WASTE MANAGEMENT AND RADIOACTIVE WASTE CHARACTERIZATION AT NRG

NKSRAD Workshop;
8-12 October 2018
Risø, Denmark

Gaël Ménard, NRG

10th of October 2018

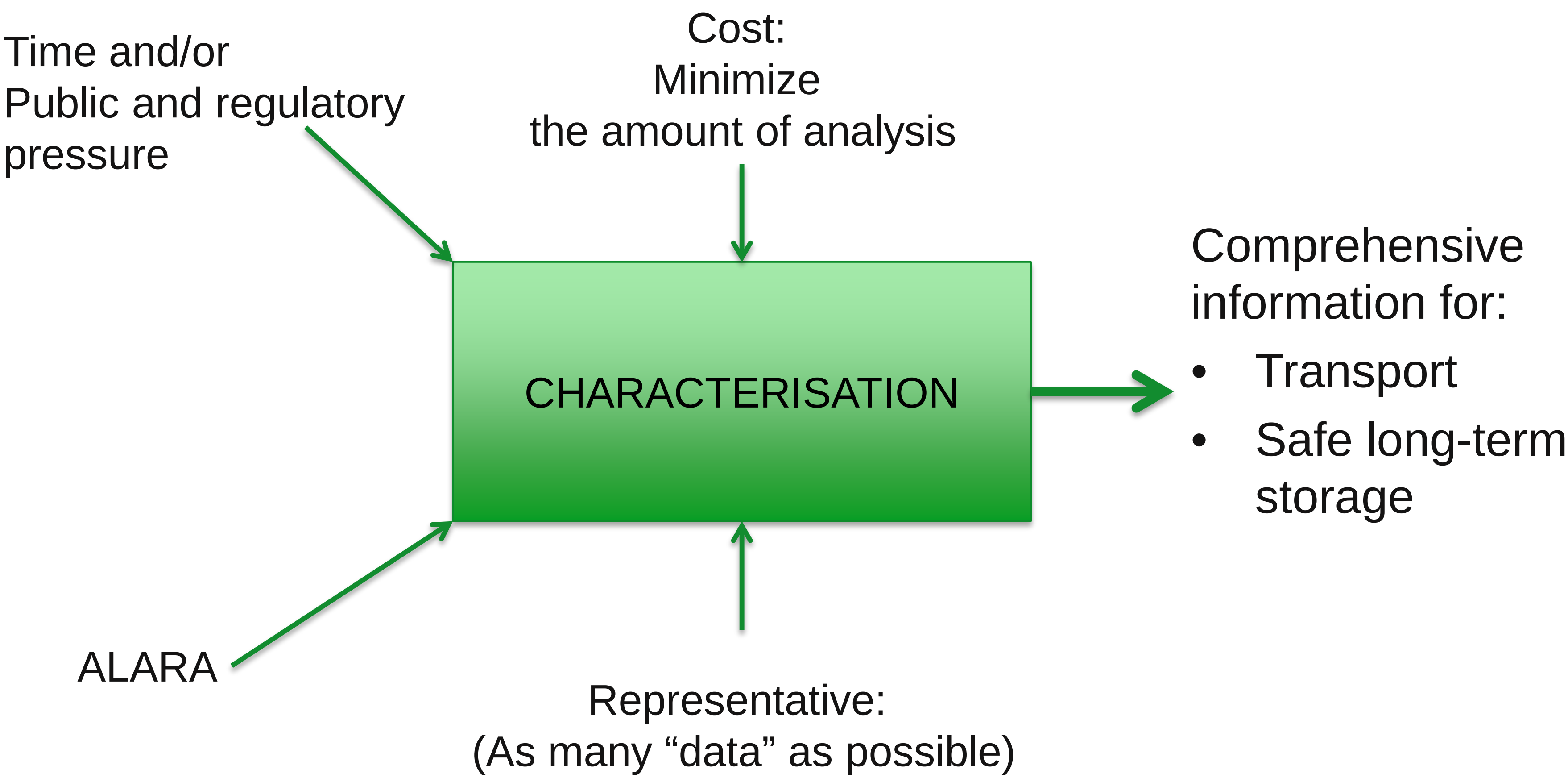
NRG

Petten site, The Netherlands

CONTENT

- Characterisation in a nutshell
- First Project: Historical Radioactive Waste
- Second Project: Ion Exchange Resins characterization
- Third Project: Decommissioning of Low Flux Reactor

CHARACTERIZATION IN A NUTSHELL



FIRST PROJECT

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HISTORICAL RADIOACTIVE WASTE

DATES

1961: High Flux Reactor operational

1984: Creation of the waste management organization (COVRA)

1990's: COVRA: from Petten to Nieuwdorp (200 km South of Petten)

2003: Opening of the Intermediate/High level waste storage facility
Start of the radioactive waste project

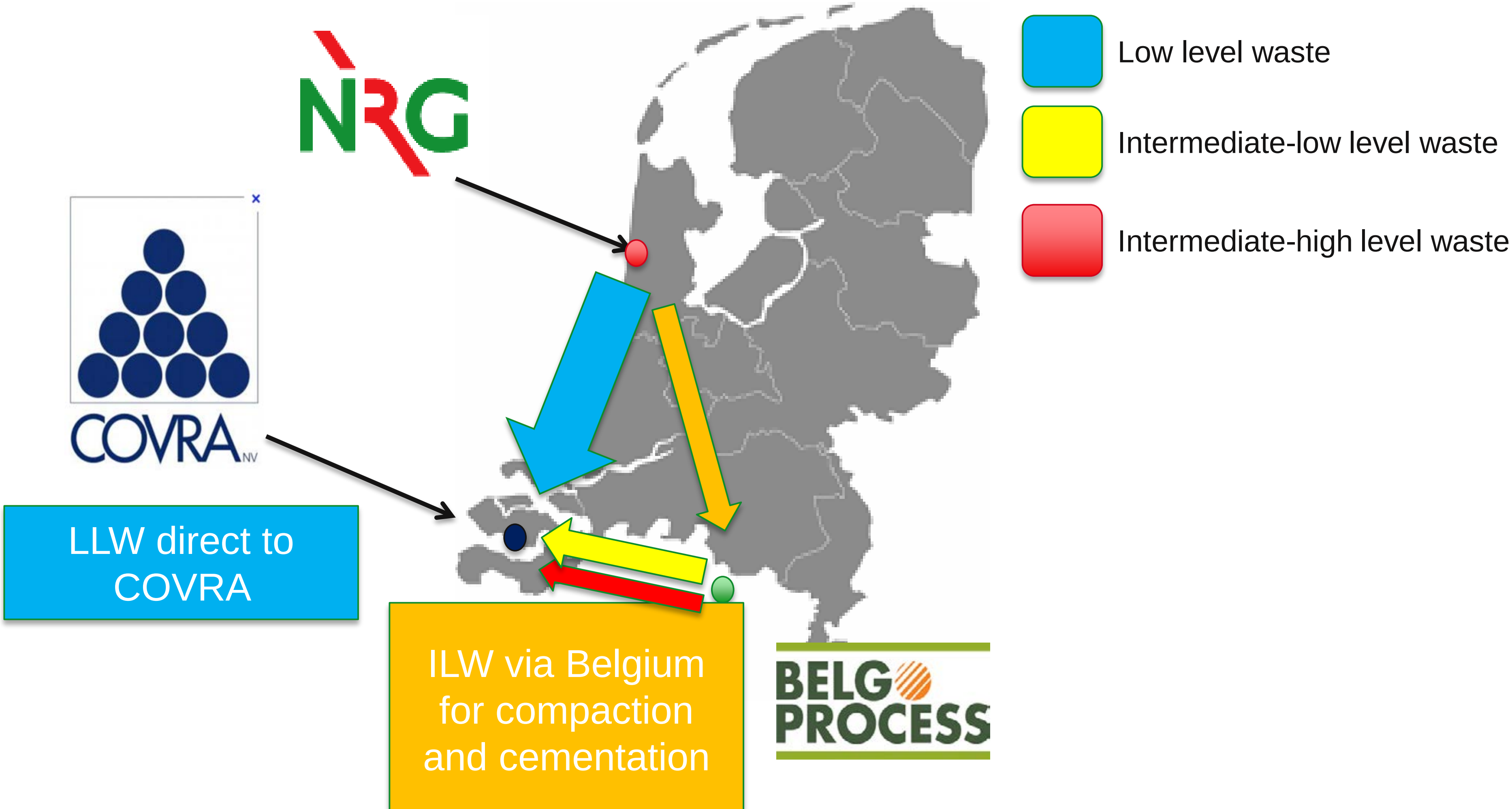
2015: First containers transported from Petten to COVRA

FIGURES

Figures:

- Considered period: 1961-1998
- 1700 waste containers
  - Extreme heterogeneity in material, contamination and activity
  - Separated waste streams treatment required
  - Footprint reduction by sorting on activities
- 8 waste streams/families identified (so far)
- Each container separated in 3 categories based on activity level:
  - Low level waste
  - Intermediate-Low level waste
  - Intermediate-High level waste

CONTEXT: TRANSPORT ROUTES

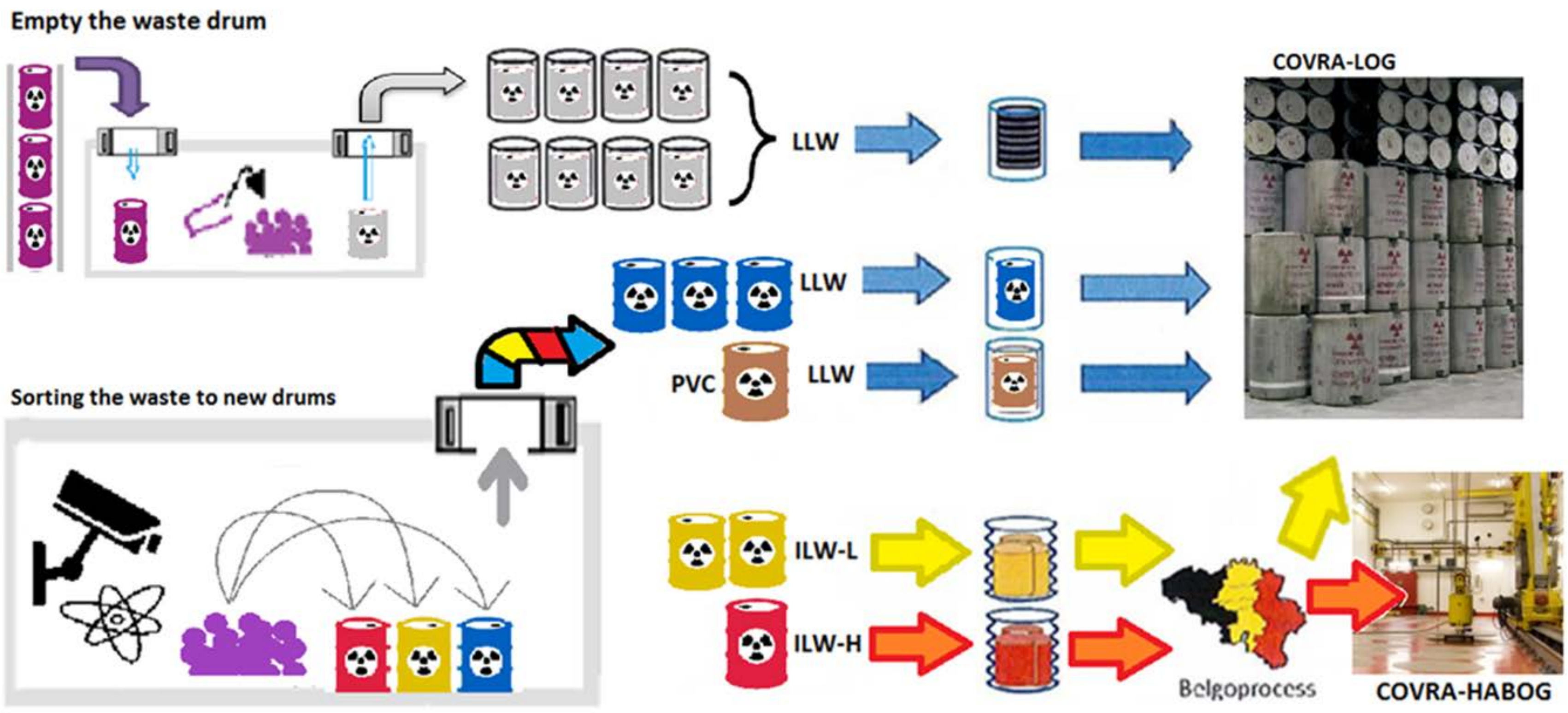


WASTE STREAMS DETERMINATION

Following IAEA recommendations:

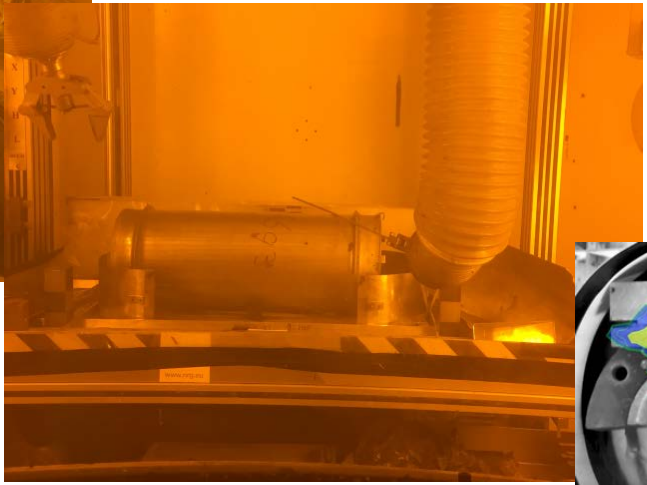
- Identification of waste streams/families based on:
  - activities
  - material composition, coming from:
    - archives
    - interview of former/current employees
- Treatment per waste streams
  - 8 identified (so far), classified and treated by increasing heterogeneity
  - determination of non-gamma emitting nuclides by calculation (nuclide vectors)
  - adaptation / evolution of the reasoning and of the established methods

PROCESS OVERVIEW

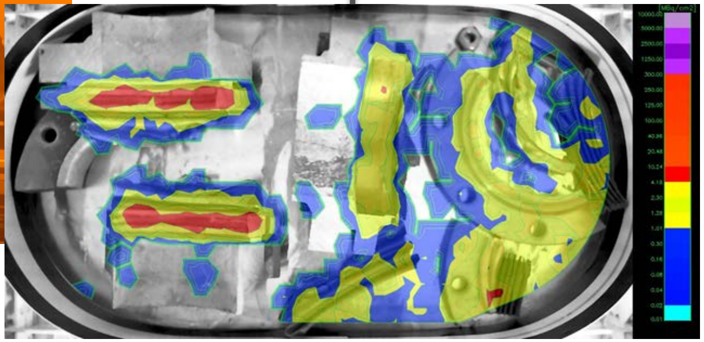


INSIGHT FIRST WASTE STREAM: MEASUREMENT

- 1st Family: Old HFR reactor vessel replaced in 1984
- Predominantly: stainless steel and aluminium



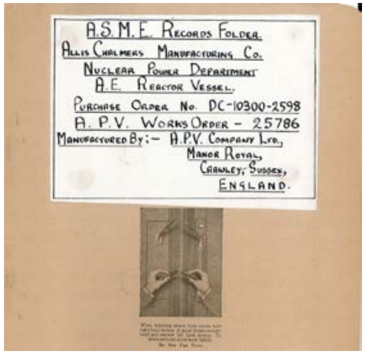
Measurement based on Co-60 emission (colored based on activity level waste)



INSIGHT FIRST WASTE STREAM: NUCLIDE VECTOR APPLICATION

Calculated via Fispact activation code taking into account:

- Position relative to the core
- Cooling time
- Composition of the material (archive)



Aluminium		Stainless Steel	
Nuclide	Ratio to Co-60	Nuclide	Ratio to Co-60
Co-60	1	Co-60	1
Fe-55	248	Ni-59	139
Ni-63	232	Fe-55	132
H-3	35	Ni-63	1.3 E+04
Al-26	3.7 E-02	H-3	2.8 E-03
Mn-53	1.7 E-05	C-14	4.2 E-04
Na-22	1.9 E-05	Mn-53	1.2 E-05
Co-60m	7.4 E-06	Cl-36	2.3 E-06
Fe-60	7.4 E-06	Co-60m	5.0 E-06
P-32	4.0 E-07	Fe-60	5.0 E-06
Si-32	4.0 E-07	Mn-54	5.6 E-08
Mn-54	3.6 E-08	P-32	8.6 E-08
C-14	5.6 E-08	Si-32	8.6 E-08
Ni-59	6.0 E-10	Ar-39	2.5 E-09
Zn-65	1.1 E-11	Al-26	6.2 E-10
Cl-36	7.1 E-13	K-42	1.1 E-11
Se-79	8.4 E-15	Ar-42	1.1 E-11
V-50	2.9 E-23	V-50	4.2 E-14
		V-49	5.5 E-14
		Ca-41	1.6 E-15
		K-40	9.0 E-20

- Final, nuclide content determined based on:
  - Gamma measurements
  - Beta's/Alpha's emitting nuclides from nuclide vector (calculated via their ratio to Co-60)

MEASUREMENT: EVALUATION OF THE NUCLIDE VECTORS

- Direct measurements:
  - Total Alpha / Total Beta
  - Gamma spectrometry

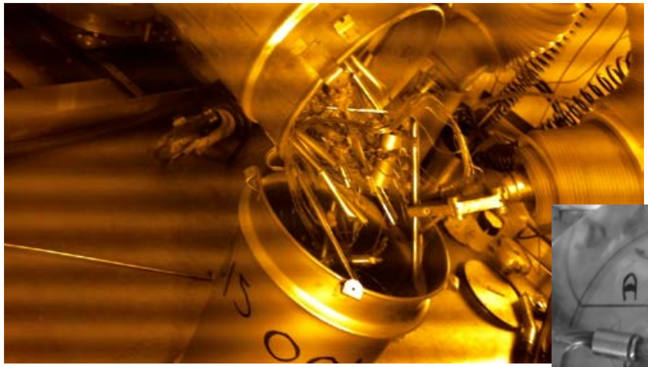
- Indirect measurements:
  - C-14 and Tritium by LSC

    After oxidative combustion and absorption of gas
  - Fe-55, Ni-63 and Sr-90 by LSC

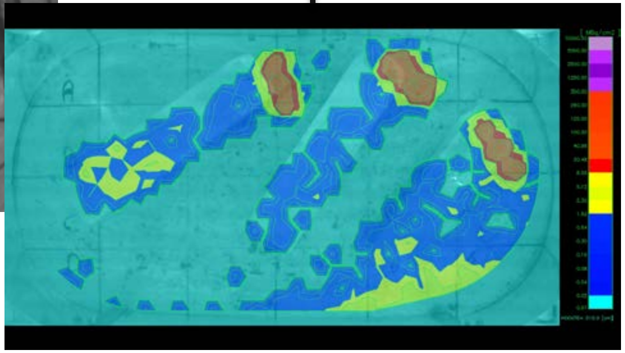
    After precipitation and purification of sample

INSIGHT SECOND WASTE STREAM: MEASUREMENT

- 2nd Family: thermocouple, control rods residues
  - Predominantly composed of 4 distinct material
  - No or little contamination



Measurement based on Co-60 emission (colored based on level waste)



SECOND WASTE STREAM: NUCLIDE VECTOR APPLICATION

- More material involved, incl. cadmium and thermocouple (residue from control rods/thermocouples)
- Determination of condition for specific nuclide vectors calculations
  - Various irradiation time
  - Various positions
  - Various cooling time
- The most conservative scenario chosen (safety during transport and storage)
- Final, nuclide content determined based on:
  - Gamma measurements
  - Beta's/Alpha's emitting nuclides from nuclide vector (calculated via their ratio to Co-60)

CONCLUSION

Outcomes:

- Nuclides vectors = useful tool to assess activities of non gamma emitting nuclides
- Heterogeneity ↗ ➔ complexity ↗

Feedback on experimental approach of historical waste:

- Complex
- Learning process
- First results from destructive evalution:
  - Conservatism by a factor 7 to 10

SECOND PROJECT

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ION EXCHANGE RESINS

ION EXCHANGE RESINS

- Continuous clean-up of the HFR primary circuit and of the water basin:
  - **Anionic IER**
  - Cationic IER

ION EXCHANGE RESINS

- Existing storage/treatment solution
  - Direct storage in containers
  - Direct cementation
  - Steam reforming (THOR process)
  - Incineration➔Ashes + Cementation

- Requirement in all cases:
  - Activities and dose
  - Nuclide content
    - Short-lived RN (Transport related): H-3; (S-35); Co-60; Ni-63; Sr-90; Cs-137
    - Long-lived RN (Storage related): C-14; Cl-36; Fe-55; Tc-99; I-129; U; Pu

OVERVIEW OF THE ANIONIC CONTINGENT

Batch	Total containers
2004	16
2009	19
2010	9
2011	10
2012	19
2014	22
2017	24

CONSTRAINT ON HOMOGENEITY

1. Inside one container (Presence of hot spots?)

2. In the different containers of a same batch

- IAEA recommendation on homogeneity of a waste stream (*IAEA-TECDOC-1573)*

  "For stable waste streams, measuring one or more key nuclides and non-radioactive elements may be sufficient to check the homogeneity. For example, a simple and stable waste stream could be declared homogeneous if NDA measurements of 137 Cs and/or 60 Co made at different locations are within a 30% relative interval"

CHARACTERISATION DECOMPOSED

Analyte

Matrix

Sampling

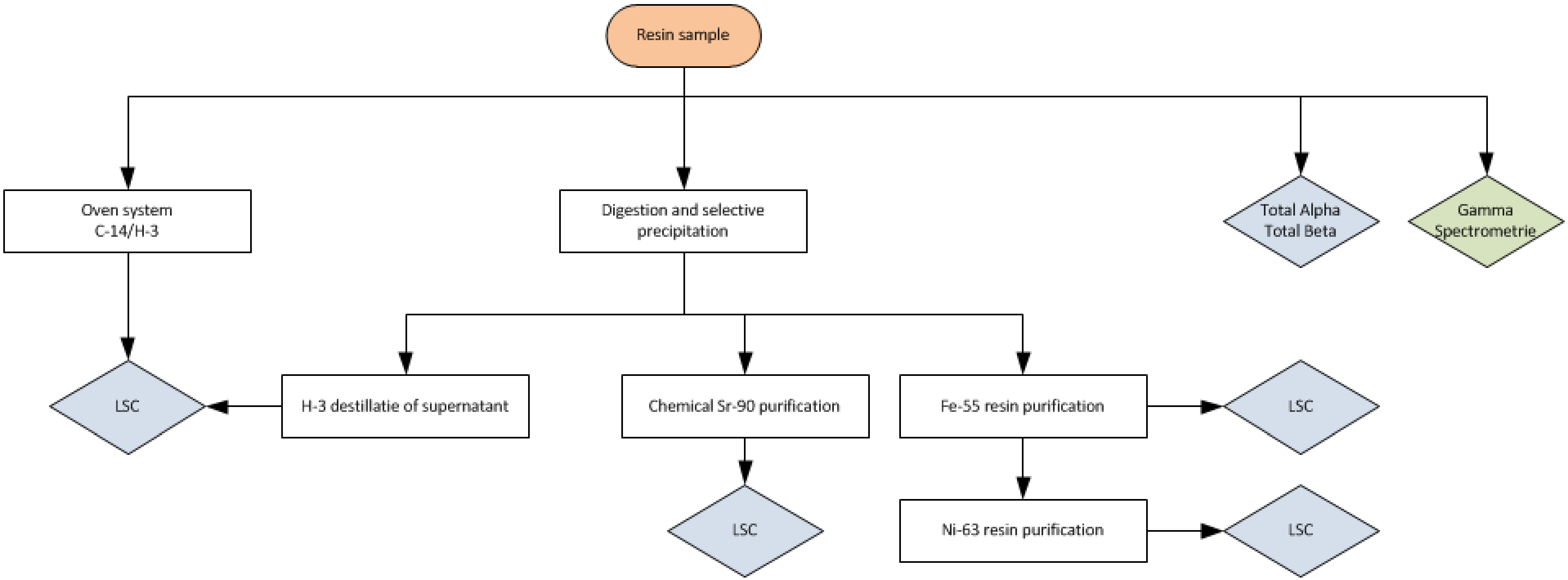
Preparation

Measurement

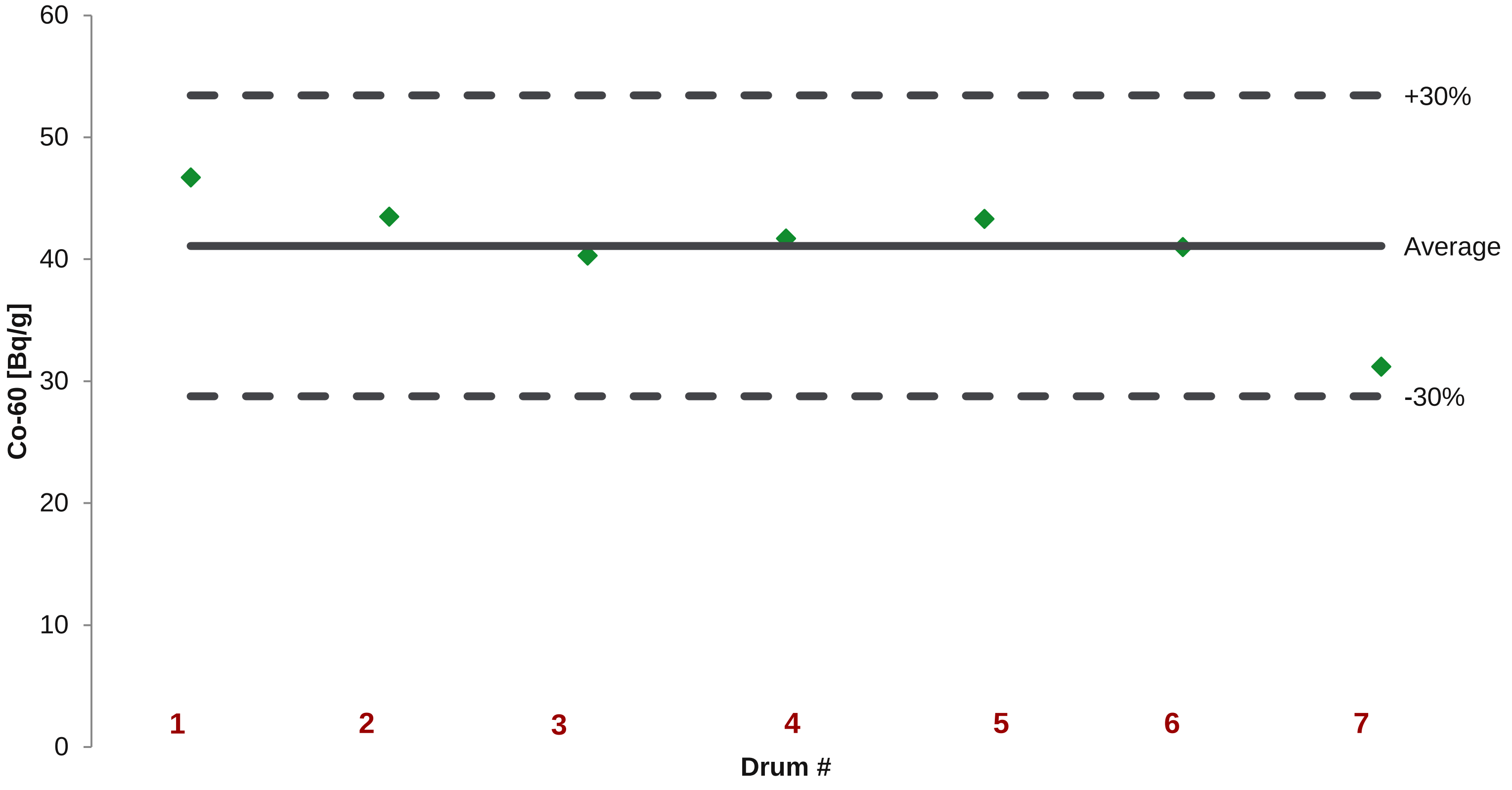
Repeatability

Analysis

PREPARATION: IER APPLICATION



RESULTS: HOMOGENEITY



RESULTS: COMPARISON OTHER LABS*

* Results are given for one specific sample batch (Bq/g)
Labs are named A, B, C

Lab	Ni-63	Fe-55	Sr-90	H-3
NRG	2.55	3822	5.5	385
A	7.2	2222	< 0.12	410
B	1.9	3870	0.13	
C	2.9			

STATUS AND CONCLUSIONS

- Containers ready for transport to the storage facility
  (Transport planned early 2019)
- Project: from scratch to successful characterization

- Next steps:
  - Starting with next containers of Cationic IER
  - More contaminated resins:
    - ALARA
    - Finding an optimal quantity of resins for analysis

THIRD PROJECT

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BUILDING DECOMMISSIONING: THE EXAMPLE OF THE LOW FLUX REACTOR IN PETTEN

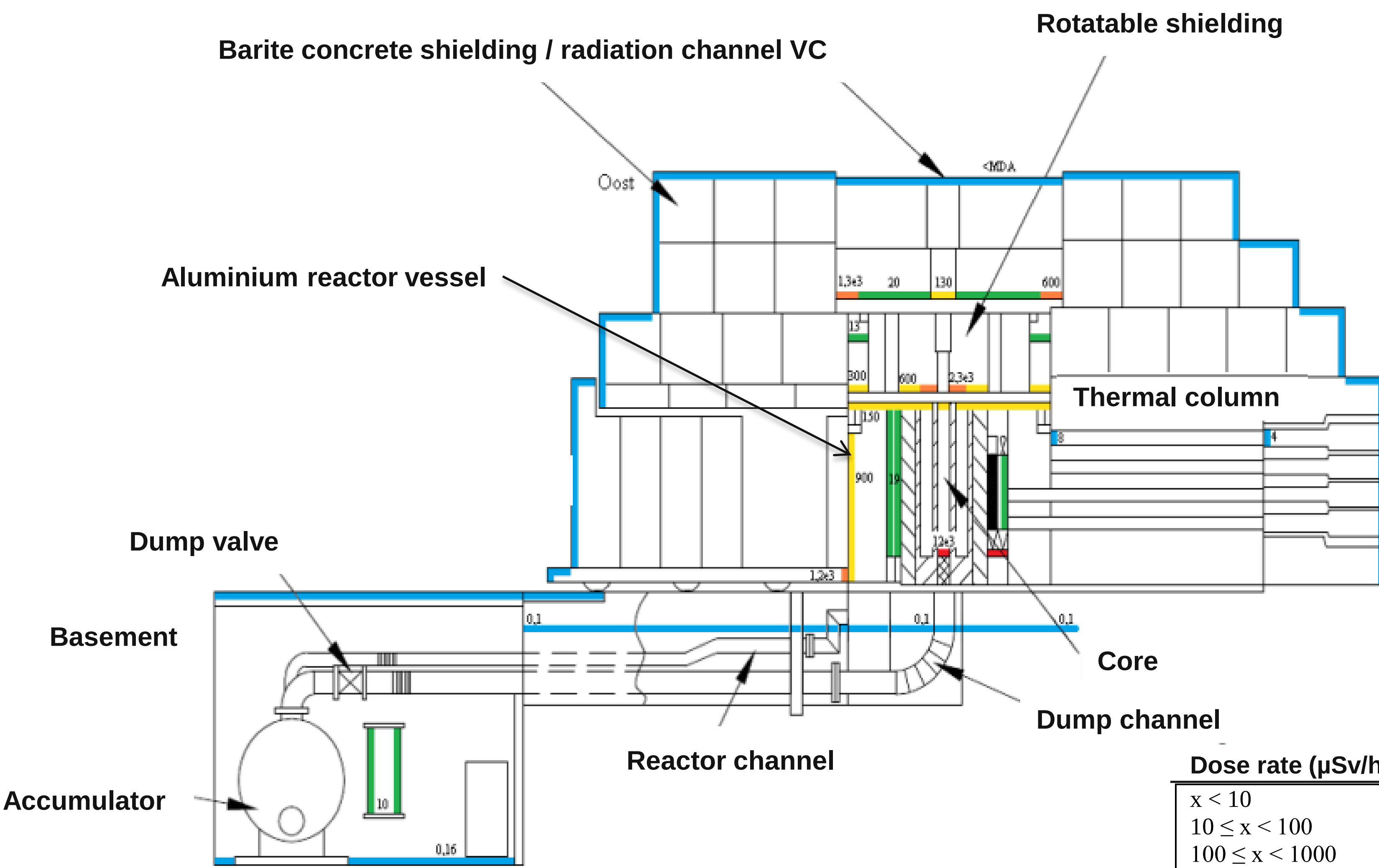
LFR - LOW FLUX REACTOR

1959

- Argonaut type reactor
- HEU (>90%) fuel in Al plates
- Max power 30 kW

2010

CROSS SECTION



Dose rate (μSv/h) at 0,25m

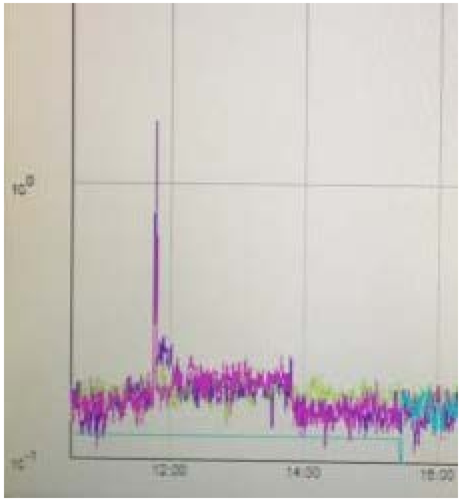
x < 10	Blauw
10 ≤ x < 100	Groen
100 ≤ x < 1000	Geel
1000 ≤x < 10000	Oranje
10000 ≤ x	Rood

DECOMMISSIONING APPROACH

REMOVAL STARTING SOURCE

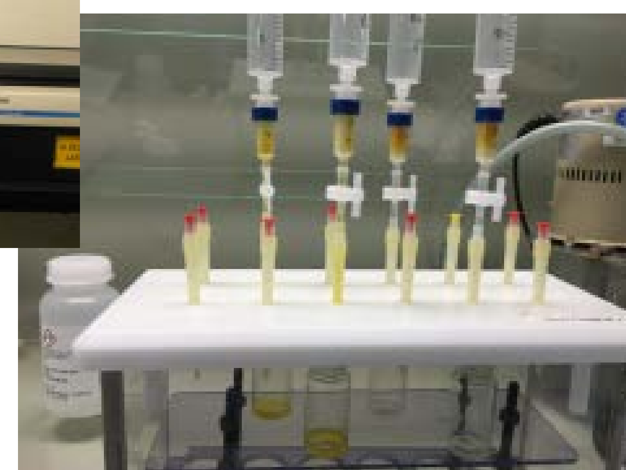
^{241}Am-Be neutron source
Only some sketches
of the design:

- Several adapters
- Practicing the procedure



WASTE MANAGEMENT
RADIOCHEMICAL CHARACTERIZATION (1/2)

- Destructive analysis of steel, aluminum, concrete and graphite
- Radionuclides: Fe-55, Ni-63, H-3 and C-14, Co-60
- Radiochemical separation with vacuum box system
- Measurement by gamma spectrometry and liquid scintillation counting (LSC)



WASTE MANAGEMENT
RADIOCHEMICAL CHARACTERIZATION (2/2)

- Extra experiments:
  - Exploratory work on waste reduction possibilities on concrete:
  - Chunk of concrete sampled from various strategic area of the reactor
  - Separation of the pebbles from the rest => Sampling of sub-sample (by size)
  - Evaluation of the contamination/activation of the different sub-samples
  - Question to be answered (hopefully)
    - Can we see a specific contamination/activation on some sub sample of concrete?
    - Economic vs. ALARA/Cleaning cost

BEFORE AND AFTER

- Final report: to ANVS – Dutch regulator
- Release of license: Jan 2019

LESSONS LEARNED

- Experience and knowledge of LFR operation and maintenance was very useful in planning dismantling activities. Don’t wait too long with actual dismantling after shut down.
- Conventional safety is as important as radiological safety. The tendency was to focus on the radiological aspects.
- The expensive Konrad-II containers turned out a cheaper solution for RWM than the planned 90 L containers
- Don’t underestimate the time for procedures, both internal and external (regulator).
- Ensure certain flexibility for changes in the permit
- Update guidance for decommissioning

THANK YOU!