
Reactor Pressure Vessel Closure
Head replacement of Belgian
Tihange 3 and Doel 4 units –
Follow-up and on-site dosimetry
ISOE 2016 - June 2nd 2016



TRACTEBEL



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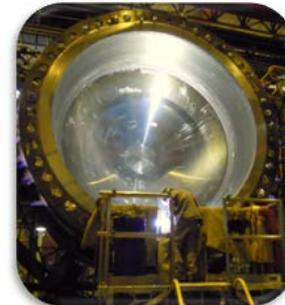
Introduction



Introduction

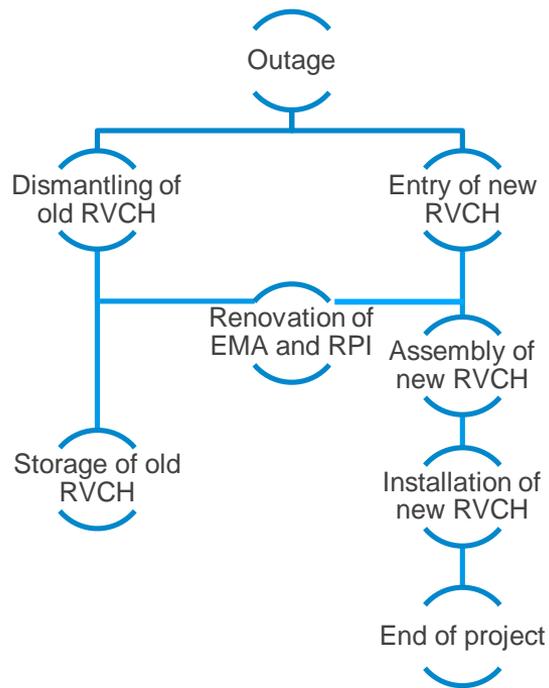
Justification and scope description

- RVCH replacement due to a risk of primary water stress corrosion cracking (PWSCC)
- In 2011, designation of Tractebel ENGIE by Engie Electrabel as owner's engineer for the replacement of Tihange 3 and Doel 4 RVCH
- Production and installation granted to AREVA NP, including:
 - New forged flange and hemispherical dome with 66 penetrations of the control rods
 - New Control Rod Drive Mechanisms (CRDM)
 - New thermal insulation
- Installation in 2 phases:
 - A partial assembly taking place in factory
 - A final assembly performed on-site after their transport

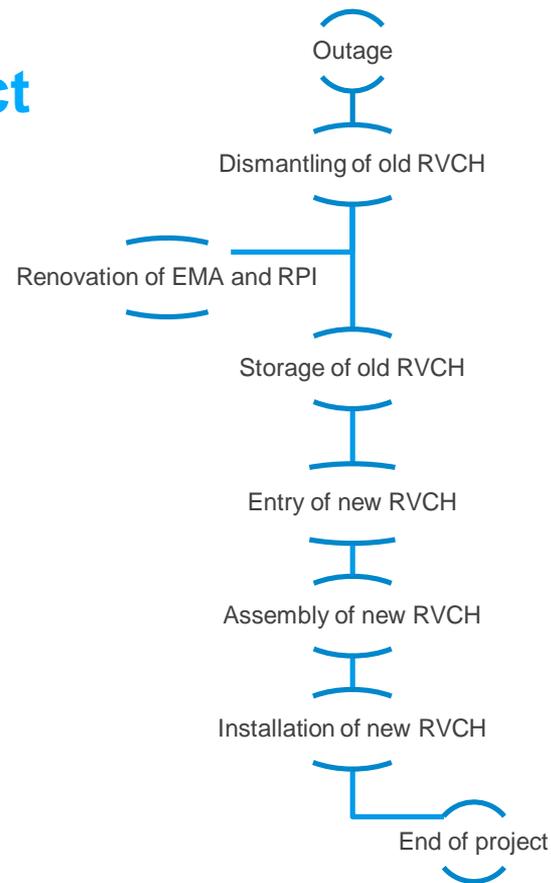


Introduction to the replacement project

Workflow of the Tihange 3 and Doel 4 projects



Tihange 3



Doel 4

Introduction to the replacement project

ALARA objectives

- Objectives:
 - No work incidents
 - No nuclear incidents (no release of radioactive substances into the environment, no on-site cross contamination, no internal human contamination, etc.)
 - Minimal collective and individual doses according to the ALARA principle
- ALARA working group (Engie Electrabel, Tractebel ENGIE, and AREVA NP)
 - Before the execution phase: implementation of the ALARA principle and estimation of the collective doses
 - During the execution phase: dosimetric follow-up and control of the radiological conditions (radiation and contamination levels) in the vicinity of the replacement site

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Preparatory works in the frame of Radiation Protection



Preparatory works in the frame of radiation protection

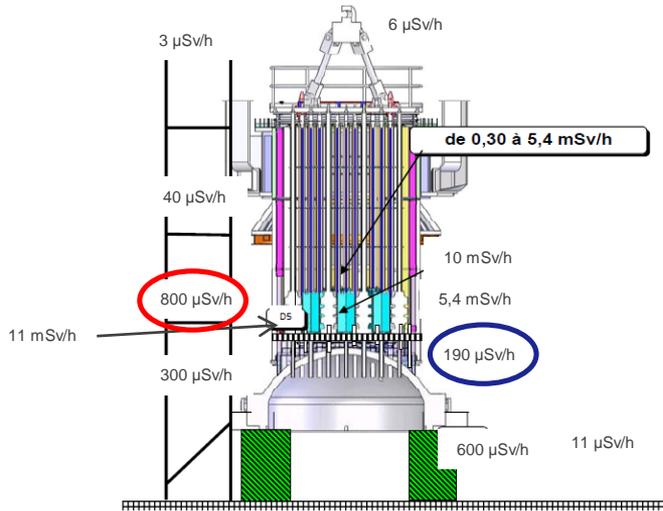
General

- Prior to the execution phase, an ALARA study and collective dose estimation were performed separately for each unit
- Collective dose estimation based on:
 - The REX of previous replacement projects performed by the contractor
 - The REX of Tihange 3 RVCH replacement project for Doel 4
 - Dose rate measurements during previous outages
 - Definition of specific tasks, related work stations and dosimetric phases for each replacement project
 - Definition of dose reduction factors (DRF) based on the REX of the Doel and Tihange NPPs

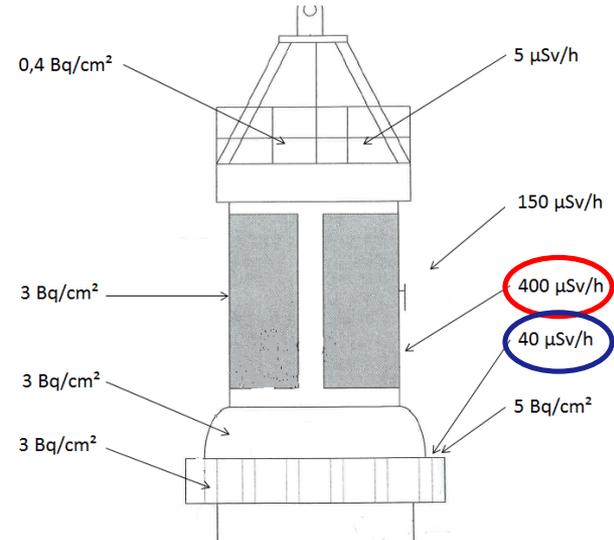
Preparatory works in the frame of radiation protection

Dose rate estimate (1)

Measurements performed during previous outages



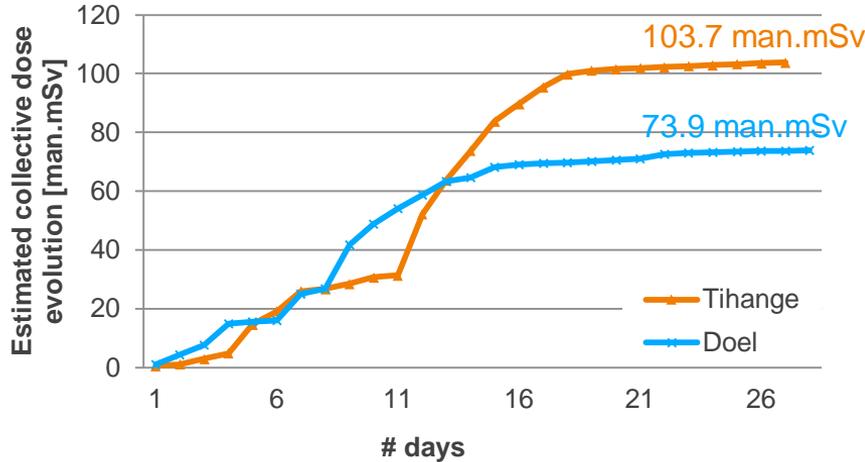
Tihange 3



Doel 4

Preparatory works in the frame of radiation protection

Dose rate estimate (2)



- Decrease of the total collective dose for the Doel 4 project:
 - Reduction of 22% of the estimated man-hours resulting from the REX of the Tihange replacement project
 - The lower dose rates around the old Doel 4 RVCH
 - The serial approach which induces a significantly lower collective dose during the assembly of the new RVCH
- Faster increase of collective dose during the first 11 days of the Doel 4 project:
 - More tasks in the preparatory phase (day 1 to 3)
 - Dismantling of the CRDMs (starting from day 9) performed close to high radiation zones

Preparatory works in the frame of radiation protection

Optimization of the collective dose

For both NPPs, different actions were taken to reduce the collective dose in the framework of ALARA:

- The reactor pool was kept filled during the works
- Cartographies were present to illustrate the high and low dose rate areas
- Additional shielding was foreseen in case hot spots were detected
- Clear indications at high dose rate areas



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On-site follow-up during execution phase



On-site follow-up

The challenge

- A large number of tasks and workers together in small work areas
- A variable dose rate around the old RVCH due to the removal of layers
- High dose rates close to the RVCH
- A high risk of contamination spread during some dismantling tasks
- Heavy equipment requiring precision works

On-site follow-up

The Tihange 3 RVCH project - Issues

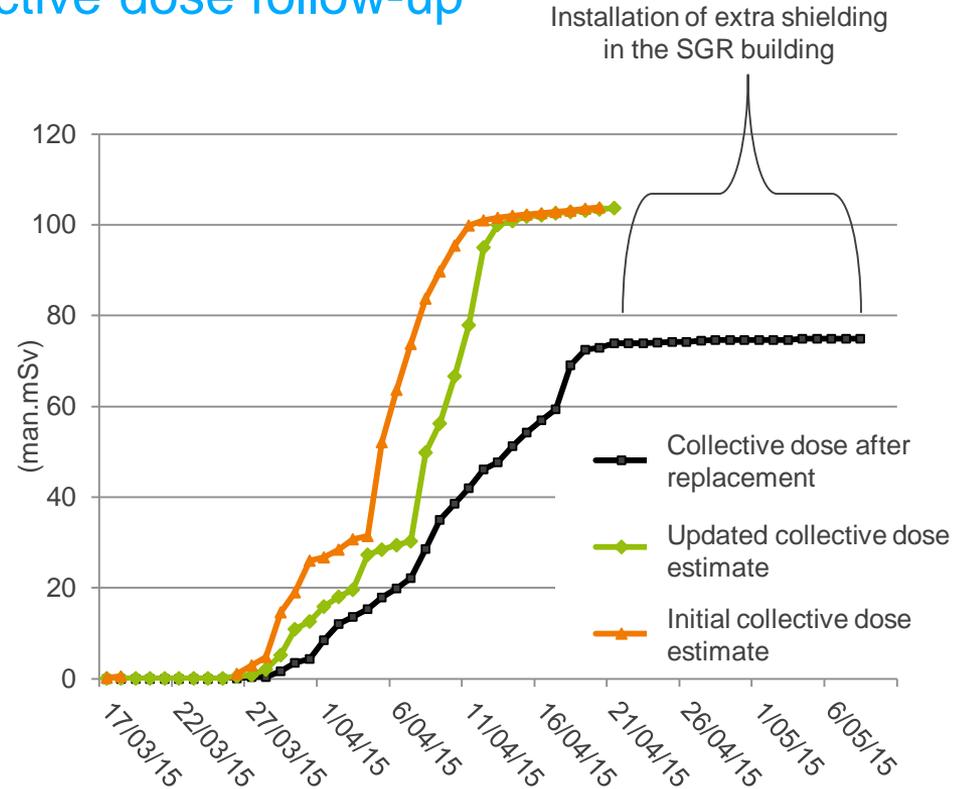
- Higher dose rates than expected at one side of the old RVCH
- Presence of contamination on the EMAs and ventilation envelope
- Manual dismantling of 9 blocked EMAs close to the old RVCH
- Problems during cutting of 2 CRDMs, requiring manual intervention
- Too high dose rates around the container used for the old RVCH transport



On-site follow-up

The Tihange 3 RVCH project – Collective dose follow-up

- Consequences of blocked EMAs:
 - Delay of the project
 - Additional collective dose due to operations close to the old RVCH (estimated collective dose = 9 man.mSv)
- Update of the estimated collective dose to include delay during the project (green curve)
- Estimated collective dose = 103.7 man.mSv
- Collective dose after replacement = 76.3 man.mSv
→ decrease of 26% mainly due to:
 - A reduced number of man-hours
 - Lower dose rates than expected around the CRDMs



On-site follow-up

The Doel 4 RVCH project - Issues

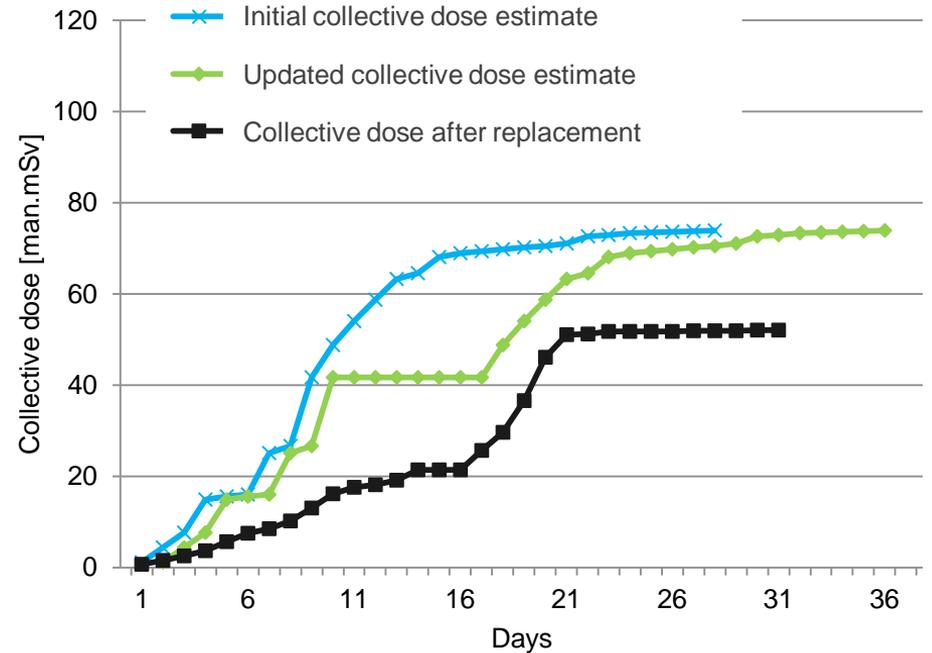
- Lower measured dose rate levels (about 30% lower compared to the Tihange project)
- Less problems with blocked EMAs
- No problems during the CRDM cutting
- High contamination of the reactor vessel dome during the cutting of the CRDM adapters:
 - Clothes contaminations were detected for several workers leaving the controlled area
 - A decontamination of the RVCH was performed
 - All cut adapters were covered with plastic bags
- Shielding of the vessel head with lead after dismantling



On-site follow-up

The Doel 4 RVCH project – Collective dose follow-up

- Update of the estimated collective dose to include one week delay due to an issue with a bimetallic weld at the new vessel head (green curve)
- Unblocking activities of some EMAs during the first days of the delayed week → weak increase in collective dose
- Larger increase in collective dose during the cutting of the CRDM adapters
- Estimated collective dose = 73.9 man.mSv
- Collective dose after replacement = 52.0 man.mSv → decrease of 30%



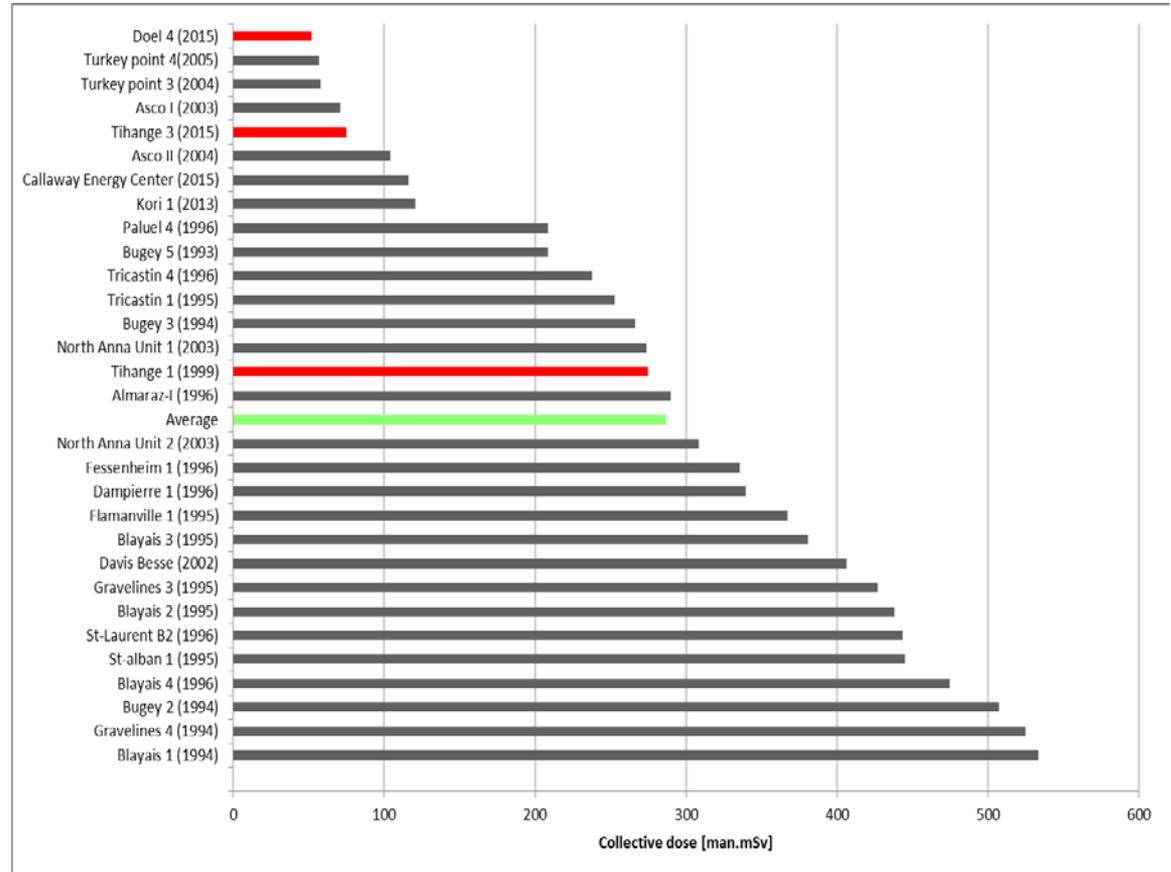
On-site follow-up

Summary

| | Tihange 3 | Doel 4 |
|---|-------------|-------------|
| Duration of the project [days] | 43 (+ 72%) | 30 (+7%) |
| Internal contamination incidents | 0 | 0 |
| Important external contamination | 1 | 1 |
| Dosimetry alarms | 3 | 3 |
| Total collective dose [man-mSv] | 76.3 (-26%) | 52.0 (-30%) |
| Max. daily collective dose [man-mSv] | 9.7 | 9.5 |
| Average daily collective dose [man-mSv] | 1.8 | 1.5 |
| Maximum cumulative individual dose [mSv] | - | 2.15 |
| Average cumulative individual dose [mSv] | - | 0.2 |

On-site follow-up International comparison

- The Tihange 3 and Doel 4 RVCH replacement projects resulted in a lesser collective dose compared to the Tihange 1 RVCH replacement in 1999
- The collective doses of the Tihange 3 and Doel 4 projects are in line with international REX



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Conclusion



Conclusion

Doel 4 and Tihange 3 RVCH replacement projects

- ALARA objectives were reached, collective doses after replacement are:
 - 76.3 man.mSv for Tihange 3
 - 52.0 man.mSv for Doel 4
- The Doel 4 project ended with 32% less collective dose compared to the Tihange 3 project:
 - Difference in approach
 - Lower dose rates
 - REX of the Tihange 3 project has been used
- Doel 4 and Tihange 3 projects are not easy to compare (different approaches, different issues, etc..)
 - Blocked EMAs and problems with CRDMs cutting in Tihange 3
 - Contamination of the vessel dome after cutting of the CRDM adapters in Doel 4

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