

# **Decommissioning the BELGONUCLEAIRE Dessel MOX Plant, from A to Y**

*Lessons learned from a long march*

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# BELGONUCLEAIRE Dessel MOX Plant 1986-2006

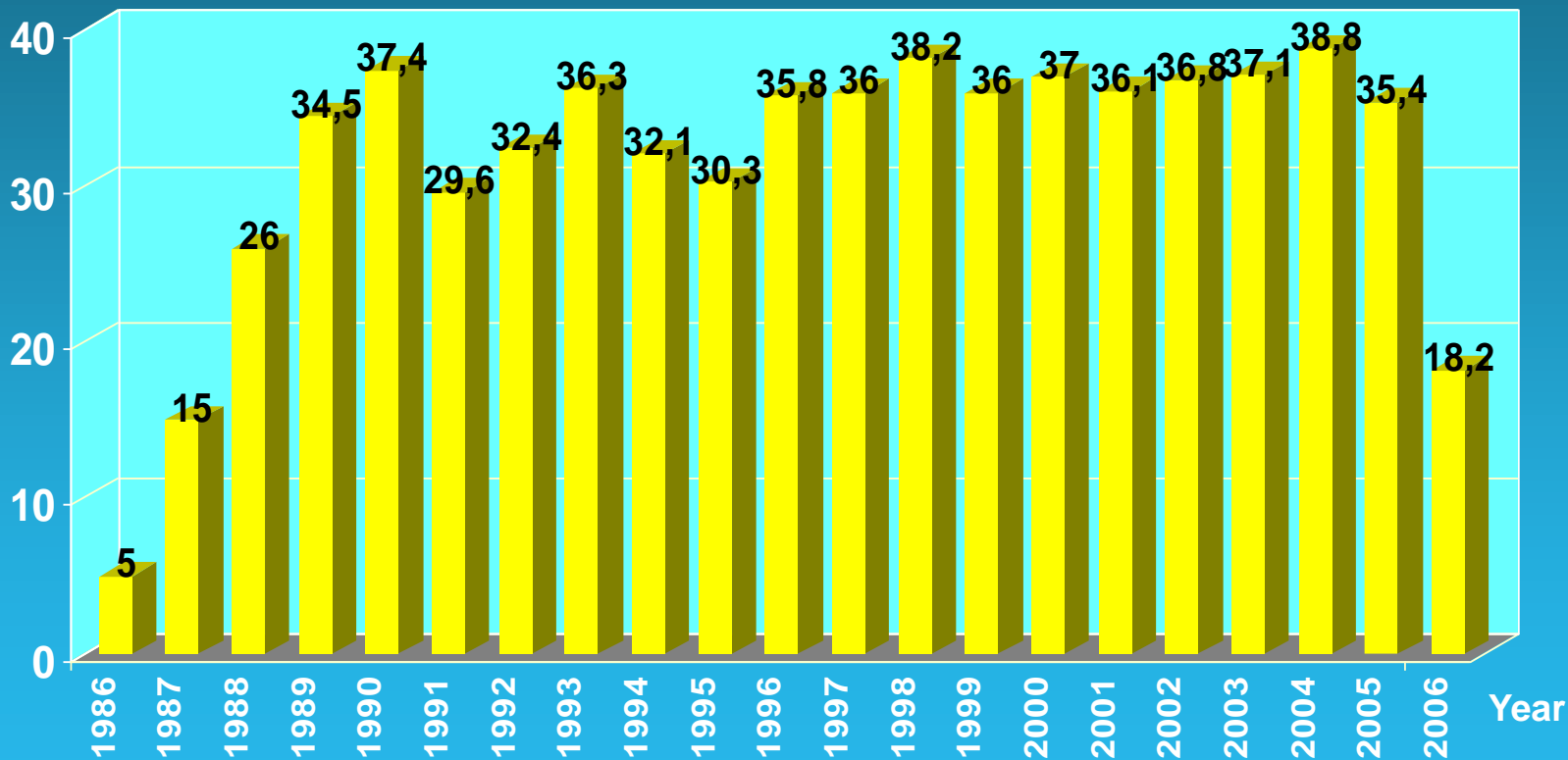


**660 tHM = 40 tons Pu = 90 reloads = 230 TWh  
for PWRs & BWRs operating in  
Belgium, France, Switzerland, Germany, Japan**



# Industrial MOX Fuel Fabrication at BNDMP

Yearly fabrication  
(ton HM)



# Industrial MOX fuel fabrication in glove boxes at BNDMP



**BNDMP workforce = 250 technicians & employees + 50 contractors**

**170 glove boxes = 200 ton of primary A3X waste**

**300 m<sup>3</sup> = 1500 200L-drums of A3X waste**

**1000 ton infrastructures to release**

**footprint MOX production building 2700 m<sup>2</sup>**

# Outline : 12 steps of decommissioning



- 1) Starting from scratch in 2002
- 2) Preparation wrt O/N
- 3) Preparation wrt FANC
- 4) Shutdown of BNDMP
- 5) Post-operational phase
- 6) Decommissioning license
- 7) Contracting decomm works
- 8) Starting decomm works
- 9) Decommissioning production equipment
- 10) Decommissioning infrastructures
- 11) Cleaning buildings and site
- 12) Formal release of the nuclear site in 2019

# Starting from scratch in 2002 (1)



- **Strengths**
  - good safety culture, no significant incident
  - no excess fissile materials
  - BN had control on **Tecnubel/Transnubel/ECS**, specialized in nuclear services, transport, formation and radioprotection
  - healthy finances
- **Weaknesses**
  - BN is a small company
  - lack of technical credibility in the field of decommissioning
- **Opportunities**
  - first of the kind project for FANC and O/N
- **Threats**
  - difficulty to release suspect plutonium wastes
  - lack of solution by O/N or BP for special types of wastes



# Starting from scratch in 2002 (2)

- Work first on weaknesses and threats
- Lack of technical credibility
  - purchase MOX decommissioning technology: successful approach with SIEMENS AG based on decommissioning of the Hanau MOX Plant
- Special types of wastes
  - develop transformation into forms acceptable for O/N
  - uranium metal, contaminated oil



# Preparation wrt O/N (1)

- **Final Decommissioning Plan (FDP)**
  - The FDP is a document applicable up to the end of decommissioning
  - Its approval by O/N means that the decommissioning project is shared by O/N, including the costs
  - The FDP can be revised and approved in case of changes
  - If necessary, the FDP may include several scenarios concerning decommissioning operations, waste on-site storage, time schedule: the costs of these scenarios have to be evaluated
- **Timing FDP:**
  - preparation started in 2002
  - FDP rev 0 submitted to O/N by the end of 2003,
  - approval by O/N of FDP rev A by the end of 2004
  - approval by O/N of FDP rev B by the end of 2008 – license granted
  - approval by O/N of FDP rev C by the end of 2013 – rev time schedule





# Preparation wrt O/N (2)

## Important issues to be addressed by FDP

- Radiological inventory, as detailed as possible, for production equipment as well as for infrastructures
- Qualification of processes
- Identification of all RA materials streams, their O/N categories and corresponding ACRIAs
- Identification of other materials streams to be released and their further treatment (recycling/melting or industrial waste)
- Estimation of total volume/weight for the different streams
- Time schedule of acceptance and transfer to O/N of the wastes
- **Necessary buffering capacity subject to O/N agreement**



# Preparation wrt O/N (3)

## Decommissioning wastes contract

Once the RA waste volumes are known, the reception and transfer to O/N of these volumes have to be fixed contractually :

- ACRIAs and PVA/PVT
- indicative time schedule
- transport modalities
- nuclear packaging to be used
- costs

In case of BNDMP, the RA waste volume of the decommissioning corresponded to 1500 drums over 4 years, compared to 100 drums per year during operation



# Preparation wrt FANC

- Filing a license request is not possible as long as the decision to shut down the nuclear installation has not been formally taken
- Exchange of information with the FANC is however necessary to make sure that the future license request will be acceptable and will be processed smoothly according to article 6 of ARBIS = **prelicensing**
- Informal discussions took place with FANC as soon as the discussions with O/N were sufficiently advanced
- The license request was prepared by BN, to be submitted to FANC as soon as possible after the decision of the Board to shut down the plant.



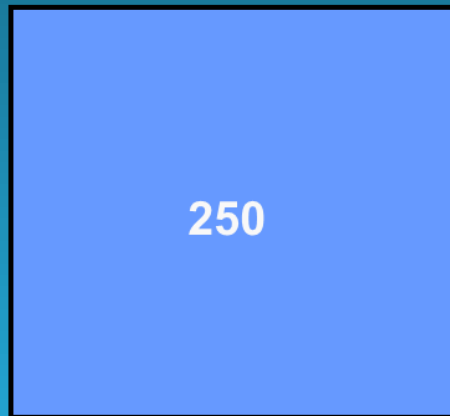
# Shutdown of BNDMP (1)

- Shutdown was started by the Enterprise Council of November 2005: the representatives of the personal were anxious about the future, and several interruptions of work had taken place
- The first phase of the Law Renault was concluded in December, allowing the Board to decide to shutdown the plant on December 22
- A social plan was negotiated in January and accepted by 61% of the personal; all employees contracts were to be terminated, with the exception of 30 people in charge of the safety during the decommissioning of the MOX plant
- The draft decommissioning license request was submitted to O/N for opinion, and the license request was officially filed by FANC in April 2006
- The production stopped smoothly in Q3-Q4 of 2006, and the excess fissile materials were sent back to the customer in 2007



# Shutdown of BNDMP (2)

## MOX fabrication



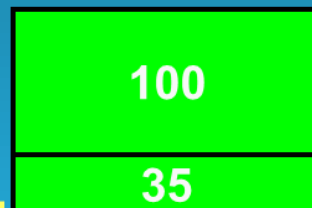
20 a

## Stand-by



3 a

## Decommissioning



8 a

- 2008 **decomm license**
- 2009 **training & qualification**
- 2010 **decomm glove boxes**
- 2011 **decomm glove boxes**
- 2012 **decomm glove boxes**
- 2013 **decomm glove boxes**
- 2014 **decomm glove boxes**
- 2015 **decomm infrastructures**
- 2016 **decomm infrastructures**
- 2017 **decomm infrastructures**
- 2018 **release\* buildings & site**
- 2019 **unconditional site release**

\* = cleaning, release & demolition of buildings



# Post-operational phase

- It was originally foreseen that the license should be available after 4 years as in previous cases
- Once the excess fissile materials were shipped back to their owners in 2007, BN notified to FANC the shutdown of the plant **according to article 17 of the ARBIS**, including the list of:
  - the activities that were still necessary during the decommissioning of the installation and must remain authorized;
  - the activities that were not necessary anymore and could be excluded.
- During the post-operational phase, several actions were undertaken, to improve the safety of the plant, within the limits of the allowed activities : removing mobile equipments and materials, reducing fire hazard, ...



# Decommissioning license (1)

## BN proposals dated April 2006:

- BN remains sole responsible wrt FANC as well as wrt O/N
- The decommissioning work should be performed by qualified personal of contractors
- Proposed decommissioning process: used by Siemens in the Hanau MOX plant, using disposable tents in underpressure , i.e. one of the 3 processes analyzed in the FDP
- Only cold cutting techniques (sawing, nibbling) were proposed to reduce fire hazard
- Reinforced waste drums were proposed to facilitate manipulation and transfer
- RA waste should be shipped along a private road towards the adjacent site of Belgoprocess-O/N



# Decommissioning license (2)

**License granted in February 2008 following art 6 ARBIS**

- **30 conditions prepared by the Scientific Council of FANC**
  - Financial resources sufficient for safe decommissioning
  - Bel V and FANC approve organization, selection criteria for the contractors, and qualification results of the contractors
  - Bel V approves work procedures, organization emergency planning, material release procedures, methods for characterization of buildings and site
  - FANC approves release of buildings and site
  - If the site can be released unconditionally, then BNDMP will be suppressed from the list of installations of class 1
  - If the site cannot be released unconditionally, BN has to perform an EIS and to propose to FANC measures for site protection and restrictions for future use
- **No time limit in the license**





# Contracting decomm. works (1)

## Failure of the fixed cost approach

- Once in possession of the decomm license, BN finalized the conditions for a decommissioning with fixed costs
- A Technical File was prepared, including specifications, all relevant work procedures, drawings and inventories
- The RFP was issued end of March 2008 towards 4 selected contractors, with bids requested by June 30
- 3 bids were received
- A major issue was the spread **in cost** (ratio 1 to 6) and **in time schedule** (ratio 1 to 2) owing to the “first of the kind” project, leading to the pileup of uncertainty margins
- Even with sound BN finances, the highest bid lead to bankruptcy



# Contracting decomm. works (2)

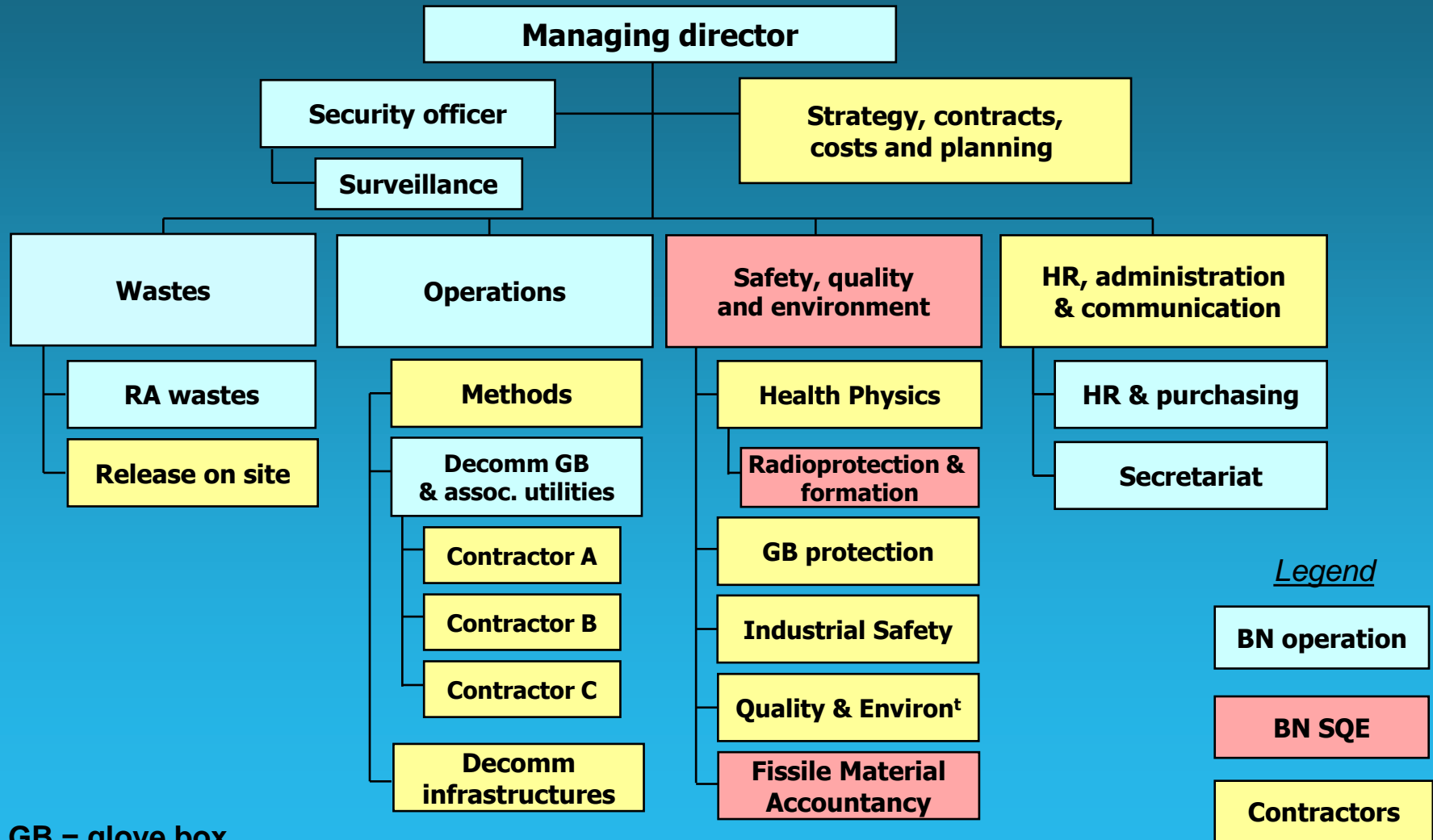
## Success of the Integrated Team approach

- If uncertainty margins are an economic issue, it is less expensive for BN to take itself the risk
- Integrated Team: combines the BN team of 35 with the teams of several contractors, under BN leadership
- Several contractors: selected by BN primarily for their specific experience and to ensure diversity and sound competition
- Studsvik GmbH: decomm of Siemens Hanau MOX Plant
- JV SCK•CEN-Belgoprocess: decomm of Eurochemic (BP) and release of materials and buildings (EHS at SCK)
- Tecnubel-ECS: knowledge of BN site and procedures

# Contracting decomm. works (3)



## Integrated Team



GB = glove box



# Contracting decomm. works (4)

## Type of contracts : 4+ years with incentivized fee

- Remuneration of hours on site with very similar hourly rates for all contractants + small fixed contribution off-site
- The contractor warrants minimal presence of manpower
- Non negative performance fee based on 3 components:
  - 55% = safety performance = incidents and dosimetry
  - 25% = waste efficiency = kg per 200L waste drum
  - 20% = time efficiency = manhours per ton material (=glove box)
- Monthly performance monitoring during project meetings
- Possibility for BN to terminate contract if performance repeatedly too bad
- Part of the fee paid yearly, balance paid at the end of the contract

# Contracting decomm. works (5)



- **Simplicity of contracts and monthly project follow-up of the costs and monthly performance monitoring are keys to success:**
  - **each contractor is aware of its accumulated fee**
  - **each contractor knows one incident can destroy his performance fee: timely action is certain**

**During the whole decommissioning project :**

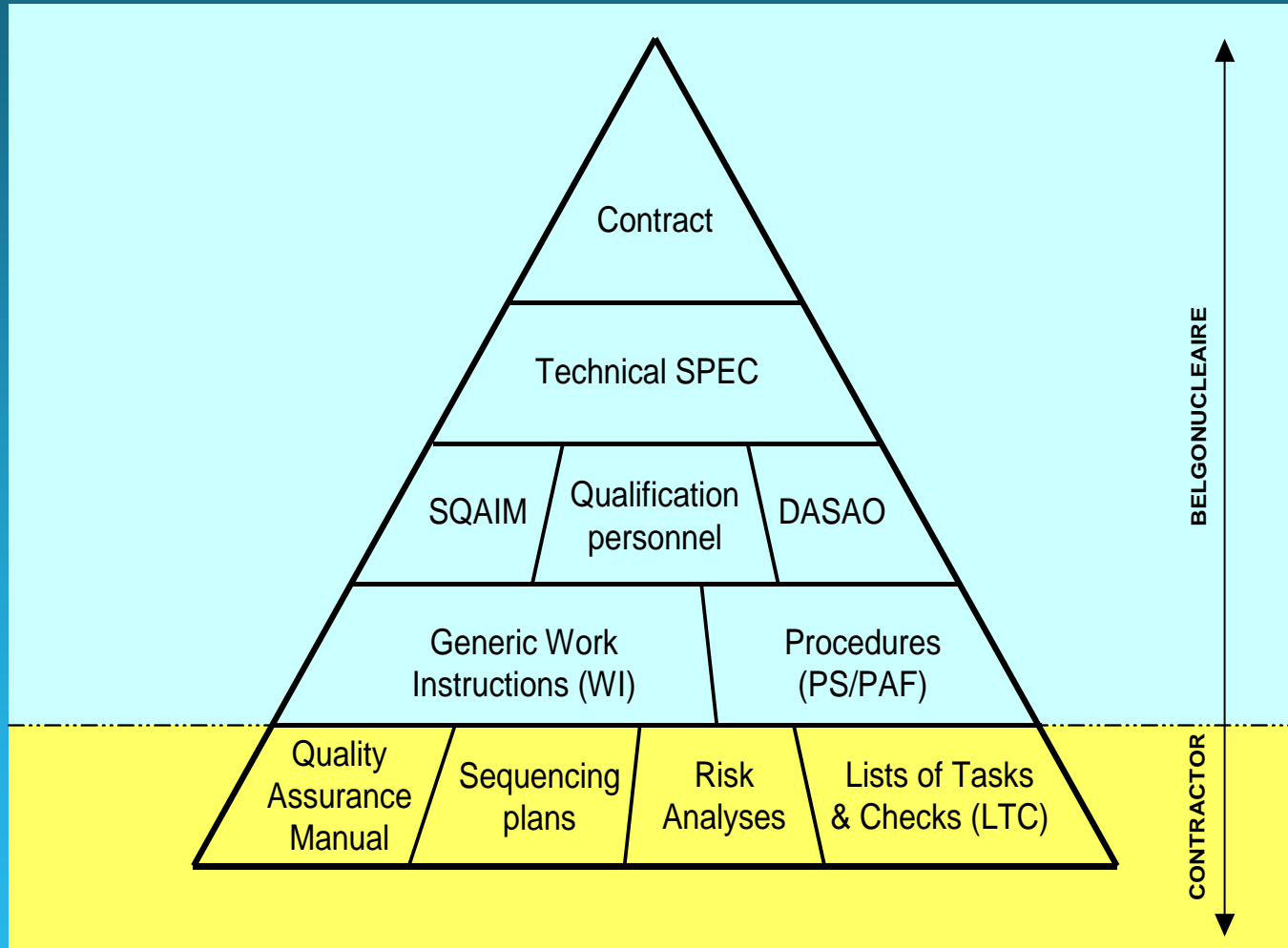
- **not a single incident**
- **not a single lawyer involved**



# Starting decommission works (1)

- **Written decommissioning instructions: the LTC**
- The decommissioning of the BNDMP corresponds to  $\approx 1000$  LTC or **List of Tasks and Controls** : the LTC is the elementary step of the decommissioning project
- Each LTC corresponds to the decommissioning of one single component; each LTC contains the following minimum
  - The risk analysis of the foreseen steps
  - The list of the tools and corresponding safety instructions
  - When necessary a sketch or picture(s) of the component
  - The succession of the decommissioning steps procedures
  - The registration of measurements like waste weights/volumes
  - Hold points for hierarchy or radioprotection or industrial safety
  - Characterization & destination of waste produced
  - Registration of waste weights/volumes in the LTC for registry in data base
- **Each LTC is released after approval by the hierarchy and by SQE**

# Starting decomm works (2)





# Starting decomm works (3)

## Formation and qualification of personal:

- Basic formation = responsibility of contractor
- Formation to the MOX environment = responsibility of BN
- Significant effort: 27 to 122 working days depending on job
- Fostering followed by evaluation and release

Function	Inspector radioprotection & safety	Operator decomm. GB	Operator decomm. Infra	Operator Waste
Number of working days	122	42	27	29

## Big investment in personal:

- Limited turnover has positive impact on safety
- But new personal is slow to start
- Necessity to repeat formation sessions at regular intervals
- Improves cohabitation of different contractors



# Starting decomm works (4)



Training simulator provided by ECS



*BNS EVL September 24, 2020*

# Starting decomm works (5)

## Centralized data base Dasao

- For safeguards, waste management, shipment documents, material characterization for release
- Ensures traceability of data for wastes and released materials

## Centralized data base Dasaov (v=vrijgave)

- For management of > 100 000 release measurements of buildings and site with resistance to human error
- Generates images of surfaces to characterize and measurement grids
- Measurements of qualified recorders are downloaded into the data base and are compared to rejection limits
- Indicates where further cleaning is necessary for unconditional release

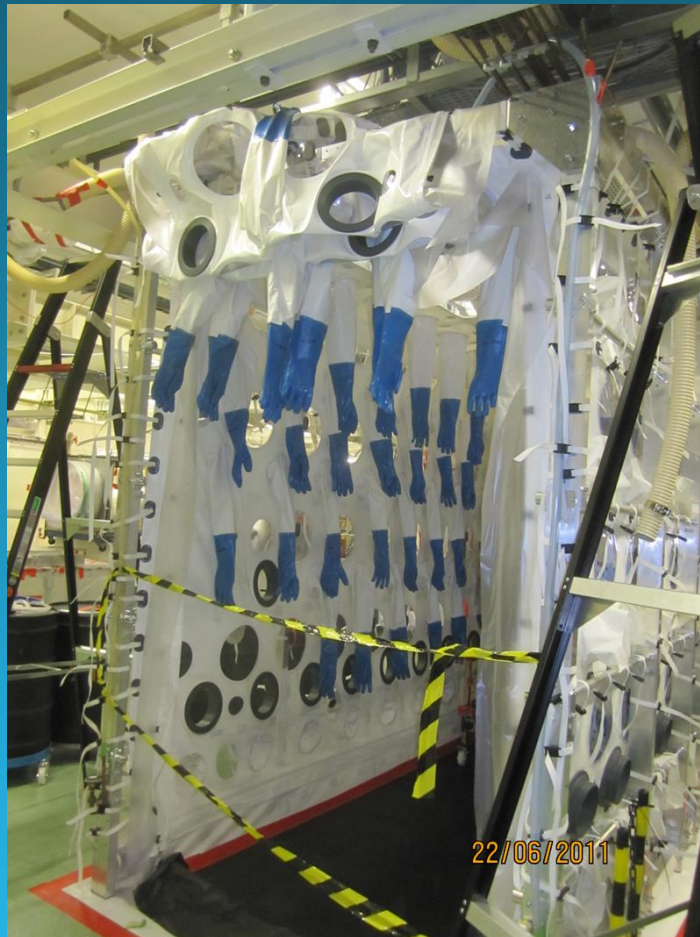
**DASAO & DASAOV : developed jointly by SCK•CEN and BN**



# Decomm. production equipt (1)

- Production equipment is normally present several times
- Decommissioning operations are repetitive
- Opportunity to standardize the decomm operations as well as the tools
- Inject REX of equipment  $n$  into the decommissioning of equipment  $n+1$  = important for personal exposure and safety
- **More easy to plan and to follow**
- Opportunity to compare different contractors in terms of performance like industrial safety, dosimetry, waste production, efficiency man.hours

# Decomm. production equipt (2)



Preparation of a “garage” disposable tent with arrival of the glovebox to be decommissioned

# Decomm. production equipt (3)



**Moving a glovebox from a platform to the floor for decommissioning**

# Decomm. production equipt (4)



**Sintering furnace**



**Automated cutting of  
30 mm thick SS GB bottomplate**



# Decomm. Infrastructures (1)

- Infrastructure equipment is largely variable and normally present only one time in the installation
- Decommissioning operations are one-shot
- The challenge lies in the radiological inventory and in the careful preparation of the work, e.g. with cold mock-up in the simulator
- Inject REX of equipment  $n$  into the decomm of equipment  $n+1$  is not evident
- **More uncertainties in planning and follow-up**
- Better to work with one contractor in order to keep the experience in one team

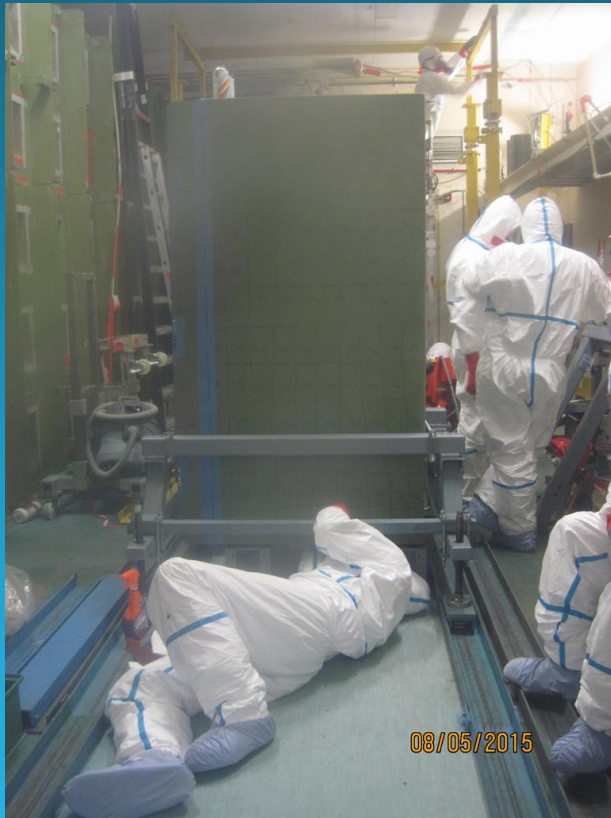
# Decomm. Infrastructures (2)



**Decomm main glove box extraction line (length +/- 100m)  
Cutting and evacuation of cuts with T-shirt bag**



# Decomm. Infrastructures (3)



**Decommissioning the contaminated vault storage room:  
vault decontamination and transport**

# Decomm. Infrastructures (4)



## Decommissioning the contaminated vault storage room:

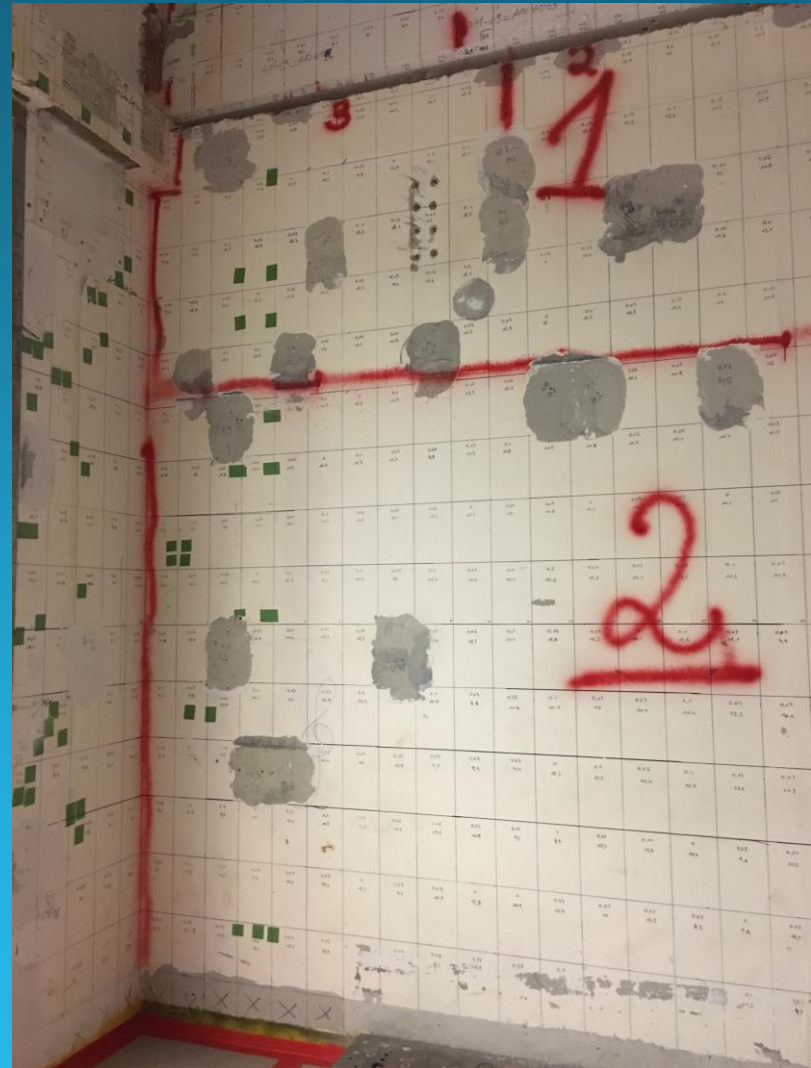
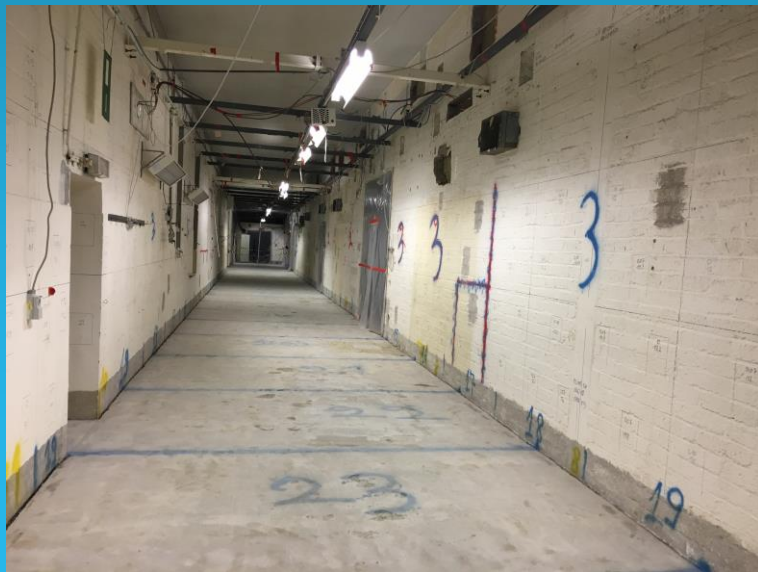
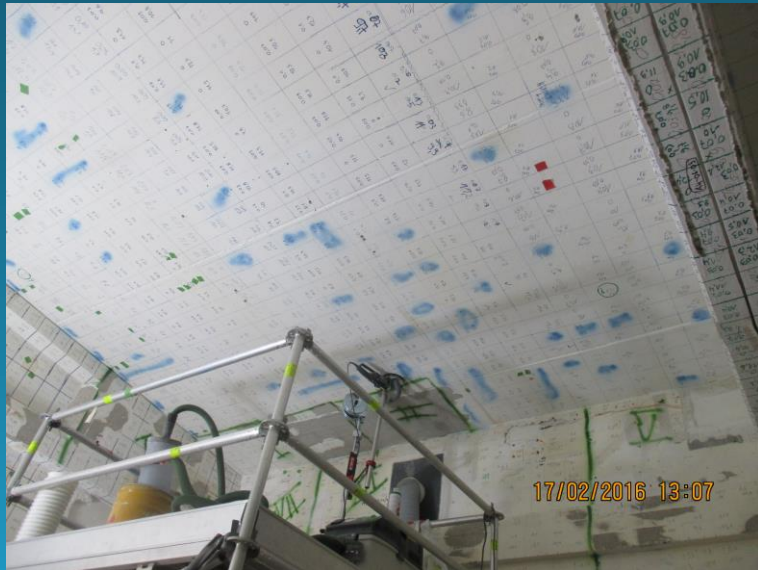
- vault steel removal → melting
- vault concrete hydraulic fracturing → industrial waste



# Cleaning buildings and site (1)

- Cleaning performed **in view of release for building demolition**
- Release criteria : defined in ARBIS 2001 and RP 113 - Table 1
- Cleaning requirement level for a given room depends on the history of the room, and may vary between floor, walls and ceiling
- All surfaces contain defects (full holes, empty holes, cracks, ...) that have first to be treated appropriately
- All surfaces are measured, measurements are downloaded in a data base (> 100.000 points for BNDMP) for later evaluation and inspection
- Final step: building radiological characterization report to be approved by FANC
- **Building may be demolished after report approval by FANC**

# Cleaning buildings and site (2)



# Cleaning buildings and site (3)



**Demolition of all buildings and field cleaning site**



# Release of the nuclear site (1)

- **Operator submits site radiological characterization report and Final Decommissioning report to FANC**
  - FANC comments these 2 reports and approves them after amendments
  - If judged necessary, FANC performs additional field radiological measurements
- **FANC issues its statement regarding the release of the site**
- **In case of unconditional release, FANC submits a proposal to the competent authority confirming:**
  - Suppression of the site from the list of class 1 installations
  - Terminates the decommissioning license
- **Royal Decree is notified in Belgian State Journal**

# Release of the nuclear site (2)



**2002**



**2019**



# Concluding remarks

- The decommissioning of the BN Dessel MOX Plant was executed smoothly, allowing integration of “young” BN personal into the teams of two contractors
- The duration of the project was larger than expected: the main reason is that the project was first of the kind for the nuclear operator as well as for the authorities: learning effect could decrease the cost by 25-30%
- Basic choices regarding HR management, contracting, waste management were confirmed by reality
- Excellent safety was achieved by extensive personal formation and continuous availability of the necessary know-how in the integrated decommissioning team
- The decommissioning costs are still open to increases owing to final waste disposal in the second half of the 21<sup>st</sup> century





Many thanks to **FANC-AFCN** and **Ondraf-Niras**

and many thanks also to the contractors:

- Tecnubel, Transnubel and ECS now **ENGIE Solutions**
- **SCK•CEN** and
- Joint Venture **Belgoproces – SCK•CEN**
- **Studsvik GmbH**
- **Tractebel Engineering**
- and others



# Questions ?