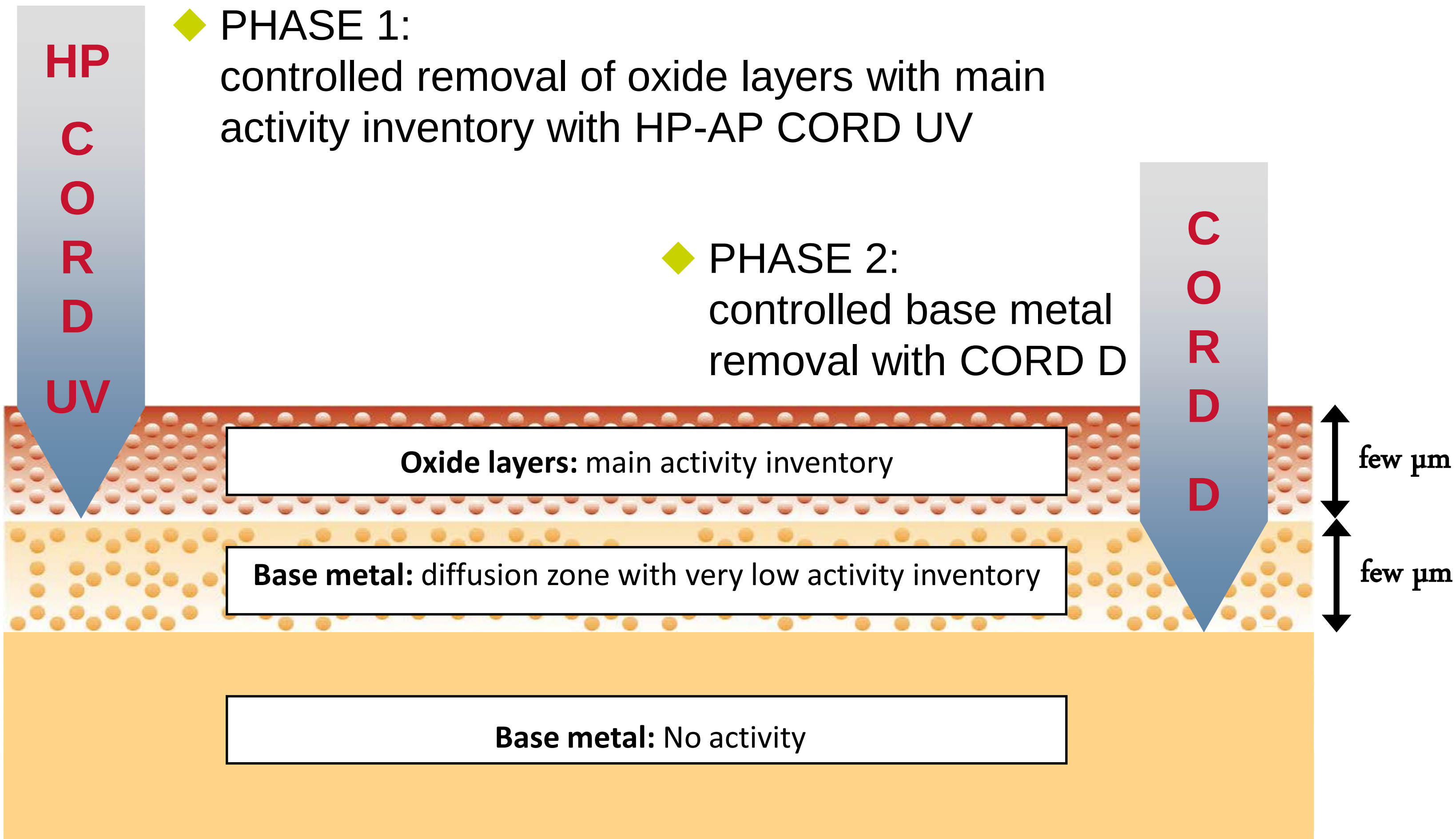
Process adapted to specific needs of Chooz A

- Plant with singular characteristics and operating history
  - Material concept, water chemistry

- Treatment process was adapted and optimized to account for this:
  - Concept validation on plant coupons in hot lab
  - Process specifically adapted to suit plant's needs
    - Chemistry: Non-standard oxide characteristics
  - Complete removal of contaminated oxide layer (15 µm)
  - Removal of outer layer of base material (9 µm, safety margin defined by EdF)

CORD UV and CORD D chosen for guaranteed success

- PHASE 1:
  controlled removal of oxide layers with main activity inventory with HP-AP CORD UV
- PHASE 2:
  controlled base metal removal with CORD D



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HP CORD UV for oxide removal

- **Established method of standard use for power plants in operation**
- **Uses very low concentrations (max. ~0,2% solution in water) of comparatively mild chemicals**
  - **Permanganic acid**
  - **Oxalic acid**
  - **Hydrogen peroxide**
- **UV-Decomposition of chemicals minimizes amount radwaste generated**
- **Dissolved activity fixed on solid matrix (ion exchangers) for much easier handling and less risk than radioactive solutions**
- **Process water is purified at the end of the process, only one system fill required**

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CORD D for controlled base metal removal

- **Controlled base metal removal of superficial layers of base metal**
- **Uniform removal with submicrometer precision**
- **Metastable process induced by intense UV radiation:**
  Chemical process stops automatically in case of equipment failure
- **No strong or highly toxic mineral acids employed, only oxalic acid**
- **Same waste minimization advantage as CORD UV**
- **Exactly the same process control parameters required, no different procedures for plant personnel**

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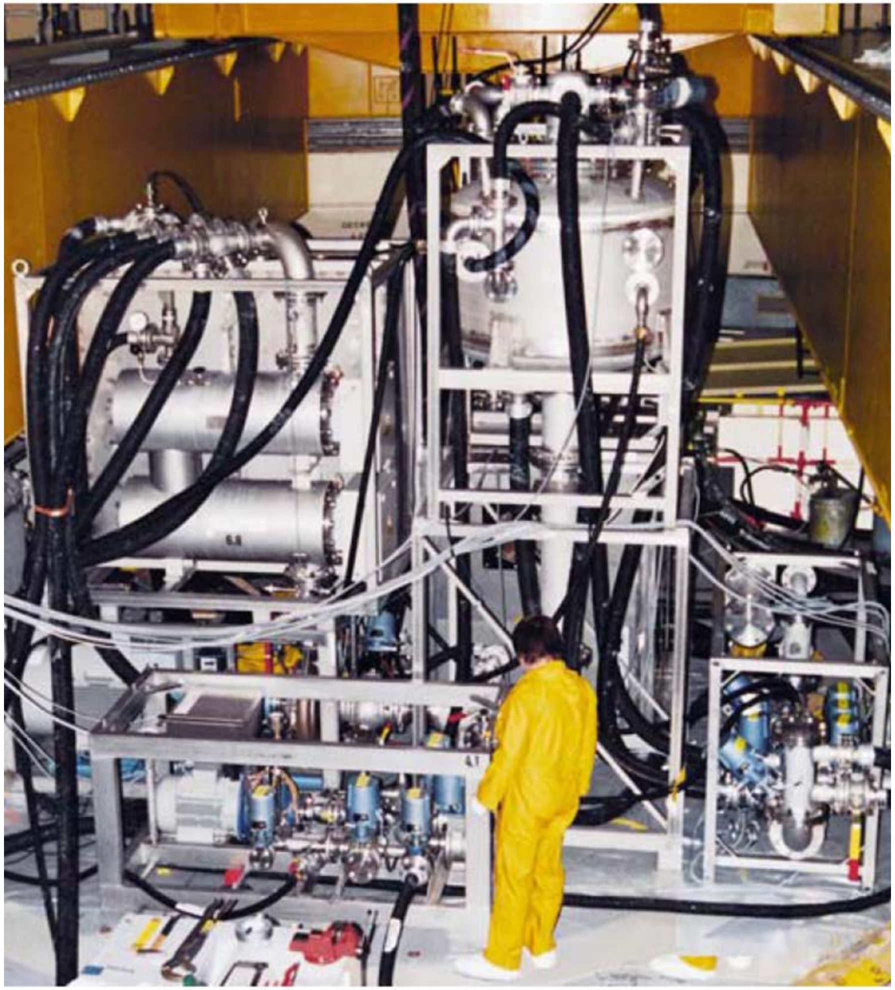
AREVA's decontamination equipment AMDA

- **Complements and completes decontamination circuit**
- **Modular design**
  - Provides <u>all</u> required components
  - Provides <u>only</u> required components
  - Flexible installation, even with limited space
- **Injection of chemicals**
- **Pumps**
- **Heaters**
- **Sampling**
- **UV reactors**
- **Ion Exchangers**
- **Process Control**
- **Highly automatized & remote controlled for dose minimization**



Picture: AREVA

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Remote process control with AREVA AMDA ensures ALARA

Picture: AREVA & EdF

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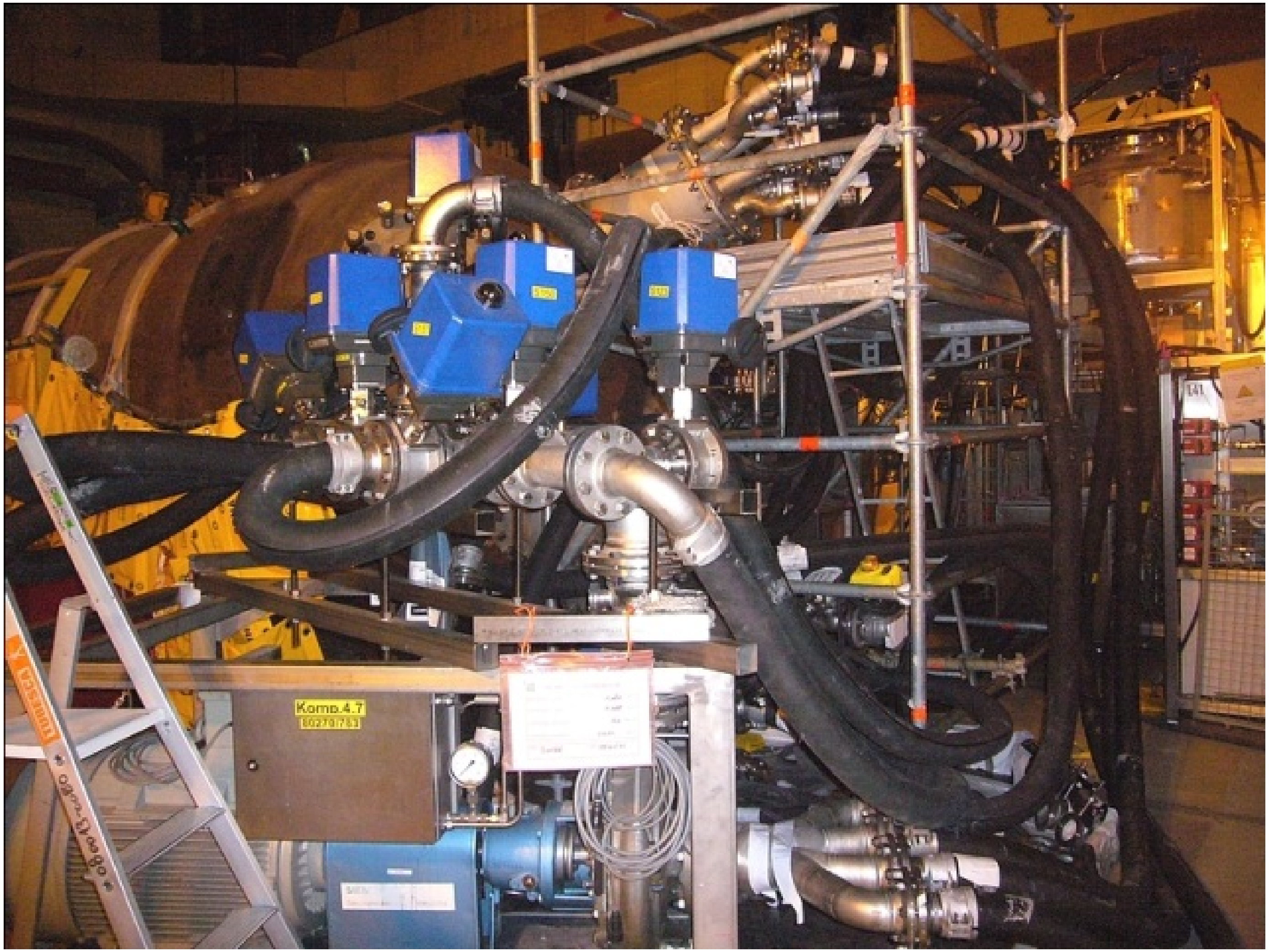
Decontamination circuit with AREVA's AMDA connected to SG (1/2)



Picture: AREVA & EdF

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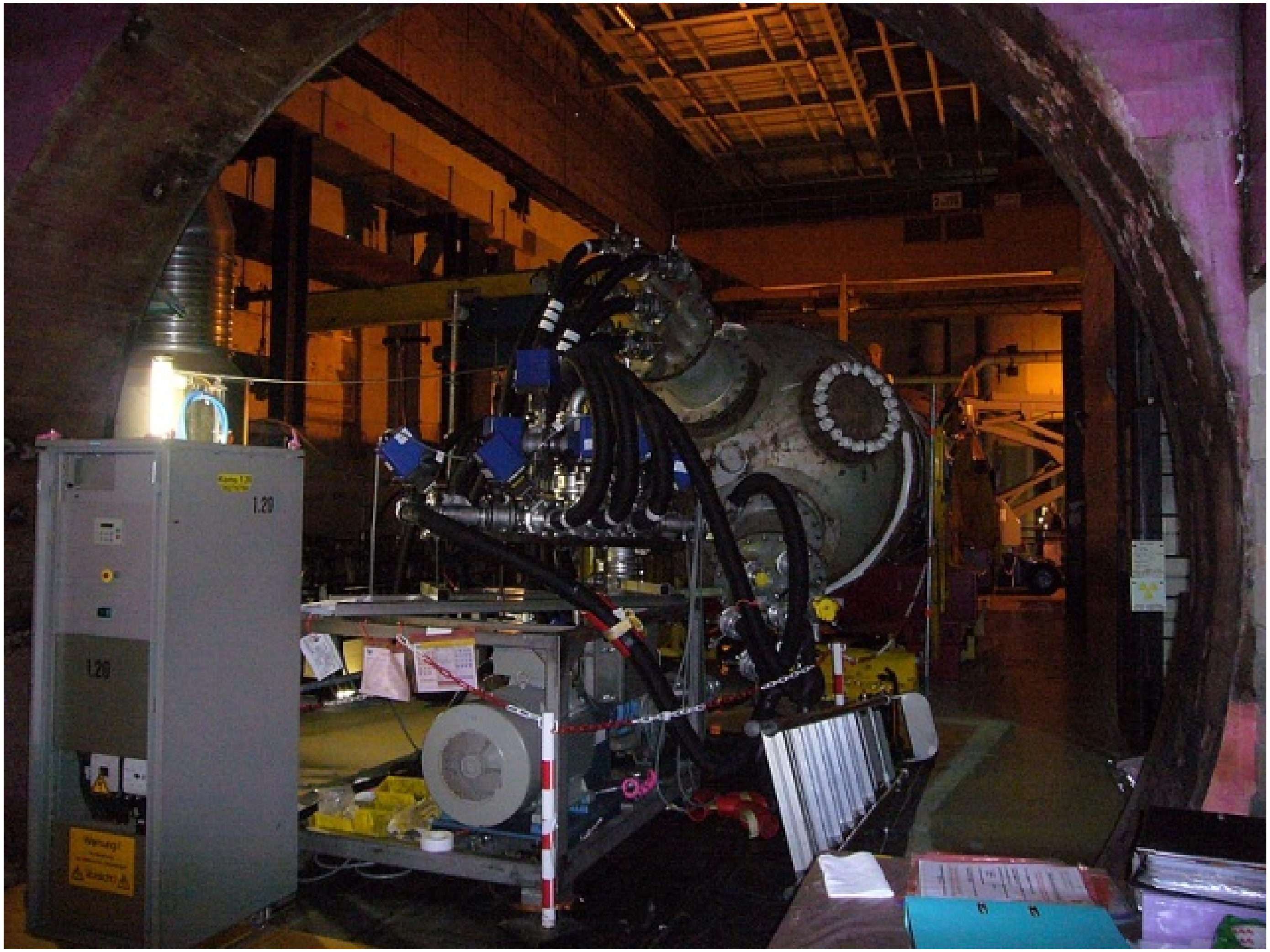
Decontamination circuit with AREVA's AMDA connected to SG (2/2)



Picture: AREVA & EdF

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Amounts of contaminated corrosion products and activity removed

- Including metal amounts from base metal removal, per component

	Fe (kg)	Cr (kg)	Ni (kg)	Activity (Bq)
SG2	93,1	37,3	16,7	4,02E+11
SG1	118,8	50,9	25,2	4,72E+11
SG3	103,7	34,2	19,3	4,23E+11
SG4	96,2	39,3	17,4	3,84E+11
Loop 3&4	11,8	5,5	2,1	1,79E+10
Loop 1&2	11,5	4,9	1,6	1,45E+10
PZR	15,8	9,2	2,8	3,66E+09
Total	451,4	182,2	85,3	1,72E+12

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SG2 and SG1 Decontamination Factors

SG2 empty/contact dose rate (µSv/h) **Average DF= 255**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
West Side	before	8	3	3	6	10	30	130	550	610	590	550	510	540	550	625	22
	after	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	DF	8	3	3	6	10	30	130	550	610	590	550	510	540	550	625	22
East Side	before	10	4	2	16	15	20	290	550	600	560	525	495	500	440	560	5
	after	1	1	2	3	3	2	1	1	1	2	2	3	2	1	1	2
	DF	10	4	1	5	5	10	290	550	600	280	263	165	250	440	560	3

SG1 empty/contact dose rate (µSv/h) **Average DF= 156**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
West Side	before	25	7	5	10	18	50	480	705	700	700	650	200	160	130	600	30
	after	1,5	1	1	1	1	1	1	1	1,5	1	1	1	1	1	1	1
	DF	17	7	5	10	18	50	480	705	467	700	650	200	160	130	600	30
East Side	before	27	8	6	17	20	16	35	90	670	610	543	480	470	640	430	50
	after	4	3	1,5	2	1	3,5	4	10	8	6	7	9	6	8	2	2
	DF	7	3	4	9	20	5	9	9	84	102	78	53	78	80	215	25

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Very low occupational exposure, particularly during operation

Work Package	Occupational Exposure
Installation and dismantlement of AMDA equipment	45 man.mSv
Performance of decontamination *including:* *process control, sampling, equipment control and maintenance, and other auxiliary works*	1,7 man.mSv (average, per large component)
Analyses (lab, HP measurements)	0,2 man.mSv (average, per large component)

Data: EdF

Amounts of radwaste generated

- **Ion Exchange Resins**
  - **27 m³ for oxide layer and secondary waste** (99+% of activity)
  - **10 m³ for base metal removal** (<1% of activity)
  - **1 m³ for waste water treatment**
  - **In total 38m³ of IX resins used for the entire application**

- **Waste Water Treatment**
  - **Alpha contamination removal from process water prior to disposal**
  - **Total of 95 m³ waste water successfully treated**
  - **Target < 1 Bq/L alpha (!!)**

- **Bag Filters**
  - **Total of 16 bag filters were used to collect solids**

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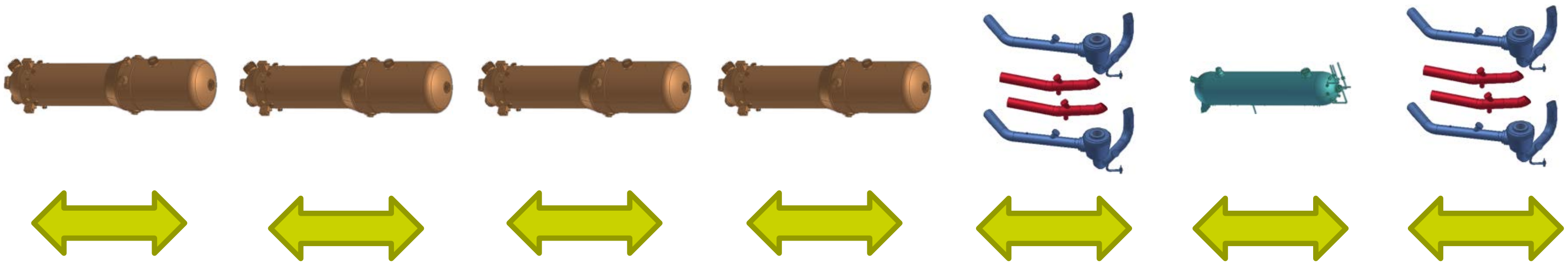
Project timeline

2011		2012												2013				
11	12	01	02	03	04	05	06	07	08	09	10	11	12	01	02	03	04	05



- **Components treated individually**
- **Longer time schedule as for simultaneous Full System Decon**
- **Time after SAFSTORE less of an issue**

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Objective accomplished: All decon targets were met

Pictures: EdF

	Average Thickness of a Chooz A SG	Average Composition of Chooz A SG	Average Contamination of layer
External Oxide Layer	3.14 µm	Iron 81.5% - Chromium 7.5% - Nickel 11%	59,5 GBq ^{60}Co
Internal Oxide Layer	6.48 µm	Iron 49% - Chromium 41% - Nickel 10%	383 GBq ^{60}Co
Base metal	9 µm removed	Stainless steel 18-10	3,4 GBq ^{60}Co

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Objective accomplished:
Total removal of contaminated layers + 9 µm base metal

Picture: AREVA & EdF

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Objective accomplished: Components leave controlled area as VLLW

- **Oxide layer and base metal removed from all the large components**
- **Steam Generators left the Chooz site as VLLW to French storage facility (ANDRA)**
- **Loops already dismantled**

Steam generator's radiological characteristics

Before	After
40000 Bq/cm²	40 Bq/cm² (CORD)
40000 Bq/cm²	2000 Bq/cm² (CeriumIV for plugged tubes)
700 µSv/h	1µSv/h
450 GBq Co60	0.65 Gbq Co60

Pictures: EdF

Content

Lessons learned and recommendations

- **Previous examinations on representative samples in hot lab enable process optimization**
- **Particularly useful in non-standard plant configurations, divergent water chemistries or unique operating history**
- **Removal of base metal generates a high volume of radwaste relative to activity removed**
- **Flexible base metal removal amount are recommed vs. fixed amounts (dynamic measurement required) to minimize waste**
- **Treating single components separately is more time consuming than a simultaneous Full System Decontamination, but feasible**
- **Virtually any decontamination target can be achieved efficiently and safely via AREVA chemical decontamination processes**

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Summary of a successful project

- **Seven (7) decontamination individual applications of large components were performed successfully and without incidents at NPP Chooz A**
  - **Removal of the complete oxide layer**
  - **Removal of ~ 9µm of base metal**
- **All decontamination objectives were accomplished**
- **All decon targets were met or exceeded**
- **Large components classified as VLLW after decontamination**
- **Removal of alpha activity in waste water prior to disposal** **(<1 Bq/L !)**
- **Pioneering work: First SGs in France to leave the controlled area**

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End of presentation

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