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The decommissioning of the ENEA RB3 Research Reactor in Montecuccolino

Italian National Agency for New Technologies
Energy and Sustainable Economic Development

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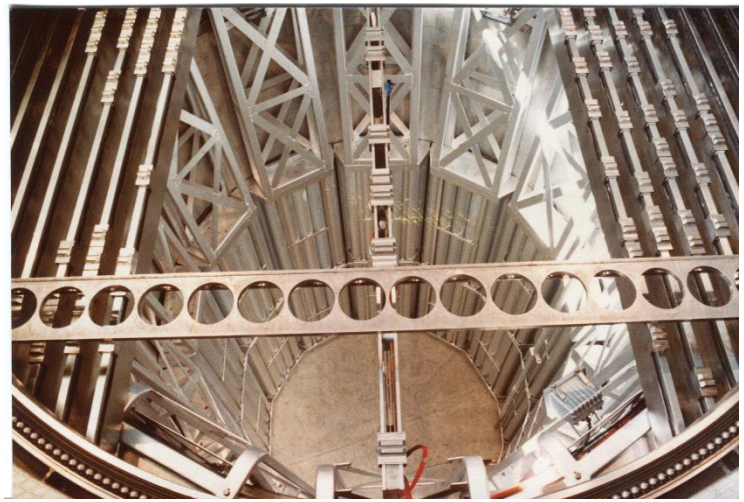
Summary

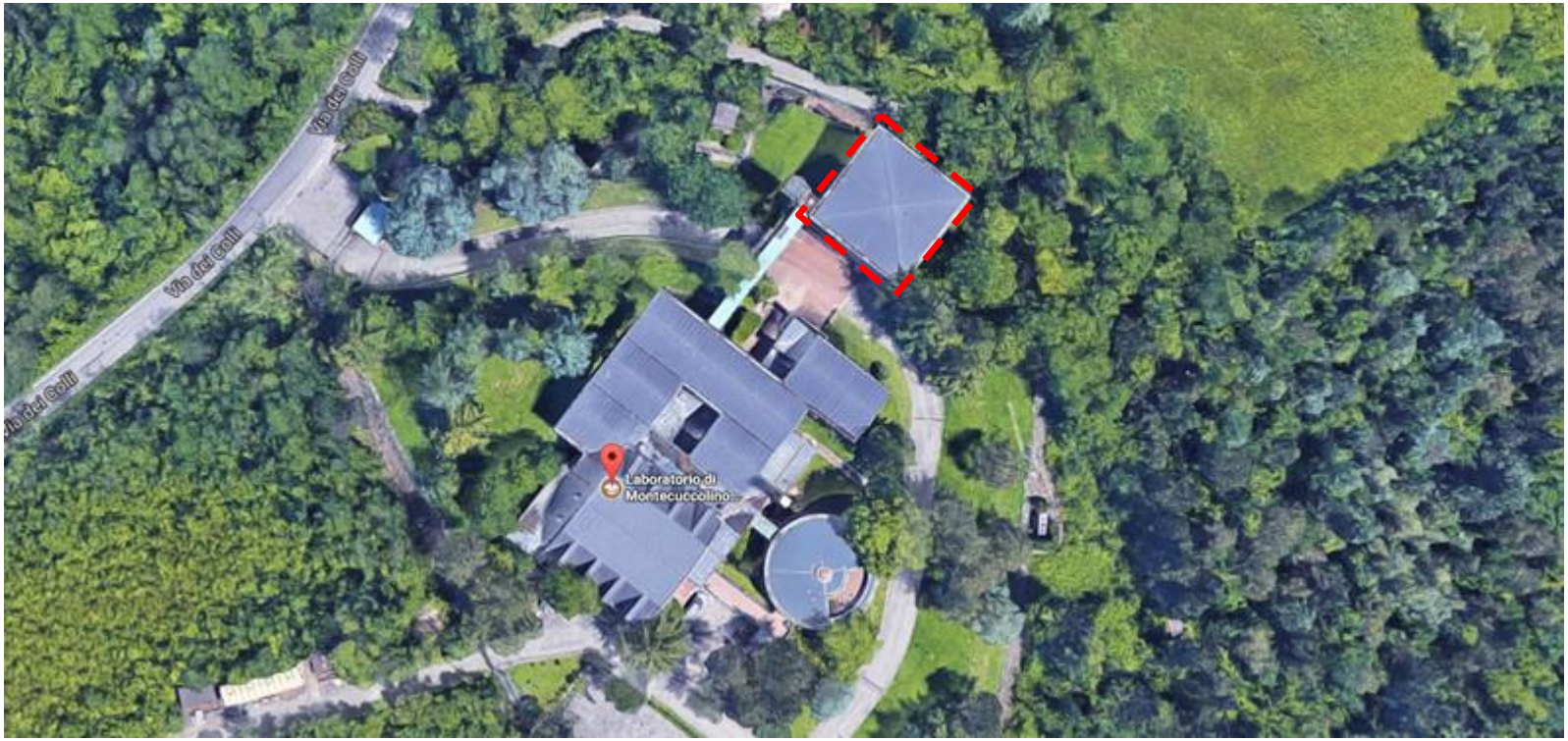
- RB3
- Characterization of materials and components
- Characterization of the building
- Characterization of the site



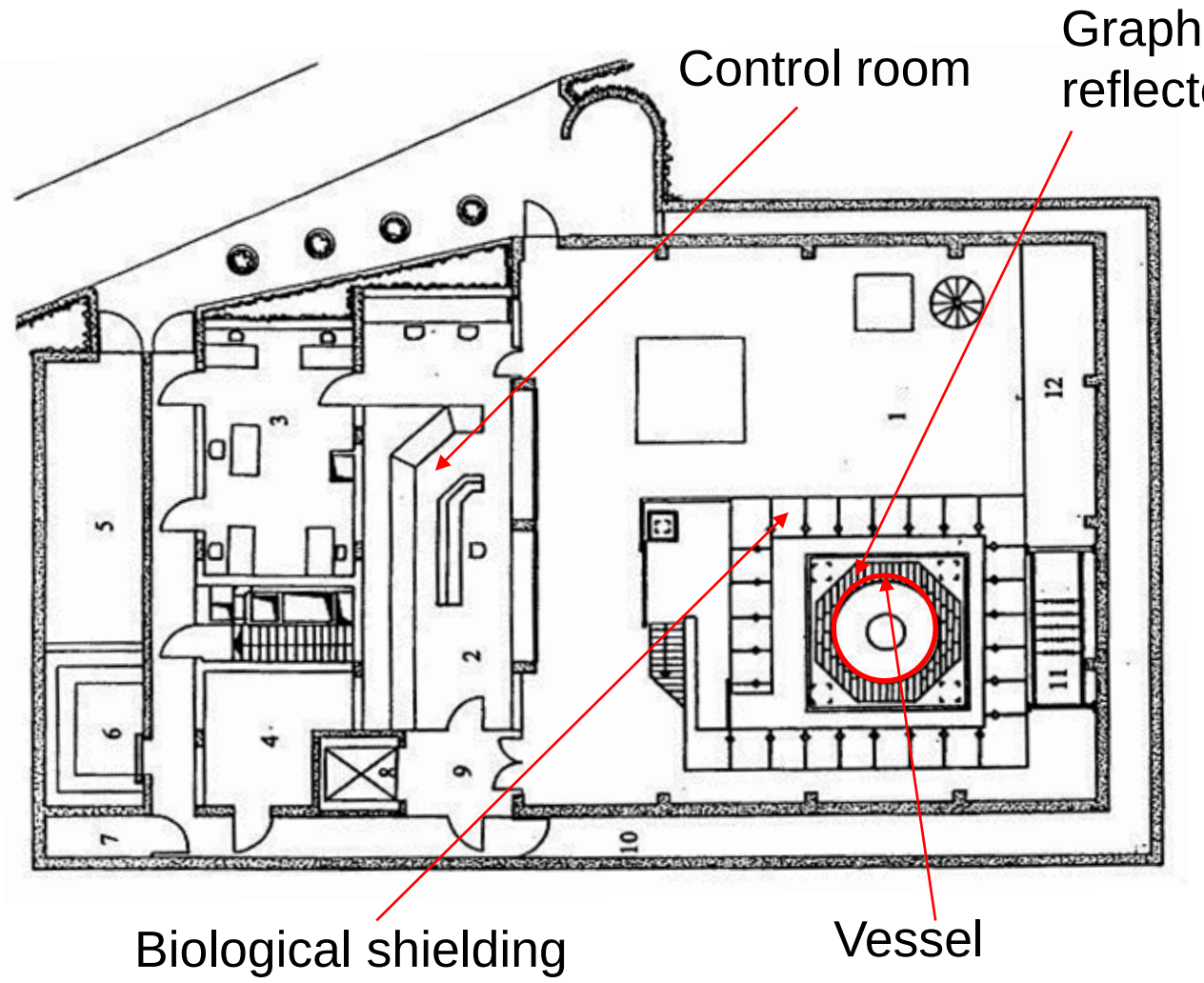
RB3 Research Reactor

- 100 Wth research installation owned and operated by ENEA in Montecuccolino, near Bologna from 1971 to 1989.
- Cylindrical aluminium vessel, about 4.3 m high and 2.9 m in diameter, with heavy water serving both as moderator and coolant. Graphite reflector + baritic concrete biological shielding.
- Provide neutronics data for the CIRENE NPP, a SGHWR that was being designed, and then partially built in Latina, starting from 1979.
- Reactor design originally developed by CEA for its Aquilon facility in Saclay in 1956.
- In the late 2010, ENEA received by ministerial decree the authorization to its dismantling, with the aim of reaching the “green field” status and with the unconditional release of its building, including the biological shielding, which is actually owned by the University of Bologna.

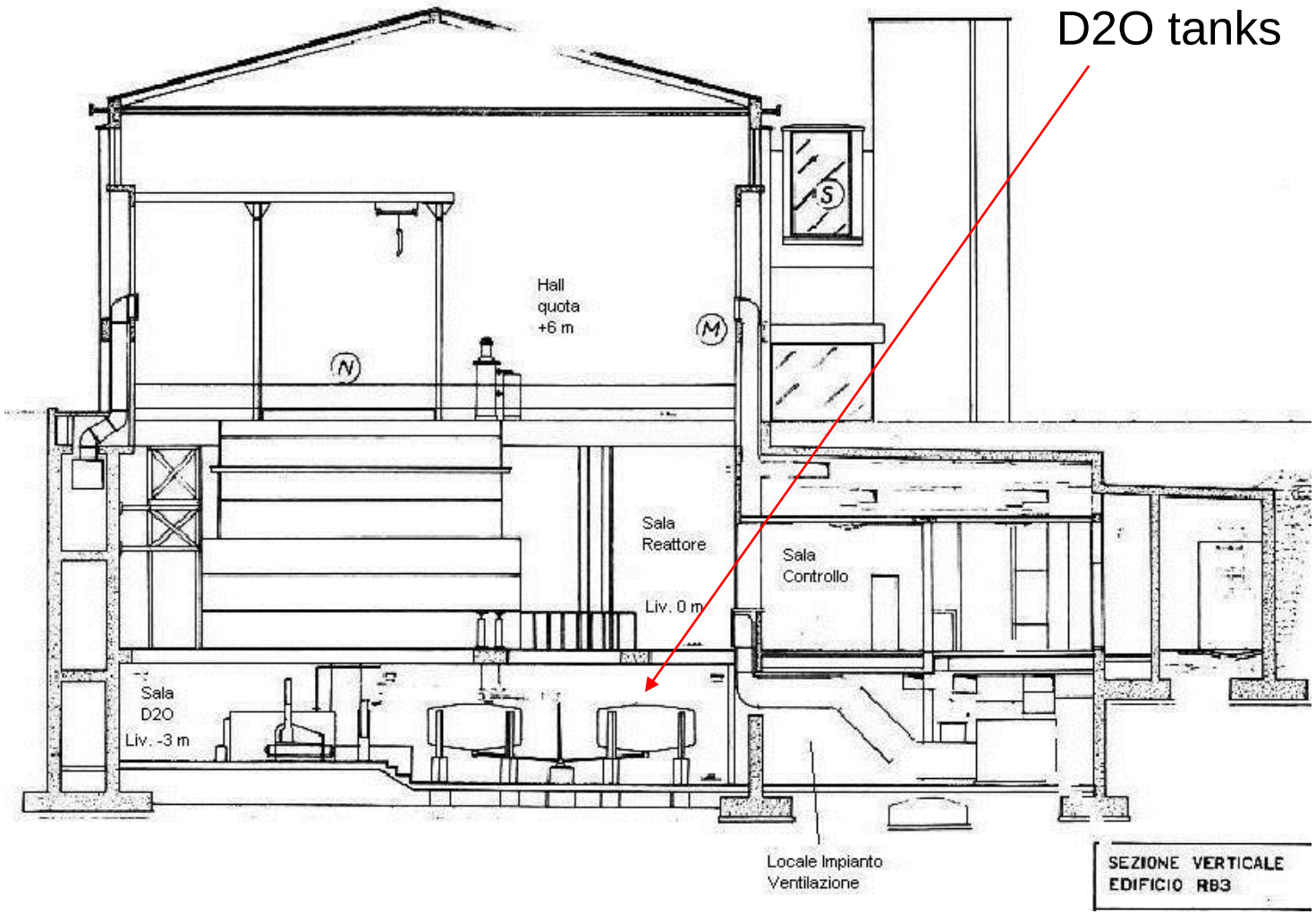
RB3 Research Reactor



RB3 Research Reactor



RB3 Research Reactor



RB3 Research Reactor

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Classification of materials and components (M&C)

A) M&C which were both in contact with possibly contaminated or activated process fluids and subject to neutron flux;

B) M&C which were in contact with possibly contaminated or activated process fluids but not directly irradiated by neutrons;

C) M&C which were irradiated by the neutron flux but which never went into contact with possibly contaminated or activated process fluids;

D) S.c. “exempt” materials, which were never irradiated and never went into contact with possibly contaminated or activated process fluids.

«Exempt» materials

- Given their **unirradiated** and **uncontaminated** status, these were subject only to a general screening through CANBERRA In Situ Object Counting Systems (**ISOCS**) to estimate any possible level of presence of **60Co** and **137Cs**;
- If the measured levels were **below the DT** of the measuring system in terms of mass concentration levels, these materials were automatically discarded without any further radiological analysis. This demonstrated the “instrumental” zero of this category of materials.
- All exempt materials were released unconditionately, for a total mass of about **30 tons**, between March 2013 and May 2015.

«Exempt» materials

Clearance limits

Radionuclide	Metals			Concrete		Other materials
	Reused	Recycle	Both reuse and recycle	Demolition		Other materials
	Surface (Bq/cm^2)	Surface (Bq/cm^2)	Mass (Bq/g)	Surface (Bq/cm^2)	Mass (Bq/g)	Mass (Bq/g)
^{3}H	10000	100000	1	10000	1	1
^{14}C	1000	1000	1	10000	1	1
^{54}Mn	10	10	1	10	0.1	0.1
^{55}Fe	1000	10000	1	10000	1	1
^{59}Ni	10000	10000	1	100000	1	1
^{60}Co	1	10	1	1	0.1	0.1
^{63}Ni	1000	10000	1	100000	1	1
^{90}Sr	10	10	1	100	1	1
^{125}Sb	10	100	1	10	1	1
^{134}Cs	1	10	0.1	10	0.1	0.1
^{137}Cs	10	100	1	10	1	1
^{152}Eu	1	10	1	10	0.1	0.1
^{154}Eu	1	10	1	10	0.1	0.1
Generic Alfa	0.1	0.1	0.1	0.1	0.1	0.01
^{241}Pu	10	10	1	100	1	1

Based on Italian L.D. n. 230/95 or on RP 89 and RP 113.

Homogeneous groups

- M&C were further grouped by ENEA into 12 s.c. "**homogeneous groups**" using **material and historic criteria**;
- Homogeneous groups are therefore constituted by components (or parts of them) made by the same material and possibly with a homogeneous and uniform activity content.

Initial screening of materials

A preliminary, special campaign was conducted to exclude the presence of various isotopes especially in the most potentially activated and contaminated materials (category A):

54Mn, 59Ni, 90Sr, 125Sb, 134Cs,
137Cs, 239Pu, 240Pu, 241Pu

were excluded from further analyses finalized to the unconditional release of materials.

Pre-characterization

For each homogeneous group, a **pre-characterization measurement campaign** was then conducted with a three-fold aim:

1) to verify if the hypothesis on the homogeneity of activity for that given group held;
2) to evaluate the minimum number of samples to be analyzed for the subsequent characterization phase with the aim of releasing the whole homogeneous group;
3) to evaluate the value of isotopic ratios of 55Fe to 60Co and of 63Ni to 60Co, so to limit the next characterization analyses only to the quantification of 60Co contents.

Characterization

All the batches of the homogeneous groups were eventually released unconditionately, for a total of about:

- 14.7 tons of stainless steel,
- 26.2 tons of baritic concrete,
- 40.3 tons of iron,
- 6.3 tons of cast iron,
- 4.5 tons of borated paraffin,
- 0.92 tons of aluminium,
- 49 tons of graphite, after 14C characterization, were transferred to another ENEA center for other nuclear uses.
- all metals were further diluted and melted in a 1:10 ratio
- all the homogeneous groups were pre-characterized, characterized and released before the end of 2014.

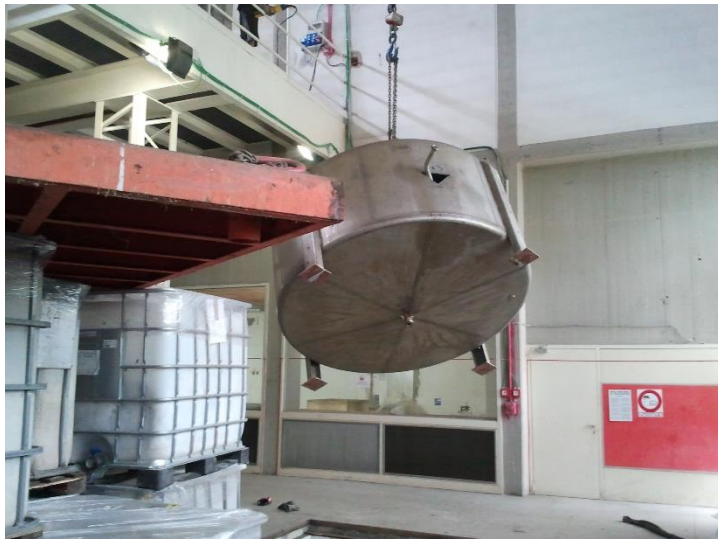
$$R_i = \frac{A_{60Co_i}}{A_{60CoLim}} + \frac{A_{63Ni_i}}{A_{63NiLim}} + \frac{A_{59Fe_i}}{A_{59FeLim}} < 1, \forall i$$

Dismantling

Dismantling

Dismantling

Dismantling



Characterization of the building

- Two main steps: **activation status of biological shielding**, **contamination status of surfaces**.
- Characterization of the activation status of the baritic concrete biological shielding:
  1) seven core drillings each 16 cm long: 1 on the floor, 1 on the northern wall, 1 on the western wall, 1 on the eastern wall, and 3 (at different heights) on the southern wall;
  2) from each drilling, four aliquots, 4 cm long, taken, so to cover the depth profile of any activation distribution inside the shielding;
  3) each aliquot was subject to gamma spectrometry to search for the presence of 60Co, 134Cs, 152Eu and 154Eu;
  4) all the 28 samples yielded results for all the four isotopes lower than a few mBq/g;

Characterization of the building

5) all activity concentration results were subject to several **Bartlett tests** to verify that all variances could be considered as representative of the same overall statistical variance;
6) then a **Noether test**, using 10 randomly chosen measurements, was put in place to verify the minimum number of samples to be used for the final characterization;
7) this resulted in **13 samples**, however, ENEA decided to use all the 28 samples to verify the free release condition for the shielding;
8) no significative activation of the shielding has been produced;
9) it could be proven that no activation of walls outside the biological shielding was in place.

Characterization of the building

Characterization of the building

- Characterization of the contamination status of the surfaces:

1) Surfaces were separated into three types: a) ceiling; b) surfaces over +6.0 m level; c) surfaces below +6.0 m level.
2) The ceiling was a false ceiling made of thin aluminium plates; these could have been contaminated by tritiated water vapours emerging from the core once open. The plates were dismantled, taken to ground, and analyzed. It was assumed that, if no contamination was found, then also the real ceiling behind it was not contaminated. This proved indeed to be the case.
3) Surfaces over +6.0 m were investigated randomly, by sampling a given number of points, quantified basing on statistical considerations.
4) All surfaces below +6.0 m were completely measured, both walls and floors.

Characterization of the building

5) The measurement technique consisted in using surface contamination meters (**Berthold LB165** and **LB124**), properly **calibrated with large area reference sources, to sum up count rates over 14C, 60Co, 134Cs, 152Eu and 154Eu**.
6) Natural radionuclides **background** in the different materials was subtracted after having made suitable averages from surely clean materials, similar to those which were to be measured inside the building.
7) As a further, **conservative penalization**, it was decided to attribute to each of the 5 above-mentioned nuclides the whole net counting over each surface portion.
8) Counting time per surface element being about **30 seconds** to reach a desired minimum detectable activity.
9) A special automated vertical translational sledge was used to carry LB165 over the portions of the walls.

Characterization of the building

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Characterization of the building

Characterization of the site

- During the operational life of the plant no radioactivity discharges were in place and therefore no environmental analyses were prescribed by the Regulatory Authority;
- The radiological status of the site prior to the construction and exercise of RB3 is not known;
- It is decided to base the characterization upon the measurement of some selected nuclides in certain soil samples;
- 12 measurements of 239+240Pu through alpha spectrometry;
- 25 gamma spectroscopy assessments for 54Mn, 60Co, 125Sb, 134Cs, 137Cs, 152Eu and 154Eu.

Characterization of the site

- Each sample will be a parallelepiped of 25x20x10 cm^3 corresponding roughly to 5 liters of humid soil;
- The site will be sampled considering both near-range and far-range positions in order to find patterns of radioactivity correlated with the distance from the RB3 building, if any at all.
- The obtained values will be confronted, through proper summations, with the limits for the free release of nuclear sites prescribed by the German national law, which correspond to the radiological non-relevance value of 10 microSv/year to the public.

Characterization of the site

Radionuclide	Concentration Limit (Bq/g)
^{54}Mn	0.09
^{60}Co	0.03
^{125}Sb	0.08
^{134}Cs	0.05
^{137}Cs	0.06
^{152}Eu	0.07
^{154}Eu	0.06
^{239}Pu	0.04
^{240}Pu	0.04

People involved

- 6 workmen from Modena Fallimenti SaS
- 12 ENEA staff (4 RP, 3 ISOCS, 3 LB165, 1 QE, 1 DoW)
- 6 ENEA Laboratories & related staff
- 1 external laboratory for characterization of rubbers (LASE, CEA Saclay)