European Working Group
“Hot Laboratories and Remote Handling”
Plenary Meeting 2007, Bucharest, Romania, September 20 – 21, 2007

PROCEEDINGS

Opening
Marin Ciocanescu, “Overview of R&D Program in Romanian Institute for Nuclear Research”, RAAN-SCN, Romania

Session 1: Hot cell facilities: Infrastructure, Refurbishment, Decommissioning
Mark Huntelaar, Renate de Vos, Lars Roobol, “License to build”, NRG, The Netherlands (Abstract)

Session 2: Waste, transport, safety and remote handling issues
Laurent Breton, Marc Masson, Bernard Vignau, “The irradiated elements cell at PHENIX”, CEA, France
Jung Won Lee, Kiho Kim, Geunil Park, Myungseung Yang, Keechan Song, “Development of remote equipment for DUPIC fuel fabrication at KAERI”, KAERI, Korea
Robert Zubler, Johannes Bertsch, Peter Heimgartner, “Aspects of working with manipulators and small samples in an αβγ-box”, PSI, Switzerland
Rik-Wouter Bosch, Willy Claes, “Handling and safety of polonium contaminated lead-bismuth capsules in a hot cell”, SCK-CEN, Belgium
Roberto Covini, Paolo Iorio, “The GIOCONDA experience of the Joint Research Centre Ispra: analysis of the experimental assemblies finalized to their safe recovery and dismantling”, ISPRA, Italy

Session 3: Post-Irradiation Examination techniques
Marcel Parvan, Ana Matei, Marin Mincu, Octavian Uta, Steve Palleck, John Montin, Shaun Abbas, ”PIE of a CANDU fuel element irradiated for a load following test in the INR TRIGA reactor”; RAAN-SCN, Romania
Atsushi Onozawa, Akio Harada, Junichi Honda, Ryo Yasuda, Masahito Nakata, Hiroyuki Kanazawa, Yasuharu Nishino, “Improved technique to measure hydrogen concentration in the cross section of the fuel cladding”, JAEO, Japan
Yury Goncharenko, Gennady Kobylyansky, Andrew Novoselov, “Adaptation of the pole figure measurement to the irradiated items from zirconium alloys”, SSC RF RIAR, Russia
Daniel Kuster, H. Wiese, P. Poerschke, V. Boutellier, ”Fuel rod profilometry with a laser scan micrometer”, PSI,
Lionel Gosmain, S. Sorieul, Aurore Michaux, Guy-Marc Decroix, "Raman spectroscopy, a new facility at LECI laboratory to investigate neutron damage in irradiated materials”, CEA, France

Boris Meunier, Yves Pontillon, Sidonie Clement, Jacqueline Debarge, Julien Piquemal, Marina Pontillon, Guillaume Volle, Sebastien Bernard, “Fission product and He release from irradiated nuclear fuels: MERARG 2 capabilities”, CEA, France

Didier Gavillet, “Analysis of complex nuclear materials with the PSI shielded analytical instruments”, PSI, Switzerland (Abstract)

J.P. Coad, D. Janney: “Summary of session 3”

Poster session

Alain Hanssens, Magali Benchikhoune Ranchoux, “Presentation of CETAMA activities (CEA analytic group)”, CEA, France

Jung Yang-Hong, “Analysis of a metallic precipitates in an irradiated simulated fuel”, KAERI, Korea


Jean-Paul Grandjean, Bernard Autran, Jean-Yves Blanc, “Experience feedback on the refurbishment of the LECA hot laboratory at Cadarache”, CEA, France (Abstract)

Christophe Valot, Thierry Blay, Laurent Caillot, Marie Pierre Ferroud-Plattet, “New device for X-ray diffraction analyses of irradiated materials”, CEA, France

Silviu Ionescu, Octavian Uta, “Tensile testings and metallographic examination on irradiated CANDU pressure tube specimens”, RAAN-SCN, Romania

Ana Matei, Marin Mincu, Ion Man, “Separation and determination of actinides from spent nuclear fuel solution by alpha spectrometry”, RAAN-SCN, Romania

Gabriela Androne, Ana Matei, “Experiments for separation and purification of $^{99}$Mo from uranium solutions with fission products as tracers”, RAAN-SCN, Romania

Quentin Auzoux, Xavier Averty, Jean-François Lecot, Gérard Pinte, Cédric Dumas, “Iodine induced stress corrosion cracking and axial creep: 2 new cladding testing facilities at Leci laboratory”, CEA, France

Pierrick Menegon, Nathalie Herlet, Yves Pontillon, Gilles Ferlay, Jean-Philippe Dancausse, “Development of a gas trapping system for fission products xenon and krypton throughout dissolution of irradiated targets and fuels in hot cells”, CEA, France

Dawn E. Janney, Thomas P. O’Holleran, Adam Robinson, “Post-irradiation-examination of irradiated fuel outside the hot cell”, Idaho National Laboratory, USA
Overview of research potential of
Institute for Nuclear Research – Pitesti

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Main organizations involved in nuclear power production

ROMANIA

PRESIDENT

PRIME MINISTER

PARLIAMENT

CNCAN
(National Commission for Nuclear activities Control)

MINISTRY OF ECONOMY AND COMERCE
(MEC)

NUCLEAR AGENCY
AN

RAAN
(Romanian Authority for Nuclear Activities)

ANDRAD
Waste Management Agency

SNN
(Nuclearelectrica
National Society)

ROMAG-PROD
(Heavy Water Plant)

SITON
(Center of Design and Engineering for Nuclear Projects
– Bucharest)

ICN
(Institute for Nuclear Research – Pitesti)

CNE-PROD
(Cernavoda Nuclear Power Plant – Production Unit)

CNE-INVEST
(Cernavoda Nuclear Power Plant – Investments Unit)

FCN
(Nuclear Fuel Factory)
Romania Map
Main R&D Organizations

- INR, Institute for Nuclear Research, Pitesti
  *Major R&D Nuclear Facilities (TRIGA Reactor, Hot Cells), Material Laboratories, Nuclear Fuel, Nuclear Safety…*

- CITON, Center for Nuclear Objectives Engineering, Bucharest
  *R&D studies related to Nuclear Installations, Nuclear Safety, Waste management…*

- ICIT, National Institute for cryogenics and isotope technologies, Rm Valcea.
  *R&D devoted to heavy water technologies*

- IFIN, Institute for nuclear physics and engineering, Bucharest
  *Atomic Energy Applications*

- University research (Politechnical University Bucharest, University of Pitesti, etc.)

- Other research centers and laboratories
INR activity outline and staff

**Activity outline**

- Nuclear Power Research as a scientific and technical support for the Romanian nuclear power programme
- Mainly dedicated to the existing NPP in the country (CANDU)
- Focused with priority on:
  - Nuclear Safety (behavior of plant materials, components, installations during accident conditions and integrity investigations);
  - Radioactive Waste Management
  - Radioprotection
- Product and services supply for NPP

**INR Staff**

- 320 – R&D qualified and experienced staff
- 240 – devices and prototype workshops and site support activities
- 90 - administration
INR ORGANIZATION

Director
Mr. Constantin PAUNOIU

Nuclear Safety Deputy Director
Mr. Marin CIOCANESCU

Scientific Deputy Director
Mr. Ilie TURCU

Financial Director
Mrs. Mariana NITA

Quality Management Group
Mr. Cristian PATTICU

Reactor Physics and Nuclear Safety
Dr. Csaba ROTH

Operation and Utilization of TRIGA Reactor
Dr. Marin PREDA

Nuclear Materials and Corrosion
Dr. Dumitru OHAI

Nuclear Fuel Performance
Dr. Grigore HORHOIANU

Post Irradiation Examination
Mr. Marcel PARVAN

Electronics
Mr. Gheorghe RADU

Out of Pile Testing
Mr. Constantin IORGA

Radioactive Waste Treatment
Mr. Ion POPESCU

Health and Physics/Radioprotection
Mr. Alexandru TOMA

Reliability and Testing
Dr. Gheorghe VIERU

Administrative and Support Activities
Human resources, Accounting, Procurement, Planning and Contracting, Library, etc.

Post-Irradiation Examination Laboratories for Evaluation of Nuclear Fuel and Structural Materials Behavior

High Activity Gamma Irradiation Station (SIGMA)

High Pressure Loops for Testing of Nuclear Fuel and Nuclear Equipment

Fuelling Machine Heads Testing Rig

Laboratories specialized in Physical, Chemical and Materials / Equipment Testing and Diagnosis,

Radioactive Waste Treatment Plant, based on Qualified and Authorized Technologies and Staff

Laboratories for Fuel Elements Manufacturing and Experimental Development of Technologies for Advanced Fuel Fabrication

Mechanical Workshops dealing with Precision Mechanics, Pressure Equipment, Lifting Devices sustained by Special Authorized Processes and Distinct Laboratories for Material and Quality Control
Institute for Nuclear Research – Pitesti
Main Fields of Activity

- Reliability and testing
- Post irradiation examination
- Reactor physics
- Corrosion
- Electronics
- Metrology
- Out-of-pile testing
- TRIGA reactor
- Design
- Radiation protection
- Radioactive wastes
- Fuel performance
Reactor Physics and Nuclear Safety Department

Objective:
Continuous improvement of the nuclear installation safety through nuclear safety analysis upgrading, development of models and, computer codes.

Activities:
- Reactor Physics Analysis
- Thermalhydraulic Analysis
- Reactor Physics Computer Methods and Codes Development
- Nuclear Safety Analysis for NPP
- Safety Assessment for Radioactive Wastes Repositories
- Experimental Methods for Reactor Physics
- Neutronic Design of In-Pile Irradiation of Romanian CANDU Type Fuel in TRIGA Reactor
- Probabilistic Safety Analysis for Cernavoda NPP, research reactors and conventional installations.

Experimental Facilities:
- Reference Neutron Spectrum Devices for Thermal and Epithermal Energies (to be Assessed as a Neutron Flux Density Etalon)
- Neutron Source Graphite Pile for Low Neutron Flux Measurements
- High Resolution Gamma Spectrometry Chain
**Objectives:**
- Technical support for irradiation tests on structural materials and nuclear fuel for CANDU type nuclear power plants.
- Irradiated and non-irradiated nuclear fuel behavior analysis in transient regime.
- Radioisotopes and irradiated materials production with applications in health, industry and environment areas

**Activities:**
- Nuclear fuel irradiation tests
- Irradiation tests on TRIGA, experimental CANDU SEU-43 fuel type, etc.
- Cernavoda NPP fuel tests in accident conditions – LOCA, RIA
- Structural materials irradiation in inactive environment (Helium)
- Power cycling tests with technical conditions specified by the beneficiary
Design, validation and authorization for new devices used in irradiation tests on nuclear fuel and structural materials.
TRIGA reactor operation and management
Reactor utilization for radioisotope production and neutron beam applications

**Experimental Facilities:**
In core irradiation devices for experimental fuel and materials
SIGMA facility for gamma irradiations
High resolution neutron diffractometer for structural analysis on nuclear materials
Neutronography installation for quantitative and qualitative analysis on nuclear fuel
Prompt gamma spectrometry installation
Thermal column for thermal and intermediary neutron flux experiments.
TRIGA reactor – cont’d

Strategic plan 2005-2010

- Maintenance of operational status of the reactor;
- Continuing TRIGA SSR 14MW conversion from HEU to LEU;
- Activities to ensure higher thermal flux for experimental channels;
- SEU 43 type experimental fuel elements testing according to specifications;
- RIA type test in ACPR, on pre-irradiated fuel;
- Alternate/multiple use of neutron flux in the reactor core and from horizontal beam tubes;
- Radioisotope production for pharmaceutical applications.
**Objectives:**

- Nuclear materials behaviors study in NPP’s, under normal, abnormal and severe accident conditions.
- Manufacturing and control technologies for advanced nuclear fuels development.
**Activities:**

- Thermo-mechanical testing of metallic and ceramic materials under different state of stress and environment conditions;
- Investigation of degradation mechanisms acting in the NPP systems/components materials;
- Reception tests on half-finished alloys;
- Fracture mechanical analysis;
- Zirconium alloys and UO2 pellets behavior under severe accident conditions;

Microstructural and fracture surfaces analysis;
Micro- and nanostructural analysis;
DRX and texture analysis;
Decontamination technologies for NPP components and equipments;
Development of technologies for UO2 sinterable powders;
Development of technologies for UO2 sintered pellets with controlled microstructure;
Technologies for Zy alloy welding concerning experimental fuel assembly;
Nuclear Fuel Engineering Laboratory

**Objectives:**
- design, analysis and performance evaluation of fuel elements and fuel bundles in operation at Cernavoda NPP;
- in reactor testing of the CANDU type fuel elements and fuel bundles.

**Activities:**

**Fuel behavior modeling:**
- $\text{UO}_2$ fission gas release, fuel swelling, thermal and mechanical behavior swelling and grain size;
- Pellet-cladding interaction; cladding thermal - mechanical behavior;
- Stress corrosion cracking (SCC).

**Computer codes development and validation:**
- Computer Codes for fuel behavior under normal conditions;
- Computer Codes for fuel behavior under accident conditions;
- Finite element computer codes. Probabilistic computer codes;

**Fuel engineering:**
- Fuel design optimization and evaluation;
- Fuel performance analyses using computer codes;
- Defective fuel analysis;
- Fuel bundle structural analyses; Heat transfer analyses;

**Fuel safety analysis**
Post-Irradiation Examination Laboratory

Objectives:
- CANDU fuel and structural materials behavior investigation after irradiation in Cernavoda Nuclear Power Plant (NPP) or in Romanian TRIGA research reactor.
- Manufacturing and sale of sealed nuclear radiation sources and radioisotopes used in industry, agriculture and medicine.
Activities:
Non-destructive Post-Irradiation Examination
- Visual Inspection and Photography
- Profilometry and Length Measurement
- Gamma Scanning and Tomography
- Eddy Current Testing to check the fuel rod cladding integrity after irradiation.

Destructive PIE
- Puncture Test
- Optical Microscopy
- Mass Spectrometry
- High Performance Liquid Chromatography (HPLC) with UV-Vis detector
- Tensile Testing and Creep Testing

Sealed Nuclear Radiation Sources
- Manufacturing of sealed 192Ir and 60Co sources for industrial radiography.

Radioactive Waste
- Radionuclide characterization
OUT-OF-PILE-TESTING Department

**Objectives:**
- design, manufacturing and test of the equipment, facilities, nuclear and non-nuclear materials in operation in the Out-of-Pile Testing Department
- design, manufacturing and operation of the specialized unique devices for out-of-pile testing on nuclear fuel
**Activities: oriented for Cernavoda NPP**

Fuel bundle out-of-pile testing:
- test assembly for the impact test
- test assembly for pressure drop tests
- test assembly for wear and endurance tests

Testing of Fuelling Machine (F/M) heads No.4 and 5 for Cernavoda NPP- Unit 2 (performed between 2001 and 2005) - first head No.4 delivered to Cernavoda NPP in August 2005.

Qualification technologies have been developed (for fuel channel closures); there have also been designed and manufactured:
- maintenance tools for the NPP (garter springs repositioning, plugging of steam generator pipe)
- installation for testing F/M rams
- F/M mechanical and electric simulator

Test rigs used for nuclear fuel qualification:
- test rig for fuel elements
- test rig for the Fuelling Machine heads
- test rig for channel closure
- test rig for reactivity control mechanisms
- test rig for vibrations
- test rig for spare ram assembly
- test rig for explosion panels
Objectives:
- Implementation of radiation and environment protection plan for ICN nuclear facilities
- R&D program destined to increase proficiency in human and environment protection against radiation-associated risks.
Activities:
- Radioecological studies of radioactive contamination transfer for agricultural and aquatic ecosystems.
- Developing of radionuclide environmental dispersion models (AQUARAD).
- Derived emission limits for nuclear reactors for gaseous and liquid effluents.
- Method and techniques for rapid sampling of tritium from atmosphere for concentration measurements.
- Testing of individual protection equipment for radioactive contaminated working environments.
- Scientific, methodological and practical support development for emergency planning and preparedness.
**Objectives:**

- treatment and conditioning of radioactive wastes resulted from the TRIGA reactor and other research laboratories of the site, the Nuclear Fuel Factory (FCN), the Cernavoda NPP, Institute for Nuclear Physics and Engineering (IFIN-HH).
- design and manufacturing of equipment and tools for the assay and measurement of radioactive samples from the environment and from working areas, which imply radioactive sources.
Activities:
Implementation of new equipments and technologies in the management of radwaste.
• Treatment technology by evaporation of liquid effluents resulted from the TRIGA reactor and conditioning of the yielded concentrate, in view of its final disposal.
• Treatment technology for liquid wastes contaminated with natural uranium, followed by uranium recovery.
• Conditioning technology for $\beta-\gamma$ low active solid wastes, in view of their final disposal.

Qualification of packages for the storage of solid and liquid radwaste from NPP:
• Stainless Steel Packages for storage of low and medium active wastes from NPP operation
• Stainless Steel Packages for storage of liquid radwaste from NPP operation/decontamination.
Objectives:
- research and development of dedicated electronic instrumentation and equipment, mainly for nuclear applications
- an R&D program for development of radiation field measurement devices
- software development for process control and data processing
Activities:

- design and manufacturing of equipment for CANDU 600 NPP, ranging from electronic instrumentation like Ionization Chamber Amplifier for reactor control with trip comparator for fast shutdown system, In-Core Flux Detector Amplifier or Dynamic Compensation Module, to computer based system control like Failed Fuel Location System (delivered to Cernavoda NPP Unit 1 in 1991 and for Unit 2 in 2005), Gaseous Fission Product Monitor (delivered to Cernavoda NPP Unit 1 in 1991 and for Unit 2 in 2005), Area Monitors.

- design and manufacturing of equipment for our research facilities, like Safety and Control System for Irradiation Devices, Radiation Dose Data Acquisition System, Meteorological Data Collector and Processing System for nuclear facilities.
Objectives:
- design of nuclear equipment, pressure vessel and laboratory devices.

Activities:
- Design of investment objectives: pre-feasibility and feasibility studies, technical designs;
- Design of research equipment and installations
- Design of equipment related to CANDU type nuclear fuel manufacturing
- Design of pressure vessels, piping and hoisting units within nuclear or classic objectives.
RELIABILITY AND TESTING

Objectives:
- qualification and production tests and certification of the equipment and instrumentation manufactured in our institute or manufactured by licensed suppliers

Activities:
- tests and certification for Cernavoda NPP equipments, such as: Failed Fuel Location System, Heat Transfer System Radiation Monitoring, Ion Chamber Amplifier, Dynamic Compensation Module, etc.
- test and certification of type A and B packages used for temporary storage and transportation of radioactive wastes.
Objective:
- Development, implementation and maintenance of a quality management system according to ISO 9001:2000 and to applicable statutory and regulatory requirements

Activities:
- Quality engineering activities for quality management system documentation;
- Quality survey activities for design and manufacturing of products for nuclear installations and conventional applications;
- Quality survey activities for nuclear installations operation;
- Quality assurance training of personnel;
- Quality management systems internal and external auditing.

Main achievements:
- INR quality management system certification by LRQA (Approval certificate No. 170254);
- INR quality management system authorization by CNCAN for research, design, manufacturing and operation activities related to the nuclear field.
IAEA Assistance and Co-operation

35 years of technical assistance and support

Establishment of the Institute for Nuclear Technologies following IAEA recommendations and significant IAEA assistance with the objective to provide the necessary technical and scientific support for the Romanian Nuclear Power Programme (1971).

Institute development with the continuous support of IAEA (fellowships, equipments, expert mission) including:

Regular Projects with INR as the main recipient:
- Development and testing of locally made fuel elements
- Building Nuclear Safety capabilities
- Development of the Cernavoda Probabilistic Safety Evaluation Studies
- Plant commissioning requirements and training
- Radiological protection
- Licensing of test facilities for CANDU 600 fuelling machine
- Full conversion of TRIGA 14-Mw Core from HEU to LEU
Regional projects

Training courses, scientific visits, expert missions, etc.

Ex: RER/9/076 Strengthening Safety and Reliability of Nuclear Fuel and Materials in Nuclear Power Plants: Upgrading the Hot Cells at INR Pitesti and development of the CANDU spent fuel examination and surveillance programme.

Others co-operation forms:
• Research contracts
• INR contribution to the IAEA activities (development of standards, experts)
IAEA Assistance and Co-operation

2007-2008

Regular Project

- ROM/4/024 Full Conversion of TRIGA 14-MW Core from HEU to LEU Fuel

Regional Projects

- RER017-Human Resource Development, Nuclear Technology Support and Regional Programme Review; Dumitru DOBREA, CP
- RER002-Strategic Planning for Management, Self-reliance, and Sustainability of National Institutions; Constantin PAUNOIU, CP
- RER033-Strengthening Capabilities for Nuclear Knowledge Preservation; Marin CONSTANTIN, CP
- RER008 – Strengthening Safety Assessment Capabilities; Ilie TURCU, CP
- RER014 – Upgrading National Capabilities in Controlling Public Exposure; Alexandru TOMA, CP
- RER022 – Support in Planning of Decommissioning of Nuclear Power Plants and Research Reactors; Csaba ROTH, CP
- RER003 – Repatriation, Management and Disposition of Fresh and/or Spent Fuel from Research Reactors; Marin CIOCANESCU, CP
- RER017 – Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region; Maria IONILA, CP
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