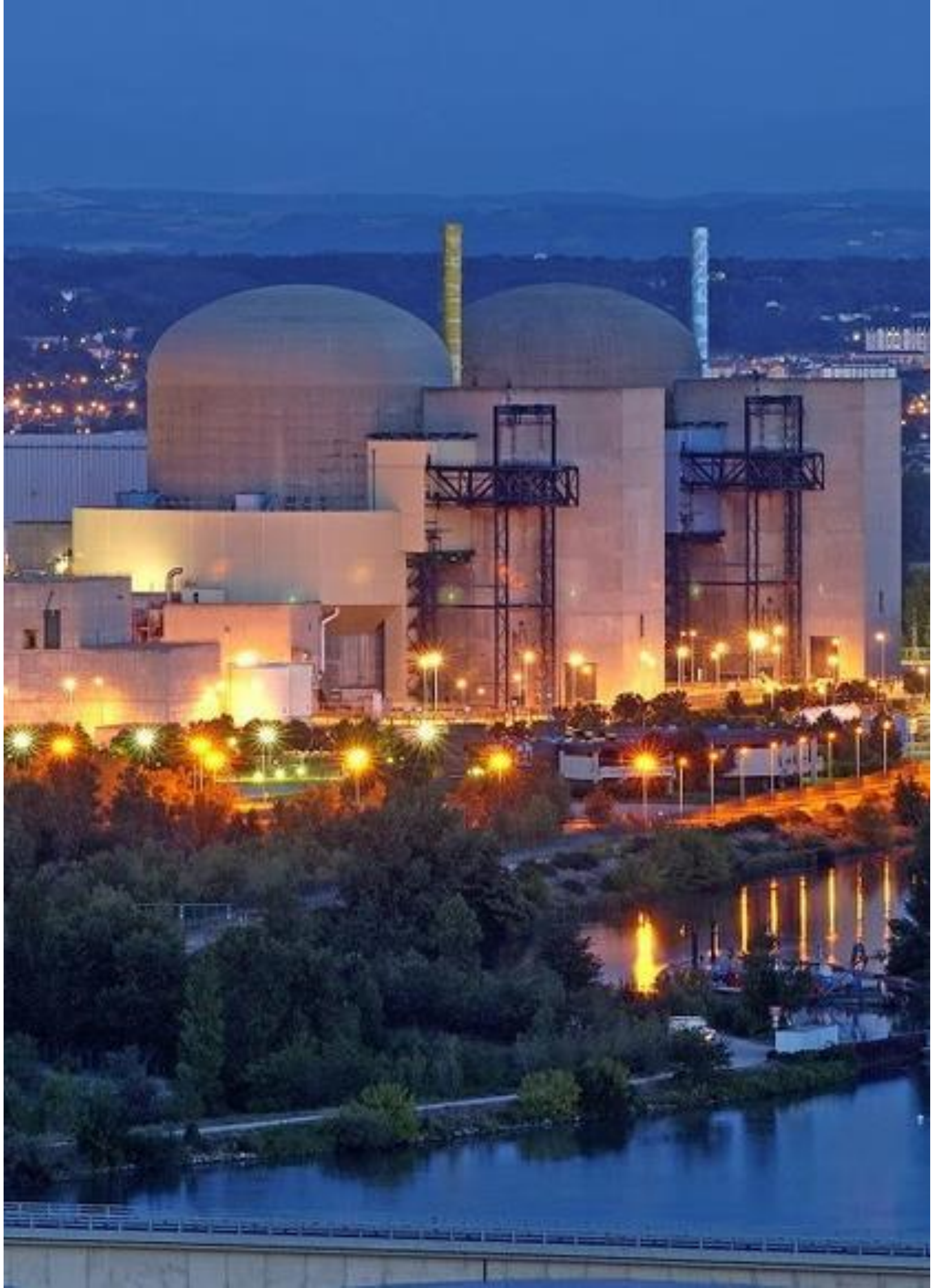
REPLACEMENT OF THE PRESSURIZER IMMERSION HEATERS

1. EDF requirements
2. EDF organization for ALARA principle
3. Intervention presentation
4. Initial predictive dosimetry
5. Risk analysis
6. Optimization actions
7. Optimized predictive dosimetry
8. Feedback and his consideration
9. Innovations and optimizations



1. EDF REQUIREMENTS

Maintenance Operations with strong stake :
The Radiation Protection Department of each Nuclear Power Plant writes a thorough analysis of optimization, in collaboration with the provider. The goal is to identify the contributing elements to the collective dose, such the source dose, the radiation protection actions and their quantified performances.

DPN (Nuclear Production Division) requirement « Radiation Protection Optimization of the workers »

Radiation protection of the workers is taken into account from the design stage. Each step into the design stage (technical specifications, call for tender, technical documents from the provider) is analyzed by a Radiation Protection Specialist (RPS = PCR in French).

2. EDF UTO ORGANIZATION FOR ALARA PRINCIPLE

UTO (TECHNICAL OPERATION UNIT) RADIATION PROTECTION SPECIFICATIONS

1. **The radiological context and the objectives of dose are supplied in a document setting out EDF specifications**

2. **From the beginning of the call for tender, the admissibility criteria are considered according to the ALARA principle by the UTO RPS**

3. **The offers technical documents are analyzed by the RPS considering :**
   - Radiological risk identification
   - Provisional dosimetry, initial and optimized including the intervention times, the dose limits and dose mapping
   - Relevance of optimization actions considered and the dosimetry gains
   - In situ organization involving the bidder RPS

4. **The in situ organization and the radiological risks optimization actions are validated in the UTO Decision committee of risks prevention before presentation in NPP ALARA committee**

5. **The equipment's qualification, done outside the radiological zone, is observed and checked by the UTO RPS. During the qualification the holder must have integrated the radiological risks**

2. EDF NUCLEAR POWER PLANT ORGANIZATION FOR THE ALARA APPROACH

1. **The optimizations actions written in the holder's technical document are transcribed in the ALARA presentation**

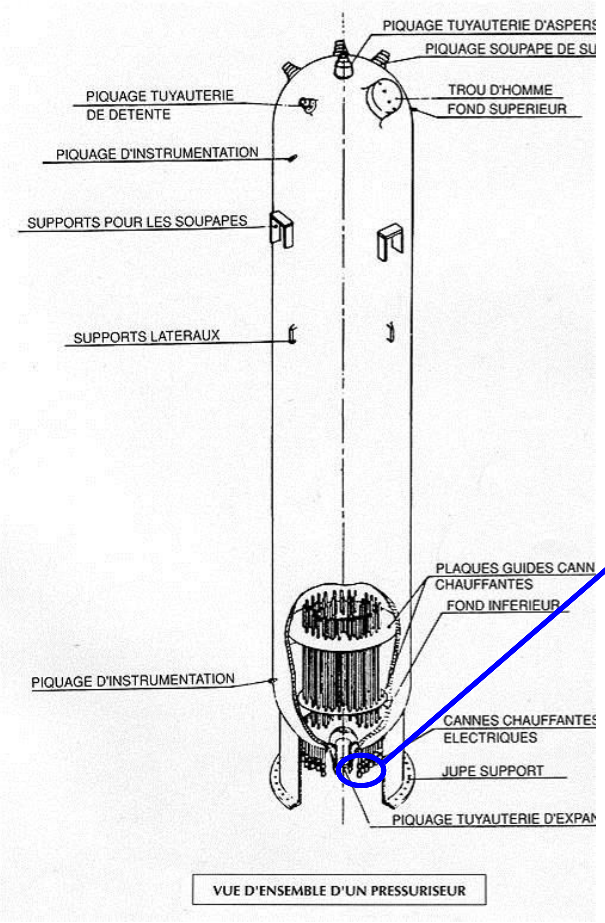
2. **The nuclear power plant organize the ALARA committee for the strong stake intervention. The holder RPS, the NPP ALARA RPS and a management representative have to be there, the UTO contract holder and the RPS UTO are invited.**

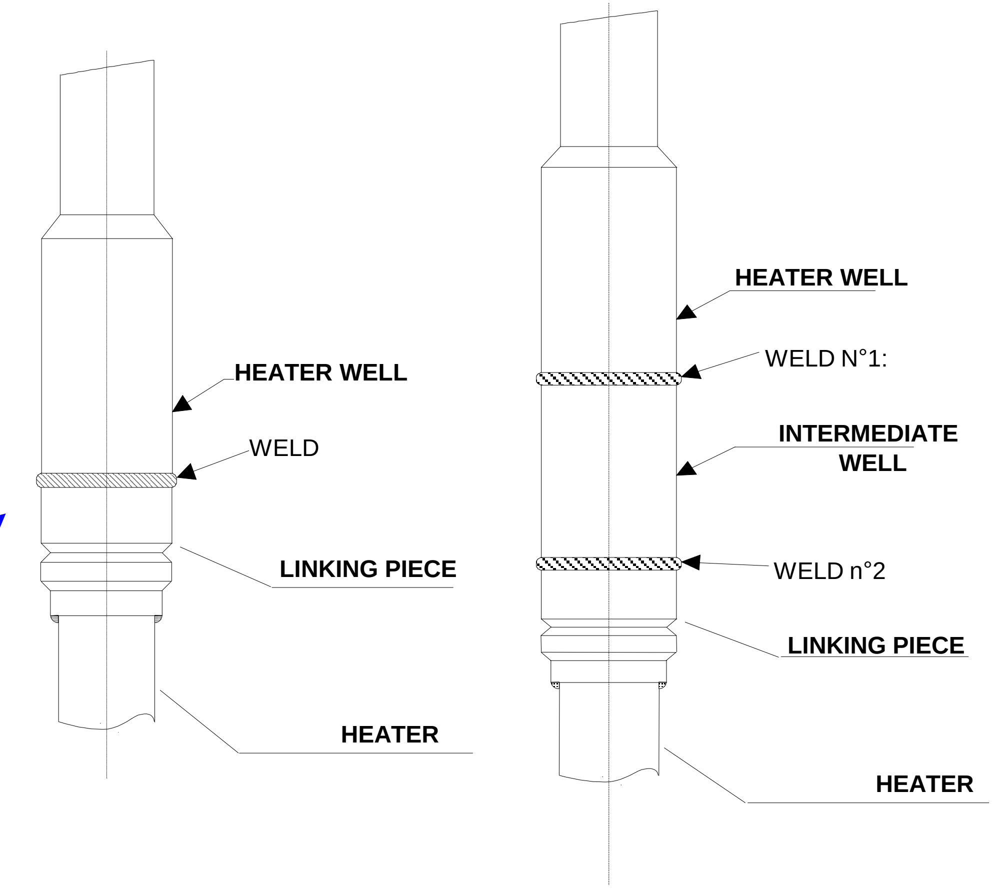
3. **The holder RPS shows the provisional optimized doses and the actions needed for the optimization. The collective dose takes into account the unit radiological state where the worksite will be.**

4. **All members of ALARA committee validate the actions according to their feasibilities. These actions are written in a report.**

5. **If one action could not be realized during the intervention, this change has to be justified and validated by the NPP direction.**

3. INTERVENTION PRESENTATION





3. INTERVENTION PRESENTATION

1. Radiological shielding installation

2. Disconnection of wires

3. Heaters Replacement

- 3.1. Installation
- 3.2. Machining of heater wells
- 3.3. Automated Cutting
- 3.4. Foucault Current Control
- 3.5. Welding (W1 et W2) and radiographic control
- 3.6. Equipment Storage

4. Electrical reconnection

5. Removal of the radiological shielding

6. Power tests

4. INITIAL PREDICTIVE DOSIMETRY

- **Basic assumptions :**
  - Replacement of 50 rods and installation of 50 intermediate sleeves.
  - Mobilization and electrical disconnection : empty PZR.
  - Use of teleoperated machines.
  - Logistics gathered

phase	**Collective dose** (H.mSv)
intervention	125,6
logistics	11,0
total	136,6 H.mSv

> 20 H.mSv

➔ Strong radiological stake

5. RISK ANALYSIS (ABSTRACT)

Risk	level	Safeguards
External exposure of the workers	**high** > 20 H.mSv	→ Specific radiological shield under the pressurizer (encompassing pressurizer expansion piping), → Automated tools, → Improved pre-job-briefing and awareness for evacuation of waste bags, → Teledosimetry during sensitive phases (rods cutting and scrapping).
Internal exposure ok the workers	**Significant risk** (opening circuit conveying contamination)	→Wearing reinforced ventilated sealed uniforms, → Aerosol detectors at the exit of airlock, → Decontamination of rods with wipes → Setting up of depression machines as close as possible to the source of contamination,
Dissemination of contamination	**high** (rod cutting and scrapping)	→Decontamination of the airlock after each scrapping shift, →aérosols detectors at the exit of airlock, →Opening the manhole ASAP to dry the bottom of the pressurizer.

6. OPTIMIZATION ACTIONS

Action	Estimated dose cost	Estimated dose Gain
Use of specific radiological shield + standard protection on pressurizer expansion piping	5,60 H.mSv (specific rad-shield OTCN)	42 H.mSv
Use of teledosimetry	Negligible	Gain on the time
Decontamination of rods with wipes	Cost and gain strongly dependent on the dose rate of the rods Gain on the risk of contamination during scrapping	
Use of automated machines (already planned in the initial offer)	Negligible	50 H.mSv (already included in the initial predictive dosimetry)
Using the automatic scrapping machine	undefined	30 %
Use of specific reinforced ventilated sealed uniforms	Nul if recontamination risk is avoided by helping the workers to undress	Gain on the risk of contamination

7. OPTIMIZED PREDICTIVE DOSIMETRY

Phase	Initial predictive dosimetry (H.mSv)	Optimized Predictive Collective dose (H.mSv)	Integrated collective dosimetry after the intervention (H.mSv)
intervention	125,6	83,6	44,4
logistics	11,0	16,6	9,6
total	136,6	100,2	54,0
gain		36,4	82,6 (46,2)

8. FEEDBACK AND HIS CONSIDERATION

More than 25 years of feedback concerning :

- The equipment : development and improvement of specific machines,
- The working environment : mounting of reinforced airlocks designed to contain the contamination,
- The organization on site : optimization of the activity sequences :
    - Non-destructive controls during the night,
    - Replacement of half a pressurizer instead of one-third
    - Management of the integrated dosimetry (using teledosimetry)

EDF ONET TECHNOLOGIES

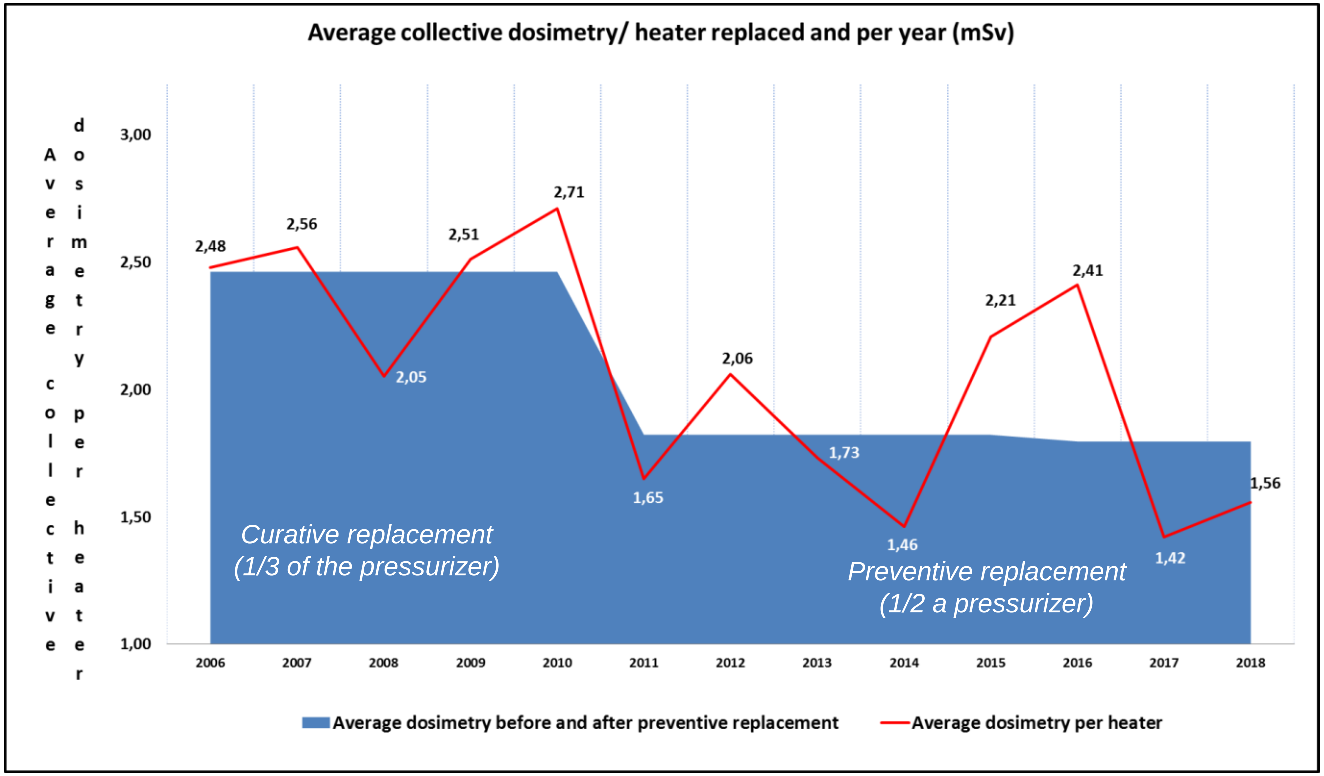
9. INNOVATIONS AND OPTIMIZATIONS

Examples of some innovations over the years :

- Specifically designed radiological shield,
- Waste bags developed for one of the most exposed activity (scrapping the removed heaters in parts),
- Equipment teleoperated,
- Reinforced ventilated sealed uniforms,
- Logistical staff dedicated to the intervention.

9. INNOVATIONS AND OPTIMIZATIONS

Dosimetry gain thanks to the optimizations and improvements over the years :



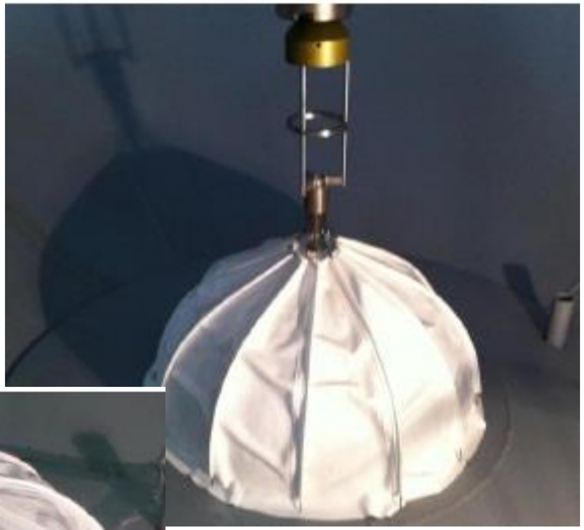
Dosimetry gain around 30 % between 2006 and 2018

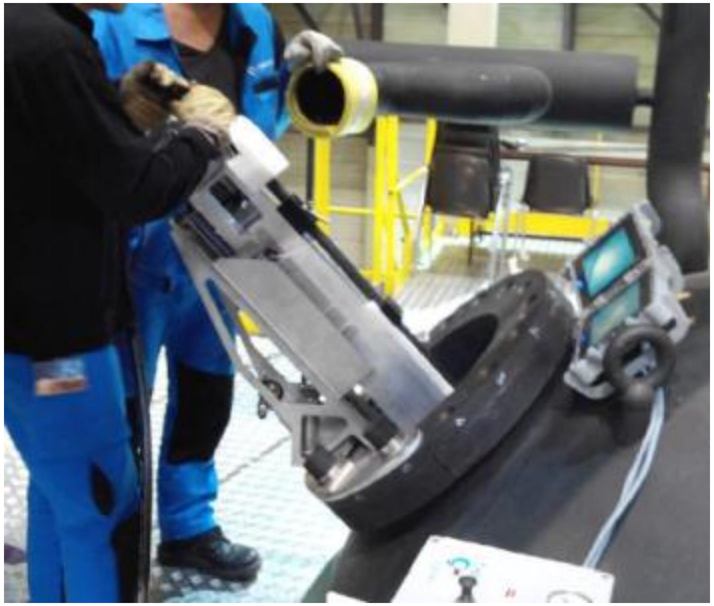
Higher average collective dosimetry / heater in 2015 and 2016 due to highly irradiation pressurizers

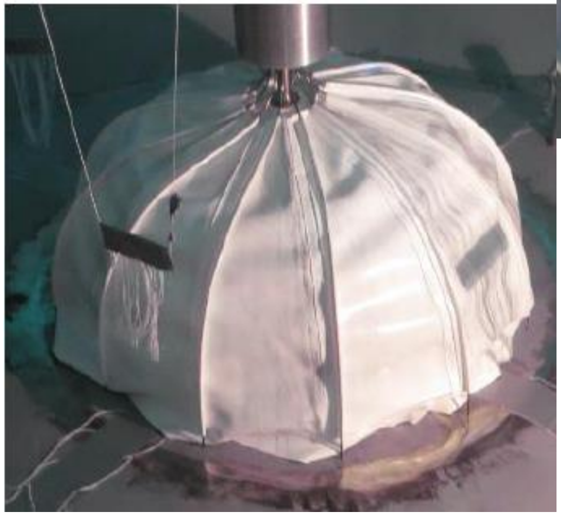
THANKS

4. PRESENTATION OF THE INTERVENTION

- **Pressurizer Strainer shutter :**
  - Target : isolate the pressurizer from the Principal Primary Circuit for phase of chamfers / welds
    - Avoid air movements at the wells
    - No longer require the Primary Circuit Vacuuming Machine to be inhibited







RADIOLOGICAL STATE BEFORE INTERVENTION

- **predictive dosimetry based on feedback (from 2006)**
- **Basic assumptions :**
  - Pressurizer empty,
  - No radiological shield.

Zones	dose rate (mSv/h)
Z0 – control station	0,005
Z1 – airlock fallback zone	0,075
Z2 – pressurizer room	0,369
Z3 – expansion piping	1,280
Z4 – Electrical cabinets	0,503
Z5 – under the pressurizer	2,882
Z6 – scrapping control station	0,06
Z6b – scrapping sas	1,000
Z7 – room for gamma ray shots	0,001

8. MANAGEMENT OF RADIOLOGICAL CLEANLINESS

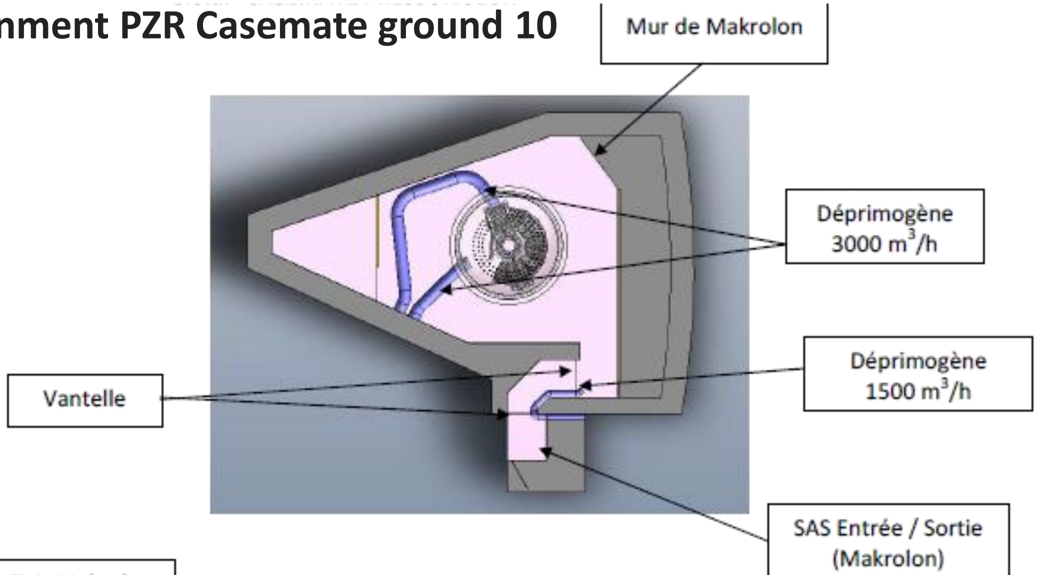
Study carried out on the sizing of the containment.

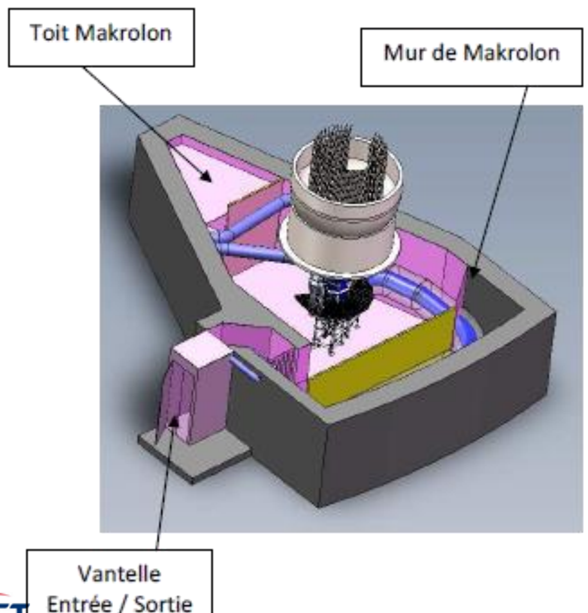
Logistics requirements :

- Replacement of heating rods:
  - Sealing of the airlock.
  - Quality of installation of the standard radiological shield.
  - Provision of 3 depression machines 3000 m3 / h.
  - Provision of 3 depression machines 1500 m3 / h.
  - Validation by the Risk Prevention Service on the compliance of the airlock to remove the logistic stopping point.
  - Installation of 3 layers of vinyl on the ground by the site staff for the PZR airlock and scrapping.
  - Decontamination of the airlock following the machining, scrapping and brushing of the cuffs (remove vinyl layers on the ground).
  - Further decontamination at the airlock / undressing.
  - Thorough decontamination of the airlock before the start of clean phases (FC, Welding, gamma ray).
- Containment :
  - Entry / exit lock.
  - Standard biological protections on the PZR dome.
  - Provision of a 1,500 m^3/h depression machine (entrance /exit airlock).
  - Removal of Insulation and floor scaffolding for access to the manhole.
  - Covering of Vinyl layers the inside of the casemate from the entrance to PZR manhole.
  - Smears made at the beginning and end of the intervention in collaboration with the Risk Prevention Service in the intervention zone.

8. MANAGEMENT OF RADIOLOGICAL CLEANLINESS

- **Static containment PZR Casemate ground 10**





<u>Listing :</u>

- 2 déprimogènes de 3000 m^3/h
- 1 déprimogène de 1500 m^3/h
- 1 vantelles Entrée / Sortie
- 5 couches de vinyle au sol SAS de travail
- 2 vantelles entre le local SAS d'accès et sas de travail

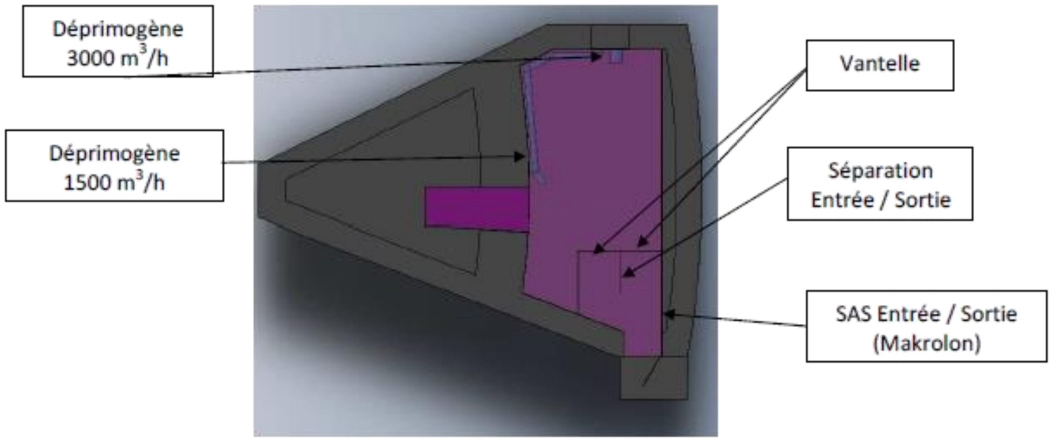
<u>Exigence :</u>

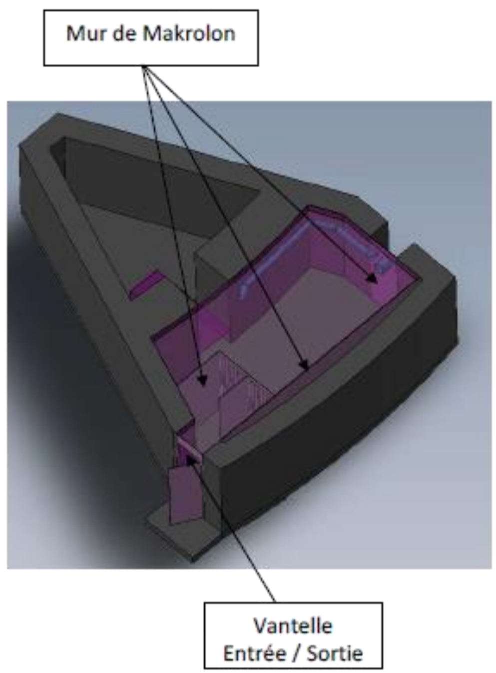
Sas de déshabillage < 400 Bq/cm^2
Vitesse du flux d'air > 0,5 m/s

Surface Makrolon = 15m^2
Surface vinyle = 215 m^2

8. MANAGEMENT OF RADIOLOGICAL CLEANLINESS

- **Static containment bucking room ground 9**





<u>Listing :</u>

- 1 déprimogènes de 3000 m^3/h
- 1 déprimogène de 1500 m^3/h
- 1 vantelles Entrée / Sortie
- 5 couches de vinyle au sol SAS de travail
- 2 vantelles entre le local SAS d'accès et sas de travail

<u>Exigence :</u>

Sas de déshabillage < 400 Bq/cm^2
Vitesse du flux d'air > 0,5 m/s

Surface Makrolon = $47 m^2$
Surface vinyle = $170 m^2$