Romanian Research and Development in Nuclear Fission

In Romania the R&D nuclear fission program is mainly developed by the Institute for Nuclear Research Pitesti, a complex R&D center created in 1972 to provide the scientific and technical support to the **National Nuclear Energy Program.**

Its activity covers a wide range of nuclear fields such as nuclear safety, nuclear fuel and materials, reactor physics, radioactive waste, radioprotection. The research activity evolves according to the **National Nuclear Strategy in R&D** specific programs.

The research activity is based on complex infrastructure consisting in TRIGA Research Reactor, Hot Cell Facility, Radioactive Waste Treatment and Conditioning Plant, Radiochemistry Laboratories operating modern investigation techniques and sustained by specialists with significant experience in the nuclear field.

R&D Nuclear Fission Main Activities

- Reactor physics calculations for CANDU reactor core using AECL computer codes and also INR developed codes
- Evaluation of CANDU nuclear fuel performances
- Safety analysis (deterministic and probabilistic) for CANDU and TRIGA Research Reactor
- Severe accidents
- Studies for advanced nuclear reactors and evaluation of advanced fuel bundles
- Assessment and increasing of performances, reliability and maintenance in relation with the NPP Life Management Program
- Tests and qualifications for nuclear equipment and instrumentation
- Structural integrity and material investigations
- Methods and Technologies for radioactive waste treatment and conditioning
- Effluents and environmental monitoring programs and studies concerning the environmental impact of nuclear activities
- Technologies for irradiations, manufacturing and supply of radioisotopes
- Education and training
- Public information for nuclear power acceptance and radiological emergency situations

INR International Participation in Nuclear Fission Projects

Collaboration with AECL - CANADA & COG (CANDU Owner Group) for research activities in the fields of:
- CANDU Nuclear Fuel Testing
- CANDU Computer Codes
- COG R&D Programs (Chemistry, Materials & Components, Fuel Channels, Safety and Licensing, Health, Safety and Environment, Industry Standard Toolset).

European Commission Framework Programs:
- 5-th Framework Programme:
  - ► PHEBEN2, JSRI
- 6-th Framework Programme:
  - ► SARNET, NULIFE, HOTLAB, COWAM2, MRT+I3, ELSY, CIP – COWAM
- 7-th Framework Programme:
  - ► CARBOWASTE
- Cooperation activities with JRC:
  - ► APSA Network – Incorporating Ageing Effects into PSA
  - ► Harmonization of Techniques and Methodologies for Measuring the Radioactivity in Environment.

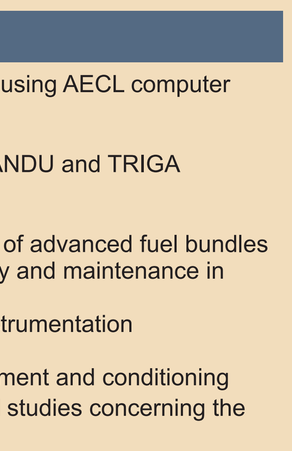
Cooperation with IAEA - Vienna consists in a continuous participation of SCN in:
- Technical Assistance Projects (TC), Research Contracts (CRP), Regional Projects
- Experts Missions, Fellowships Training.

Collaboration with other nuclear research centers:
- **CEA:** Nuclear Energy, Radioactive Waste, Decommissioning of Nuclear Facilities
- **IRSN:** PHEBUS, ASTEC, ICARE/CATHARE, CATHARE 2
- **GRS Braunschweig - Germany:** Models and Computer Codes Related to the Final Storage of Spent Fuel in Salt Formations; Deterministic Analysis of Spent Fuel Storage in Granite Formations
- **DoE – Lawrence Berkeley National Laboratory U.S.A:** Concepts for Storage of Low and Medium Active Waste and of Spent Fuel
- **DBE Peine - Germany:** Impact Assessment of Radwaste for Storage in Granite.

TRIGA Research Reactor

TRIGA - SSR (Steady State Reactor)

Technical characteristics:
- Fuel: **LEU (20 % U^{235} by weight)**
- Control rods: **8**
- Maximum Power: **14 MW**
- Maximum Thermal Flux: **2,9 x 10^{14} n/cm^2s**
- Max. Central Fuel Temperature: **750^0 C**
- Core lifetime: **16000 MW- day.**



TRIGA - ACPR (Annular Core Pulsing Reactor)

Technical characteristics:
- Fuel Type: **LEU (12 % U^{235} by weight)**
- Control rods: **6**
- Transient rods: **2 fast transient rods and 1 adjustable transient rod**
- Steady state power: **500 kW**
- Maximum peak power: **20.000 MW**
- Maximum core energy release: **106 MW s**
- Puls width: **4.6 ms ½ peak power**
- Prompt neutron lifetime: **32 µs.**

Irradiation devices, loops, capsules.

Activities:
- Irradiation of Romanian nuclear fuel for performance assessment under normal and accident conditions
- Structural materials irradiation
- Neutronic, mechanical design and fabrication of a new TRIGA control rod
- Prompt gamma spectrometry
- Development of reference spectra irradiation facilities at the TRIGA-SSR thermal column
- Neutron Activation Analysis
- Neutronography
- Neutron diffraction
- Collaboration with AECL – CANADA: Power cycling test of a Canadian CANDU fuel
- Full conversion of TRIGA 14 MW Core from HEU to LEU Fuel
- Studies on ^{99}Mo production
- Collaboration with Oak Ridge National Laboratory (ORNL): Assessment of ^{99}Mo production technology at SCN - TRIGA research reactor
- Participation in FP6 MTR+I3 Project – "Integrated Infrastructure Initiative to reinforce European experimental capabilities for testing material"

Post-irradiation Examination Laboratory

6 Hot cells
- 2 alpha-gamma heavy concrete hot cells for maximum gamma activity - 37x10^3 TBq.
- 2 alpha-gamma steel hot cells: for Chemistry Cell and Metallography analysis, maximum gamma activity - 37 TBq.
- Hot Cell for Optical Microscopy, maximum gamma activity - 3.7 TBq.
- Hot Cell for Mechanical Testing, maximum gamma activity - 3.7 Tbq.

Radiochemistry Laboratory:
- Mass Spectrometer with thermal ionization;
- High Performance Liquid Chromatograph (HPLC) with UV-VIS detector;
- High Resolution Gamma Spectrometry Chain;
- Spectrophotometer.
- Portable Gamma Spectrometry Chain for Radwaste Characterization.

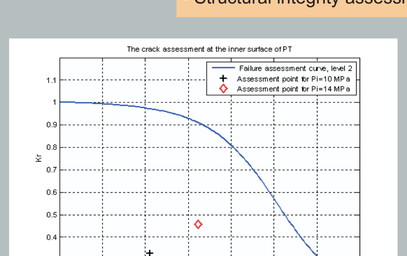
Activities:
- PIE of experimental fuel rods irradiated in the 14 MW TRIGA reactor, for performance evaluation of Romanian CANDU fuel;
- Post-irradiation examination of structural materials for Cernavoda NPP reactor;
- Post-irradiation examination of TRIGA LEU fuel rods as part of the program for conversion of TRIGA reactor to LEU fuel
- Physical-chemical analysis, metallography and mechanical testing of materials from Cernavoda NPP to investigate defect causes.
- Concept and completion of a TIG welding machine to seal the ^{192}Ir and ^{60}Co sources;
- Manufacturing and sale of sealed ^{192}Ir sources for industrial radiography;
- Participation in:
  - IAEA CRP -"Examination and Documentation Methodology for Water Reactor Fuel" (ED-WARF-II);
  - IAEA RER/9/076 - "Strengthening Safety and Reliability of Nuclear Fuel and Materials in Nuclear Power Plants";
  - FP6 HOTLAB Project -"European Hot Laboratories Research Capacities and Needs";

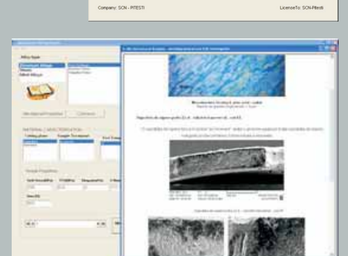
Structural Integrity of Critical Components in Nuclear Facilities

Stage I
- Identification of the structural integrity applications;
- Establishment of the component to be investigated;
- Thermal-mechanical and media loading defining.

Stage II
- Tensile tests;
- K, J parameters obtaining;
- Microstructure Analysis;
- Data base developing.

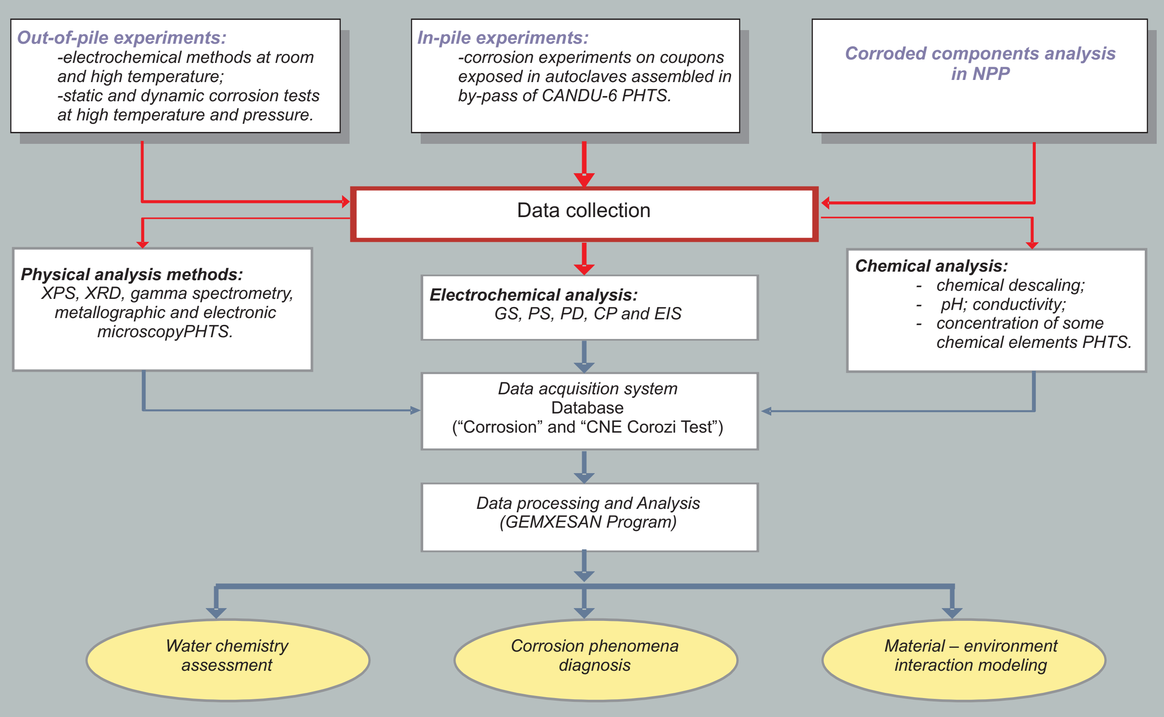
Stage III
- Defects modeling;
- Analysis level defining;
- FAD diagram drawing;
- Structural integrity assessment.

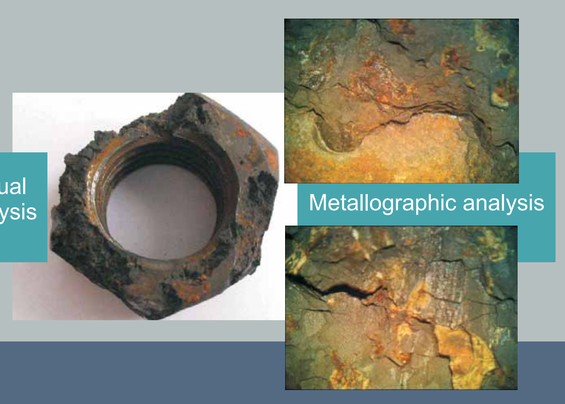


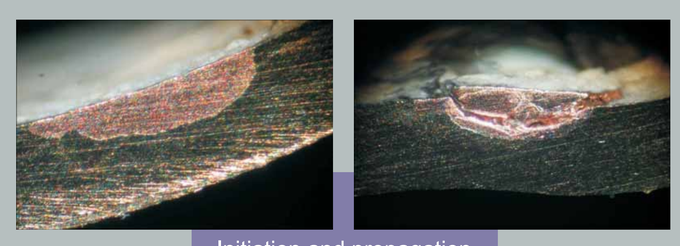


Integrated Network for Structural Integrity Monitoring of Critical Components in Nuclear Facilities - RIMIS - Project under the R&D National Program, 2006-2008
NULIFE - FP 6 Project – contribution in the WP "Lifetime Evaluation and Integrity Assessment, 2006 - 2009

Corrosion Assessment and Diagnosis







Initiation and propagation of pitting by the dezincfication process

Reactor Physics and Nuclear Safety

INR Computer Codes & Methodologies

CANDU NPP

Classical Canadian Methodology: POWDERPUFS → MULTICELL → RFSP

INR Methodology: WIMS → PIJXYZ (FFCP Transport 3D for Reactivity Device Simulation) → DIREN (Diffusion 3D Code)

Special Applications

WIMS → PIJXYZ → LEGENTR 3D Transport Code (Global & Local Calculations)

CP_2D (Detailed 2D, Factor Geometries FFCP Transport)

MCNP Monte Carlo

SCALE

AECL Codes | **NEA DB Codes** | **INR Codes**

3D Power Distribution Representation by DIREN

Detailed flux distribution by Sn transport LEGENTR

Power Densities map in the plain z=198 cm - F6 control rod fully inserted
By INR transport code LEGENTR – performed for FP6- ELSY Project

Investigation of void effect in two-phase model for CANDU Channel

Two phase model for reactivity void effect
Void fraction=62.58%
Fresh fuel element powers (normalised to the mean power) - comparison between two-phase model and homogeneised model.

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