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Comparison of decommissioning options for the example of 2 research reactors of type TRIGA

*In Remembrance to
Mrs. Barbara Jünger-Gräf*

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- Comparison of the Immediate Dismantling and the Deferred Dismantling
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Introduction

- Objectives of the Study
 - Systematic description of two projects on the decommissioning of TRIGA research reactors at German Cancer Research Center
 - Evaluation of advantages and disadvantages of the applied decommissioning options to answer the question

„Which is the most appropriate decommissioning option?“

- Pre-requisites for such a study are promising:
 - Research reactors comparable with respect to safety relevant design and to regulatory and technical framework
 - Same operator / responsible persons for both research reactors
 - Access on information for a period of 25 years possible

Background

- Advantages and disadvantages of immediate and deferred dismantling – a first evaluation

	Immediate Dismantling	Deferred Dismantling
Costs of decommissioning	😊	😞
Collective effective dose	😞	😊
Need for remote dismantling techniques	😞	😊 (?)
Clearance measurements (-> nuclide vector)	😊	😞
Amount of radioactive waste	😞	😊
Availability of necessary dismantling techniques	😞	😊 (?)
Operator's availability on facility know-how	😊	😞
Availability of qualified personnel	😊	😞
Social aspects	😊	😞
Availability of the necessary infrastructure	😊	😞

Background

- Example from the practice – the situation might be different

Comparison of immediate and deferred dismantling of units 1 – 4 of Greifswald NPP

			Direct	Deferred
Cost	Mill. DEM	Total	5,110	6,077
		Only decom.	2,375	3,371
Dose commitment	manSv		17.0	20.2
Radioactive waste volumes	m ³		22,790	25,794

from: „nuclear safety and the environment –
Decommissioning of nuclear installations in the European Union“
European Commission Report EUR 18860 EN, 1998

Background

- International consensus: immediate dismantling to be preferred
 - IAEA Safety Standard Requirement WS-R-5

*4.2 The **preferred decommissioning strategy shall be immediate dismantling**. ... If the deferred dismantling or entombment strategy is chosen, the operator shall provide a justification for the selection. ...*
 - IAEA Int. Conference on Decommissioning in Berlin, 2002
Section 2.A – Decommissioning Strategies and Regulations

*... All have advantages and disadvantages, but **immediate dismantling is the generally preferred option**. ...*
 - WENRA WGWD Decommissioning Safety Levels of March 2007

*D-15: A strategy shall be produced and documented... .The report should explain the reasons for the preferred option, and **options involving deferred decommissioning shall be rigorously justified**.*

Background

- Nevertheless, deferred dismantling might be justified
 - IAEA Expert Group (TECDOC-1478, 2005)

„ ... When selecting a proper decommissioning strategy in a specific facility, a range of general and site specific factors needs to be considered, typically, in a multi-attribute analysis. ...“
 - IAEA Int. Conference on Decommissioning in Athens (2006)

Penal and plenary session on the question: „**Is deferred dismantling a justifiable decommissioning option?**“

 - Some answers:
 - *“See above mentioned TECDOC-1478”*
 - *“Depending on the individual case”*
 - *“Interims storage of large components as a combined approach”*
 - *“Only a justified option for “developing countries””*

Background

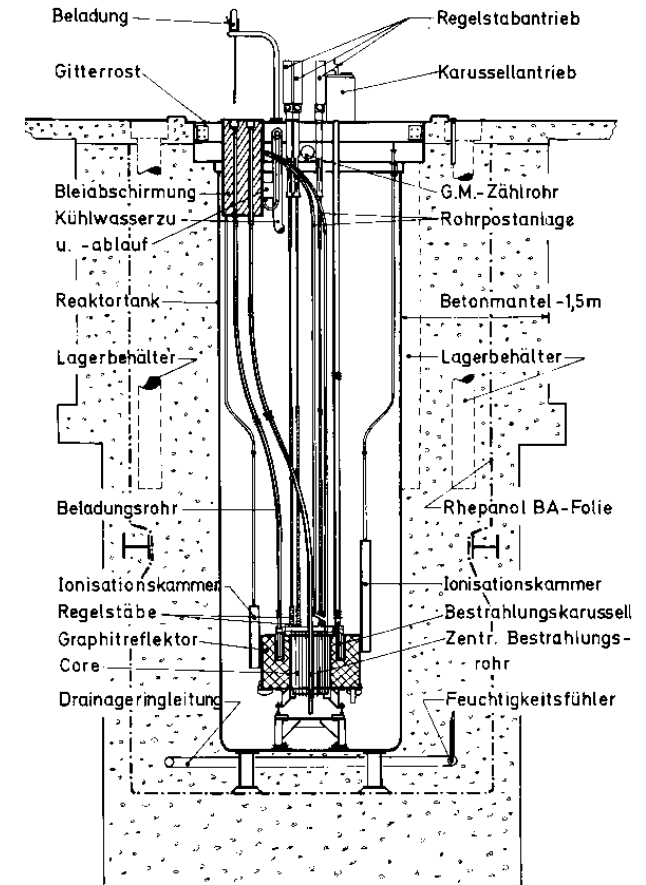
- Conclusions up to now:
 - For each individual case it needs to be analyzed which decommissioning option is the most favourable
 - The challenge (for the responsible of the nuclear facility) is „just“ to identify those criteria and related scales to be applied during that analysis
 - Results of on nuclear facility need a careful check if to be applied at another nuclear facility

Also:

There are only few studies on the comparison of real decommissioning projects with respect to the implemented decommissioning option!

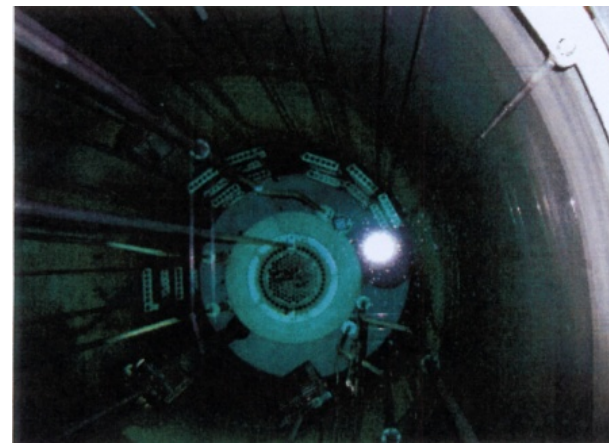
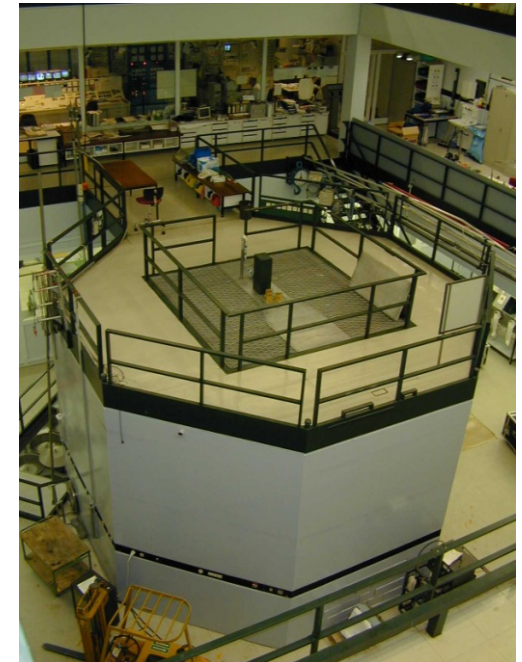
Overview on the two Research Reactors and their Decommissioning

- Basic information on TRIGA HD I
 - Tank reactor of type TRIGA Mark I (250 kW thermal power)
 - Core: MTR fuel elements with 20% U-235 in circular (kreisförmiger) geometry
 - Biological shield embedded completely in the foundation
 - Primary and secondary loop (no redundancy)



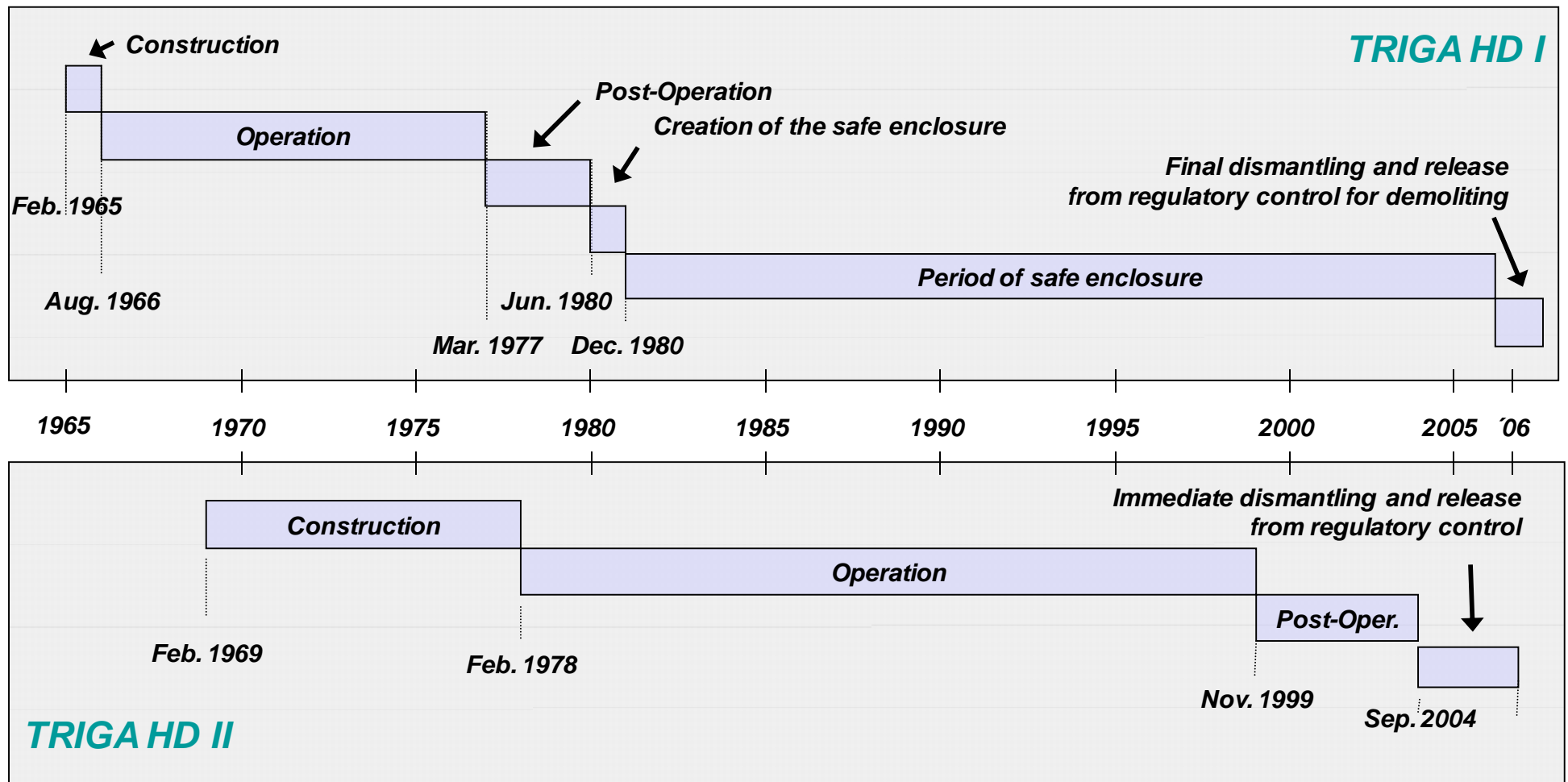
Overview on the two Research Reactors and their Decommissioning

- Basic information on TRIGA HD II
 - Tank reactor of type TRIGA Mark I* (250 kW thermal power)
 - Core: MTR fuel elements with 20% U-235 in hexagonal geometry
 - Biological shield (embedded half in foundation, half in reactor hall)
 - Primary and secondary loop (partially redundant)



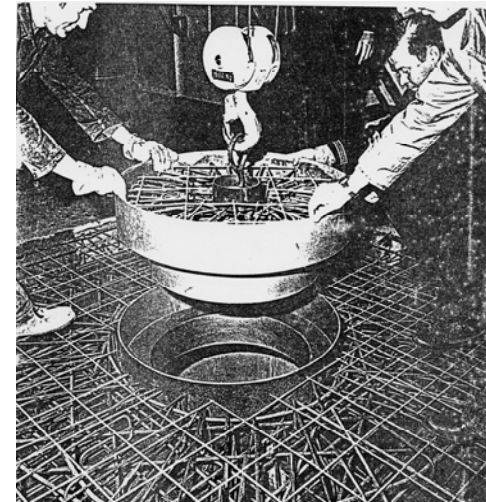
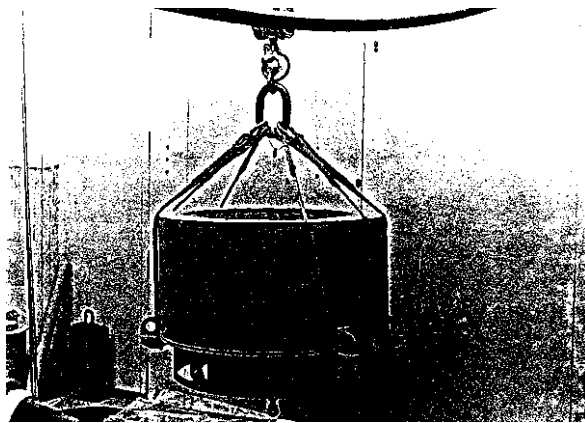
Overview on the two Research Reactors and their Decommissioning

- Overview on the lifecycle of both research reactors



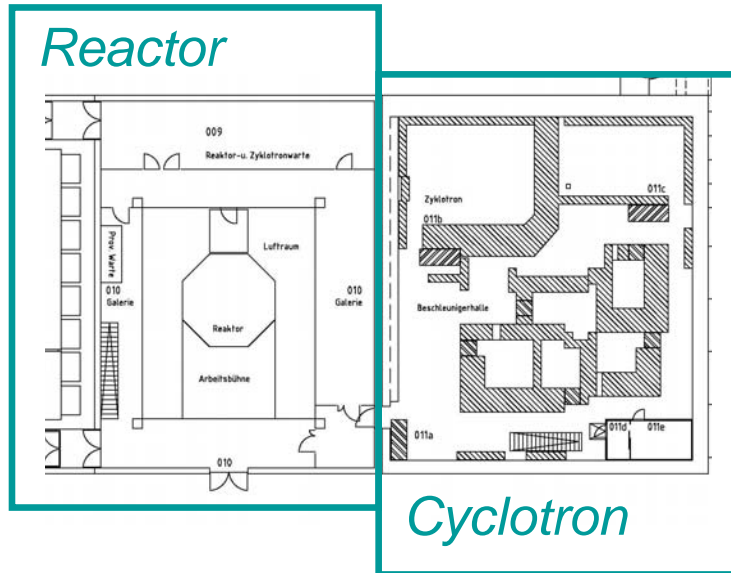
Overview on the two Research Reactors and their Decommissioning

- Illustration of the decommissioning of TRIGA HD I



Overview on the two Research Reactors and their Decommissioning

- Illustration of the decommissioning of TRIGA HD II



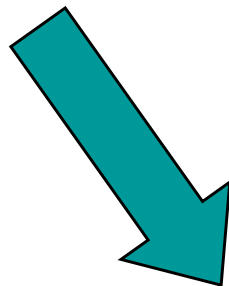
Comparison of the Immediate Dismantling and the Deferred Dismantling

- Concept of the study

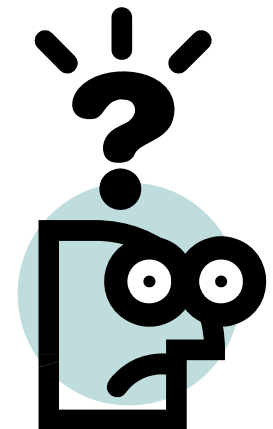
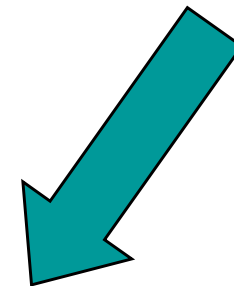
Collection of available information and processing / structuring of that information



Determination of a set of evaluation aspects, on which the analysis and the comparison should be based and which helped to structure the available information



Evaluation of the information and deduction of results for the intended comparison.



Comparison of the Immediate Dismantling and the Deferred Dismantling

- Evaluation results

Evaluation Issues	Immediate Dismantling	Deferred Dismantling
Use of the building / site	😊	😊
Collective effective dose	😊	😞
Identification & management of radioactive material	😊	😊
Amount of radioactive waste (concrete only)	😞	😊
Operator's availability on know-how on the facility / availability of qualified personnel	😊	😊
Complexity of the dismantling activities and of dismantling techniques	😊	😊
Availability of necessary dismantling techniques	😊	😊
Availability of a disposal route	😐	😊
Availability of the necessary infrastructure	😊	😞

Experiences and Conclusions

- Both research reactors could be dismantled without any safety relevant deficiencies
- In both decommissioning projects the selected decommissioning option allowed the intended use of the former reactor building in an optimized way
- The collective effective doses of both decommissioning projects were of same order of magnitude
 - But: progress in radiation protection know how and experiences can be observed in case of the immediate dismantling

Experiences and Conclusions

- Especially for TRIGA HD I, i.e. for the safe enclosure
 - Challenge of incomplete documentation on the reactor could be solved with help of former staff expert
 - Missing information on the use of the reactor building during the period of safe enclosure resulted in increased effort during the clearance process
- As lessons learned
- Ensure as much as possible a complete documentation
 - Lay down in the license for safe enclosure all remaining structures, systems & components of the reactor
- As a result of study of 1979: expectation of unrestricted release of biological shield after the period of safe enclosure, but in fact: changed clearance levels resulted in some radioactive waste

Summary

- At the German Cancer Research Centre the two TRIGA research reactors were successfully dismantled using
 - deferred dismantling for TRIGA HD I and
 - immediate dismantling for TRIGA HD II
- Both decommissioning projects
 - did not reveal any safety relevant deficiencies but
 - allowed an early use of the reactor buildings
- The study performed did not allow a general preference for one of the decommissioning options
 - But: with respect to burdens for future generations the immediate dismantling can be regarded more preferable