NATIONAL REPORT BRAZIL

R2D2P WORKSHOP
SAFETY ASSESSMENT FOR DECOMMISSIONIG
RISØ ● 04-08 OCTOBER 2010

Pablo Andrade Grossi [1]
Nerbe Ruperti [2]

CDTN/DPD/CNEN [1]
DIREJ/DRS/CNEN [2]
National Nuclear Energy Commission

CENTRO DE DESENVOLVIMENTO DA TECNOLOGIA NUCLEAR

Comissão Nacional de Energia Nuclear

CONTENTS

- Legal and regulatory framework
- Basics of decommissioning / decommissioning planning
- Transition from operation to decommissioning
- Characterization survey
- Cost estimates
- Decommissioning technologies

LEGAL AND REGULATORY FRAMEWORK

- ***The National Standard NN-9.01: Decommissioning of Nuclear Facilities is under development*** by the regulatory body with the cooperation of national experts in the subject;
- All Brazilian R2D2P participants were invited as representatives of theirs research institutes to perform this joint work;
- Based on the following documents:
  - WS-R-5, Decommissioning of Facilities Using Radioactive Material;
  - DS333, Decommissioning of Nuclear Facilities;
  - DS376, Safety Assessment for Decommissioning of Facilities Using Radioactive Material

LEGAL AND REGULATORY FRAMEWORK

- As Brazilian Representatives for R2D2P project, we have been worked on the ***diffusion of the decommissioning culture in Brazil*** focusing on the establishment of the ***National Policy regarding to decommissioning***, creation of a National Work Group skilled on Decommissioning Planning and Projects, preparation of ***national standards and procedures*** and ***promotion of the development of Decommissioning Plans for Brazilian Research Reactors***

- According to the Regulatory Body, the ***National Standard NN-9.01 will be available in January 2012***

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LEGAL AND REGULATORY FRAMEWORK

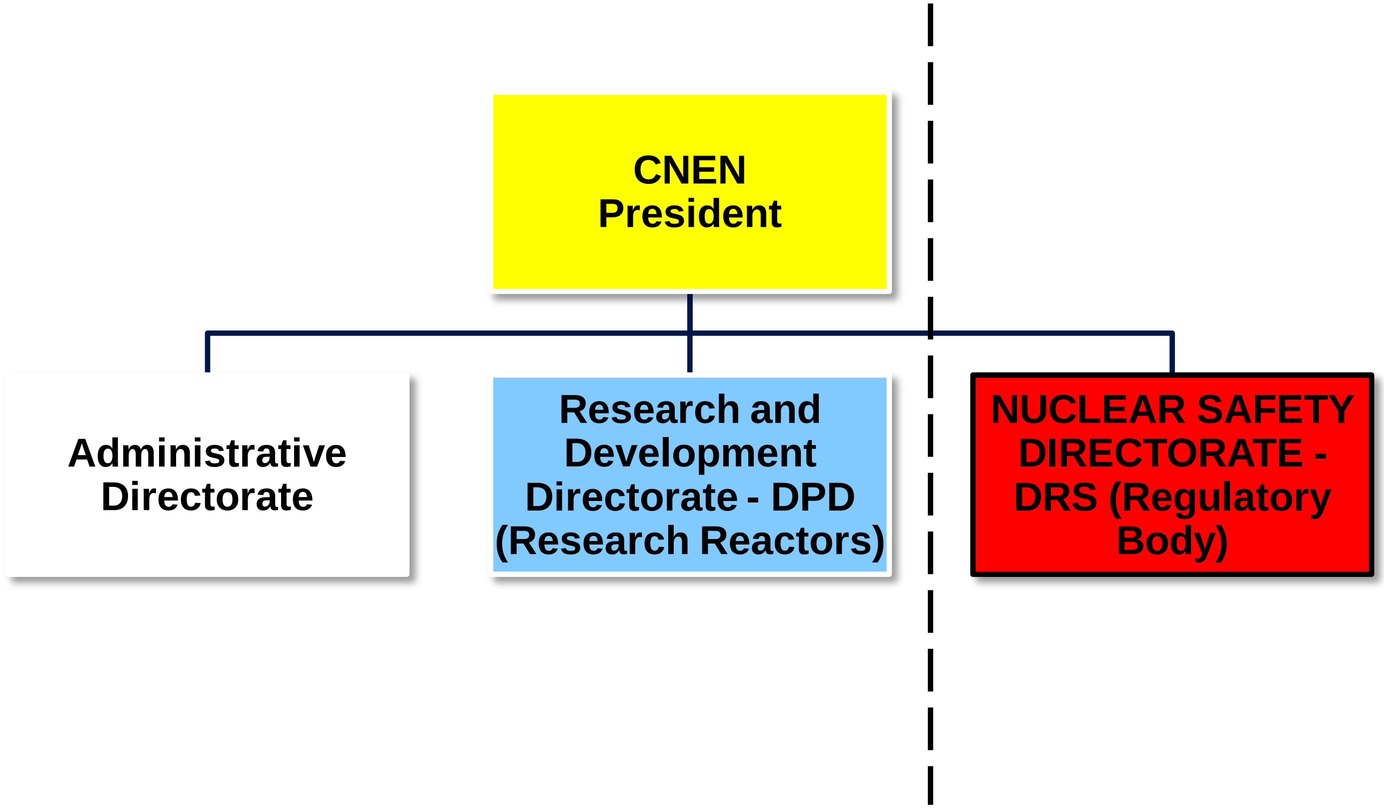
- The Constitution of 1988 of the Federal Republic of Brazil states in its articles 21 and 177 that the Union has the exclusive competence for managing and handling all nuclear energy activities, including the operation of nuclear power plants.
- The Union holds also the monopoly of the survey, mining, milling, exploitation and exploration of nuclear minerals, as well as of the activities related to industrialization and commerce of nuclear minerals and materials, and is also responsible for the final disposal of radioactive waste.

LEGAL AND REGULATORY FRAMEWORK

- The National Nuclear Energy Commission (Comissão Nacional de Energia Nuclear - **CNEN**) was created in 1956, and is:
  - responsible for **regulating, licensing and controlling** nuclear energy utilization (Nuclear Safety Directorate, **DRS/CNEN**);
  - in charge of research and development and production of radioisotopes (Research and Development Directorate, **DPD/CNEN**). The DPD is also responsible for receiving and disposing off radioactive waste from the whole country.

LEGAL AND REGULATORY FRAMEWORK

- The National Nuclear Energy Commission - CNEN



LEGAL AND REGULATORY FRAMEWORK

- Environmental Licensing:
  - **IBAMA** (Institute for Environmental and Renewable Natural Resources) under the Ministry for Environment is responsible for the environmental licensing process.

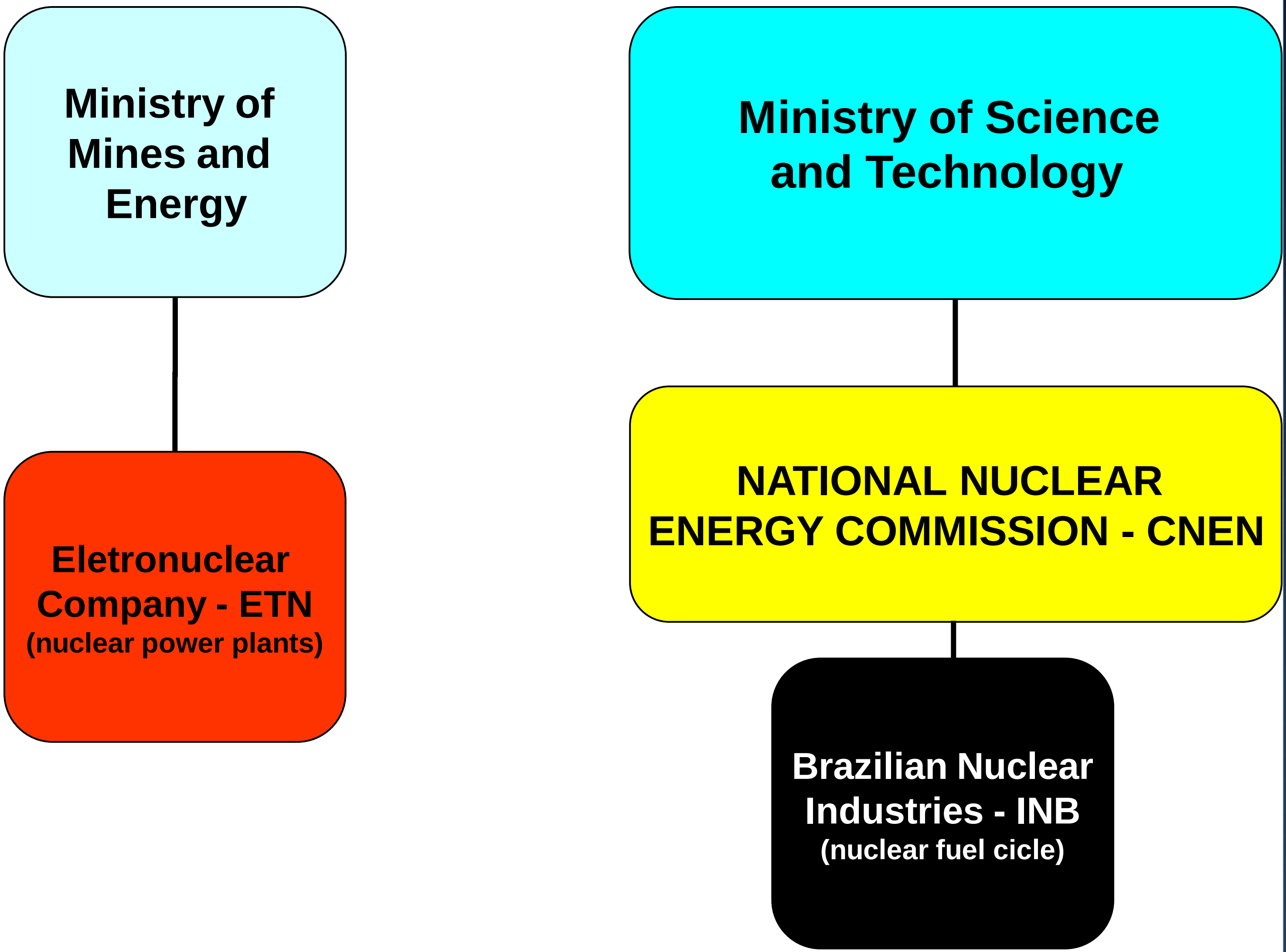
LEGAL AND REGULATORY FRAMEWORK

Other Brazilian organizations involved in Nuclear Safety:

- Eletrobras Termonuclear S.A. (**ELETRONUCLEAR**):
  - Responsible for Angra I and Angra II NPPs.
- Nuclear Industries of Brazil (**INB***):
  - nuclear fuel manufacturing plant;
  - yellow-cake production plant;
  - uranium enrichment plant;
  - mining facility in operation since 2000;
  - monazite sand extraction facility.

* CNEN owns 99.9983 % of INB.

LEGAL AND REGULATORY FRAMEWORK



DOCUMENTS APPLIED TO IPR-R1 DECOMMISSIONING ACTIVITIES

- "Developed Devices for Dismantling and Maintenance of IPR-R1 Research Reactor" (NI-AT4-004/95) 1995. (under revision)
- "Shielding and Criticality Safety Analyses of a Latin American Cask for Transportation and Interim Storage of Spent Fuel From Research Reactors ", 2003.
- "Characterization of Burned Fuel of the TRIGA IPR – R1 Research Reactor Using Monteburns Code ", 2002.
- CDTN 0023 (Radioactive Waste Management)
- CDTN (Radiation Protection Plan)

BASICS OF DECOMMISSIONING / DECOMMISSIONING PLANNING

BASICS OF DECOMMISSIONING / DECOMMISSIONING PLANNING

CDTN decide to start an internal project (Aug 2010):

"Planning of Decommissioning activities for IPR-R1 Research Reactor"

- **Expected Goals:**
  - ***Develop the IPR-R1 Decommissioning Plan in a joint work with CDTN´s Experts***
  - **Use the developed plan for IPR-R1 as a model and after extending to all Brazilian Research Reactors, and other facilities;**

Project Manager: Pablo Andrade Grossi (R2D2P representative)

BASICS OF DECOMMISSIONING / DECOMMISSIONING PLANNING

In the actual stage we have a good draft with relevant information, contents, structure and general aspects to be considered in a research reactor decommissioning plan, as you can see in the attached file (*DECOMMISSIONING PLAN__TRIGA IPR-R1.doc*).

This document was reviewed R2D2P representatives after some suggestions from AIEA staff (Vladan and Ernest) to reorganize the presented information considering some IAEA publications (Safety Reports Series No. 45 - Standard Format and Content for Safety Related Decommissioning Documents, Standardized Cost Items For Decommissioning Projects, among several others as shown as reference inside the document).

We encountered some delays due to very limited human resources to develop each activity planning described on the chapters of the document.

BASICS OF DECOMMISSIONING / DECOMMISSIONING PLANNING

To contour this lack of people we proposed to the Director of our Research Institute the creation of a internal project entitled "Planning of Decommissioning Activities for IPR-R1 Research Reactor" only available in Portuguese (attached file: *Projeto Draft_Planejamento de Atividades de Descomissionamento para Instalações do CDTN.doc*) allowing the contribution of specialists of our institute on each particular Decommissioning Planning issue.

This project is now under final evaluation by the CDTN's projects approval staff.

Other activities accomplished to keep de wheel moving were discussions and interactions with the regulators highlighting the importance of development the national regulatory framework on Decommissioning.

A national group is involved on this issue and a national standard is under development but only available in Portuguese (*Norma Descomissionamento - Draft 0 Jul2009.doc* attached).

We were invited to contribute with the development of this national standard

BASICS OF DECOMMISSIONING / DECOMMISSIONING PLANNING

(ADDITIONAL INFORMATION)

DECOMMISSIONING OPTIONS (PRIORITY)

1) Protective storage in an intact condition after removal of all fuel assemblies and readily removable radioactive components and wastes (***safe enclosure***);
2) Removal of all radioactive materials and thorough decontamination of the remaining structures to permit unrestricted use (***immediate dismantling***);

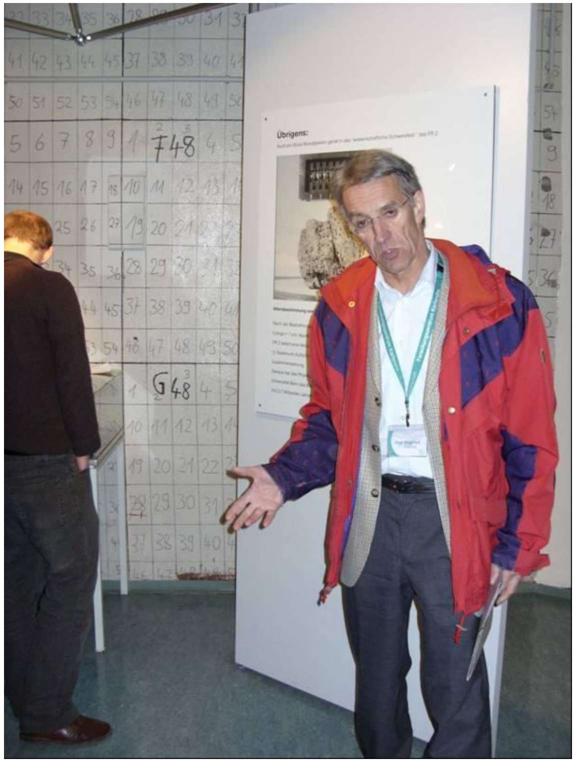
END STATE OF DECOMMISSIONING ACTIVITIES

- The main option is ***use the area for nuclear proposes*** since this reactor area is at ***CDTN's site***, and there are often ***demands for new nuclear facilities***.
  - (*as a historical museum of a TRIGA technology*)
- After some decades the final goal will be the ***unrestricted use*** of the place, ***after the full decontamination***.

END STATE OF DECOMMISSIONING ACTIVITIES

- A good solution was adopted by FZK – *Forschungszentrum Karlsruhe*. The FR2 ***reactor was decommissioned*** and the ***auxiliary installation and rooms*** were ***completely decontaminated***, so that the area is now a ***museum of nuclear science*** [TREN/05/NUCL/S07.55436, 2007].

END STATE OF DECOMMISSIONING ACTIVITIES

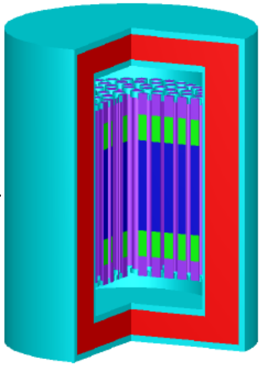


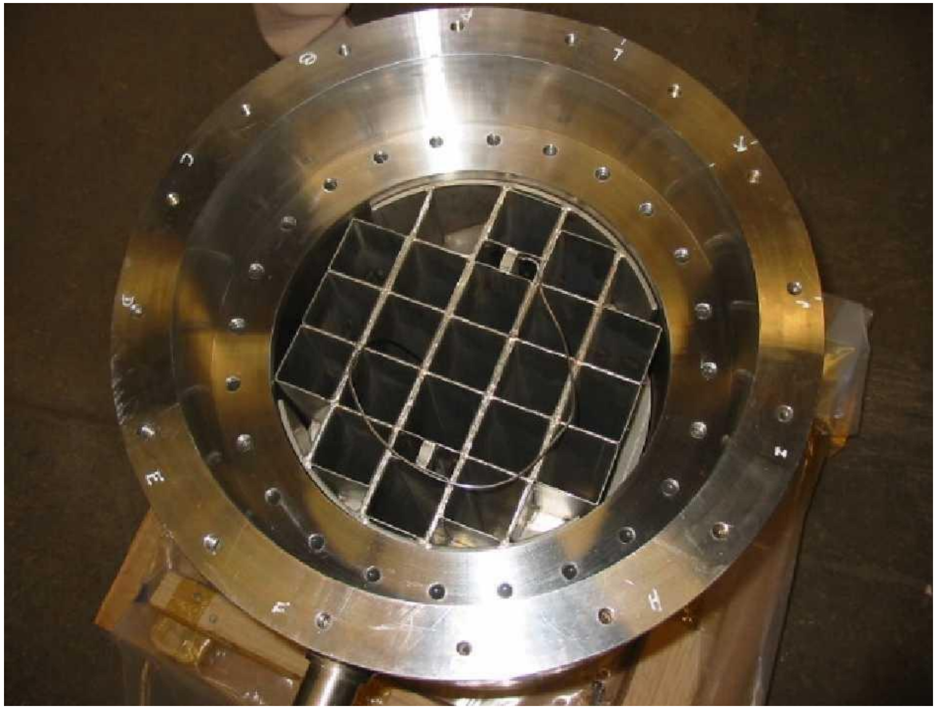
BRAZILIAN ONGOING ACTIVITIES

- Disassembly procedures and equipments
  - review and updating
- Spent fuel safe storage/transport package (cask in development / dry storage)
  - IAEA regional project
  - prototype performance tests
  - correction of the non-conformities

LATIN AMERICAN CASK

Numerical Assessment
Project Parameters





Prototype – external view

Prototype – internal view

2 basket types (78 TRIGA or 21 MTR elements) USD$ 60,000.00

IPR-R1 LIFETIME ESTIMATION

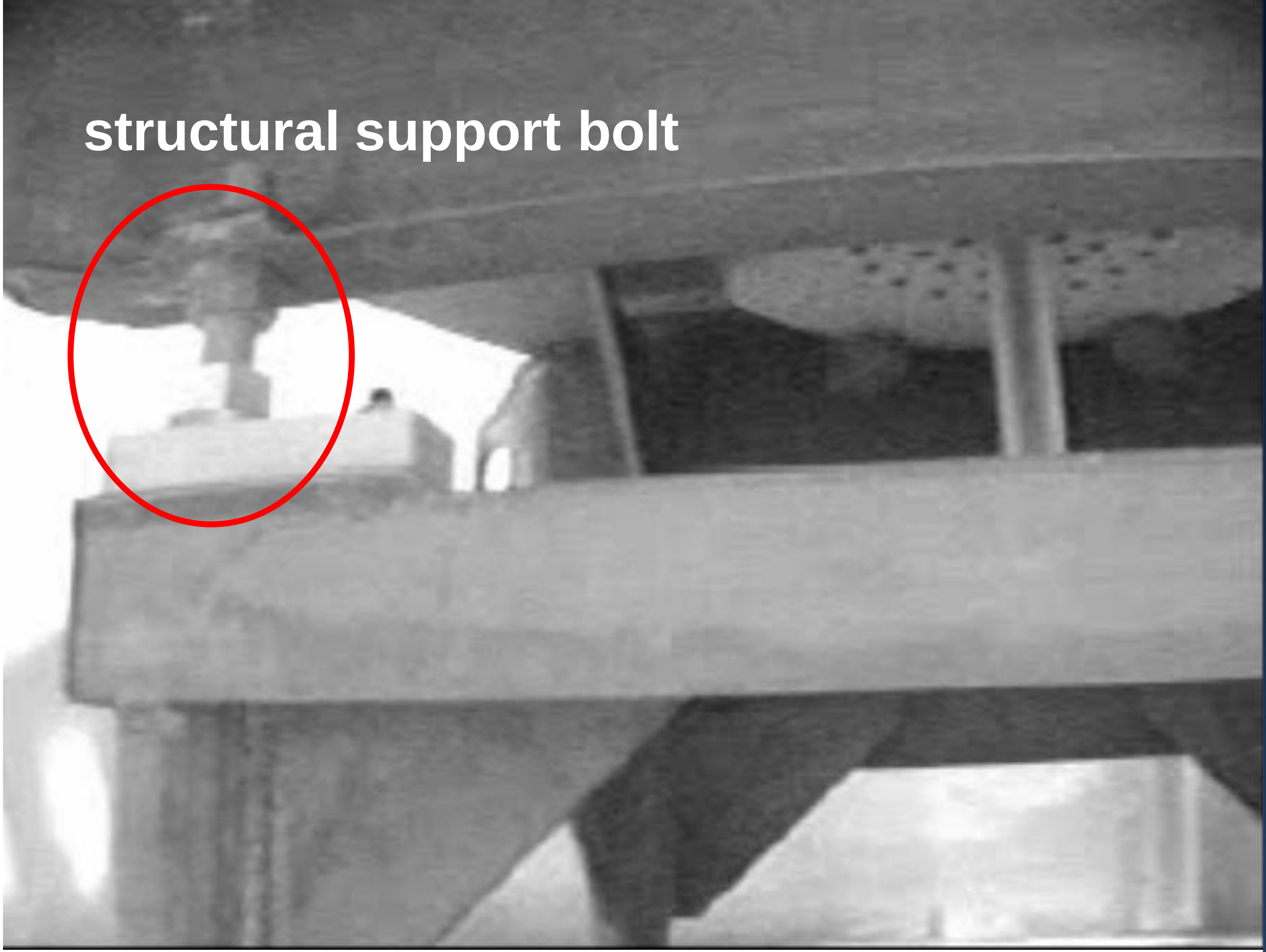
- ***Codes:***
  - ***MCNP transport;***
  - ***ORIGEN 2.1 burn-up;***
  - ***MONTEBURNS radioactive decay.***
- ***Parameters for numerical simulations:***
  - *68 fuel elements inserted* on TRIGA core (note: there are 5 fresh stainless-steel elements that have never been used);
  - operation at *250 kW* (conservative hypothesis);
  - average work demand based on the past 48 operation years,

IPR-R1 LIFETIME ESTIMATION

- ***Actual Status:***
  - reduction of 96 g of ^{235}U mass, regarding to initial mass of 2.3 kg;
  - a total burn-up near to 4.17% or 2000 MWh until June 2008.
- ***Results of Lifetime estimation:***
  - The estimated lifetime for the IPR-R1 is of more ***34 years*** with a ***total burn-up of 3500 MWh***.
  - The final burn-up of 12.1 % (mean of 68 elements) were observed, indicating a reduction of 307 g of ^{235}U mass.
  - The total burn-up of the *central elements* would be *less than 20%* (as recommend by the manufacturer).

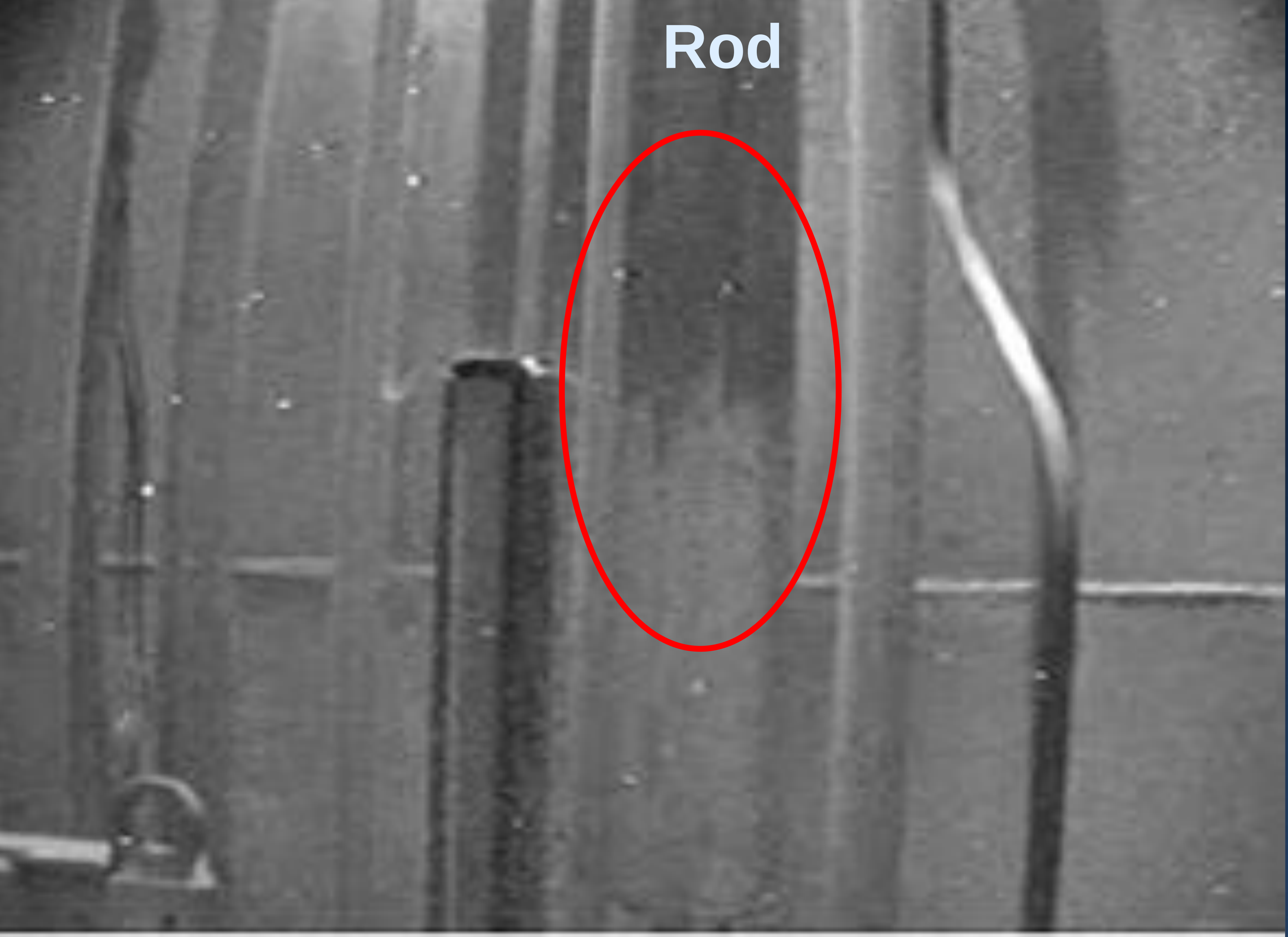
Assessment of Safety Conditions

Visual Inspection - Camera immersed in to the pool

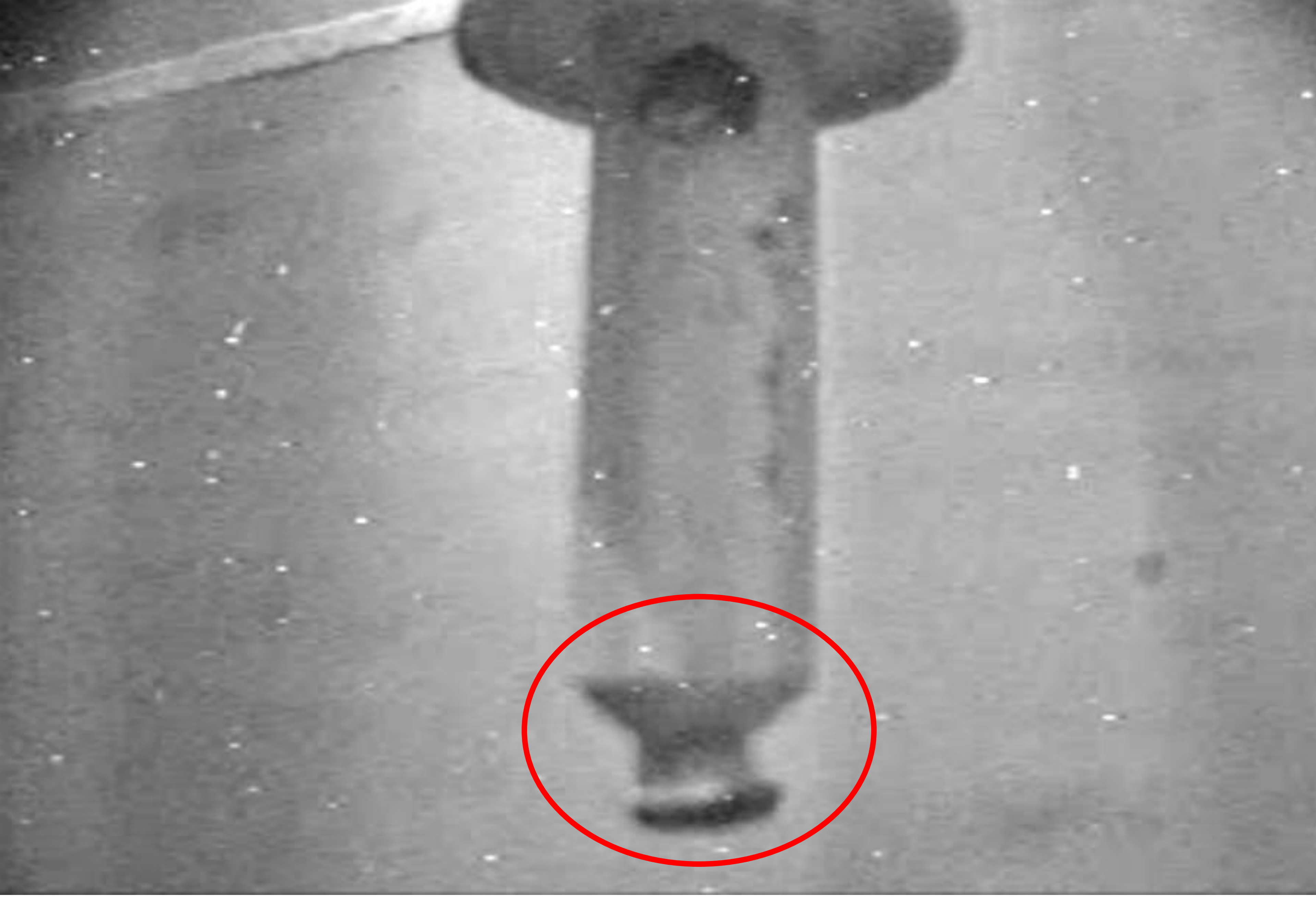


Visual Inspection - reactor structure

Fuel being taken for inspection



Rod oxidation gradient



Fuel pin – deformed / kneaded

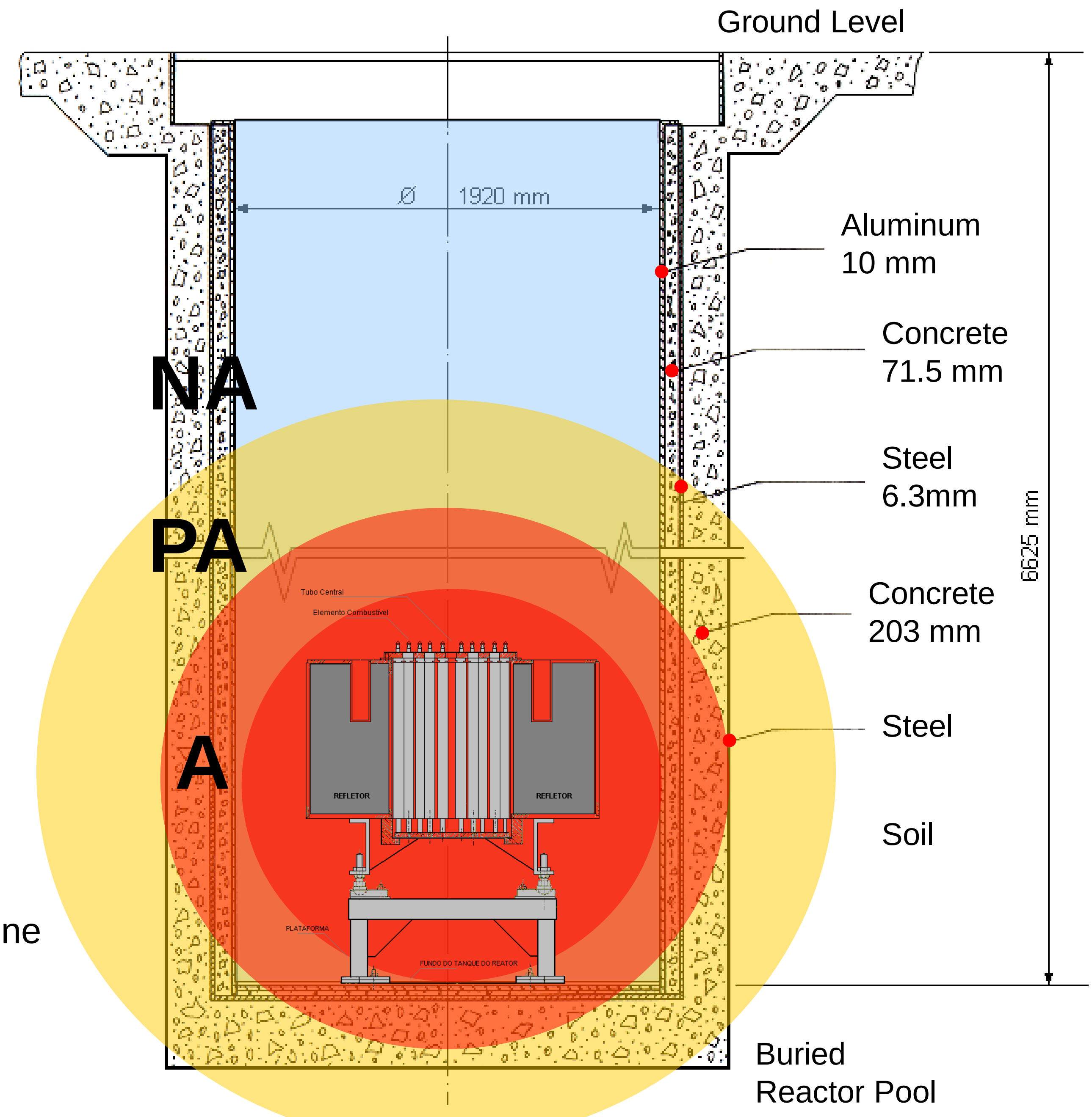
ASSESSMENT OF TYPE AND AMOUNTS OF RADWASTE

- **Codes:**
  - **MCNP transport;**
  - **ORIGEN 2.1 burn-up;**
  - **MONTEBURNS radioactive decay.**

A – Activated Zone

PA – Probable Activated Zone

NA – Non-Activated Zone



Assessment of Type and Amounts of Radwaste

- This simulation will give the first approach for the characterization plan:
  - grid map;
  - equipment;
  - sampling program;
  - radiation protection planning for this tasks.
- Waste management strategy
- Waste and cost minimization.

BRAZILIAN ONGOING ACTIVITIES

- Internal and National Standards
  - Joint Convention and decommissioning policy
- Waste management
  - Brazilian Nuclear Program
    - Budget PAC
  - Interministerial Committee
  - National Waste Management Program
    - WM Brazilian Agency
    - Repository for LLW and ILW
    - Storage facility for spent fuel

DECOMMISSIONING PLAN

- ***QA plan:*** there are Quality Assurance Program and a Team that takes care of this subject. For the decommissioning activities will be developed specific procedures, including audits.
- ***Radiation Protection*, *Health and Safety plan:*** additional procedures will be developed for the surveillance, characterization, demolishing and decontamination activities, including radiological and non-radiological risks.
- ***Characterization plan:*** description of characterization (deepness of sampling, grid, number of samples, analysis, etc).
- ***Decontamination plan:*** radiological criteria for clearance level; decontamination; classification, recycling and reuse of the material.
- ***Waste management plan:*** segregation and collection procedures, processing options, packaging, storage and disposal routes for the radioactive waste.

IPR-R1 DECOMMISSIONING PLAN (DRAFT)

cnen
Comissão Nacional
de Energia Nuclear

CDTN
CENTRO DE DESENVOLVIMENTO
DA TECNOLOGIA NUCLEAR

TRIGA IPR-R1 RESEARCH REACTOR DECOMMISSIONING PLAN (DRAFT)

Rev. 0

September 2010

CONTENTS

IPR-R1 DECOMMISSIONING PLAN (DRAFT)

IPR-R1 DECOMMISSIONING PLAN (DRAFT)

1 INTRODUCTION

1.1 *OBJECTIVES*

2 TRIGA IPR-R1 DESCRIPTION

2.1 *Historical aspects*

Description of the nuclear reactor, the site and the surrounding area that could affect, and be affected by decommissioning

2.2 *Operational Data Recovery*

Recover the operational life history of the nuclear reactor, authorized activities, licenses and authorizations, reasons for taking it out of service, and the planned use of the nuclear installation and the site during and after decommissioning

2.3 *Building Description and Aspects*

Identification of structural characteristics, alterations, restructuration and significant plant modifications

2.4 *Site location and using area description*

2.5 *Drawings and maps*

DECOMMISSIONING PLAN CONTENTS

1. **INTRODUCTION**
2. **OBJECTIVE**
3. **TRIGA IPR-R1 DESCRIPTION**
   - Historical
   - Properties and construction aspects
   - Lifetime estimation
   - Location and using area description
   - Drawings and maps
4. **DECOMMISSIONING STRATEGY AND END STATE**
5. **RESPONSIBILITIES**

DECOMMISSIONING PLAN CONTENTS

6. **FINANCIAL ASPECTS**
7. **QUALITY ASSURANCE PROGRAM**
8. **RELATED DOCUMENTATION**
   - Federal Standards
   - CNEN Standards and Procedures
   - CDTN Procedures
   - Environmental Standards
   - IAEA Recommendations
   - Other relevant documents

DECOMMISSIONING PLAN CONTENTS

9. **CHARACTERIZATION PROGRAM**
   - Maps of the installation
   - Contamination Level Approach
   - Gridding for Sampling and number of samples to be taken
   - Clearance Values
   - Analysis and Results (Standard Values)
   - Destiny of the samples (release or stored as witness)
   - Classification of the material as non-radioactive or radioactive waste, recyclable, reusable material

DECOMMISSIONING PLAN CONTENTS

10. **TEAMS AND ACTIVITIES (FLOWSHEET)**
    - Reactor Operation
    - Health & Safety
    - Radiological Protection
    - Waste Management
    - Infra-structure & General Maintenance
    - Administrative and Financial
    - Legal
    - Environmental
    - Risk, Burn-up and Waste Approach Assessment
    - Audit and QA
    - Communication

DECOMMISSIONING PLAN CONTENTS

11. **EQUIPMENT AND INSTRUMENT**
12. **ROUTES**
    - Personnel
    - Wastes
    - Other Materials
13. **EMERGENCY PLAN**
14. **TIMETABLE**
15. **CONCLUSION**
16. **TABLE OF REVISION**
17. **ANNEXES**

TRANSITION FROM OPERATION TO DECOMMISSIONING

TRANSITION FROM OPERATION TO DECOMMISSIONING

Main issues to be addressed:

- The intention is to utilize the RR operation staff to be intensely involved on the decommissioning activities.
- The cost of safety enclosure will be evaluated at the beginning of the transition phase to redefine the decommissioning option: Safety Enclosure (how long and why) or Immediately Dismantling (why and main benefits)
- Reassessment of the desired/expected End State
- Be sure that when necessary, all necessary arrangements are available for the dismantling phase

CHARACTERIZATION SURVEY

CHARACTERIZATION SURVEY

- Maps of the installation
- Definition of Contamination Level Approach

- On-site and off-site radiation and contamination status (accomplishing contamination surveys):
  - •Contaminated structures
  - •Contaminated systems and equipments
  - •Surface soil contamination
  - •Subsurface soil contamination
  - •Surface water contamination
  - •Groundwater contamination
- Explicit requirements for appropriate radiological criteria for guiding decommissioning
- Release criteria measurement/verification methods
- Description of the monitoring programme, equipment and methods to be used to verify that the site will comply with the release criteria
- Final confirmatory radiological survey at the end of decommissioning

CHARACTERIZATION SURVEY

- Gridding for Sampling and number of samples to be taken
- Clearance Values (Safety Standards Series No. RS-G-1.7)

Application of the Concepts of Exclusion, Exemption and Clearance. Definition of Clearance Criteria and Final release criteria.

- Definition of scaling factors, radionuclide vectors, “fingerprints”
- Analysis and Results (Standard Values)

CHARACTERIZATION SURVEY

- Destiny of the samples (release or stored as witness)
- Classification of the material as non-radioactive or radioactive waste, recyclable, reusable material

CHARACTERIZATION SURVEY

- EQUIPMENTS AND INSTRUMENTS

SIMPLE MONITORING INSTRUMENTS			
Application	**Detector**	**Characteristics**	**Remarks**
Alpha emitters	proportional – various windows sizes	0.4 to 3 Bq/100 cm^2 sensitivity for scanning	Sensitivity depending on type of surface
	scintillation	3 Bq/100 cm^2 sensitivity for scanning	Sensitivity depending on type of surface
Beta emitters	proportional – various windows sizes	3 Bq/100 cm^2 sensitivity for scanning	Sensitivity depending on type of surface
	Geiger-Muller	3 Bq/100 cm^2 sensitivity for scanning	Sensitivity depending on type of surface
Gamma emitters	Geiger-Muller	Measurement at 50% above background	Better sensitivity with time integration
	proportional	Measurement at 50% above background	Better sensitivity with time integration
	scintillation	Measurement at 50% above background	Better sensitivity with time integration
Note: These instruments can be used for scanning or in a time integration mode for increased precision during direct measurements			

CHARACTERIZATION SURVEY

- EQUIPMENTS AND INSTRUMENTS

FIELD RADIATION DETECTORS FOR NUCLIDE-SPECIFIC MEASUREMENTS			
Application	**Detector**	**Characteristics**	**Remarks**
Alpha emitters	Sealed –large area proportional counter	Minimum deectable activity (MDA) of 0.3 Bq/g or 2 Bq/100 cm^2	Used as X ray spectrometer
	FIDLER (Field Instrument for Determination of Low Energy Radiation)	MDA of 70 Bq/100 cm^2 for Pu mix	Can be used for scanning, detects X rays
	Array of Si or Ge crystals	MDA of 0.03 Bq/g for Pu mix in 1 hour	Detects X rays or 60 keV line of ^{241}Am
Beta emitters	Scintillating fibres	MDA of 0.2 Bq/g for ^{90}Sr in 1 minute	Provides some nuclide / energy discrimination
Gamma emitters	NaI gamma spectrometer	10×10 cm crystall measures background nuclide concentrations in minutes	Low energy resolution
	Ge gamma spectrometer	Larger types can measure 0.004 Bq/g in 10 minutes	High energy resolution

CHARACTERIZATION SURVEY

- EQUIPMENTS AND INSTRUMENTS

RADIATION DETECTORS FOR DOSE RATE MEASUREMENTS			
Application	**Detector**	**Characteristics**	**Remarks**
Active	pressurised ionisation chamber	<100 nSv/h sensitivity	high precision
	Geiger-Muller	100 nSv/h sensitivity	Energy compensation needed
	proportional	100 nSv/h sensitivity	Energy compensation needed
	scintillator	<100 nSv/h sensitivity	Dual phosphor or tissue for flat energy response (used in current mode)
Passive	Thermoluminescence dosemeter	<50 nSv/h in 1 month	Good for wide area deployment
	Film badge	100 μSv/month	Sensitivity not sufficient for background measurements
	Electret ionisation chamber		Measures radon as well
Active/passive	Electronic dosemeter		Good for personal monitoring

COST ESTIMATES

COST ESTIMATES

- Until now the *cost estimation* has not been done.
- This will be one of the task to be addressed by the proposed Decommissioning Group.
- The IPR-R1 Reactor belongs to CDTN, one research institute of CNEN, and then the *decommissioning costs* will be provided by CNEN (CNEN is a institution of the Science and Technology Ministry).

COST ESTIMATES

Evaluation of the estimated costs for each decommissioning options considering the safety requirements and types of waste generation.

The detailed costs will be calculated during the final planning - Total costs and cost breakdown for individual elements (preparing a detailed time table)

Build inflation into the cost calculations, allowing margin for uncertainties

COST ESTIMATES

Include the costs for waste and materials management, e.g. conditioning, storage, disposal of radioactive waste; nuclear fuel; release of materials, buildings, site(s), considering the tasks:

(a) Pre-decommissioning actions, e.g. decommissioning planning;

(b) Facility shutdown activities, e.g. removal of the spent fuel, system reconfiguration
and retirement, decontamination and immobilization of
residual contamination;

(c) (Limited) procurement of equipment and materials;

(d) (Limited) dismantling activities and characterization of radioactive
inventory;

(e) Waste processing, storage and disposal (including hazardous waste);

(f) Site security, surveillance and maintenance;

(g) Transition project management;

(h) Other costs, including asset recovery.

COST ESTIMATES

IAEA TRS-446: Decommissioning of Research Reactors: Evolution, State of The Art, Open Issues
http://www-pub.iaea.org/MTCD/publications/PDF/TRS446_web.pdf
IAEA: Financial Aspects of Decommissioning
http://www-pub.iaea.org/MTCD/publications/PDF/te_1476_web.pdf
NEA: Decommissioning Funding: Ethics, Implementation, Uncertainties
http://www.nea.fr/html/rwm/reports/2006/nea5996-decommissioning.pdf
NEA: Decommiss. Nuclear Power Plants: Policies, Strategies and Costs
http://213.253.134.43/oecd/pdfs/browseit/6603221E.PDF
STANDARDIZED COST ITEMS FOR DECOMMISSIONING PROJECTS

DECOMMISSIONING TECHNOLOGIES

INTERMEDIATE STORAGE FACILITY

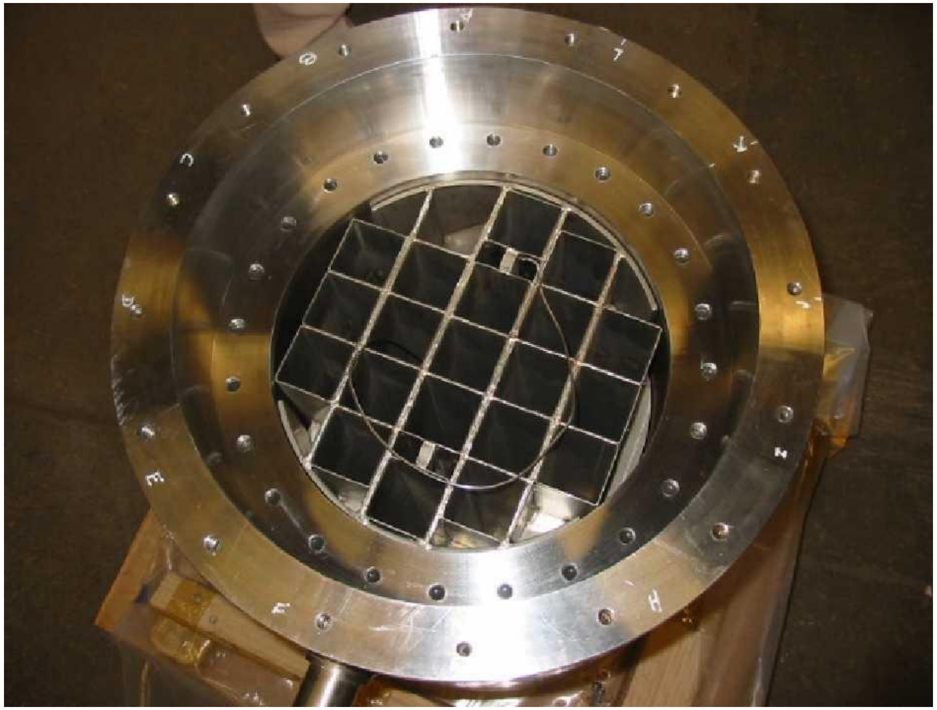
- CDTN has an *Intermediate Storage Facility*, which the area is 30m x 15m, and 7m high. This facility has the requirements to store the radioactive waste.
- *Other materials* will be classified as recyclable, regular or hazardous material and treated according to the *environmental* standards (10.000 ABNT Norm Series).
- There are already some systems to store safely and temporally all activated materials.

Intermediate Storage Facility

- Some technical alternatives has been made for spent fuel storage and transport (cask / wet storage), and other *packages*, which were developed and licensed for the Goiania's accident, could be also used in emergency cases.

Package developed to receive the ^{137}Cs source from the Goiania's radiological accident.

Latin American Cask



Crushing Facility

Until 2004

Only demonstration

Today

- **Compaction force: 16 ton**
- **Volume Reduction: 1:5 to 1:7**

Chemical Treatment Facility

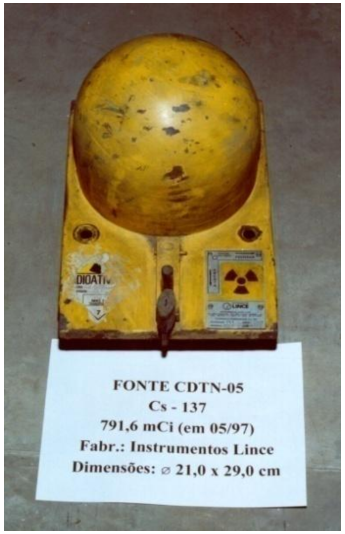
Cementation Facility

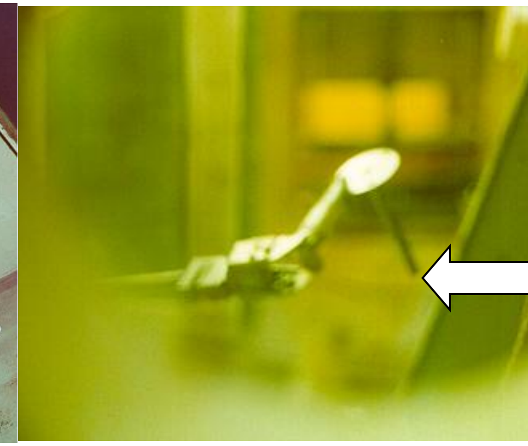
Laboratory for Dismantling of Lightning Rods

- About **1600 241Am lightning rods** were dismantled, generating about **7500 radioactive plates**, that will be **conditioned in a 200 L drum**

Laboratory for Dismantling of Sealed Sources

Characteristics of the Sealed Sources





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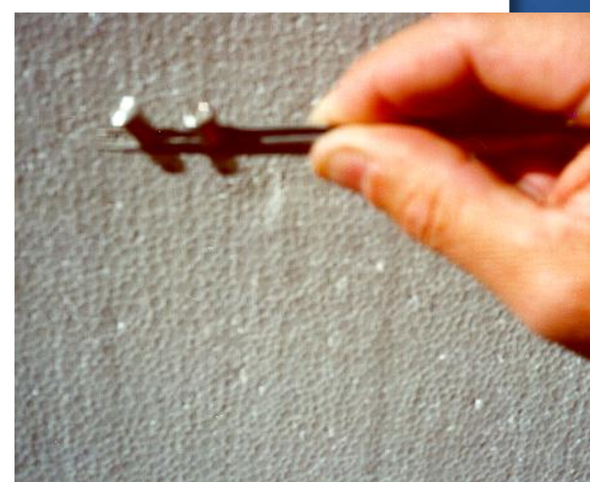
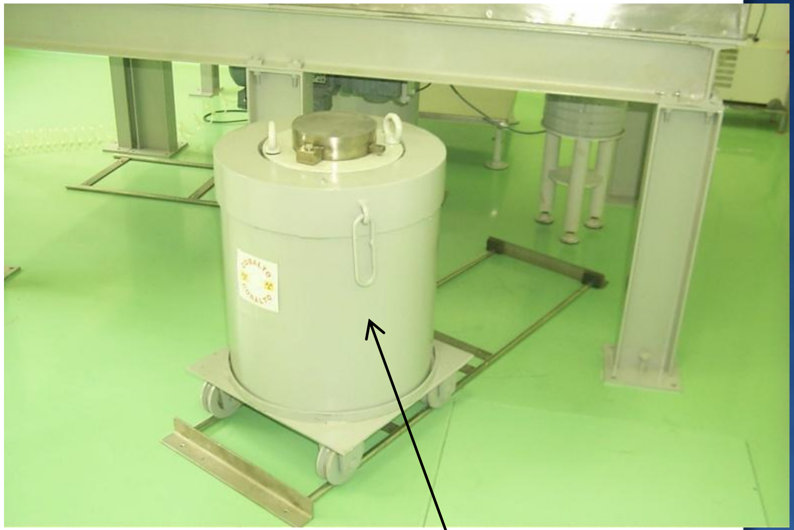


Details of the Sealed Sources Treatment Laboratory



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WASTE PROCESSING FROM NUCLEAR POWER PLANTS

- Angra I & Angra II

Super compacting of 2.229 drums

APPLICATION OF DECONTAMINATION TECHNIQUES

- Reduction of radiation exposure
- Reduction of volume of active waste
- Salvage equipment
- Reduction of overall waste disposal costs
  - Free release waste disposal $100/ m^3$
  - Low Level waste disposal $5.000/ m^3$
  - Intermediate level waste $1.000.000/ m^3$

TECHNIQUES FOR METAL

- Chemical decontamination
  - Concentrated or diluted chemical reagents
  - Effective for complex geometry
  - Requires efficient recycling of the chemical
  - Unless the site has a process for either solidifying liquid waste or processing it, avoid liquid decontamination methods
  - They produce large volumes of secondary wastes
- Electrochemical methods
- Abrasive- blasting techniques
  - Wet techniques
  - Dry techniques
  - Provided secondary wastes are controlled can be efficient.
- Melting
  - Cannot envisage a suitable application on a research reactor site.

TECHNIQUES FOR CONCRETE

- Activated concrete removal
  - Pneumatic breaker
  - Diamond drill
  - Expanding grout
- Activated concrete will contain Tritium, general principal avoid wet methods, otherwise spread secondary contamination
- Depth will generally preclude scabbling or shaving
- Most efficient hydraulic crusher, if all surfaces accessible, however maximum thickness 0.5m
- Usually driven to pneumatic breaker
  - Can achieve up to 5 m^3 /h

THANK YOU FOR YOUR ATTENTION

pabloag@cdtn.br
nruperti@cnen.gov.br

For more detailed information about this information contents