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# Decommissioning of the pool reactor Thetis in Ghent, Belgium

*The Thetis research pool reactor (with a nominal power of 150 kW) of the Ghent University was operational from 1967 till December 2003. The first phase of the decommissioning of the reactor, the removal of the spent fuel from the site, took place in 2010. The cumulative dose received was only 404 man · μSv. During the second phase, the transition period between the removal of the spent fuel in 2010 and the start of the decommissioning phase in March 2013, 3-monthly internal inspections and inspections by Bel V, were performed. The third and final decommissioning phase started on March 18, 2013. The total dose received between March 2013 and August 2013 was 1561 man · μSv. The declassification from a Class I installation to a Class II installation was possible by the end of 2015. The activated concrete in the reactor pool will remain under regulatory control until the activation levels are lower than the limits for free release.*

***Stilllegung des Poolreaktors Thetis im belgischen Ghent.*** *Der Thetis Poolreaktor der Universität in Ghent wurd von 1967 bis zum Dezember 2003 mit einer Nennleistung von 150 kW betrieben. In der ersten Phase der Stilllegung wurde in 2010 der abgebrannte Brennstoff entfernt. Dabei betrug die kumulierte Dosis 404 man · μSv. Bis zum März 2013 dauerte die Übergangsphase, in der dreimonatlich interne und offizielle (durch Bel V) Inspektionen durchgeführt wurden. Am 18. März 2013 startete die endgültige Stilllegung. Dabei wurden die Arbeiter zwischen März und August 2013 mit insgesamt 1561 man · μSv belastet. Zu Ende des Jahres 2015 wurde die Anlage von einer Class I in eine Class II Anlage umdeklariert. Der aktivierte Beton im Reaktorpool bleibt unter behördlicher Aufsicht solange, bis der Aktivierungsgrad die Grenzwerte für eine Freimessung unterschreiten.*

## 1 Introduction

The Thetis research reactor at the University of Ghent was a light water cooled and moderated pool type reactor with a nominal power of 150 kW, using low enriched Uraniumoxide (5 % $^{235}$U). The reactor was operational from 1967 till 2003 and was mainly used for the production of radionuclides for material analysis and for neutron activation analysis (NAA).

The unloading of the reactor core and the decommissioning of the reactor took place in 2 phases. The first phase, which was completed in 2010, was the removal of the fuel elements from the reactor pool and their interim storage at Belgoprocess. The second phase was the dismantling of the infrastructure, which started in March 2013 and was completed beginning of 2014.

This publication gives an overview of the whole decommissioning and dismantling process, starting from the licensing procedure for decommissioning till the final decommissioning phase in 2013 and the free release of the reactor building in 2015.

## 2 Licensing procedure for decommissioning and dismantling

The licensing procedure for the decommissioning of the Thetis reactor was based on the requirements of the Federal Agency for Nuclear Control (FANC) in Belgium, on the IAEA Safety Requirements "WS-R-2" (Predisposal Management of Radioactive Waste, including Decommissioning) and on the IAEA Safety Guides "WS-G-2.1" (Decommissioning of Nuclear Power Plants and Research Reactors), "WS-G-2.2" (Decommissioning of Medical, Industrial and Research Facilities) and "WS-G-2.4" (Decommissioning of Nuclear Fuel Cycle Facilities).

In order to obtain this license, a safety report was written, containing the description of the installation, a radiological and toxic inventory, the dismantling strategy (purpose, dismantling alternatives, safety principals and criteria, destination of the site, …), project management (information about personnel, documentation and financing), a quality system and a description of all the dismantling activities, including planning, decontamination and dismantling techniques, clearance, re-use of materials, safety analysis, incident analysis, emergency planning, security, an ALARA study and an environmental report.

All safety related modifications during the decommissioning had to be approved by FANC and Bel V.

## 3 Transition period (2004 – 2010)

During the transition period between the shutdown of the reactor in December 2003 and the unloading of the reactor core in 2010, 3-monthly internal inspections and monthly inspections by Bel V were performed with the emphasis on ventilation, pneumatic pumps, demineralisation loop, reactor pool, control room, safety systems, radiation monitoring, underpressure, alarms, reactor water activity, reactor water temperature and the water level in the reactor pool.

## 4 Unloading of the reactor pool

The first phase of the decommissioning of the reactor, removal of the spent fuel from the site, took place in 2010, under the existing license for operation of the reactor.

  

Due to a lack of detailed reliable documentation on the reactor, visual inspection of the reactor pool, using an underwater camera, was realised, as well as information collection from former workers. These led to several technical improvements on site and the creation of an up-to-date safety report, including detailed risk analysis, ALARA studies and checklists.

Sipping tests by reducing the hydrostatic pressure were performed on the fuel elements, before unloading them from the reactor pool, to search for micro-leaks. No leak was detected.

The fuel elements were placed in a TNB 145 transport container on which a leak test was performed before transportation of the fuel to Belgoprocess in Dessel.

Due to the fuel's exotic composition, Ghent University declared its spent fuel as radioactive waste, allowing for final conditioning in seven 400 liter drums containing an internal basket with 4 concentric cylinders for the fuel elements, an additional central cylinder for cut plugs and a special cement mixture containing $LiNO_3$.

During this first phase, the cumulative dose received was only 404 man · μSv.

## 5 Transition period between removal of the spent fuel and start of the decommissioning phase (09/2010 – 03/2013)

During the transition period between the removal of the spent fuel in 2010 and the start of the decommissioning phase in March 2013, 3-monthly internal inspections and inspections by Bel V, regarding ventilation, radiation monitoring, underpressure, alarms, waterlevel, reactor water activity and reactor water temperature, were performed. Finally, a decommissioning license was received from the FANC on May 15, 2012.

## 6 Final decommissioning phase (2013 – 2015)

The second and final decommissioning phase started on March 18, 2013. The different phases, performed during the final decommissioning period from March 2013 till August 2013 were:

- Primary mapping of the installations and the reactor building,
- Asbestos removal (part 1),
- Dismantling of the instrumentation/rabbitsystem/internal reactor parts (graphite, grid, core plate),
- Dismantling of water circuits and ventilation system, stripping of contaminated installations,
- Decontamination of the infrastructure.

During this final phase, Bel V performed 6-weekly inspections on the reactor site and attended twice a month the weekly meetings between the different contracting parties (UGhent, SCK, Belgoprocess and dBase). The total dose received during this period was 1561 man · μSv.

One incident, rated INES 1 on the INES Scale, occurred in April 2013. Due to a power outage, the underpressure in the reactor building was temporarily lost. This incident didn't have any radiological consequences.

After removal of all the infrastructure from the reactor pool, it was found that the bottom plate and the concrete under the bottom plate were activated. This wasn't predicted in the initial radiological inventory. The last asbestos removal phase and the removal of the activated bottom plate took place end of 2013.

The final radiological survey in order to free release the Thetis reactor building (except the reactor pool) was performed in 2015. One contamination had been detected by Bel V in a former lab. After removal of this contamination the reactor building was free released.

The declassification from a Class I installation to a Class II installation was possible by the end of 2015. The activated concrete in the reactor pool will remain under regulatory control until the activation levels are lower than the limits for free release. The total activation of the bottom plate is approximately 0.34 MBq $^{60}Co$ and 3,1 MBq $^{152}Eu$.

## 7 Waste management program

All materials were selectively collected in waste categories. Specific waste drums were used to collect the waste. All drums were radiologically characterised. The results of the characterisation determined the removal paths of the material:

- Radioactive waste was transported to NIRAS/Belgoprocess for interim storage.
- Low level radioactive metallic waste will be sent to Studsvik (Sweden) or Energy Solutions (US) for melting.
- Some of the metallic scrap and combustible waste could be free released.

All information of each drum was saved in a data management system.

The waste management program allowed removal of all radioactive material from the reactor, while reducing also the amount of radioactive waste, using up-to-date measurement techniques and methodologies.

## 8 Conclusion

The goal of the decommissioning was the free release of the reactor building. Due to the unexpected activation of the concrete, the bottom plate of the reactor pool will remain under regulatory control until the activation levels are lower than the limits for free release.

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