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# DECOM LFR EAN 2019

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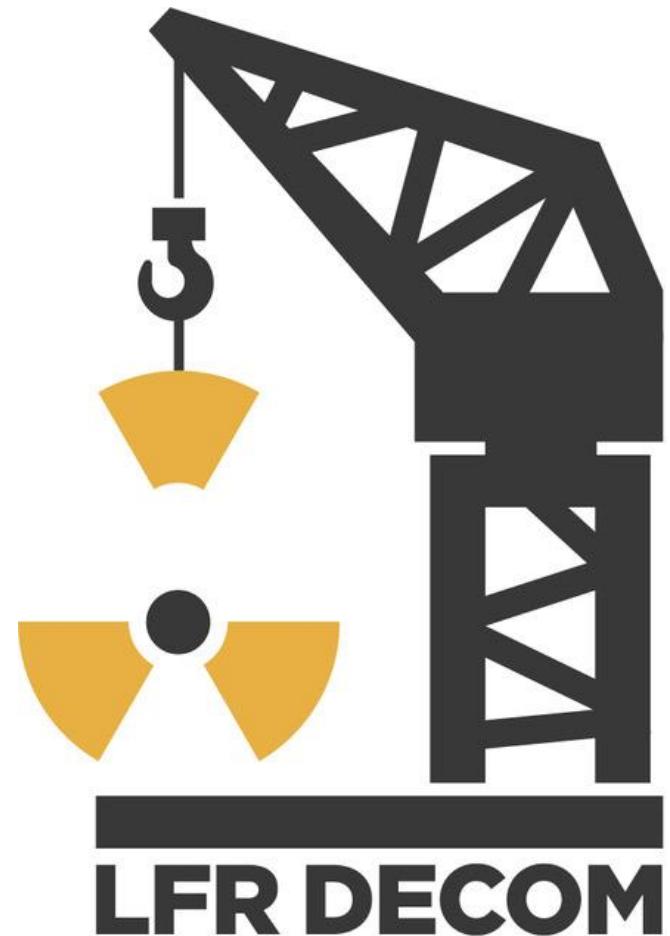
Not classified

Folkert Draaisma

11 maart 2019



# DOSE ESTIMATION AND OPTIMISATION DURING DECOMMISSIONING THE LOW FLUX REACTOR



# DOSE ESTIMATION AND OPTIMISATION DURING DECOMMISSIONING THE LOW FLUX REACTOR

30 kW



# PROGRAM

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1. Introduction
2. Permit
3. Preparations
4. Pictures
5. Clearance and Waste
6. Radiation Protection
7. Lessons learned



# ARGONOUT TYPE REACTOR

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Research reactor, mainly for education and training

First criticality, 28-09-1960

Maximal thermal power, 30 kW (1983)

Upgrade van 10 naar 30 kW in 1983

Uranium used, 11 gram

Last operation, December 2010

HEU Fuel and coolant (water) removed, Summer 2012

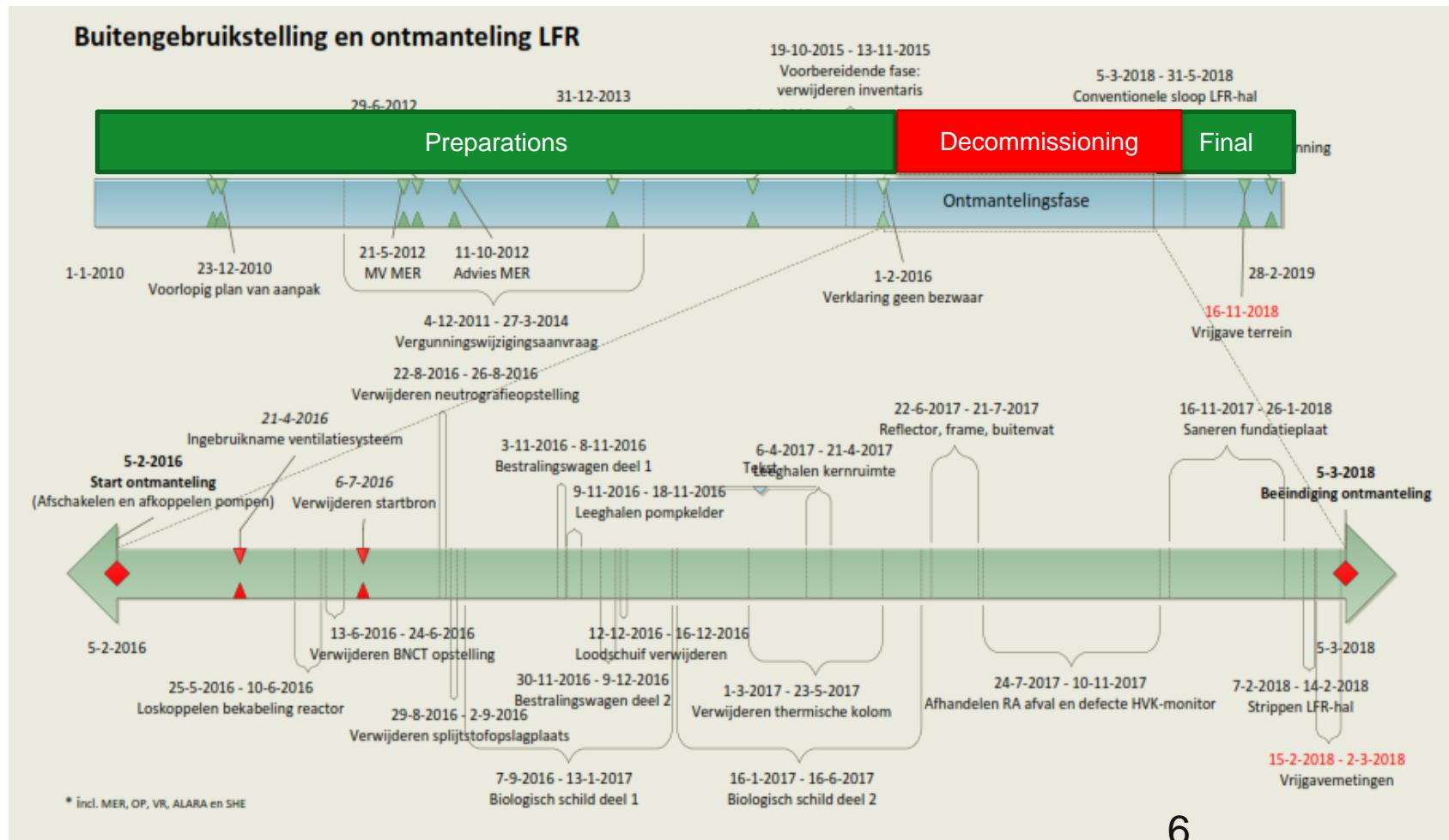
Permit for decommissioning in force, February 2015.

Clearance of the reactor hall, March 2018

Decommissioning complete, including removal of all radioactive material, Februari 2019.

# TIME LINE

Preparations: 5 years  
 Decommissioning: 2,5 year  
 Final phase: 1 year



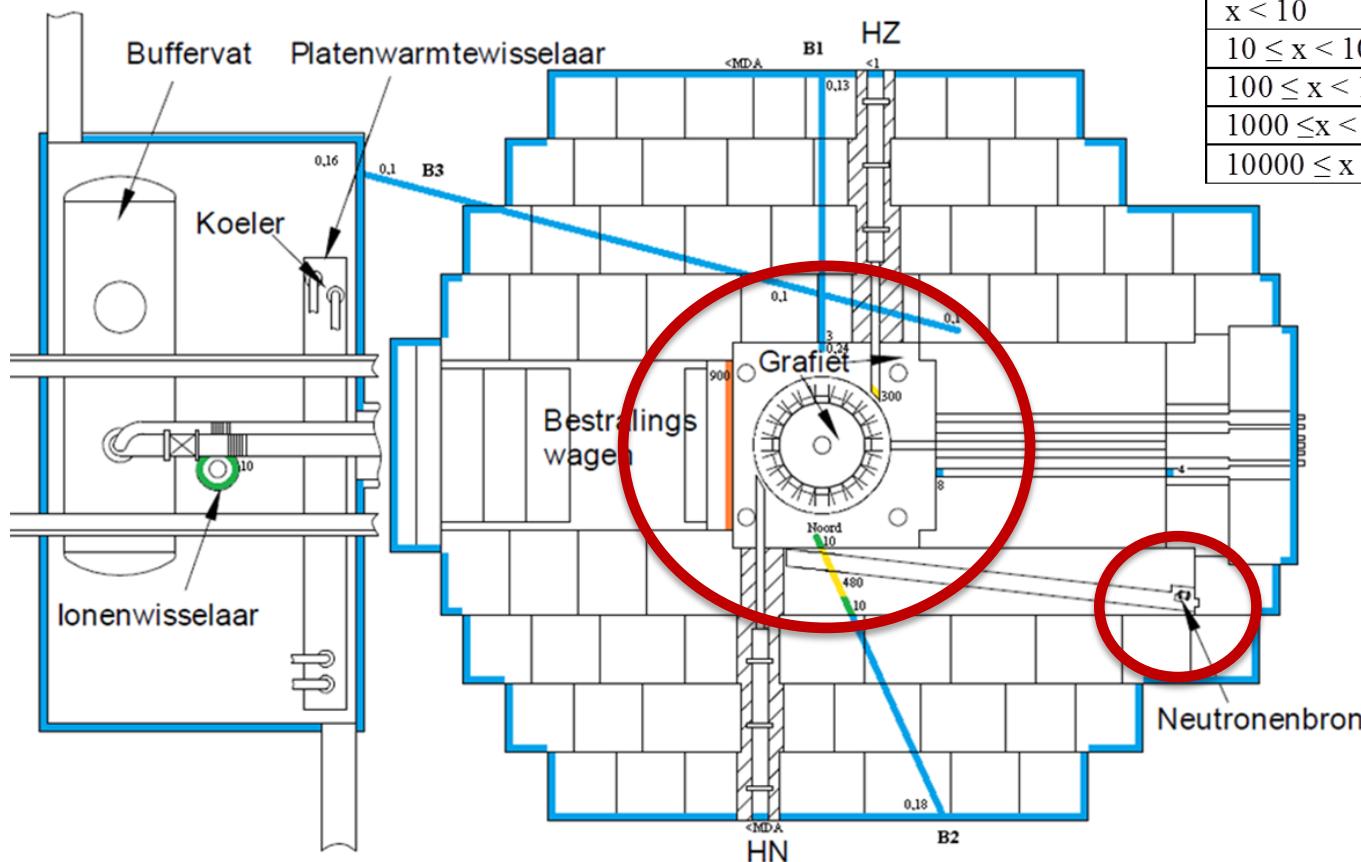
# PREPARATION

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Decommissioning Plan and Licence application incl. EIA  
and Plan of Approach – Security plan – Financial Assurance –  
Clearance plan materials

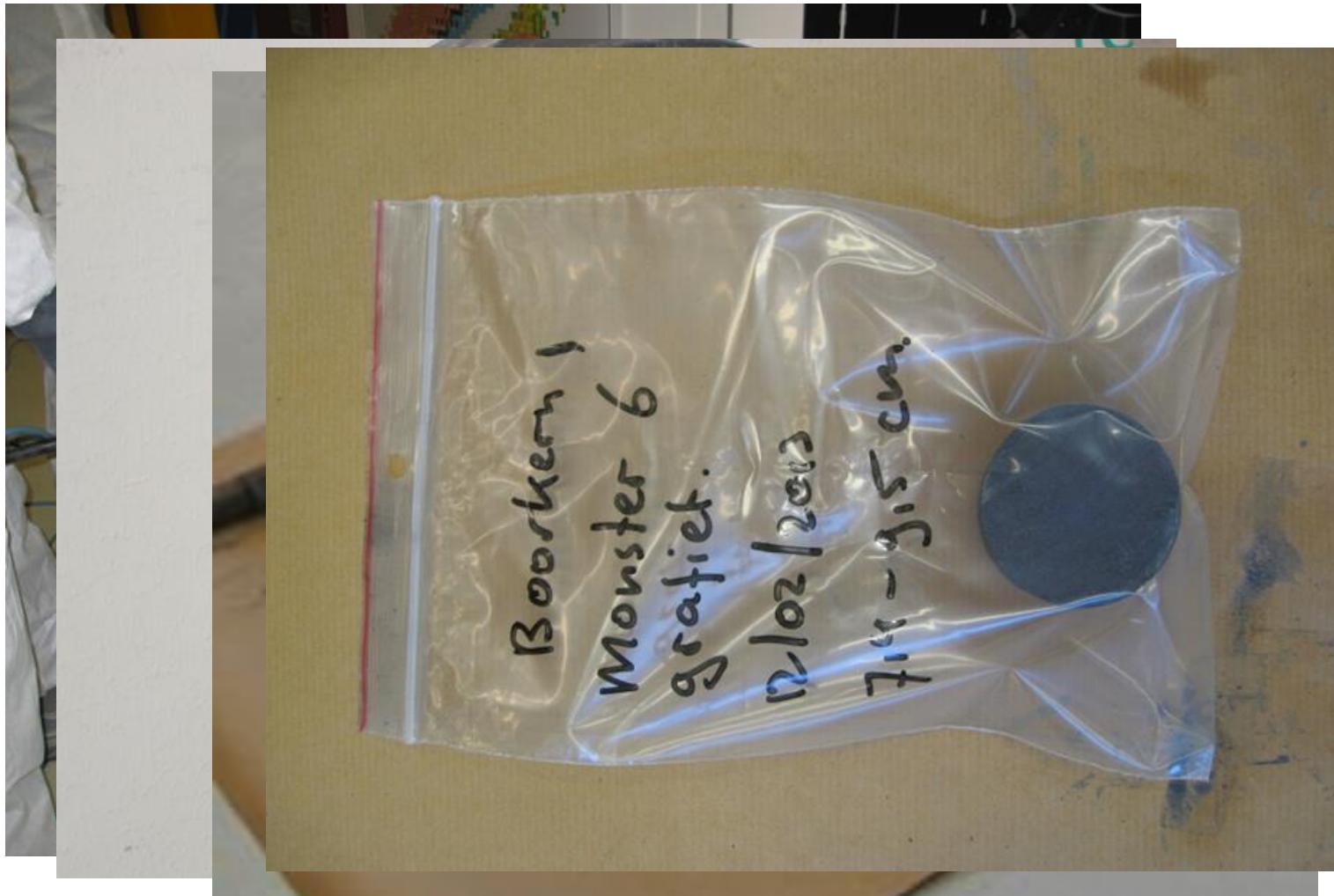
Dose rate measurements → Zoning  
Activation calculations  
Sampling – degree of activation → ‘clean’ concrete or RA waste?  
Lessons learned from decommissioning the same type of reactors  
SHE plan  
ALARA plan  
Internal Permit with dose constraints  
Activity break down – work plans  
Hold points

# DOSE RATE ZONES LFR (TOP VIEW)



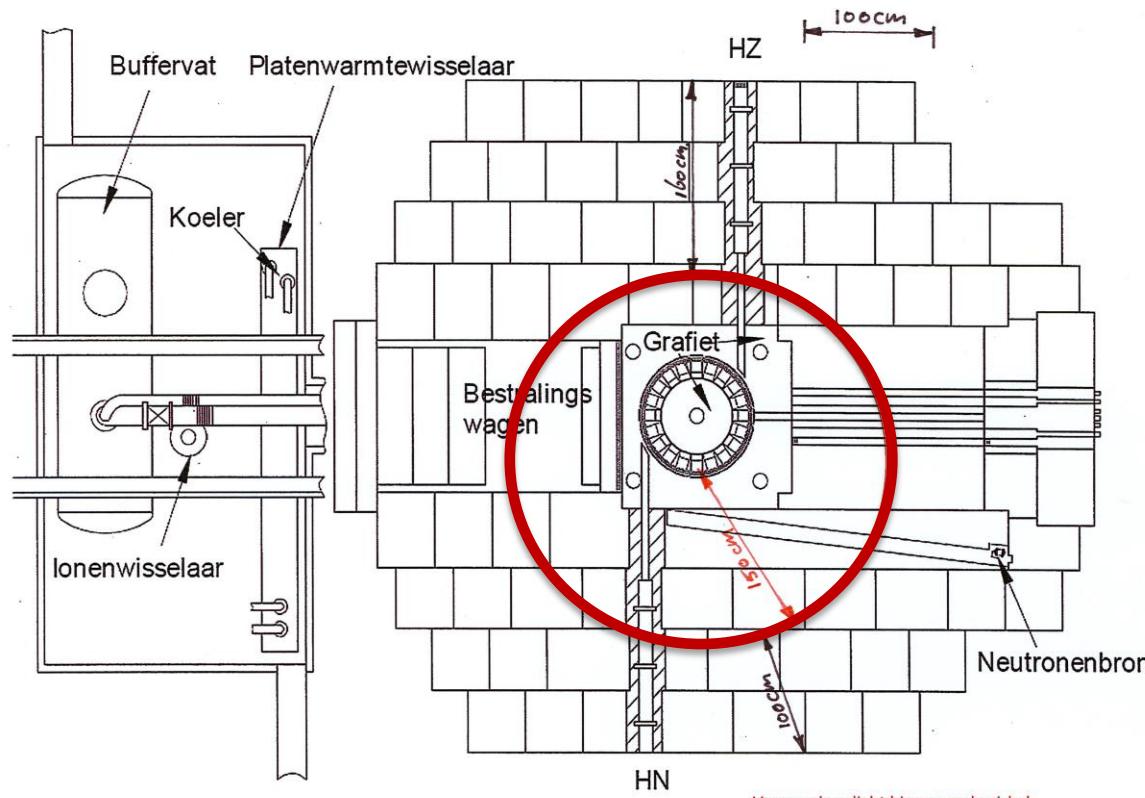
Dosistempo ( $\mu$ Sv/uur)	
x < 10	Blauw
10 ≤ x < 100	Groen
100 ≤ x < 1000	Geel
1000 ≤ x < 10000	Oranje
10000 ≤ x	Rood

# SAMPLING REACTOR



# MATERIAL ABOVE CLEARANCE LEVELS

150 cm



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# ACTIVITIES

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Activity break down:

23 activities e.g

- Ventilation system
- Boot or Start source
- Biological shield (not active)
- Thermal column
- Graphite reflector
- Biological shield (active)
- Foundation plate (active)
- Clearance LFR hall
- Asbestos remediation
- Demolition LFR hall
- Clearance location

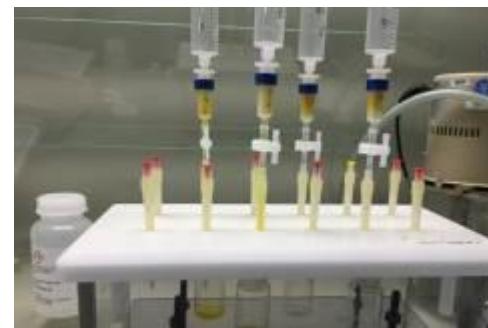
# CLEARANCE MEASUREMENTS



# LABORATORY ANALYSES

## Gamma radiation

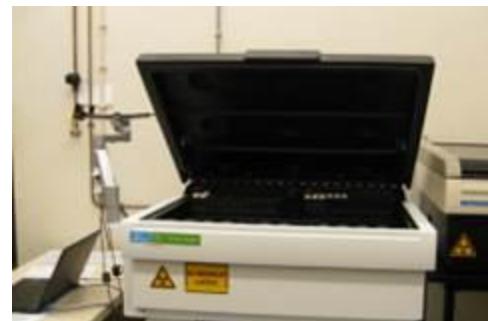
Gamma spectrometry



## Beta radiation

For specific nuclides

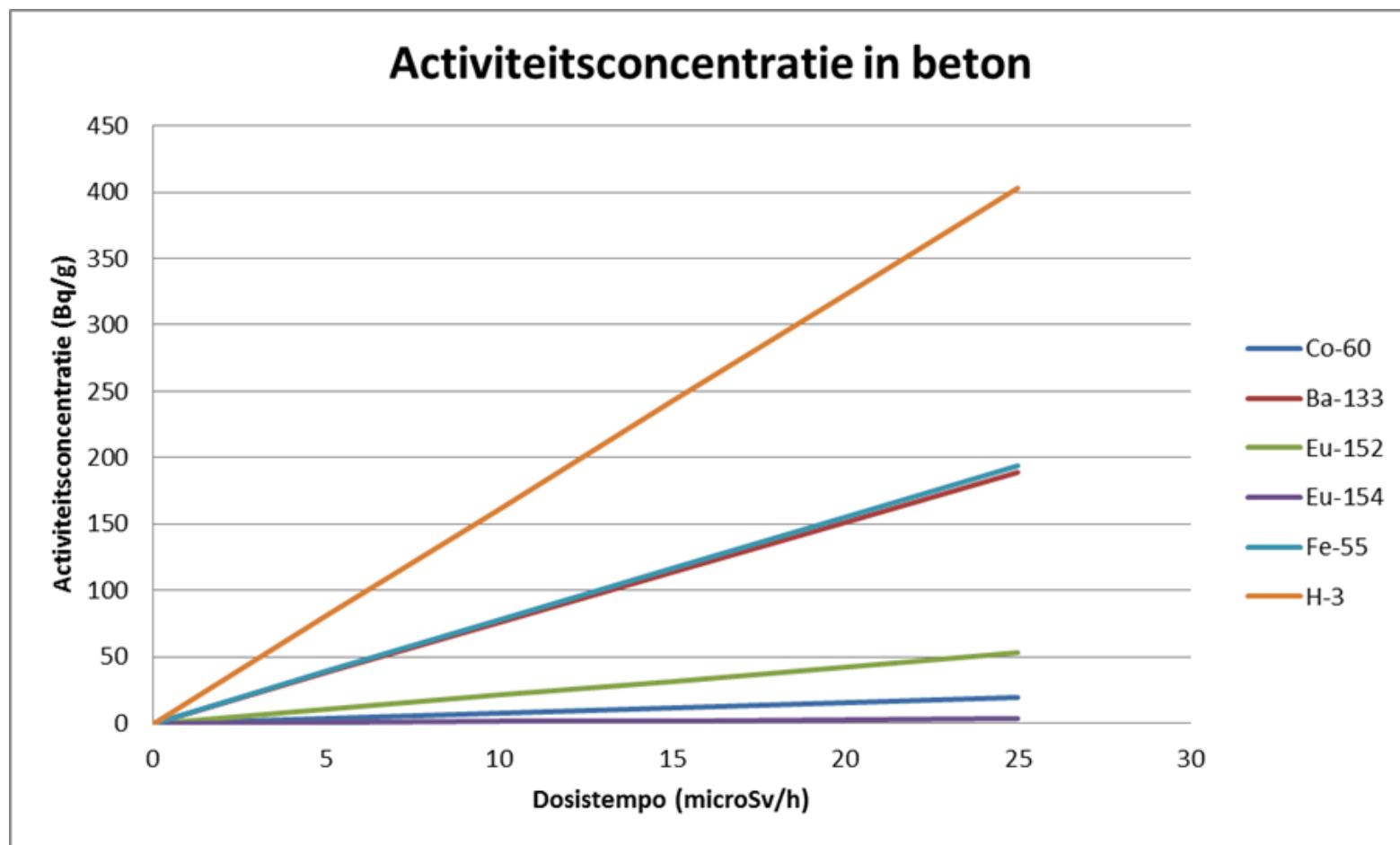
- H-3
- C-14
- Fe-55
- Ni-63



Total costs per material per point on  
y-axis activation graph € 2000,=



# ACTIVATION GRAPH



# HOUSEKEEPING



# NEW AIR TREATMENT SYSTEM



# REMOVING NEUTRON START SOURCE



Training in mock up



# BIOLOGICAL SHIELD



# REACTOR FOUNDATION



# AVAILABLE PACKAGES



Konrad II  
3300 liter  
€ 60 – € 80 per liter

400 liter drum  
200 liter  
€ 40 – € 75 per liter

90 liter drum  
96 liter  
€ 70 – € 150 per liter

# CLEARANCE REACTOR HALL



# CLEARANCE CRITERIA

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## Materials:

- Guideline for the clearance of materials during the decommissioning of a nuclear facility, TÜV Nord, Hamburg 30 juni 2012
- Uitvoeringsregeling stralingsbescherming EZ, 20 november 2013
- Besluit basisveiligheidsnormen stralingsbescherming, 23 oktober 2017

## Building:

- Guideline for the clearance of buildings during the decommissioning of a nuclear facility. TÜV Nord, Hamburg, 30 juni 2012
- Uitvoeringsregeling stralingsbescherming EZ, 20 november 2013
- Besluit basisveiligheidsnormen stralingsbescherming, 23 oktober 2017

## Location:

- Guideline for the clearance of sites during the decommissioning of a nuclear facility, TÜV Nord, Hamburg, 30 juni 2012.
- Strahlenschutzverordnung – StrlSchV, 20 juli 2001

# CLEARANCE LEVELS

	Co-60 [Bq/kg]	Eu-152 [Bq/kg]	Fe-55 [Bq/kg]	H-3 [Bq/kg]
Bs*	1000	10.000	$1 \cdot 10^7$	$1 \cdot 10^9$
BbS	100	100	$1 \cdot 10^6$	$1 \cdot 10^5$
StrlSchV	30	70	6000	3000

\* Untill 6 Februari 2018

# ASBESTOS REMEDIATION



# WASTE

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Material	conventional [*1000 kg]	COVRA [*1000kg]	% RA waste
concrete	260	37	14%
graphite	10	5	50%
lead	15	1,5	10%
metal	25	2	8%
remainder	20	0,5	2,5%
total	330	46	14%

# RADIATION PROTECTION

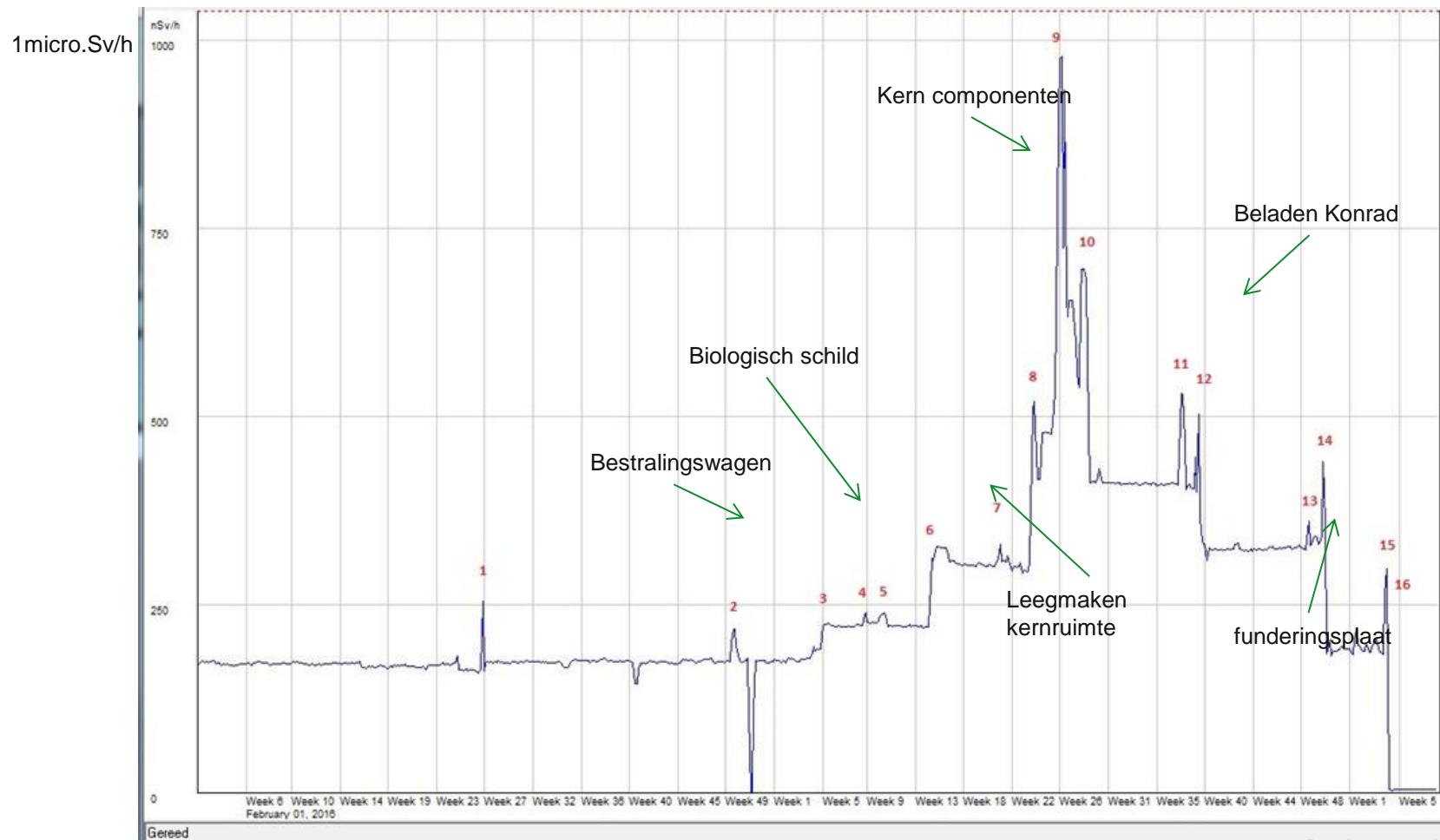
	result	Dose restriction
Collective dose	1.46 man.mSv	20.5 man.mSv
Personal dose	0.68 mSv	5 mSv
External parties	0.25 mSv	0.1 mSv

Activities with an important contribution to the collective dose:

- removal of activated parts of the biological shield
- removal of core elements (reflector, frame and vessel)

Removal neutron start source 185 GBq AmBe: max task dose 10 micro.Sv

# DOSE RATE



# LESSONS LEARNED

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- Conventional safety is equal to radiation safety.
- Do not underestimate the costs for maintaining installations and facilities.
- The costs of working hours increase fast, but the costs of radioactive waste go faster.
- Bats can cause delay.
- Do not start before all critical parameters are known:  
characterisation, packages, transport.
- But don't wait till all details are known.
- Availability of the work force is a critical success factor.
- Keep all stakeholders involved by the project.

# RESULT

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**THANK YOU FOR YOUR ATTENTION!**

*about the decommissioning of the LFR:*  
[utube.com/watch?v=SWMxIDQiB6A&t=6s](https://www.youtube.com/watch?v=SWMxIDQiB6A&t=6s)