EDF Source Term Reduction Project

Main outcomes and further developments

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Radiation Protection context at EDF

Radiation Protection Requirements Toughening

Dose Reduction is a strategic stake → **Regulation respect**

Nuclear acceptability

Collective Dose

Quasi-linear decrease for 20 years

- **1991 ➔ 2,44 man.Sv/unit**
- **2011 ➔ 0,72 man.Sv/unit**

Personal Dose

1992 ➔ too much workers with Dose > 20 mSv/y

2011 ➔ 0 worker with Dose > 18 mSv/y

2 workers with Dose > 16 mSv/y

Why must EDF control doses in the next years ?

Major works planned until 2020 → **Important increase of the number of working hours spent in controled area**

New-Built NPPs → **R.P. taken into account from design phase**

0,35 man.Sv for EPR

Source Term Reduction Project at EDF

2 ways for dose improvement

Better organize the shutdown schedule

Play directly on source term

Source Term Reduction Project

2003 - 2011

- **Long Term view**
- **R&D developments (code, modelling)**
- **Operational procedures improvements**
- **Material improvements**

OUTLINE

Special focus on :

Some Research and Developments advances

Upstream studies

OSCAR code

Operational aspects

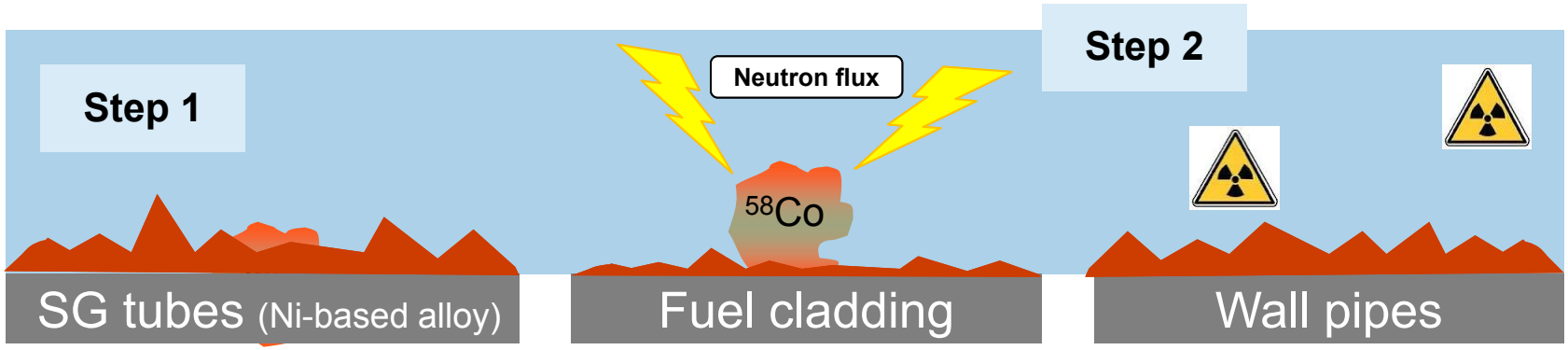
Zinc injection

Recommendation guidelines

Design aspects

Impact of stellites on Radiation protection

Research & Development : Upstream studies



1 : Metal species releasing

BOREAL experimental loop

Objective 1

To model releasing by an empirical law based on the BOREAL database (pH, T, ...)

In good progress

Objective 2

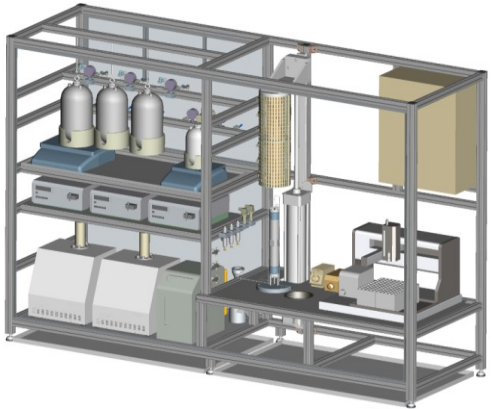
To define material specifications for manufacturing

Very difficult issue but significant progress on hardness and oxide composition

2 : Nickel solubility at high temperature

Theory and measurements with industrial partners

- Uncertainties remains important on nickel solubility data at international level
- Design of our own High Temperature cell to scan wide range of pH, T and chemical conditioning



Research & Development : OSCAR code

Collaborative work CEA – EDF – AREVA NP

INPUT DATA

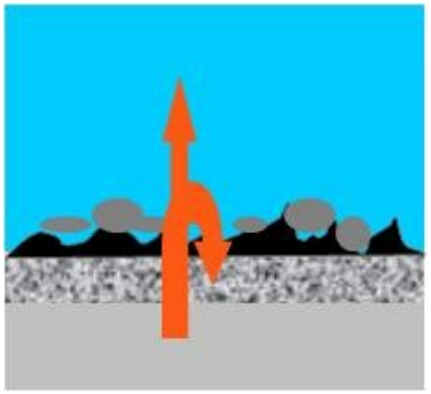
Geometry

Operation

Fuel

Material

Releasing into water



metal species (Ni, Fe, Co)

Behaviour in RCS

- ***Thermo-chemical Database***
- ***Solubility***
- ***Deposition***
- ***Radioactive decay***
- ***Activation under neutronic flux***

OUTPUT DATA

Activity concentration

Deposited activity

Dose rates

Element masses

Specific Poster

At this conference

Modeling of corrosion products contamination in PWR with the calculation code OSCAR V1.2

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F. Dacquait (CEA Cadarache)
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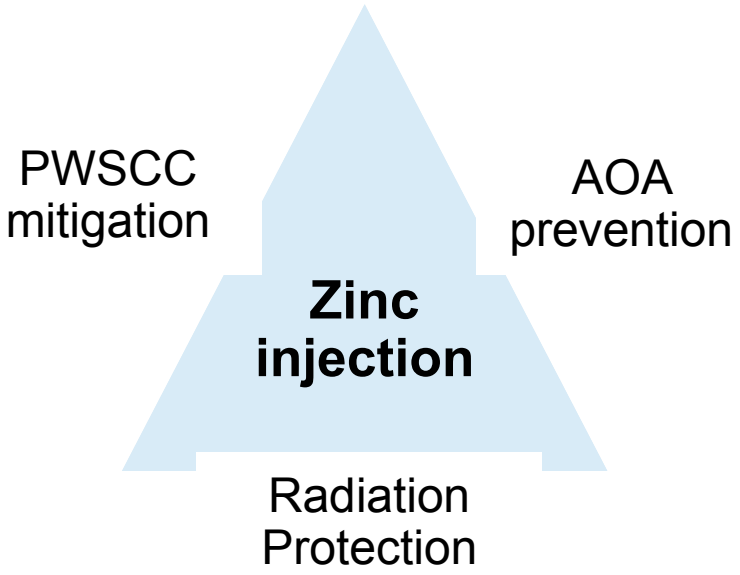
Zinc injection outcomes at EDF



Specific experiments for Rad. Prot.

Bugey 2 (2004)	Bugey 4 (2006)
Curative	Preventive before SGR

No negative impact on dose rates

No real gain over the injection period

Deployment in progress on 14 new units

Monitoring program planned to quantify R.P. gains

EMECC and CZT in-situ spectrometry measurements

Dose rates measurements
(usual indexes + specific measurements on SG tubes)

EMECC device

Recommendations guidelines for shutdown

Oxygenation : Beware of misconception

A good oxygenation will be able to decontaminate the primary loops !!

CENSURED

	Fuel	Loops	
Metal species	Ni / NiO	$NiFe_2O_4$	Different chemical species !!
Behavior under acid and oxidizing conditioning	Soluble form	Stable form	Different behaviour during oxygenation

Oxygenation can only RECONTAMINATE loops if performed in non-optimal conditions

→ **Recommandation Guidelines**

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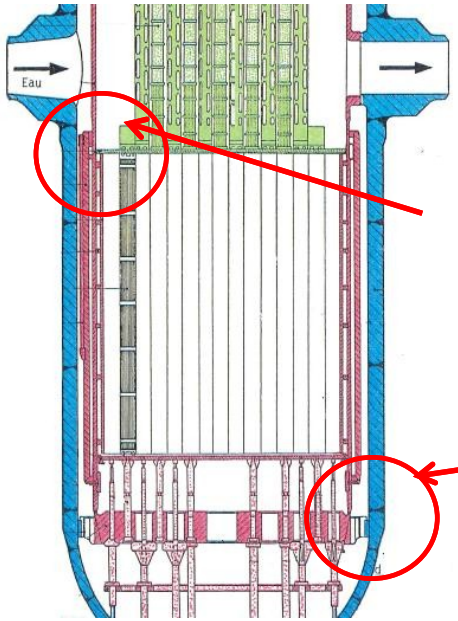
Impact of Stellites on Radiation Protection

Cobalt-based material (60%) used for its good mechanical properties → Activation of ^{59}Co into ^{60}Co under neutron flux if abrasion or incidental damage

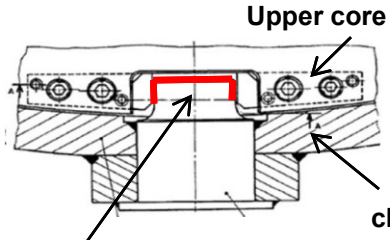
Main origins	Pumps bearing (buttering)	Valves	Guidance mechanisms or support equipment of vessel internals	Rod cluster control assembly mechanism
	Incidental damage	≈ 15% of Outage Collective Dose	Normal wear	≈ 30 à 50% of Outage Collective Dose

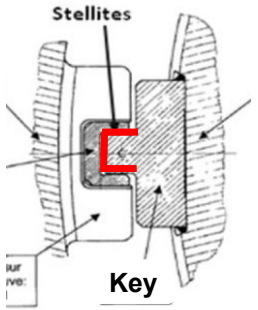


Vessel internals

Guidance device of upper core plate

Core support plate keys





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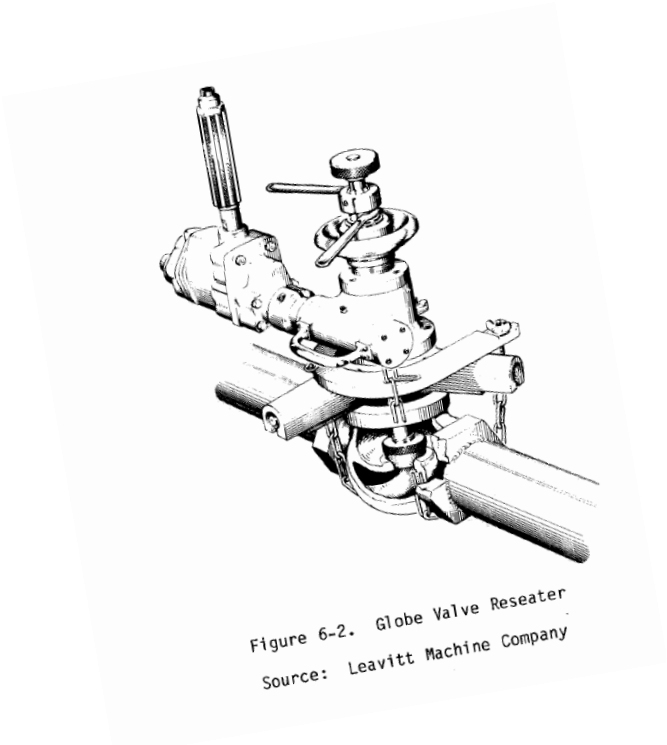
Impact of Stellites on Radiation Protection

Solutions

1	Replacement materials	Difficult from technological and safety qualification reasons
2	Even more precaution must be taken during grinding operation of Stellites surfaces in valves in order to limit ^{60}Co source term	



Special care with grinding operations

Protection	Use of plastic film to collect fragment particles Blocking up of the pipes to avoid dissemination
Cleaning	Use of suction devices to clean the valve after work
Checking	Check of the cleanness before reassembly

Conclusion

Source term reduction is an important matter of concern for EDF fleet performances

STR project has been launched for 9 years in order to reduce contamination levels and dose rates

Investigations about innovative technologies

Practical answers in operation

EDF New-Built NPPs

In operation EDF fleet

Thanks for your attention !

