Coordinated Research Activities

Annual Report and Statistics for 2007

July 2008
Research Contracts Administration Section
Department of Nuclear Sciences and Applications
International Atomic Energy Agency
http://cra.iaea.org/
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EXECUTIVE SUMMARY

In 2007, a total of €6 606 194 were obligated for the Agency’s Coordinated Research Activities (€6 515 957 from the regular budget and €90 237 from extrabudgetary resources). Most of the Coordinated Research Activities are carried out via Coordinated Research Projects (CRPs) which bring together research institutes in both developing and developed Member States to collaborate on research topics of common interest. At the end of 2007, work was being carried out on 115 CRPs, 37 in Major Programme 1 – Nuclear Power, Fuel Cycle and Nuclear Science, 71 in Major Programme 2 – Nuclear Techniques for Development and Environmental Protection, and in 7 Major Programme 3 – Nuclear Safety and Security. The total amount obligated for these activities in 2007 was 15% more than in 2006, largely due to the implementation of 28 new CRPs.

At the end of 2007 work was being carried out under 976 contracts and 562 agreements with institutes in 110 Member States. 72% of the funds obligated for contracts in 2007 were in respect of institutions in developing countries, primarily in the areas of food and agriculture and human health.

During 2007, 21% of the Chief Scientific Investigators participating in Agency CRPs were female researchers. Efforts will continue to increase the participation of women and younger researcher in the Coordinated Research Activities.

The forty two completed CRPs evaluated in Appendix E resulted in 9 PhDs, one masters degree and in the publishing of about 800 articles and reports, scientific papers, proceedings of scientific conferences and contribution to international conferences, as well as 13 IAEA TECDOCs, and various scientific databases and websites. Detailed evaluation reports on the outputs, effectiveness, impact, recommended future action, and resulting publications of these completed CRPs are included in in Appendix E of this report.
1. INTRODUCTION

Article III of the IAEA Statute authorizes the IAEA to encourage and assist research on, and development and practical application of, atomic energy for peaceful purposes throughout the world and to foster the exchange of scientific and technical information, as well as the exchange of scientists in the field of peaceful uses of atomic energy. The IAEA’s Coordinated Research Activities stimulate and coordinate the undertaking of research in selected nuclear fields by scientists in IAEA Member States.

The IAEA supports research under its programmes, subprogrammes and projects that are listed in its approved Programme and Budget. These Coordinated Research Activities are normally implemented through Coordinated Research Projects (CRPs) which bring together research institutes in both developing and developed Member States to collaborate on research topics of common interest. The IAEA may also respond to proposals from institutes for participation in the research activities under individual research contracts not related to a CRP. A small portion of available funds is used to finance individual projects, which deal with topics covered by the IAEA’s scientific programme.

The IAEA also supports doctoral CRPs, which are designed to strengthen promotion of research on nuclear technologies in developing Member States through pair building between agreement and contract holders. These CRPs include a PhD training programme at the contract holders’ institutions. One doctoral CRP currently implemented by the Human Health programme addresses the improvement of radiotherapy outcome in AIDS cancer patients.

Further information on the IAEA’s Coordinated Research Activities, including current information on CRPs and programme areas supported, information on policies and procedures and the management of the activities is available on the IAEA’s Coordinated Research Activities website at:

http://cra.iaea.org/
2. COORDINATED RESEARCH ACTIVITIES IN SUPPORT OF IAEA PROGRAMMES AND SUBPROGRAMMES

The Coordinated Research Activities reported in this document are conducted in support of the following IAEA programmes and subprogrammes (Ref: GC(50)/6 of July 2006).

**Major Programme 1: Nuclear Power, Fuel Cycle and Nuclear Science**
- Programme A.: Nuclear Power
- Programme B.: Nuclear Fuel Cycle and Materials Technologies
- Programme C.: Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development
- Programme D.: Nuclear Science

**Major Programme 2: Nuclear Techniques for Development and Environmental Protection**
- Programme E.: Food and Agriculture
- Programme F.: Human Health
- Programme G.: Water Resources
- Programme H.: Assessment and Management of Marine and Terrestrial Environments
- Programme I.: Radioisotope Production and Radiation Technology

**Major Programme 3: Nuclear Safety and Security**
- Programme J.: Safety of Nuclear Installations
- Programme K.: Radiation and Transport Safety
- Programme L.: Management of Radioactive Waste
- Programme M.: Nuclear Security

The Subprogrammes supported by the CRPs are listed in Appendix D.

Results of the research are available to all Member States and are disseminated through national, international and IAEA scientific and technical publications. The Coordinated Research Activities are complementary to the Agency’s Technical Cooperation Projects, with the knowledge gained via coordinated research used to enhance the quality of Technical Cooperation Projects. Some research results are directly relevant to Technical Cooperation Projects and lead to successful implementation of these projects, while some Technical Projects lead to participation in Coordinated Research Activities. In addition, CRPs and TC Projects may also be carried out simultaneously.
3. COORDINATED RESEARCH ACTIVITIES IN 2007

During 2007, 115 CRPs were carried out. 37 in Major Programme 1 – Nuclear Power, Fuel Cycle and Nuclear Science, 71 in Major Programme 2 – Nuclear Techniques for Development and Environmental Protection, and 7 in Major Programme 3 – Nuclear Safety and Security. The total amount obligated for these activities in 2007 was 15% more than in 2006, largely due to the implemention of 28 new CRPs. In terms of benefits to Member States through their participating research institutions, number of awards and degree of funding, the Coordinated Research Activities constitute a significant component of the IAEA’s overall programme.

Coordinated Research Activities Budget

In 2007, the IAEA obligated a total of €6 606 194 in support of research projects under its Coordinated Research Activities. Of this total amount, 25.5% (€1 685 048) was used to finance 80 Research Coordinated Meetings (RCMs) held every 12 - 18 months during the life of a Coordinated Research Project (CRP).

849 contracts and 152 agreements were concluded in 2007 with institutes in Agency Member States based on careful evaluation of research proposals received from institutes in Member States. Annex I lists, by country, the number of proposals received and awards made.

At the end of 2007, there were 115 active CRPs, the majority thereof in Major Programme 2, with 11 CRPs approved, but not yet initiated. Total obligations amounted to €1 177 935 in Major Programme 1, €5 171 174 in Major Programme 2 and €257 085 in Major Programme 3.

Contracts and Agreements

In 2007, 1001 contracts and agreements were concluded with institutes in IAEA Member States. The total number of contracts includes 774 research contracts, 74 technical contracts, and one doctoral contract. In addition, 152 new agreements were concluded with institutes in Agency Member States in 2007. The average contract size was €5 760 per annum, about 2.7% more than the 2006 average. TABLE 1, FIGURE 1 and FIGURE 2 summarize all awards by Programme in 2007.

Member States Participation

Institutes in 105 Agency Member States participated in the CRA in 2007. 72% of the funds obligated for contracts were made to institutions in developing countries. Technical contract awards were made to institutions from developed and developing countries.
CRP Subjects

CRPs under which work was being carried out at end of 2007, related to the following programmes:

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<tr>
<th>Prog.</th>
<th>Subject</th>
<th>Number of Active CRPs</th>
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<td>B.</td>
<td>Nuclear Fuel Cycle and Materials Technologies</td>
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<tr>
<td>C.</td>
<td>Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development</td>
<td>2</td>
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<tr>
<td>D.</td>
<td>Nuclear Sciences</td>
<td>21</td>
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<tr>
<td>E.</td>
<td>Food and Agriculture</td>
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<tr>
<td>F.</td>
<td>Human Health</td>
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<tr>
<td>G.</td>
<td>Water Resources</td>
<td>4</td>
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<tr>
<td>H.</td>
<td>Assessment and Management of Marine and Terrestrial Environment</td>
<td>3</td>
</tr>
<tr>
<td>I.</td>
<td>Radioisotopes Production and Radiation Technology</td>
<td>12</td>
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<tr>
<td>J.</td>
<td>Safety of Nuclear Installations</td>
<td>2</td>
</tr>
<tr>
<td>K.</td>
<td>Radiation and Transport Safety</td>
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</tr>
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<td>L.</td>
<td>Management of Radioactive Waste</td>
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<td><strong>Total</strong></td>
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TABLE 1. SUMMARY OF FUNDS OBLIGATED BY PROGRAMME IN 2007

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<td>2 481 353</td>
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<td>Grand Total:</td>
<td>4 825 251</td>
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| Total Contract Awards: 4 889 351 | Total CRP Purchases: 31 795 | Total RCM Expenditures: 1 685 048 |
FIGURE 1 illustrates the proportion of regular budget and extra-budgetary funding in 2007.

![Pie chart showing regular budget and extra-budgetary funds in 2007.](image)

FIGURE 2. Distribution of all 2007 Obligations by Programme and Type of Expenditure (in thousands).

![Bar chart showing obligations by programme and type of expenditure.](image)

Details of 2007 total awards by project and type of award are provided in TABLE 2. Annex II lists total awards by country and programme.
TABLE 2. DISTRIBUTION OF 2007 TOTAL FUNDS OBLIGATED BY AGENCY PROJECT

<table>
<thead>
<tr>
<th>Prog</th>
<th>Research Contracts</th>
<th>Technical Contracts</th>
<th>Doctoral Contracts</th>
<th>CRP Purchases</th>
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<th>Overall Total</th>
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<th>Technical Contracts</th>
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### TABLE 2. DISTRIBUTION OF 2007 TOTAL FUNDS OBLIGATED BY AGENCY PROJECT

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<th>Technical Contracts</th>
<th>Doctoral Contracts</th>
<th>CRP Purchases</th>
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<th>RCMs</th>
<th>Overall Total</th>
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<td>74</td>
<td>669 900</td>
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<td>6 000</td>
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</table>

*Includes multiple funding*
At the end of 2007, there were 1538 active research contracts and agreements supported by the IAEA. 94% of these represented participation in the 115 active CRPs shown in Appendix A and 6% were individual contracts and agreements. 80 RCMs (see Annex III) were held in support of the CRPs and an amount of €1 685 048 was spent in support of these meetings. 30 of these RCMs were hosted by Member States, as listed in Annex IV. FIGURE 3 shows the distribution of contracts and agreements by Major Programme, and FIGURE 4 shows the distribution of CRPs and RCMs held during the year, by programme.

**FIGURE 3.** Active Contracts and Agreements by Major Programme at End 2007

![Bar chart showing distribution of contracts and agreements by Major Programme](image)

<table>
<thead>
<tr>
<th>Major Programme 1</th>
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<th>Major Programme 3</th>
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<tbody>
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<td>Nuclear Power</td>
<td>Nuclear Fuel Cycle and Materials Technologies</td>
<td>Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development</td>
</tr>
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<td>Nuclear Science</td>
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</table>


3.1. Member State Participation

The distribution of all contract awards in 2007 by country is shown in Annex II and Annex V. 72% of the funds awarded for contracts were made to institutes in developing countries. FIGURE 5 shows the geographical distribution of all contract awards in 2007.
3.2. **Extra Budgetary Funding**

Extra budgetary funds amounting to €90 237 were obligated in 2007 for financing contracts and RCMs. The obligated funds were from Norway, the United States of America and the Nuclear Security Multi-donors Fund as shown in Table 3.

**TABLE 3. SUMMARY OF 2007 EXTRA BUDGETARY FUNDS OBLIGATED**

<table>
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<th>Funds</th>
<th>CRP Code</th>
<th>Type of Expenditure and Amount in €</th>
<th>RCMs</th>
<th>Contracts</th>
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<td>€</td>
<td>Number</td>
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<td></td>
<td></td>
<td>Scale Indigenous Molybdenum 99</td>
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<tr>
<td></td>
<td></td>
<td>Production using Low Enriched</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Uranium (LEU) Fission or Neutron</td>
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<td></td>
<td>Activation</td>
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<td>Developing Techniques for Small</td>
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<td>Scale Indigenous Molybdenum 99</td>
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<td>Production using Low Enriched</td>
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3.3. **Coordinated Research Projects Completed in 2007**

18 CRPs were completed in 2007, 4 of which concerned topics in Nuclear Power, Fuel Cycle and Nuclear Science, 11 in Nuclear Techniques for Development and Environmental Protection, and 3 in Nuclear Safety and Security. A list of these CRPs is included in Appendix C.
4. CRP EVALUATION REPORTS FOR COMPLETED CRPs

Coordinated Research Projects must be fully evaluated within one year after their completion. 39 CRPs were completed in 2006: 11 related to Nuclear Power, Fuel Cycle and Nuclear Science, 19 related to Nuclear Techniques for Development and Environmental Protection, and 9 to Nuclear Safety and Security.

Evaluations of 42 CRPs (10 completed in 2005, 28 completed in 2006, and 4 completed in 2007) are included in Appendix E. Work supported under these CRPs resulted in 9 PhDs, one masters degree and in the publishing of about 800 articles and reports, scientific papers, proceedings of scientific conferences and contribution to international conferences, as well as 13 IAEA TECDOCs, and various scientific databases and websites. Detailed reports on the outputs, effectiveness, impact, recommended future action, and resulting publications of these completed CRPs are included in Appendix E of this report.
## TOTAL NUMBER OF PROPOSALS RECEIVED AND CONTRACTS AND AGREEMENTS CONCLUDED IN 2007

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* Also includes contracts and agreements resulting from proposals received in previous years

**Annex I.1**
TOTAL NUMBER OF PROPOSALS RECEIVED AND CONTRACTS AND AGREEMENTS CONCLUDED IN 2007

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* Also includes contracts and agreements resulting from proposals received in previous years

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959  149  1108  832  17  152  1001

* Also includes contracts and agreements resulting from proposals received in previous years

Annex 1.3
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Note: The table above shows the distribution of total 2007 contract obligations by country and programme.
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**Annex II.3**
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**Annex 14**
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### RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

**CRP I3.10.14**
- **Cont:** 4  **Agree:** 13
- **File Code:** I3-RC-951.4
- **Start:** 2007-09-10  **End:** 2007-09-13  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Cleveland John
- **No. of previous meetings:** 3  **Date of last meeting:** 2006-09-11  **Location of last meeting:** Vienna

**Meeting Description:**
Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Utilize Natural Circulation

**Actual Cost (AFIMS):**
- **Account:** 5220  **Fund:** 1017  **Cost Centre:** A4010221  **User Project:**  **Amount:** € 18 522.49
- **Account:** 5220  **Fund:** 1010  **Cost Centre:** A4010221  **User Project:**  **Amount:** € 13 615.70

**Total:** € 32 138.19

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**CRP I3.10.13**
- **Cont:** 0  **Agree:** 10
- **File Code:** I3-RC-833.3
- **Start:** 2007-06-18  **End:** 2007-06-22  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Tyobeka Mzubanzi Bismark
- **No. of previous meetings:** 2  **Date of last meeting:** 2005-10-17  **Location of last meeting:** Vienna

**Meeting Description:**
Conservation and Application of High Temperature Gas Cooled Reactor (HTGR) Technology: Advances in HTGR Fuel Technology Development

**Actual Cost (AFIMS):**
- **Account:** 5220  **Fund:** 1010  **Cost Centre:** A4030221  **User Project:**  **Amount:** € 21 032.88

**Total:** € 21 032.88

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**CRP I2.50.01**
- **Cont:** 10  **Agree:** 6
- **File Code:** I2-RC-983.2
- **Start:** 2007-06-04  **End:** 2007-06-08  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Kuznetsov Vladimir
- **No. of previous meetings:** 1  **Date of last meeting:** 2005-11-21  **Location of last meeting:** Vienna

**Meeting Description:**
Small Reactors Without On-Site Refuelling

**Actual Cost (AFIMS):**
- **Account:** 5220  **Fund:** 1010  **Cost Centre:** A4040221  **User Project:**  **Amount:** € 29 072.12

**Total:** € 29 072.12

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**CRP I3.20.07**
- **Cont:** 2  **Agree:** 3
- **File Code:** I3-RC-1052.1
- **Start:** 2007-04-23  **End:** 2007-04-26  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Stanculescu Alexander
- **No. of previous meetings:** 0  **Date of last meeting:**  **Location of last meeting:**

**Meeting Description:**
Analyses of and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems

**Actual Cost (AFIMS):**
- **Account:** 5220  **Fund:** 1010  **Cost Centre:** A4020221  **User Project:**  **Amount:** € 10 965.00

**Total:** € 10 965.00

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**Annex III.2**
B  Nuclear Fuel Cycle and Materials Technologies  (3)

B.2. Nuclear Power Reactor Fuel Engineering

CRP T1.20.19  
Cont: 6  Agree: 10  
Optimisation of Water Chemistry Technologies and Management to Ensure Reliable Fuel Performance at High Burnup and in Ageing Plants  
File Code: T1-RC-1029.2  
Start: 2007-12-11  End: 2007-12-14  Location: Chennai  
Country: India  
Project Officer: Killeen John Christopher  
No. of previous meetings: 1  
Date of last meeting: 2006-07-04  
Location of last meeting: VIC A0742  
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CRP T1.20.17  
Cont: 6  Agree: 4  
Delayed Hydride Cracking (DHC) of Zirconium Alloy Fuel Cladding  
File Code: T1-RC-984.2  
Start: 2007-03-12  End: 2007-03-15  Location: Pitesti  
Country: Romania  
Project Officer: Inozemtsev Victor  
No. of previous meetings: 1  
Date of last meeting: 2005-06-06  
Location of last meeting: Nyköping  
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B.4. Topical Nuclear Fuel Cycle Issues

CRP T1.30.11  
Cont: 2  Agree: 6  
File Code: T1-RC-938.4  
Country: India  
Project Officer: Hosadu Parameswara Nawada  
No. of previous meetings: 2  
Date of last meeting: 2004-10-25  
Location of last meeting: Hefei, Anhui  
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Annex III.3
C.2. Energy Economy Environment (3E) Analysis

CRP I1.10.05  Greenhouse Gas (GHG) Mitigation Strategies and Energy Options
Cont: 12   Agree: 3
Country: Austria
Project Officer: Jalal Ahmed
No. of previous meetings: 1   Date of last meeting: 2006-12-05   Location of last meeting: VIC F0879

Est. Cost (AWMS):  Budget: C2020213   EUR: 0.00   Other: 30 000.00
Actual Cost (AFIMS):  Account: 5220   Fund: 1017   Cost Centre: C2020213   Amount: € 18 604.82
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C.3. Nuclear Knowledge Management

CRP L5.30.01  Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation
Cont: 6   Agree: 2
Country: Austria
Project Officer: Ruysen Marie Laure
No. of previous meetings: 1   Date of last meeting: 2006-11-13   Location of last meeting: VIC A0478

Est. Cost (AWMS):  Budget: C3030253   EUR: 0.00   Other: 25 350.00
Actual Cost (AFIMS):  Account: 5220   Fund: 1010   Cost Centre: C3030253   Amount: € 16 363.05
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D. Nuclear Science (19)

D.1. Atomic and Nuclear Data

CRP F4.10.22  Parameters for Calculation of Nuclear Reactions of Relevance to Non-Energy Nuclear Applications
Cont: 2   Agree: 6
File Code: F4-RC-934.3  Start: 2007-12-10   End: 2007-12-14   Location: A2313
Country: Austria
Project Officer: Capote Noy Roberto Mario
No. of previous meetings: 2   Date of last meeting: 2005-11-28   Location of last meeting: VIC A0418

Est. Cost (AWMS):  Budget: D1020341   EUR: 0.00   Other: 22 500.00
Actual Cost (AFIMS):  Account: 5220   Fund: 1017   Cost Centre: D1020341   Amount: € 18 047.18
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Annex III.4
## RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

**CRP F4.10.24**  
Minor Actinide Neutron Reaction Data (MANREAD)  
File Code: F4-RC-1054.1  
Project Officer: Mengoni Alberto  
No. of previous meetings: 0  
Date of last meeting:  
Location of last meeting:  

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**CRP F4.30.17**  
Heavy Charged-particle Interaction Data for Radiotherapy  
File Code: F4-RC-1078.1  
Project Officer: Capote Noy Roberto Mario  
No. of previous meetings: 0  
Date of last meeting:  
Location of last meeting:  

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**CRP F4.30.16**  
Data for Surface Composition Dynamics Relevant to Erosion Processes  
File Code: F4-RC-1051.1  
Project Officer: Clark Robert Edward Holmes  
No. of previous meetings: 0  
Date of last meeting:  
Location of last meeting:  

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**CRP F4.30.15**  
Atomic Data for Heavy Element Impurities in Fusion Reactors  
File Code: F4-RC-1005.2  
Project Officer: Clark Robert Edward Holmes  
No. of previous meetings: 1  
Date of last meeting: 2005-11-14   Location of last meeting: Vienna  

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Annex III.5
## RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

### CRP F4.10.23

**Development of a Reference Database for Ion Beam Analysis**

- **File Code:** F4-RC-1000.2
- **Start:** 2007-06-18  **End:** 2007-06-21  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Abriola Daniel Hugo
- **No. of previous meetings:** 1  **Date of last meeting:** 2005-11-21  **Location of last meeting:** Vienna

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### CRP F4.30.14

**Atomic and Molecular Data for Plasma Modelling**

- **File Code:** F4-RC-993.2
- **Start:** 2007-06-18  **End:** 2007-06-20  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Humbert Denis Pierre
- **No. of previous meetings:** 1  **Date of last meeting:** 2005-09-26  **Location of last meeting:** Vienna

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### CRP F4.20.05

**Reference Database for Neutron Activation Analysis**

- **File Code:** F4-RC-999.2
- **Start:** 2007-05-07  **End:** 2007-05-09  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Kellett Mark Adrian
- **No. of previous meetings:** 1  **Date of last meeting:** 2005-10-03  **Location of last meeting:** Vienna

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### CRP F4.20.06

**Updated Decay Data Library for Actinides**

- **File Code:** F4-RC-1002.2
- **Start:** 2007-03-28  **End:** 2007-03-30  **Location:** Vienna  **Country:** Austria
- **Project Officer:** Kellett Mark Adrian
- **No. of previous meetings:** 1  **Date of last meeting:** 2005-10-17  **Location of last meeting:** Vienna

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Annex III.6
## D.2. Research Reactors

**CRP F1.20.20**  
Cont: 5  
Agree: 4  
File Code: F1-RC-1023.2  
Start: 2007-10-08  
End: 2007-10-10  
Location: Berlin  
Country: Germany  
Project Officer: Mank Guenter

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**CRP T1.20.18**  
Cont: 7  
Agree: 7  
File Code: T1-RC-1013.2  
Start: 2007-04-16  
End: 2007-04-20  
Location: Bucharest  
Country: Romania  
Project Officer: Goldman Ira Neal

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## D.3. Utilization of Accelerators and Instrumentation

**CRP F1.20.16**  
Cont: 5  
Agree: 3  
File Code: F1-RC-964.3  
Start: 2007-12-10  
End: 2007-12-14  
Location: Chiang Mai  
Country: Thailand  
Project Officer: Muelhauser Francoise

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**CRP F1.20.17**  
Cont: 4  
Agree: 0  
File Code: F1-RC-980.3  
Start: 2007-12-04  
End: 2007-12-06  
Location: Vienna  
Country: Austria  
Project Officer: Dytlewski Nikolai

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RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

CRP F1.10.13  
Cont: 3  Agree: 3  
File Code: F1-RC-1074.1  
Start: 2007-11-12  End: 2007-11-14  
Location: Lisbon  
Country: Portugal  
Project Officer: Dytlewski Nikolai  
No. of previous meetings: 0  
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CRP F1.20.18  
Cont: 7  Agree: 1  
File Code: F1-RC-1004.2  
Start: 2007-08-20  End: 2007-08-22  
Location: Vienna  
Country: Austria  
Project Officer: Muelhauser Francoise  
No. of previous meetings: 1  
Date of last meeting: 2005-12-12  
Location of last meeting: Vienna  
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CRP F1.20.21  
Cont: 6  Agree: 2  
File Code: F1-RC-1056.1  
Location: Hokkaido  
Country: Japan  
Project Officer: Muelhauser Francoise  
No. of previous meetings: 0  
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CRP F1.20.19  
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File Code: F1-RC-998.2  
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Country: Austria  
Project Officer: Dytlewski Nikolai  
No. of previous meetings: 1  
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Annex III.8
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

**D.4. Nuclear Fusion Research**

CRP F1.30.09  
Cont: 8  
Agree: 2  
File Code: F1-RC-897.3  
Start: 2007-04-09  
End: 2007-04-13  
Location: Beijing  
Country: China

Project Officer: Louzeiro Malaquias Artur Jorge

No. of previous meetings: 2  
Date of last meeting: 2005-06-01  
Location of last meeting: Warsaw

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**E. Food and Agriculture (16)**

E.1. Sustainable Intensification of Crop Production Systems

CRP D1.20.09  
Cont: 11  
Agree: 2  
File Code: D1-RC-1070.1  
Start: 2007-11-26  
End: 2007-11-30  
Location: Vienna  
Country: Austria

Project Officer: Nguyen Minh-Long

No. of previous meetings: 0  
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Total: € 28 703.07

**E.2. Nuclear Fusion Research**

CRP D1.50.08  
Cont: 13  
Agree: 5  
File Code: D1-RC-888.4  
Start: 2007-10-15  
End: 2007-10-19  
Location: Vienna  
Country: Austria

Project Officer: Dercon Gerd

No. of previous meetings: 3  
Date of last meeting: 2006-03-27  
Location of last meeting: VIC F0513

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Annex III.9
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

CRP D2.30.25
Cont: 12   Agree: 5
File Code: D2-RC-950.3
Location: Reykjavik
Country: Iceland

Project Officer: Lokko Yvonne Rosaline
No. of previous meetings: 2
Date of last meeting: 2006-04-10
Location of last meeting: Nanjing

Effective Cost (AWMS): Budget 1010.00
Cost Centre 35 000.00
Currency 0.00
Interpretation 0.00
Other 35 000.00

Actual Cost (AFIMS): Account 5220
Fund 1010
Cost Centre E1050321
User Project
Amount
Unliquidated: €38 304.57
Total: €39 629.57

CRP D2.40.11
Cont: 11   Agree: 3
File Code: D2-RC-937.3
Location: Stellenbosch
Country: South Africa

Project Officer: Lagoda Pierre Jean Laurent
No. of previous meetings: 2
Date of last meeting: 2005-11-14
Location of last meeting: Seoul

Effective Cost (AWMS): Budget 1010.00
Cost Centre 30 000.00
Currency 0.00
Interpretation 0.00
Other 30 000.00

Actual Cost (AFIMS): Account 5220
Fund 1010
Cost Centre E1040321
User Project
Amount
Unliquidated: €22 768.66
Total: €24 620.88

CRP D1.20.08
Cont: 11   Agree: 1
File Code: D1-RC-943.3
Location: Yinchuan
Country: China

Project Officer: Heng Lee Kheng
No. of previous meetings: 2
Date of last meeting: 2005-11-21
Location of last meeting: Meknes

Effective Cost (AWMS): Budget 1010.00
Cost Centre 32 785.10
Currency 0.00
Interpretation 0.00
Other 32 785.10

Actual Cost (AFIMS): Account 5220
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Amount
Unliquidated: €21 961.79
Total: €23 587.61

CRP D2.30.24
Cont: 9   Agree: 4
File Code: D2-RC-899.3
Start: 2007-03-19   End: 2007-03-23
Location: Cordoba
Country: Argentina

Project Officer: Shu Qingyao
No. of previous meetings: 2
Date of last meeting: 2005-09-05
Location of last meeting: Seoul

Effective Cost (AWMS): Budget 1010.00
Cost Centre 30 000.00
Currency 0.00
Interpretation 0.00
Other 30 000.00

Actual Cost (AFIMS): Account 5220
Fund 1010
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Unliquidated: €34 361.78
Total: €36 601.57

Annex III.10
### RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

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### E.2. Sustainable Intensification of Livestock Production Systems

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Annex III.11
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

**CRP D3.10.24**
- **Cont: 10**
- **Agree: 5**
- **File Code: D3-RC-960.2**
- **Start: 2007-04-19**
- **End: 2007-04-28**
- **Location: Urbana-Champaign, Ill. Country: United States of America**
- **Project Officer:** Schlink Anthony Charles
- **No. of previous meetings:** 1
- **Date of last meeting:** 2005-09-12
- **Location of last meeting:** Zurich

**Est. Cost (AWMS):**
- **Regular Budget**: E2030321
- **Cost Centre**: E2030321
- **Currency**: EUR
- **Interpretation**: 0.00 EUR
- **Other**: 30 000.00

**Actual Cost (AFIMS):**
- **Account**: 5220
- **Fund**: 1010
- **Cost Centre**: E2030321
- **User Project**: E200321
- **Amount**: € 27 401.88
- **Unliquidated**: € 1 252.24
- **Total**: € 28 654.12

**CRP D3.20.25**
- **Cont: 14**
- **Agree: 4**
- **File Code: D3-RC-1049.1**
- **Start: 2007-03-19**
- **End: 2007-03-23**
- **Location: Vienna Country: Austria**
- **Project Officer:** Crowther John
- **No. of previous meetings:** 0
- **Date of last meeting:**
- **Location of last meeting:**

**Est. Cost (AWMS):**
- **Regular Budget**: E2030321
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- **Currency**: EUR
- **Interpretation**: 0.00 EUR
- **Other**: 40 000.00

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- **User Project**: E200321
- **Amount**: € 35 098.07
- **Total**: € 35 098.07

**CRP D3.20.23**
- **Cont: 14**
- **Agree: 2**
- **File Code: D3-RC-988.2**
- **Start: 2007-03-05**
- **End: 2007-03-09**
- **Location: Nairobi Country: Kenya**
- **Project Officer:** Viljoen Gerrit Johannes
- **No. of previous meetings:** 1
- **Date of last meeting:** 2005-05-09
- **Location of last meeting:** Dakar

**Est. Cost (AWMS):**
- **Regular Budget**: E2030321
- **Cost Centre**: E2030321
- **Currency**: EUR
- **Interpretation**: 0.00 EUR
- **Other**: 35 000.00

**Actual Cost (AFIMS):**
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- **User Project**: E200321
- **Amount**: € 23 005.22
- **Total**: € 23 005.22

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Annex III.12
E.3. Strengthening Compliance with Food and Environmental Safety Standards through Good Agricultural Practices

CRP D6.10.23
Cont: 7  Agree: 4

Testing the Efficiency and Uncertainty of Sample Processing for Analysis of Food Contaminants

Country: Argentina

Project Officer: Brodesser Peter Josef

No. of previous meetings: 2  Date of last meeting: 2005-02-21  Location of last meeting: Madurai

---

F. Human Health (17)

F.1. Nuclear Techniques in Nutrition and Disease Prevention

CRP E4.30.20
Cont: 7  Agree: 2

Nutrition and HIV/AIDS: The Efficacy of Food Based Interventions Evaluated by Stable Isotope Techniques

Country: Austria

Project Officer: Davidsson Lena Margareta

No. of previous meetings: 1  Date of last meeting: 2006-03-01  Location of last meeting: VIC A2775

---

Annex III.13
**RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME**

**CRP E4.30.18**  
Zinc Nutrition During Early Life  
File Code: E4-RC-1010.2  
Start: 2007-09-24  End: 2007-09-26  Location: Vienna  
Country: Austria  
No. of previous meetings: 1  
Date of last meeting: 2005-12-07  
Location of last meeting: Vienna  
Project Officer: Davidsson Lena Margareta  

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**CRP E4.10.14**  
Exposure to Toxic and Potentially Toxic Elements in Women of Childbearing Age in Developing Countries  
File Code: E4-RC-1009.2  
Country: Austria  
No. of previous meetings: 1  
Date of last meeting: 2005-11-21  
Location of last meeting: Vienna  
Project Officer: Hyder S.M. Ziauddin  

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**CRP E4.30.16**  
Assessment of Total Energy Expenditure and Body Composition for Older Adult Subjects with Different Lifestyles  
File Code: E4-RC-944.3  
Country: Austria  
No. of previous meetings: 1  
Date of last meeting: 2005-12-12  
Location of last meeting: Guatemala City  
Project Officer: Davidsson Lena Margareta  

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**F.2. Nuclear Medicine and Diagnostic Imaging**

**CRP E1.30.34**  
Assessment of Left Ventricular Function in Coronary Artery Disease with Nuclear Techniques  
File Code: E1-RC-1076.1  
Start: 2007-12-10  End: 2007-12-13  Location: Vienna  
Country: Austria  
No. of previous meetings: 0  
Date of last meeting:  
Location of last meeting:  
Project Officer: Dondi Maurizio  

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Annex III.14
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

CRP E3.50.19
Cont: 11   Agree: 0
Improved Accuracy of Molecular and Immunological Markers for Prediction of Efficacy of Antimalarials
File Code: E3-RC-992.2
Location: Vienna
Country: Austria
Project Officer: Khan Baldip Kaur
No. of previous meetings: 1   Date of last meeting: 2005-09-05
Location of last meeting: Vienna

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CRP E3.50.32
Cont: 11   Agree: 3
Resource Sparing Treatment of Head and Neck Cancer
File Code: E3-RC-1058.1
Location: Vienna
Country: Austria
Project Officer: Dondi Maurizio
No. of previous meetings: 0   Date of last meeting: |
Location of last meeting: |

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Total: € 28 843.83

F.3. Radiation Oncology and Cancer Treatment

CRP E3.50.23
Cont: 6   Agree: 1
Performance of Rest Myocardial Perfusion Imaging in the Management of Acute Chest Pain in the Emergency Room
File Code: E3-RC-942.3
Location: Vienna
Country: Austria
Project Officer: Rosenblatt Eduardo
No. of previous meetings: 2   Date of last meeting: 2005-12-05
Location of last meeting: Cairo

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Total: € 10 827.53

CRP E3.50.28
Cont: 11   Agree: 3
Investigation of Optimal Radiotherapy Regimen and Type of Irradiation in Treatment of Painful Bone Metastasis
File Code: E3-RC-1064.1
Location: Vienna
Country: Austria
Project Officer: Jeremic Branislav
No. of previous meetings: 0   Date of last meeting: |
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Total: € 14 984.57

Annex III.15
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

CRP E1.30.33  Evaluation of the Biological Safety and Clinical Efficacy of 177 Lu-EDTMP for Bone Pain Palliation in Metastatic Prostate Cancer (PhaseI/II Clinical Trial)
Country: Austria
Project Officer: Zaknun John
No. of previous meetings: 0  Date of last meeting:  Location of last meeting:

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Total: € 15 728.74

CRP E3.30.22  Doctoral CRP on Clinical and Experimental Studies to Improve Radiotherapy Outcome in AIDS Cancer Patients
Country: Austria
Project Officer: Zubizarreta Eduardo Hernan
No. of previous meetings: 2  Date of last meeting:  Location of last meeting:

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Total: € 17 108.99

CRP E3.30.27  Improving Outcomes in Radiotherapy Using New Strategies of Treatment Delivery with Focus on Oesophageal Cancer
Country: Austria
Project Officer: Rosenblatt Eduardo
No. of previous meetings: 0  Date of last meeting:  Location of last meeting:

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Total: € 16 811.45

F.4. Quality Assurance and Metrology in Radiation Medicine

CRP E2.40.14  Development of Procedures for in Vivo Dosimetry in Radiotherapy
Country: Austria
Project Officer: Izewska Joanna
No. of previous meetings: 1  Date of last meeting:  Location of last meeting:

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Unliquidated: € 1 285.00

Total: € 13 922.30

Annex III.16
## RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

### CRP E2.10.05
- **Harmonization of Quality Practices for Nuclear Medicine Radioactivity Measurements**
- **File Code**: E2-RC-987.2
- **Start**: 2007-09-24, **End**: 2007-09-28
- **Location**: Vienna, **Country**: Austria
- **Project Officer**: Newman Brent David
- **No. of previous meetings**: 0
- **Date of last meeting**: 2005-06-27, **Location of last meeting**: Vienna

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### CRP E2.40.13
- **Development of procedures for quality assurance for dosimetry calculations in radiotherapy**
- **File Code**: E2-RC-946.2
- **Start**: 2007-08-06, **End**: 2007-08-10
- **Location**: Vienna, **Country**: Austria
- **Project Officer**: Vatnitskiy Stanislav
- **No. of previous meetings**: 1
- **Date of last meeting**: 2004-06-28, **Location of last meeting**: Vienna

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### CRP E2.10.06
- **Testing of the Implementation of the Code of Practice for Dosimetry in X-Ray Diagnostic Radiology**
- **File Code**: E2-RC-1011.2
- **Start**: 2007-07-09, **End**: 2007-07-13
- **Location**: Vienna, **Country**: Austria
- **Project Officer**: McLean Ian Donald
- **No. of previous meetings**: 1
- **Date of last meeting**: 2005-11-28, **Location of last meeting**: Vienna

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### G. Water Resources (3)

#### G.1. Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

### CRP F3.20.05
- **Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency**
- **File Code**: F3-RC-1082.1
- **Start**: 2007-11-26, **End**: 2007-11-30
- **Location**: Vienna, **Country**: Austria
- **Project Officer**: Newman Brent David
- **No. of previous meetings**: 0
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**Total**: € 10 849.56

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Annex III.17
G.2. Reference Isotope Data and Analysis for Hydrological Applications

CRP F3.40.10 Isotope Methods for the Study of Water and Carbon Cycle Dynamics in the Atmosphere and Biosphere
Cont: 4 Agree: 6
File Code: F3-RC-981.2 Start: 2007-12-03 End: 2007-12-07 Location: Vienna Country: Austria
Project Officer: Araguas Araguas Luis Jesus
No. of previous meetings: 1 Date of last meeting: 2005-05-02 Location of last meeting: VIC A2774

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Total: € 12 055.22

H. Assessment and Management of Marine and Terrestrial Environments (2)

H.2. Radioecological and Isotopic Solutions for Coastal Marine Problems (RISCMAR)

CRP K4.10.10 Applications of Radiotracer and Radioassay Technologies to Seafood Safety Assessment
Cont: 7 Agree: 6
Project Officer: Jeffree Ross Anthony
No. of previous meetings: 0 Date of last meeting: Location of last meeting:

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Total: € 24 682.54
## H.3. Ocean Climate Coupling and Carbon Cycling (OC4)

### I.1. Technology Support to Radioisotopes, Radiopharmaceuticals and Radioanalytical Services

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### I.2. Radiation Technology for Industrial Applications and a Safer Environment

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<td>Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Selective Separation Purposes</td>
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**Annex III.19**
RESEARCH COORDINATION MEETINGS (RCMs) HELD IN 2007 BY SUBPROGRAMME

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**CRP F1.10.12**

- **Cont:** 8
- **Agree:** 8
- **File Code:** F1-RC-1018.2
- **Start:** 2007-11-12
- **End:** 2007-11-16
- **Location:** Mumbai
- **Country:** India

**Project Officer:** Muelhauser Françoise

**No. of previous meetings:** 1

**Date of last meeting:** 2006-04-19

**Location of last meeting:** VIC F0513

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**CRP F2.20.44**

- **Cont:** 10
- **Agree:** 5
- **File Code:** F2-RC-1059.1
- **Start:** 2007-08-27
- **End:** 2007-08-31
- **Location:** Vienna
- **Country:** Austria

**Project Officer:** Jin Joon Ha

**No. of previous meetings:** 0

**Date of last meeting:**

**Location of last meeting:**

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**CRP F2.20.43**

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- **Agree:** 3
- **File Code:** F2-RC-1061.1
- **Start:** 2007-06-11
- **End:** 2007-06-15
- **Location:** Berlin
- **Country:** Germany

**Project Officer:** Jin Joon Ha

**No. of previous meetings:** 0

**Date of last meeting:**

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J. Safety of Nuclear Installations (1)


**CRP J7.10.11**

- **Cont:** 12
- **Agree:** 4
- **File Code:** J7-RC-1081.2
- **Start:** 2007-12-10
- **End:** 2007-12-14
- **Location:** Vienna
- **Country:** Austria

**Project Officer:** Willers Andrew

**No. of previous meetings:** 0

**Date of last meeting:**

**Location of last meeting:**

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**Total:** € 25 547.04

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K. Safety of the Transport of Radioactive Material

CRP J1.30.11
Cont: 0  Agree: 9
File Code: J1-RC-1045.1
Country: Austria

The Appropriate Level of Regulatory Control for the Safe Transport of Naturally-Occurring Radioactive Material (NORM)

No. of previous meetings: 0  Date of last meeting:  
Location of last meeting:

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Unliquidated: € 1 502.34
Total: € 14 256.78

L. Management of Radioactive Waste (2)

L.2. Disposable Waste: Management of Radioactive Waste and Disused Sealed Sources

CRP T2.10.25
Cont: 5  Agree: 15
File Code: T2-RC-1040.1
Start: 2007-09-10  End: 2007-09-14  Location: Moscow
Country: Russian Federation

Behaviour of Cementitious Materials in Long Term Storage and Disposal of Radioactive Waste

No. of previous meetings: 0  Date of last meeting:  
Location of last meeting:

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L.4. Residual Waste: Decommissioning of Installations and Remediation of Sites

CRP T2.40.07
Cont: 3  Agree: 11
File Code: T2-RC-959.3
Start: 2007-12-03  End: 2007-12-07  Location: Huisinec Rez
Country: Czech Republic

Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities

No. of previous meetings: 2  Date of last meeting: 2006-11-13  Location of last meeting: Sellafield

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Unliquidated: € 1 502.34
Total: € 14 256.78
## COUNTRIES WHERE RESEARCH COORDINATION MEETINGS (RCMs) WERE HELD IN 2007

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Annex V.1
### 2007 TOTAL CONTRACT OBLIGATIONS BY COUNTRY

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## 2007 TOTAL CONTRACT OBLIGATIONS BY COUNTRY

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<td>Senegal</td>
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### A. Nuclear Power

#### A.1 Nuclear Power Plant Operating Performance and Life Cycle Management

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<th>Duration</th>
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<th>Partners</th>
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<tbody>
<tr>
<td>I21018</td>
<td>Master Curve Approach to Monitor the Fracture Toughness of Reactor Pressure Vessel in Nuclear Power Plants</td>
<td>2005-03-01 to 2008-12-31</td>
<td>KANG, Ki Sig</td>
<td>Belgium, Bulgaria, Czech Republic, Finland, Germany, Hungary, Japan(2), Korea, Republic of, Mexico, Russian Federation, Spain, United States of America(3)</td>
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<tr>
<td>I21019</td>
<td>Review and Benchmark of Calculation Methods for Structural Integrity Assessment of Reactor Pressure Vessels During Pressurized Thermal Shocks</td>
<td>2005-09-15 to 2008-12-31</td>
<td>KANG, Ki Sig</td>
<td>China, Russian Federation, Czech Republic, Finland, Germany, Hungary, Korea, Republic of, Netherlands, Slovakia</td>
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#### A.4 Technology Development for Advanced Reactor Lines

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<tr>
<td>I25001</td>
<td>Small Reactors without On-Site Refuelling</td>
<td>2004-12-01 to 2008-12-31</td>
<td>KUZNETSOV, Vladimir</td>
<td>Brazil, Croatia, India, Indonesia, Lithuania, Morocco, Russian Federation(4), Italy, Japan(2), United States of America(3)</td>
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<tr>
<td>I31013</td>
<td>Conservation and Application of High Temperature Gas Cooled Reactor (HTGR) Technology: Advances in HTGR Fuel Technology Development</td>
<td>2000-11-01 to 2008-12-31</td>
<td>KUPITZ, Juergen</td>
<td>China, France, Germany, Japan, Korea, Republic of, Netherlands, Russian Federation, South Africa, Turkey, United States of America</td>
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<td>I31014</td>
<td>Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Utilize Natural Circulation</td>
<td>2004-03-01 to 2008-02-29</td>
<td>CLEVELAND, John</td>
<td>Argentina, India, Slovakia, France, Germany, Italy(2), Japan, Korea, Republic of, Netherlands, Russian Federation, Spain, Switzerland, United States of America(3)</td>
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ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

131015  Advances in Nuclear Power Process Heat Applications
Duration: 2007-03-01 to 2010-02-28 Officer: KHAMIS, Ibrahim
Contracts: 3 Argentina, India, Syrian Arab Republic
Agreements: 7 China, France, Germany, India, Japan, Russian Federation, South Africa

Duration: 2007-09-15 to 2011-09-14 Officer: CLEVELAND, John
Contracts: 3 China(2), India
Agreements: 7 Canada, Finland, Italy, Korea, Republic of, Russian Federation, Switzerland, United States of America

132004  Studies of Innovative Reactor Technology Options for Effective Incineration of Radioactive Waste
Duration: 2001-12-15 to 2007-05-31 Officer: STANCULESCU, Alexander
Contracts: 4 China, Czech Republic, India, Russian Federation
Agreements: 15 Belgium, China, France(2), Germany(2), Hungary(2), Italy, Japan, Netherlands(2), Poland, Russian Federation(2)

132006  Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS)
Duration: 2005-10-01 to 2010-09-30 Officer: STANCULESCU, Alexander
Contracts: 5 Belarus, Brazil, China, Poland, Russian Federation(2)
Agreements: 21 Belgium, France(2), Germany(3), Greece, Hungary, Italy(2), Japan, Netherlands, Pakistan, Poland, Russian Federation(2), Spain(2), Sweden, Ukraine, United States of America

132007  Analyses of and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems
Duration: 2006-09-15 to 2009-09-14 Officer: STANCULESCU, Alexander
Contracts: 2 India, Russian Federation
Agreements: 3 France, Japan, Korea, Republic of

Appendix A.2
### ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

**B  Nuclear Fuel Cycle and Materials Technologies**

**B.2 Nuclear Power Reactor Fuel Engineering**

<table>
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<th>Project Title</th>
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<th>Countries/Regions</th>
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<tr>
<td>T12017</td>
<td>Delayed Hydride Cracking (DHC) of Zirconium Alloy Fuel Cladding</td>
<td>2005-03-01 to 2009-12-31</td>
<td>INOZEMTSEV, Victor</td>
<td>Argentina, Canada, India, Lithuania, Pakistan, Romania</td>
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<td>Brazil, Korea, Republic of, Russian Federation, Sweden</td>
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<td>T12019</td>
<td>Optimisation of Water Chemistry Technologies and Management to Ensure Reliable</td>
<td>2006-05-01 to 2011-04-30</td>
<td>KILLEEN, John Christopher</td>
<td>Bulgaria, China, Czech Republic, Romania, Russian Federation, Ukraine</td>
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<td></td>
<td>Fuel Performance at High Burnup and in Ageing Plants</td>
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<td></td>
<td>Canada, Finland, France, Hungary, India, Japan, Korea, Republic of, Sweden(2), United States of America</td>
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<tr>
<td>T13012</td>
<td>Spent Fuel Performance Assessment and Research (SPAR II)</td>
<td>2004-12-01 to 2008-12-31</td>
<td>DANKER, William J, LOVASIC, Z.</td>
<td>Argentina, Hungary, Slovakia</td>
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<td>Canada, France, Germany(2), Japan(2), Spain, United Kingdom, United States of America</td>
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<tr>
<td></td>
<td>tion (P&amp;T) Systems in View of Minimizing Long Term Environmental Impact</td>
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**B.3 Management of Spent Fuel from Nuclear Power Reactors**

<table>
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<tr>
<td>T11005</td>
<td>Greenhouse Gas (GHG) Mitigation Strategies and Energy Options</td>
<td>2006-09-15 to 2009-12-31</td>
<td>JALAL, Ahmed</td>
<td>Argentina, Brazil, Bulgaria, China, Cuba, India, Iran, Islamic Republic of, Lithuania, Pakistan, Romania, Russian Federation, Syrian Arab Republic</td>
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**C Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development**

**C.2 Energy Economy Environment (3E) Analysis**

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<th>Duration</th>
<th>Officer(s)</th>
<th>Countries/Regions</th>
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<tbody>
<tr>
<td>I11005</td>
<td>Greenhouse Gas (GHG) Mitigation Strategies and Energy Options</td>
<td>2006-09-15 to 2009-12-31</td>
<td>JALAL, Ahmed</td>
<td>Argentina, Brazil, Bulgaria, China, Cuba, India, Iran, Islamic Republic of, Lithuania, Pakistan, Romania, Russian Federation, Syrian Arab Republic</td>
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Appendix A.3
## C.3 Nuclear Knowledge Management

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<th>Countries/Regions</th>
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<tbody>
<tr>
<td>L53001</td>
<td>Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation</td>
<td>2006-09-15 to 2009-09-14</td>
<td>RUYSSEN, Marie Laure</td>
<td>Bulgaria, Jordan, Pakistan, Philippines, Romania, Russian Federation</td>
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## D Nuclear Science

### D.1 Atomic and Nuclear Data

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<th>Project Title</th>
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<th>Countries/Regions</th>
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</thead>
<tbody>
<tr>
<td>F41022</td>
<td>Parameters for Calculation of Nuclear Reactions of Relevance to Non-Energy Nuclear Applications</td>
<td>2003-03-15 to 2007-12-31</td>
<td>CAPOTE NOY, Roberto Mario</td>
<td>China, Belgium, France, Japan, Netherlands, United States of America(2)</td>
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<tr>
<td>F41023</td>
<td>Development of a Reference Database for Ion Beam Analysis</td>
<td>2005-07-01 to 2008-06-30</td>
<td>ABRIOLA, Daniel Hugo</td>
<td>China, Croatia, Portugal, Russian Federation, Finland, France, Germany, Greece, Italy, United Kingdom</td>
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<tr>
<td>F41024</td>
<td>Minor Actinide Neutron Reaction Data (MANREAD)</td>
<td>2007-07-01 to 2011-06-30</td>
<td>MENGONI, Alberto</td>
<td>Belarus, Hungary, Romania, Russian Federation, Austria, Belgium, France, Germany, Greece, Italy, Japan, United States of America</td>
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<tr>
<td>F42005</td>
<td>Reference Database for Neutron Activation Analysis</td>
<td>2005-07-01 to 2008-12-31</td>
<td>KELLETT, Mark Adrian</td>
<td>Argentina, Hungary, Nigeria, Slovenia, Belgium(2), United States of America</td>
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Appendix A.4
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

F42006  Updated Decay Data Library for Actinides
Duration: 2005-09-15 to 2008-12-31  Officer: KELLETT, Mark Adrian
Contracts: 4  China, India, Romania, Russian Federation
Agreements: 3  France, United Kingdom, United States of America

F43014  Atomic and Molecular Data for Plasma Modelling
Duration: 2005-06-15 to 2009-06-14  Officer: HUMBERT, Denis Pierre  2nd Officer: CLARK, R.
Agreements: 11  France, Germany(2), Italy, Japan(2), Sweden, United Kingdom(2), United States of America(2)

F43015  Atomic Data for Heavy Element Impurities in Fusion Reactors
Duration: 2005-09-15 to 2010-12-31  Officer: CLARK, Robert Edward Holmes
Contracts: 3  China, Russian Federation(2)
Agreements: 9  Australia, France(2), Germany, Japan, United Kingdom, United States of America(3)

F43016  Data for Surface Composition Dynamics Relevant to Erosion Processes
Duration: 2007-07-01 to 2012-06-30  Officer: CLARK, Robert Edward H.
Contracts: 2  Russian Federation(2)
Agreements: 7  Canada, Finland, France, Germany, Japan, United States of America(2)

F43017  Heavy Charged-particle Interaction Data for Radiotherapy
Duration: 2007-09-15 to 2010-12-31  Officer: CAPOTE NOY, Roberto M.
Contracts: 2  Brazil, Russian Federation
Agreements: 9  Germany(2), Italy, Japan, Spain, Switzerland(2), United Kingdom, United States of America

D.2  Research Reactors
F12020  Development and Application of the Techniques of Residual Stress Measurements in Materials
Duration: 2006-03-15 to 2009-03-14  Officer: PARANJPE, Shrinivas K.
Contracts: 5  Hungary, Pakistan, Romania, Russian Federation, South Africa
Agreements: 4  Czech Republic, Germany, India, Netherlands

Appendix A.5
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

T12018 Developing Techniques for Small Scale Indigenous Molybdenum 99 Production Using Low Enriched Uranium (LEU) Fission or Neutron Activation

Duration: 2005-09-15 to 2009-09-14 Officer: GOLDMAN, Ira Neal 2nd Officer: RAMAMOORTHY, N.
Contracts: 7 Chile, Egypt, Kazakhstan, Libyan Arab Jamahiriya, Pakistan, Romania(2)
Agreements: 7 Argentina, India, Indonesia, Korea, Republic of, Poland, United States of America(2)

T12020 Conversion of Miniature Neutron Source Research Reactors (MNSR) to Low Enriched Uranium (LEU)

Duration: 2006-09-15 to 2009-09-14 Officer: ADELFANG, Pablo 2nd Officer: GOLDMAN, Ira Neal
Contracts: 6 China, Ghana, Nigeria, Iran, Islamic Republic of, Pakistan, Syrian Arab Republic
Agreements: 1 United States of America

D.3 Utilization of Accelerators and Instrumentation

F11013 Improvement of the Reliability and Accuracy of Heavy Ion Beam Nuclear Analytical Techniques

Duration: 2007-09-15 to 2011-12-31 Officer: DYTLEWSKI, Nikolai 2nd Officer: MANK, Guenter
Contracts: 3 Croatia, Portugal, South Africa
Agreements: 2 Finland, Germany

F12016 Ion Beam Modification of Insulators

Duration: 2004-08-01 to 2008-07-31 Officer: MUELHAUSER, Francoise
Contracts: 5 Bulgaria, Croatia, Serbia, South Africa, Thailand
Agreements: 3 Germany, Portugal, United Kingdom

F12018 Development of Harmonized QA/AC Procedures for Maintenance and Repair of Nuclear Instruments

Duration: 2005-09-15 to 2008-09-14 Officer: MUELHAUSER, Francoise
Contracts: 7 Argentina, Cuba(2), India, Mexico, Poland, United Republic of Tanzania
Agreements: 1 Netherlands
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

F12019  Development of Nuclear Microprobe Techniques for the Quantitative Analysis of Individual Microparticles
Duration: 2005-07-01 to 2008-11-30 Officer: DYTLEWSKI, Nikolai
Contracts: 5 Croatia, Hungary(2), Portugal, South Africa
Agreements: 1 France

F12021  Improved Production and Utilization of Short Pulsed, Cold Neutrons at Low-medium Energy Spallation Neutron Sources
Duration: 2006-09-15 to 2010-09-15 Officer: MUELHAUSER, Francoise
Contracts: 6 Argentina, Czech Republic, India, Indonesia, Malaysia, Russian Federation
Agreements: 2 Japan, United States of America

G42002  Unification of Nuclear Spectrometry Applications: Integrated Techniques as a New Tool for Material Research
Duration: 2006-09-15 to 2009-12-31 Officer: MARKOWICZ, Andrzej 2nd Officer: MUELHAUSER, F.
Contracts: 6 Argentina, Croatia, Cuba, Greece, Slovenia, United Arab Emirates
Agreements: 8 Australia, Austria, Belgium(2), Germany, Italy, United Arab Emirates, United States of America

D.4 Nuclear Fusion Research

F13010  Joint Research Using Small Tokamaks
Duration: 2004-09-01 to 2008-12-31 Officer: LOUZEIRO MALAQUIAS, Artur Jorge
Contracts: 11 Belgium, Brazil(3), China, Czech Republic, Egypt, Portugal(2), Russian Federation, United Kingdom
Agreements: 5 Canada, China, Iran, Islamic Republic of, Russian Federation, Thailand

F13011  Pathways to Energy from Inertial Fusion - an Integrated Approach
Duration: 2006-06-15 to 2010-06-14 Officer: MANK, Guenter
Contracts: 10 Czech Republic, Hungary, India, Korea, Republic of, Poland, Romania, Russian Federation(3), Uzbekistan
Agreements: 9 France, Germany, Japan(2), Spain(2), United Kingdom, United States of America(2)

F13012  Integrated Approach to Dense Magnetized Plasma Applications in Nuclear Fusion Technology
Duration: 2007-09-15 to 2012-09-14 Officer: LOUZEIRO MALAQUIAS, Artur Jorge
Contracts: 7 China, Poland(2), Russian Federation(2), Singapore, Ukraine
Agreements: 2 Italy, Russian Federation

Appendix A.7
## E. Food and Agriculture

### E.1 Sustainable Intensification of Crop Production Systems

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Project Title</th>
<th>Duration</th>
<th>Officers</th>
<th>Contracts</th>
<th>Agreements</th>
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<tbody>
<tr>
<td>D12008</td>
<td><strong>Selection for Greater Agronomic Water-Use Efficiency in Wheat and Rice Using Carbon Isotope Discrimination</strong></td>
<td>2003-11-01 to 2008-10-31</td>
<td>HENG, Lee Kheng</td>
<td>11</td>
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<td>Algeria, Australia, Bangladesh, China(2), India, Morocco, Pakistan, Philippines, Syrian Arab Republic, Yemen</td>
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<td>D12009</td>
<td><strong>Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions: A Role for Isotopic Techniques</strong></td>
<td>2007-09-15 to 2012-09-14</td>
<td>NGUYEN, Minh-Long</td>
<td>11</td>
<td>2</td>
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<tr>
<td></td>
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<td></td>
<td>Burkina Faso, China(2), Malawi, Morocco, Pakistan, Turkey, United States of America(2), Vietnam, Zambia</td>
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<tr>
<td>D15008</td>
<td><strong>Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides</strong></td>
<td>2002-11-01 to 2007-12-31</td>
<td>DERCON, Gerd</td>
<td>12</td>
<td>5</td>
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<tr>
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<td></td>
<td>Austria, Brazil, Chile, China(2), Morocco, Pakistan, Poland, Romania, Turkey, United Kingdom, Vietnam</td>
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<tr>
<td>D15009</td>
<td><strong>Integrated Soil, Water and Nutrient Management in Conservation Agriculture</strong></td>
<td>2004-12-01 to 2009-11-30</td>
<td>DERCON, Gerd</td>
<td>9</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Argentina, Australia, Brazil, Chile, India, Morocco, Pakistan, Turkey, Uzbekistan</td>
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<tr>
<td>D15010</td>
<td><strong>Selection and Evaluation of Food (Cereal and Legume) Crop Genotypes Tolerant to Low Nitrogen and Phosphorus Soils through the Use of Isotopic and Nuclear-Related Techniques</strong></td>
<td>2006-06-15 to 2011-12-31</td>
<td>ADU-GYAMFI, Joseph J.</td>
<td>12</td>
<td>5</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Brazil, Burkina Faso, Cameroon, China, Cuba, Germany, Ghana, Malaysia, Mexico, Mozambique, Sierra Leone, United States of America</td>
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</tr>
</tbody>
</table>

Appendix A.8
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

D23024  Physical Mapping Technologies for the Identification and Characterization of Mutated Genes Contributing to Crop Quality
Duration: 2002-10-01 to 2008-12-31  Officer: LOKKO, Yvonne Rosaline
Contracts: 8  Argentina, Bulgaria, China(2), Czech Republic, Pakistan(2), Poland
Agreements: 4  Germany, Iceland, United Kingdom, United States of America

D23025  Pyramiding of Mutated Genes Contributing to Crop Quality and Resistance to Stress Affecting Quality
Duration: 2004-07-01 to 2009-12-28  Officer: SHU, Qingyao
Contracts: 10  Bulgaria, China(2), India, Iran, Islamic Republic of, Korea, Republic of, Pakistan, Poland, Thailand, The Frmr. Yug.Rep. of Macedonia
Agreements: 5  Australia, Colombia, France, Japan, United Kingdom

D23026  Identification and Pyramiding of Mutated Genes: Novel Approaches for Improving Crop Tolerance to Salinity and Drought
Duration: 2004-12-01 to 2009-11-30  Officer: SPENCER, Marie Madeleine
Contracts: 17  Bulgaria, China(2), Cuba, Egypt, Ghana, India(2), Indonesia, Italy, Pakistan, Philippines, Thailand, Tunisia(2), Turkey, Vietnam
Agreements: 5  Australia, Israel, Italy, United States of America(2)

D23027  Molecular Tools for Quality Improvement in Vegetatively Propagated Crops Including Banana and Cassava
Duration: 2005-05-01 to 2010-04-30  Officer: LAGODA, Pierre Jean L.  2nd Officer: MBA, Romuald Emma Chikelu
Contracts: 12  Bangladesh, Brazil(2), China, Cuba, Ghana, India, Indonesia, Kenya, Mexico, Nigeria, Philippines
Agreements: 5  Colombia, Czech Republic, France, United Kingdom(2)

D24011  Effects of Mutagenic Agents on the DNA Sequence in Plants
Duration: 2003-09-15 to 2008-12-31  Officer: LAGODA, Pierre Jean L.
Contracts: 10  Bulgaria, China(2), Colombia, India, Korea, Republic of, Philippines, Poland, South Africa, United States of America
Agreements: 3  United Kingdom, United States of America(2)

D41018  Improvement of Codling Moth SIT to Facilitate Expansion of Field Application
Duration: 2002-05-01 to 2007-04-30  Officer: VREYSEN, Marc
Contracts: 7  Argentina(2), Brazil, Chile, Czech Republic, Syrian Arab Republic, United States of America
Agreements: 4  Canada, South Africa, Switzerland, United States of America

Appendix A.9
D41019  Molecular Technologies to Improve the Effectiveness of SIT  
Duration: 2003-06-12 to 2008-06-11  Officer: HENDRICHS, Jorge  2nd Officer: FRANZ, Gerald  
Contracts: 3  China, India, Thailand  
Agreements: 12  Australia, Germany, Greece(3), Italy(2), New Zealand, United Kingdom(2), United States of America(2)

D41020  Improving Sterile Male Performance in Fruit Fly Sterile Insect Technique (SIT) Programmes  
Duration: 2004-07-01 to 2009-12-31  Officer: HENDRICHS, Jorge  
Contracts: 15  Argentina(2), Brazil, China, Croatia, Greece, Israel, Mauritius, Mexico(2), Philippines, Portugal, South Africa, Thailand, United Kingdom  
Agreements: 6  Australia(2), France, Spain, United States of America(2)

D41021  Development of Mass Rearing for New World (Anastrepha) and Asian (Bactrocera) Fruit Fly Pests in Support of Sterile Insect Technique (SIT)  
Duration: 2004-11-15 to 2009-11-14  Officer: HENDRICHS, Jorge  2nd Officer: CACERES BARRIOS, Carlos  
Contracts: 19  Argentina(2), Bangladesh, Brazil(2), Costa Rica, Greece, Israel, Kenya, Mauritius, Mexico(2), Pakistan, Philippines, Samoa, Sri Lanka, United States of America(2), Vietnam  
Agreements: 2  Australia, Italy

E.2  Sustainable Intensification of Livestock Production Systems

D31024  Development and Use of Rumen Molecular Techniques for Predicting and Enhancing Livestock Productivity  
Duration: 2003-11-15 to 2009-11-14  Officer: SCHLINK, Anthony C.  2nd Officer: BOETTCHER, Paul John  
Contracts: 10  Brazil, China(2), Colombia, Cuba, Ethiopia, Germany, India, Thailand, United States of America  
Agreements: 5  Australia, Japan, New Zealand, Switzerland, United Kingdom

D31025  Gene-based Technologies in Livestock Breeding: Characterization of Small Ruminant Genetic Resources in Asia  
Duration: 2004-12-01 to 2009-11-30  Officer: BOETTCHER, Paul John  2nd Officer: MALEK, Massoud  
Contracts: 12  Bangladesh, Brazil, China(2), Indonesia, Iran, Islamic Republic of(2), Kenya, Norway, Pakistan, Sri Lanka, Vietnam  
Agreements: 2  Italy, Malaysia

D32023  Veterinary Surveillance of Rift Valley Fever (RVF)  
Duration: 2005-05-01 to 2010-04-30  Officer: VILJOEN, Gerrit Johannes  2nd Officer: SCHATEN, Kathrin  
Contracts: 12  Burkina Faso, Democratic Rep. of the Congo, Gambia, Germany, Guinea, Kenya, Mali, Mauritania, Senegal, South Africa, Uganda, Yemen  
Agreements: 2  France, Germany
### D32024  Control of Contagious Bovine Pleuro Pneumonia (CBPP)

- **Duration:** 2006-03-15 to 2011-03-14  
- **Officer:** UNGER, Hermann  
- **Contracts:** 14  
- **Agreements:** 2  
- **2nd Officer:** VILJOEN, Gerrit Johannes  
- **Countries:** Angola, Austria, Botswana, Burkina Faso, Cameroon, Côte d'Ivoire, Kenya(2), Mali, Namibia, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

### D32025  The Early and Rapid Diagnosis of Transboundary Animal Diseases: Phase I - Avian Influenza

- **Duration:** 2006-12-15 to 2010-12-31  
- **Officer:** CROWTHER, John  
- **2nd Officer:** VILJOEN, Gerrit Johannes  
- **Contracts:** 12  
- **Agreements:** 4  
- **Countries:** Burkina Faso, China, Côte d'Ivoire, Ethiopia, Ghana, Niger, Nigeria, Philippines, South Africa, Sudan, United States of America, Vietnam

### D32026  The Early and Sensitive Diagnosis and Control of Peste des Petits Ruminants (PPR)

- **Duration:** 2007-09-15 to 2012-12-31  
- **Officer:** UNGER, Hermann  
- **2nd Officer:** SCHATEN, Kathrin  
- **Contracts:** 12  
- **Agreements:** 3  
- **Countries:** Bangladesh, Burkina Faso, Cameroon, China, Côte d'Ivoire, Ghana, India, Mali, Nigeria, Pakistan, Sudan, Turkey

### D42010  Improved and Harmonized Quality Control for Expanded Tsetse Production, Sterilization and Field Application

- **Duration:** 2003-06-12 to 2008-12-31  
- **Officer:** FELDMANN, Udo  
- **2nd Officer:** PARKER, Andrew Gordon  
- **Contracts:** 12  
- **Agreements:** 2  
- **Countries:** Belgium, Burkina Faso, Costa Rica, Czech Republic, Ethiopia, Kenya, Slovakia(2), South Africa, Switzerland, Uganda, United Republic of Tanzania

### D42012  Improving SIT for Tsetse Flies through Research on their Symbionts and Pathogens

- **Duration:** 2007-03-15 to 2012-03-14  
- **Officer:** HENDRICH, Jorge  
- **2nd Officer:** ABD ALLA, Adly Mohamed Mohamed  
- **Contracts:** 8  
- **Agreements:** 12  
- **Countries:** Burkina Faso, Cameroon, Ghana, Kenya(2), South Africa, Uganda, United Republic of Tanzania

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Appendix A.11
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

E.3 Strengthening Compliance with Food and Environmental Safety Standards through Good Agricultural Practices

D52035 Integrated Analytical Approaches to Assess Indicators of the Effectiveness of Pesticide Management Practices at a Catchment Scale
Duration: 2006-12-15 to 2011-12-14 Officer: MAESTRONI, Britt Marianna
Contracts: 10 Argentina, Brazil, Bulgaria, Chile, China, Costa Rica, Ecuador, India, Kenya, Philippines
Agreements: 5 Australia, Cyprus, Germany(2), Sweden

D61023 Testing the Efficiency and Uncertainty of Sample Processing for Analysis of Food Contaminants
Duration: 2002-04-01 to 2007-12-31 Officer: BRODESSER, Peter Josef
Contracts: 7 Argentina, China, Colombia, Hungary, India(2), Thailand
Agreements: 0

F Human Health

F.1 Nuclear Techniques in Nutrition and Disease Prevention

E41014 Exposure to Toxic and Potentially Toxic Elements in Women of Childbearing Age in Developing Countries
Duration: 2005-07-01 to 2008-06-30 Officer: HYDER, S.M. Ziauddin 2nd Officer: DAVIDSSON, Lena Margaret
Contracts: 7 Bangladesh, Belarus, Chile, China, Nigeria, Russian Federation, Slovenia
Agreements: 2 Australia, Japan

E43015 The Application of Isotopic and Nuclear Techniques in Studies Related to Intrauterine Growth Restriction (IUGR) Issues in Populations from Developing Countries
Duration: 2003-09-15 to 2007-11-30 Officer: DAVIDSSON, Lena Margaret
Contracts: 10 Bangladesh, Brazil, India(2), Morocco, Pakistan, South Africa, Sudan, United Kingdom, United Republic of Tanzania
Agreements: 1 United States of America

E43016 Assessment of Total Energy Expenditure and Body Composition for Older Adult Subjects with Different Lifestyles
Duration: 2003-11-01 to 2007-10-31 Officer: DAVIDSSON, Lena Margaret
Contracts: 6 Brazil, Chile, China, Guatemala, India, Morocco
Agreements: 2 New Zealand, United States of America

Appendix A.12
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

E43017  Assessment of Nutrients Uptake from Biofortified Crops in Populations from Developing Countries
Contracts: 4  Bangladesh, Mexico, United States of America(2)
Agreements: 0

E43018  Zinc Nutrition During Early Life
Duration: 2005-09-15 to 2008-09-14  Officer: DAVIDSSON, Lena Margareta
Contracts: 9  Bangladesh, Guatemala, India(2), Iran, Islamic Republic of, Kenya, Morocco, Pakistan, United States of America
Agreements: 3  France, United Kingdom, United States of America

E43019  Body Fat and its Relationship with Metabolic Syndrome Indicators in Overweight Pre-Adolescents and Adolescents
Duration: 2005-12-15 to 2010-12-31  Officer: CHEIKH ISMAIL, Leila I.  2nd Officer: DAVIDSSON, Lena Margareta
Contracts: 12  Australia, Bangladesh, Brazil, China, Egypt, India, Iran, Islamic Republic of, Jamaica, Lebanon, Malaysia, Mexico, Morocco
Agreements: 3  Australia, Mexico, United States of America

E43020  Nutrition and HIV/AIDS: The Efficacy of Food Based Interventions Evaluated by Stable Isotope Techniques
Duration: 2005-12-15 to 2010-12-14  Officer: DAVIDSSON, Lena Margareta
Contracts: 7  Ethiopia(2), India, South Africa(2), Thailand, United Republic of Tanzania
Agreements: 2  Denmark, United Kingdom

G34001  Development of Standardised Mass Rearing Systems for Male Anopheles Arabiensis Mosquitoes
Duration: 2005-09-15 to 2010-12-31  Officer: BENEDICT, Mark Quentin  2nd Officer: ROBINSON, Alan
Contracts: 10  Belgium, Ghana, Italy, Kenya, Pakistan, Sudan, United Kingdom(2), United Republic of Tanzania, United States of America
Agreements: 2  French Polynesia, United Kingdom

G34002  Biology of Male Mosquitoes in Relation to Genetic Control Programmes
Duration: 2007-12-01 to 2012-12-31  Officer: BENEDICT, Mark Quentin  2nd Officer: ROBINSON, Alan
Contracts: 6  Burkina Faso, Cuba, Denmark, Ghana, Sweden, Syrian Arab Republic
Agreements: 4  United Kingdom(2), United States of America(2)

Appendix A.13
## ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

### F.2 Nuclear Medicine and Diagnostic Imaging

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Project Title</th>
<th>Duration</th>
<th>Officer</th>
<th>Countries/Regions</th>
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<tr>
<td>E13028</td>
<td>Standardisation and Quality Control of In-House Prepared Radiopharmaceuticals for Nuclear Oncology</td>
<td>2004-06-01 to 2008-12-31</td>
<td>SOLANKI, Kishor K.</td>
<td>Algeria, Cuba, India, Singapore, Turkey, Uruguay</td>
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<tr>
<td>E13029</td>
<td>Evaluation of a Single Utilization of Pulmonary Perfusion Scintigraphy in Patients with Suspected Pulmonary Embolism</td>
<td>2004-09-01 to 2008-09-30</td>
<td>WATANABE, Naoyuki</td>
<td>Czech Republic, India(2), Slovenia, Turkey, Uruguay</td>
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<tr>
<td>E13031</td>
<td>Role of Nuclear Cardiology Techniques in Ischemia Assessment with Exercise Imaging in Asymptomatic Diabetes</td>
<td>2006-03-15 to 2009-03-14</td>
<td>DONDI, Maurizio</td>
<td>Algeria, Argentina, Bangladesh, Chile, Colombia, Cuba, Egypt, India, Israel, Lebanon, Pakistan, Slovenia, South Africa, United States of America, Uruguay, Vietnam</td>
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<tr>
<td>E13032</td>
<td>Performance of Rest Myocardial Perfusion Imaging in the Management of Acute Chest Pain in the Emergency Room</td>
<td>2007-03-15 to 2010-03-14</td>
<td>DONDI, Maurizio</td>
<td>Brazil(2), Chile, Cuba, India, Pakistan, Slovenia, South Africa(2), Vietnam</td>
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</tbody>
</table>

Appendix A.14
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

E15019 Improved Accuracy of Molecular and Immunological Markers for Prediction of Efficacy of Antimalarial Drugs
Duration: 2005-06-15 to 2009-06-14 Officer: KHAN, Baldi Kaur
2nd Officer: DONDI, Maurizio
Contracts: 10 Burkina Faso, Cameroon(2), Colombia, Kenya(2), Mali(2), Sudan, United Kingdom
Agreements: 0

E15020 Application of FDG-PET and Molecular Gene Profiling for Risk Stratification of Diffuse Large B-Cell Non-Hodgkin’s Lymphoma in Different Ethnic Populations
Duration: 2006-09-15 to 2011-12-31 Officer: KHAN, Baldi Kaur
2nd Officer: DONDI, Maurizio
Contracts: 8 Brazil, France, Hungary, India, Korea, Republic of, Philippines, Thailand, Turkey
Agreements: 2 Italy, United Kingdom

F.3 Radiation Oncology and Cancer Treatment

E13033 Evaluation of the Biological Safety and Clinical Efficacy of 177 Lu-EDTMP for Bone Pain Palliation in Metastatic Prostate Cancer (Phase I/II Clinical Trial)
Duration: 2007-03-15 to 2010-12-31 Officer: ZAKNUN, John
2nd Officer: PILLAI, Maroo Raghavan Ambi
Contracts: 6 Chile, India, Italy, Pakistan, Poland, Uruguay
Agreements: 2 India, Italy

E33022 Doctoral CRP on Clinical and Experimental Studies to Improve Radiotherapy Outcome in AIDS Cancer Patients
Duration: 2003-06-15 to 2009-06-14 Officer: ZUBIZARRETA, Eduardo Hernan
2nd Officer: SALMINEN, Eeva Kaarina
Contracts: 8 Canada, China, India, South Africa, Uganda, United Kingdom, United Republic of Tanzania, Zimbabwe
Agreements: 2 United Kingdom, United States of America

E33023 Resource Sparing Treatment of Head and Neck Cancer
Duration: 2003-09-15 to 2008-12-31 Officer: ROSENBLATT, Eduardo
Contracts: 5 Algeria, Egypt, Morocco, Pakistan, Thailand
Agreements: 1 Netherlands

E33025 Resource Sparing Curative Treatment in Breast Cancer
Duration: 2005-10-01 to 2011-09-30 Officer: ROSENBLATT, Eduardo
2nd Officer: SALMINEN, Eeva Kaarina
Contracts: 10 Canada, Cuba, Egypt(2), Ghana, Morocco, Nigeria, Pakistan, Peru, Turkey
Agreements: 2 Finland, Japan

Appendix A.15
E33026  **Clinical/Radiobiological Study on Viral-Induced Cancers’ Response to Radiotherapy, with Comprehensive Morbidity Assessment**  
Duration: 2006-09-15 to 2011-09-14  
Officer: ZUBIZARRETA, Eduardo  
2nd Officer: SALMINEN, Eeva Kaarina  
Contracts: 9  
Agreements: 2  
Brazi, Canada, India, Morocco, Pakistan, Peru, South Africa, The Frmr.Yug.Rep. of Macedonia, United Kingdom  
Austria, Korea, Republic of

E33027  **Improving Outcomes in Radiotherapy Using New Strategies of Treatment Delivery**  
Duration: 2006-12-15 to 2010-12-31  
Officer: ROSENBLATT, Eduardo  
2nd Officer: SALMINEN, Eeva Kaarina  
Contracts: 7  
Agreements: 1  
Canada, China, Croatia, India, Pakistan, South Africa, Thailand  
United States of America

E33028  **Investigation of Optimal Radiotherapy Regimen and Type of Irradiation in Treatment of Painful Bone Metastasis**  
Duration: 2007-07-01 to 2010-06-30  
Officer: JEREMIC, Branislav  
2nd Officer: SALMINEN, Eeva Kaarina  
Contracts: 9  
Agreements: 3  
Algeria, Brazil, Egypt, India, Lithuania, Mexico, Serbia, The Frmr.Yug.Rep. of Macedonia, United Kingdom  
Spain(3)

E33029  **Radiotherapy and Chemotherapy in Advanced Non-Small Cell Lung Cancer**  
Duration: 2007-12-01 to 2011-12-31  
Officer: JEREMIC, Branislav  
2nd Officer: SALMINEN, Eeva Kaarina  
Contracts: 13  
Agreements: 0  
Canada, Chile, Croatia, Egypt, India, Malaysia, Malta, Morocco, Pakistan, Panama, Peru, South Africa, Tunisia

F.4  **Quality Assurance and Metrology in Radiation Medicine**

E21005  **Harmonization of Quality Practices for Nuclear Medicine Radioactivity Measurements**  
Duration: 2004-12-15 to 2008-12-14  
Officer: PALM, Stig Harald  
2nd Officer: MEGHZIFENE, Ahmed  
Contracts: 5  
Agreements: 4  
Brazil, Cuba, Iran, Islamic Republic of, Romania, Turkey  
Czech Republic, India, Korea, Republic of, United States of America

E21006  **Testing of the Implementation of the Code of Practice for Dosimetry in X-Ray Diagnostic Radiology**  
Duration: 2005-11-15 to 2008-11-30  
Officer: MCLEAN, Ian Donald  
2nd Officer: MEGHZIFENE, Ahmed  
Contracts: 8  
Agreements: 4  
Brazil, China, Cuba, Czech Republic, Hungary, Korea, Republic of, Thailand, Vietnam  
Austria, Finland, Greece, United Kingdom

Appendix A.16
### E24014 Development of Procedures for in Vivo Dosimetry in Radiotherapy

- **Duration**: 2004-12-15 to 2007-12-14
- **Officer**: IZEWSKA, Joanna
- **Contracts**: 4 Brazil, China, Croatia, Poland
- **Agreements**: 2 Canada, United Kingdom

### G Water Resources

#### G.1 Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

- **F32004 Isotopic Techniques for Assessment of Hydrological Processes in Wetlands**
  - **Duration**: 2006-09-15 to 2011-09-14
  - **Officer**: ITO, Mari
  - **Contracts**: 12 Argentina, Brazil, Cameroon, Colombia, Czech Republic, Ghana, India, Mozambique, Pakistan, Turkey, Uganda, United Republic of Tanzania
  - **Agreements**: 6 Australia, Austria, France, Spain, United Kingdom, United States of America

- **F32005 Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency**
  - **Duration**: 2007-09-15 to 2011-09-14
  - **Officer**: NEWMAN, Brent David
  - **Contracts**: 5 China, Mexico, Morocco, Pakistan, Tunisia
  - **Agreements**: 1 Austria

- **F33015 Isotopic Age and Composition of Stream Flow as Indicators of Groundwater Sustainability**
  - **Duration**: 2004-07-01 to 2010-12-31
  - **Officer**: VITVAR, Tomas
  - **Contracts**: 11 Argentina, Brazil, China, Colombia, Ghana, Morocco, Pakistan, Serbia, Slovakia, Turkey, Vietnam
  - **Agreements**: 3 Austria, Netherlands, Portugal

#### G.2 Reference Isotope Data and Analysis for Hydrological Applications

- **F33016 Geostatistical Analysis of Spatial Isotope Variability to Map the Sources of Water for Hydrology Studies**
  - **Duration**: 2006-09-15 to 2010-09-15
  - **Officer**: ARAGUAS ARAGUAS, Luis Jesus
  - **Contracts**: 11 Austria, Croatia, Cuba, Greece, Mexico, Pakistan, Slovakia, Slovenia, Syrian Arab Republic, Thailand, Uganda
  - **Agreements**: 1 Canada
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

H Assessment and Management of Marine and Terrestrial Environments

H.2 Radioecological and Isotopic Solutions for Coastal Marine Problems (RISCMAR)

K41010 Applications of Radiotracer and Radioassay Technologies to Seafood Safety Assessment
Duration: 2007-09-15 to 2011-09-14 Officer: JEFFREE, Ross Anthony
Contracts: 7 Brazil, Chile, Ghana, Pakistan, Philippines, Thailand, Vietnam
Agreements: 6 Canada, China, France, French Polynesia, Japan, Switzerland

H.3 Ocean Climate Coupling and Carbon Cycling (OC4)

K41009 Nuclear and Isotopic Studies of the El Niño Phenomenon in the Ocean
Duration: 2004-03-01 to 2009-02-28 Officer: SANCHEZ CABEZA, Joan Albert
Contracts: 4 Indonesia, Israel, Jordan, Peru
Agreements: 6 Australia(2), Monaco, New Zealand, United States of America(2)

H.5 Assessment in Support of Sustainable Management of the Terrestrial Environment

G41003 Radiochemical, Chemical and Physical Characterisation of Radioactive Particles in the Environment
Duration: 2000-12-01 to 2007-12-31 Officer: WEGRZYNEK, Dariusz 2nd Officer: FESENKO, Sergev
Contracts: 5 Brazil, Hungary, Kazakhstan, Russian Federation, Ukraine
Agreements: 7 Denmark, Finland, Germany, Israel, Norway, Spain, United States of America

I Radioisotope Production and Radiation Technology

I.1 Technology Support to Radioisotopes, Radiopharmaceuticals and Radioanalytical Services

F22040 Development of generator technologies for therapeutic radionuclides
Duration: 2004-07-01 to 2008-06-30 Officer: PILLAI, Maroor Raghavan Ambi
Contracts: 7 Brazil, China, Cuba, India, Mexico, Poland, Vietnam
Agreements: 5 Germany, Italy, Korea, Republic of, Russian Federation, United States of America

F22041 Improved High Current Liquid and Gas Targets for Cyclotron Produced Radioisotopes
Duration: 2005-12-15 to 2009-12-31 Officer: HAJI-SAEID, Seyed Mohammad
Contracts: 5 Iran, Islamic Republic of, Korea, Republic of, Saudi Arabia, Syrian Arab Republic, Turkey
Agreements: 8 Belgium, Canada, Denmark, Finland, Germany, Hungary, United States of America(2)

Appendix A.18
### ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

<table>
<thead>
<tr>
<th>Code</th>
<th>Project Description</th>
<th>Duration</th>
<th>Officer(s)</th>
<th>2nd Officer(s)</th>
<th>Countries</th>
<th>Agreements</th>
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<tbody>
<tr>
<td>F22042</td>
<td>Development of Therapeutic Radiopharmaceuticals Based on 177Lu for Radionuclide Therapy</td>
<td>2006-10-15 to 2010-10-14</td>
<td>PILLAI, Maroor Raghavan</td>
<td>ZAKNUN, John</td>
<td>Argentina, Brazil, Chile, Cuba, Czech Republic, India, Pakistan, Peru, Russian Federation, Uruguay</td>
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<td>Austria, China, Hungary, Italy, Poland, United States of America</td>
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<tr>
<td>F22045</td>
<td>Development of 99mTc Radiopharmaceuticals for Sentinel Node Detection and Cancer Diagnosis</td>
<td>2007-09-15 to 2011-12-31</td>
<td>PILLAI, Maroor Raghavan</td>
<td>ZAKNUN, John</td>
<td>Argentina, Brazil, China, Greece, India, Mexico, Pakistan, Romania, Uruguay</td>
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<td>Austria, France, Germany, Hungary, Italy, Japan, Portugal, Switzerland(2)</td>
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<tr>
<td>F23023</td>
<td>Applications of Nuclear Analytical Techniques to Investigate the Authenticity of Art Objects</td>
<td>2004-11-15 to 2008-11-14</td>
<td>HAJI-SAEID, Seyed Mohammad</td>
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<td>Brazil(2), China, Croatia, Cuba, Ghana, Hungary, Kazakhstan, Lebanon, Malaysia, Mexico, Peru, Syrian Arab Republic</td>
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<td>I.2</td>
<td>Radiation Technology for Industrial Applications and a Safer Environment</td>
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<td>F11012</td>
<td>Neutron Based Techniques for the Detection of Illicit Materials and Explosives</td>
<td>2005-12-15 to 2010-12-31</td>
<td>MUELHAUSER, Francoise</td>
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<td>Chile, Egypt, Georgia, India, Poland, Russian Federation(2), South Africa</td>
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<td>F21010</td>
<td>Validation of Tracers and Software for Inter-Well Investigations</td>
<td>2004-07-01 to 2008-06-30</td>
<td>JIN, Joon Ha</td>
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<td>Argentina, Brazil, China, Indonesia, Pakistan, Philippines, Vietnam</td>
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Appendix A.19
ACTIVE COORDINATED RESEARCH PROJECTS AT END 2007

F22044  Evaluation and Validation of Radioisotopes Generators-Based Radiotracer for Industrial Applications
Duration: 2007-07-01 to 2011-06-30  Officer: JIN, Joon Ha
Contracts: 10  Brazil, China, Costa Rica, Cuba, Ghana, India, Korea, Republic of, Pakistan, Poland, Thailand
Agreements: 5  Australia, Chile, France, Germany, Norway

F22046  Development of Radiation-Processed Products of Natural Polymers for Application in Agriculture, Healthcare, Industry and Environment
Duration: 2007-12-01 to 2011-12-31  Officer: SAFRANY, Agnes
Contracts: 11  Algeria, Argentina, Bangladesh, Brazil, Egypt, Ghana, Philippines, Poland, Thailand, Turkey, Vietnam
Agreements: 5  Canada, France, Japan, Malaysia, United Kingdom

F23024  Electron Beam Treatment of Organic Pollutants Contained in Gaseous Streams
Duration: 2004-12-15 to 2008-12-14  Officer: SAMPA, Maria Helena de O.
Contracts: 8  Belarus, Bulgaria, China, Korea, Republic of, Malaysia, Poland, Romania, Russian Federation
Agreements: 5  China, Japan, Saudi Arabia, Spain, United States of America

F23026  Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Selective Separation Purposes
Duration: 2007-09-15 to 2011-12-31  Officer: SAMPA, Maria Helena de O. 2nd Officer: HAJI-SAEID, Seyed Mohammad
Contracts: 11  Argentina, Brazil, Egypt, Hungary, India, Korea, Republic of, Malaysia, Poland, Syrian Arab Republic, Thailand, Turkey
Agreements: 4  France, Japan, Switzerland, United States of America

J  Safety of Nuclear Installations
J.3  Development and use of advanced tools for safety assessment
J72005  Evaluation of Uncertainties in Best Estimate Accident Analysis
Duration: 2006-06-15 to 2009-06-14  Officer: MODRO, Slawomir Michael
Contracts: 6  Brazil, Bulgaria, China, India, Iran, Islamic Republic of, Russian Federation
Agreements: 8  Croatia, Czech Republic, Germany, Italy, Japan, Russian Federation, Slovenia, Switzerland

Appendix A.20
### J.6 Safety of Research Reactors and Fuel Cycle Facilities

<table>
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<tr>
<th>Project</th>
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<tr>
<td>J71011</td>
<td>Modelling and Analysis of Radionuclides Transport and Source Term Evaluation within Containment / Confinement and Release to the Environment, for Research Reactors</td>
<td>2007-04-15 to 2010-04-14</td>
<td>WILLERS, Andrew, VARLEY, Kasturi Kalyanee</td>
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### K Radiation and Transport Safety

<table>
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<tr>
<td>K.6</td>
<td>Safety of the Transport of Radioactive Material</td>
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<tr>
<td>J13011</td>
<td>The Appropriate Level of Regulatory Control for the Safe Transport of Naturally-Occurring Radioactive Material (NORM)</td>
<td>2007-03-01 to 2010-02-28</td>
<td>WANGLER, Michael Ervin, VARLEY, Kasturi Kalyanee</td>
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<td>Brazil, Canada, France, Germany, Iran, Islamic Republic of, Israel, Romania, United Kingdom, United States of America</td>
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### L Management of Radioactive Waste

<table>
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<td>L.2</td>
<td>Disposable Waste: Management of Radioactive Waste and Disused Sealed Sources</td>
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<tr>
<td>T21024</td>
<td>The Use of Numerical Models in Support of Site Characterization and Performance Assessment Studies of Geologic Repositories</td>
<td>2005-10-01 to 2010-09-30</td>
<td>NEERDAEL, Bernard A. G.</td>
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<td>Brazil, China, Lithuania, Romania, Ukraine</td>
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<th>Title</th>
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<td>Australia, Belgium, China, Czech Republic, Egypt, France, India, Korea, Republic of, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom</td>
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<tr>
<td>T23015</td>
<td>Upgrading of Near Surface Disposal Facilities</td>
<td>2007-11-01 to 2012-12-31</td>
<td>NACHMILNER, Lumir</td>
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<td>Argentina, Bulgaria, Cuba, Hungary, Romania, Ukraine(2)</td>
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<td>France, India</td>
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Appendix A.21
### L.4 Residual Waste: Decommissioning of Installations and Remediation of Sites

<table>
<thead>
<tr>
<th>T24007</th>
<th>Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities</th>
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<tbody>
<tr>
<td></td>
<td>Duration: 2004-05-01 to 2009-04-30 Officer: LARAIA, Michele</td>
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<td></td>
<td>Contracts: 3 Brazil, Cuba, Russian Federation</td>
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<td>Agreements: 11 Argentina, Austria, Belgium, Czech Republic, Denmark, Korea, Republic of(2), Norway, Slovakia, Ukraine, United Kingdom</td>
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Appendix A.22
## A. Nuclear Power

### A.1. Nuclear Power Plant Operating Performance and Life Cycle Management

<table>
<thead>
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<th>CRP</th>
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<tbody>
<tr>
<td>I21020</td>
<td>Advanced Surveillance, Diagnostics, and Prognostics Techniques Used for Health Monitoring of Systems, Structures, and Components in Nuclear Power Plants</td>
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### A.4. Technology Development for Advanced Reactor Lines

<table>
<thead>
<tr>
<th>CRP</th>
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<tbody>
<tr>
<td>I31017</td>
<td>Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the MONJU Reactor Vessel</td>
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## B. Nuclear Fuel Cycle and Materials Technologies

### B.4. Topical Nuclear Fuel Cycle Issues

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<tr>
<th>CRP</th>
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<tbody>
<tr>
<td>T12021</td>
<td>Front-and Back-End of Multilayer Coated Particle Fuel Cycle for High Temperature Gas-Cooled Reactors (HTGR) and Selected SMRs</td>
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## D. Nuclear Science

### D.1. Atomic and Nuclear Data

<table>
<thead>
<tr>
<th>CRP</th>
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<tbody>
<tr>
<td>F44002</td>
<td>Nuclear Data Libraries for Advanced Systems: Fusion Devices (FENDL-3)</td>
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## E. Food and Agriculture

### E.1. Sustainable Intensification of Crop Production Systems

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<tr>
<td>D42013</td>
<td>Applying GIS and Population Genetics for Managing Livestock Insect Pests</td>
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## F. Human Health

### F.4 Quality Assurance and Metrology in Radiation Medicine

<table>
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<tr>
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<tr>
<td>E24015</td>
<td>Doctoral CRP on Quality Assurance of the Physical Aspects of Advanced Technology in Radiotherapy</td>
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## H. Assessment and Management of Marine and Terrestrial Environments

### H.1. Marine Environmental and Radiological Assessment (MERAl)

<table>
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<th>CRP</th>
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<tr>
<td>K41011</td>
<td>Benchmarking Calibration for Low-Level Gamma Spectrometric Measurements of Environmental Samples</td>
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## J.3 Safety of Nuclear Installations


<table>
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<tr>
<th>CRP</th>
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<tr>
<td>J41007</td>
<td>Analysis and Development of Safety Performance Indicators (SPIs) for Nuclear Power Plants (Assisting in the Use of Safety Management Tools)</td>
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Appendix B.1
<table>
<thead>
<tr>
<th>L.</th>
<th>Management of Radioactive Waste</th>
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<tr>
<td>L.4.</td>
<td>Residual Waste: Decommissioning of Installations and Remediation of Sites</td>
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<tr>
<td>T24008</td>
<td>Planning, Management and Organizational Aspects in Decommissioning of Nuclear Facilities</td>
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<thead>
<tr>
<th>M</th>
<th>Nuclear Security</th>
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<tr>
<td>M.3</td>
<td>Detecting and Responding to Malicious Activities involving Nuclear and other Radioactive Materials</td>
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<td>J02001</td>
<td>Application of Nuclear Forensics in Illicit Trafficking of Nuclear and other Radioactive Materials</td>
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Appendix B.2
## COORDINATED RESEARCH PROJECTS COMPLETED IN 2007

### A Nuclear Power

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<tr>
<td>I31012</td>
<td>Evaluation of high temperature gas cooled reactor performance</td>
<td>1997-11-01 to 2006-12-31</td>
<td>KUPITZ, Juergen</td>
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<tr>
<td>I32005</td>
<td>Updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects</td>
<td>1999-10-01 to 2006-12-31</td>
<td>STANCULESCU, Alexander</td>
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### D Nuclear Science

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<tr>
<td>F12017</td>
<td>Development of new techniques and applications of accelerator mass spectrometry</td>
<td>2004-12-15 to 2007-12-15</td>
<td>DYTLIEWSKI, Nikolai</td>
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<td>F13009</td>
<td>Dense magnetized plasmas</td>
<td>2001-12-15 to 2007-04-30</td>
<td>LOUZEIRO MALAQUIAS, Artur J.</td>
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### E Food and Agriculture

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<td>D31023</td>
<td>Integrated approach for improving small scale market oriented dairy systems</td>
<td>2001-11-01 to 2006-12-31</td>
<td>BOETTCHER, Paul John</td>
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<td>D32022</td>
<td>The development of strategies for the effective monitoring of veterinary drug residues in livestock and livestock products in developing countries</td>
<td>2002-01-01 to 2006-12-31</td>
<td>CANNAVAN, Andrew</td>
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<td>D42009</td>
<td>Enabling Technologies for the Expansion of Sterile Insect Technique (SIT) for Old and New World Screwworm</td>
<td>2001-08-01 to 2007-03-31</td>
<td>HENDRICHS, Jorge</td>
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### F Human Health

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<td>E13024</td>
<td>Improvement in the treatment of acute lymphoblastic leukemia (ALL) by the detection of minimal residual disease (MRD)</td>
<td>2002-10-24 to 2006-12-31</td>
<td>KHAN, Baldeep Kaur</td>
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<tr>
<td>E13027</td>
<td>Role of Radionuclide Techniques in the Diagnosis of Early Dementia</td>
<td>2003-07-01 to 2007-12-31</td>
<td>WATANABE, Naoyuki</td>
<td>2007-12-14</td>
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<td>E24012</td>
<td>Development of TLD-based quality audits for radiotherapy dosimetry in non-reference conditions</td>
<td>2001-12-15 to 2007-02-28</td>
<td>IZEWSKA, Joanna</td>
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<td>E24013</td>
<td>Development of procedures for quality assurance for dosimetry calculations in radiotherapy</td>
<td>2004-04-01 to 2007-12-06</td>
<td>VATNITSKIY, Stanislav</td>
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**G  Water Resources**

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<tr>
<td>F32003</td>
<td>Design criteria for a network to monitor isotope compositions of runoff in large rivers</td>
<td>2002-04-01 to 2006-12-31</td>
<td>VITVAR, Tomas</td>
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**H  Assessment and Management of Marine and Terrestrial Environments**

<table>
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<tr>
<td>K41008</td>
<td>Nuclear Applications to Determine Bioaccumulation Parameters and Processes used for Establishing Coastal Zone Monitoring and Management Criteria</td>
<td>2002-12-15 to 2005-12-14</td>
<td>WARNAU, Michel M.R.</td>
<td>2007-10-08</td>
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**I  Radioisotope Production and Radiation Technology**

<table>
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<td>F21009</td>
<td>Industrial Process Gamma Tomography</td>
<td>2003-03-15 to 2006-12-31</td>
<td>JIN, Joon Ha</td>
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**L  Management of Radioactive Waste**

<table>
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<th>Project Title</th>
<th>Duration</th>
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COORDINATED RESEARCH PROJECTS COMPLETED IN 2007

T21022  Characterization and Performance Studies and Demonstration in Underground Research Laboratories of Swelling Clays as Engineered Barriers of Geological Repositories
Duration: 2004-03-01 to 2008-02-29
Terminated: 2007-10-22
Primary Officer: GRAY, Malcolm Norman

T21023  New Development and Improvements in Processing of "Problematic" Radioactive Waste Streams
Duration: 2003-03-15 to 2007-03-14
Terminated: 2007-12-14
Primary Officer: DRACE, Zoran
### MAJOR PROGRAMME 1: NUCLEAR POWER, FUEL CYCLE AND NUCLEAR SCIENCE

<table>
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<tr>
<td>A.1 Nuclear Power Plant Operating Performance and Life Cycle Management</td>
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<tr>
<td>A.4 Technology Development for Advanced Reactor Lines</td>
<td>I2, I3</td>
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<td>B.1 Information and Analysis of the Nuclear Fuel Cycle and Materials Management</td>
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<tr>
<td>B.2 Nuclear Power Reactor Fuel Engineering</td>
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<tr>
<td>B.3 Management of Spent Fuel from Nuclear Power Reactors</td>
<td>T1</td>
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<tr>
<td>B.4 Topical Nuclear Fuel Cycle Issues</td>
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Appendix E
CRP No. 1152 (D15007)

CRP Evaluation Report

Title of the Coordinated Research Project:
Integrated Soil, Water and Nutrient Management for Sustainable Rice-Wheat Cropping Systems in Asia

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 2001-10-01 through 2006-11-30

Total Cost: € 308 405.11

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To improve the productivity and sustainability of rice-wheat cropping systems through increased efficiency of water and nutrient use.

(b) Specific (CRP):
To modify existing water and nutrient management systems, and improve soil management in both traditional and emerging (raised beds, non-puddled soil, direct seeding) tillage systems, for sustainable intensification of cereal production.

Outputs:

(a) Research:

a.1 Improved understanding of the dynamics and balances of soil nutrients and water under conventional and emerging tillage practices for rice-wheat production systems. Experiments have shown the effects of traditional flooded (flat puddled beds) and innovative aerobic (furrow irrigated raised beds, FIRB) cropping systems on crop yields, water and nitrogen dynamics. Rice yields in permanent raised beds and under direct planting were at least 20% lower than those in traditional flooded system. A higher N loss (20%) from applied N fertilizers was observed in raised beds, compared to the puddled transplanted system. The existing rice varieties used for traditional flooded system were found to respond adversely in raised beds with zero tillage.

a.2 Recommendations for improved soil, water and nutrient management in rice-wheat systems formulated. Participants assessed the impact of residue management and cropping systems on water and nutrient flows and developed strategies for management of external inputs of macro (N, P, K & S) and micro – nutrients. Mulching for rice and wheat gives variable responses across sites in comparison with non-mulched treatments and the reasons are poorly understood. Aerobic rice cultivation system (including intercropping) with straw mulch has been shown to be very successful in China and is recommended for adoption in high rainfall areas and those with polluted surface waters and in grain legume (soybean and peanut) cropping areas. Moreover, FIRB system offers prospects to improve WUE. However, current nitrogen fertilizer practices (forms, rates, timing, placement) used in FIRB/AC and flats result in poor use efficiency and potential adverse environmental effects including nitrate pollution of ground and surface waters and atmospheric pollution (ammonia, nitrous oxide), especially when overused.

a.3 Means to extrapolate experimental findings across the rice-wheat system developed. Modelling approaches using the CERES-rice and CERES –wheat embedded in the Decision Support System for Agrotechnology Transfer (DSSAT) were evaluated by the technical contractor J.K. Ladha (IRRI) to evaluate the most appropriate resource conserving technologies,
RCTs (tillage, direct-seeding, bed-planting) for different situations across the R-W areas. The results of the modelling study were presented at the annual meeting the American Society of Agronomy, New Orleans, November 2007. This modelling study suggests that wheat can be satisfactorily grown with various RCTs but for rice the RCTs need refinement to improve yield. The CERES model was able to capture the major effects of crop management with RCTs on rice and wheat yield but needs improvement for estimating N uptake by rice.

(b) Others:

b.1 NARS capacity to conduct integrated soil, water and nutrient management studies with the aid of nuclear techniques enhanced. Contract holders, most of them participants of the IRRI organized Rice-Wheat Consortium were trained in the use of nuclear and isotopic-based techniques in their research.

b.2 Research findings communicated to the wider community. Results of the project were summarized in IAEA Soils Newsletter and in the reports of the RCMs. In the course of the project, participants have disseminated the research results through publication of scientific papers, guidelines and conference communications and workshop presentations. An IAEA TECDOC containing 11 manuscripts from the participants is on preparation.

Effectiveness of CRP:

(a) In reaching Specific Objective:

This CRP demonstrated the importance of the integrated approach to crop, soil, water and nutrient management in evaluating the productivity of traditional and innovative rice-wheat systems. The use of nuclear and isotopic techniques was instrumental to provide an improved understanding of the dynamics and balances of soil nutrients and water under both systems. Under a favourable moisture regime, the novel aerobic cultivation could produce comparable yields as the flooded system with potential water savings of up to 100%. Although water savings can be considerable, some issues such as the yield reduction observed under water-limiting conditions and the losses of fertilizer N in gaseous forms need further investigation. New rice varieties will need to be developed to cope with aerobic conditions and the increasing incidence of water scarcity. The performance of wheat in terms of yield was satisfactory with zero tillage, either on flat or raised beds. The fertilizer N recovery was also similar (50-60%) in the conventional and zero-tilled practices but water savings of about 20% were possible on raised beds.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

This CRP developed integrated crop, soil, water and nutrient management practices for sustainable rice-wheat cropping systems in Asia using isotopic, nuclear and related techniques. Thus, this project with focus on the sustainable production of rice-wheat in Asia contributed to the objectives of project area E1.02 of the IAEA PWB 2001/2002-2003/2004-2005/2006-2007 "Development of soil management and conservation practices for sustainable crop production and environmental protection". The main objective of this project area is to improve soil conservation, sustainable crop production and environmental protection by identifying and promoting appropriate practices using isotopic, nuclear and related techniques.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

FIRBs are viable layouts in many situations in the short-term but studies on their long-term performance and resilience are beyond the scope of the CRP. Long-term experiments are required to assess the impact of the management practices developed on soil productivity and sustainability of the rice-wheat cropping systems. During the final RCM it was recommended to initiate long-term trials to properly study the impact of the new tillage–cropping management practices on water and nutrient cycling and fluxes. Some contractors found difficulties in organizing their data and writing manuscripts for publication.
Impact of the CRP:

The main results obtained from the CRP provide timely information on the management of rice-wheat systems for optimum crop production and conservation of water and nutrient resources. In view of its focused objectives, this CRP has generated information on the comparative advantages/limitations of rice-wheat cropping systems grown under aerobic cultivation against conventional flooded cultivation. It has been demonstrated that there was no loss of yield when rice was grown in aerobic soil in areas where annual rainfall was over 800-1200 mm and straw mulching was practiced. However in situations with lower annual rainfall, the existing paddy rice varieties produced lower yield on raised beds. New varieties will need to be developed to cope with aerobic rice culture and the increasing incidence of water scarcity. Nitrogen losses from N-15 labelled fertilizer were at least 20% higher under aerobic conditions compared to the conventional flooded system. Thus any potential water savings should be considered against the reduction in grain yield and the losses of fertilizer N. Regardless of the growing conditions, the efficiency of utilization of fertilizer N in rice or subsequent wheat crops did not exceed 60%, suggesting that effective N management to increase efficiency and reduce losses continues to be a top research priority.

Relevance of the CRP:

Rice and wheat are the two most important cereals for world food security. The rice-wheat production system occupies 21 million ha of cultivated land in the Asian subtropics. In south Asia, the system occupies about 13 million ha, extending across the Indo-Gangetic flood plain into the Himalayan foothills. The rice-wheat production system provides staple grain for more than 4000 million people, approximately about 80% of world’s population. Waterlogged cultivation of transplanted rice is the traditional practice, consuming more than 80 % of the freshwater used in agriculture. A novel approach to save water is to grow rice on raised beds (aerobic) instead of continuously flooded paddies (anaerobic). These same beds can be used to grow wheat in rotation with rice. The CRP involving participants from Australia, China, Bangladesh, Nepal, India and Pakistan, examined this novel approach against the traditional system in term of crop yield and their influence on integrated soil-water-nutrient management using nuclear, isotopic and related techniques.

Recommended future action by Agency:

Future actions to develop new initiatives have been taken. A Consultants Meeting on “Selection and development of germplasm tolerant to nutritional stress in tropical crops” has been held in Vienna, July 2005 and a new CRP D1.50.10 on this subject has been initiated. A new CRP on “Conservation Agriculture” (D1.50.09) was also initiated.

Resulting Publications:

- Internal: An IAEA TECDOC (11 manuscripts) is in preparation
- External: A total of 60 papers generated by the participants. They are classified as follows: 47 journal and conference papers published; 5 papers to be submitted and 8 communications in conference proceedings.
Title of the Coordinated Research Project:

Improvement of Tropical and Subtropical Fruit Trees through Induced Mutations and Biotechnology

Section/Division:

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered:

2000-08-01 through 2005-12-31

Total Cost:

€ 400 709.98

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

To generate and characterise radiation induced and natural genetic diversity in tropical and subtropical fruit trees for improving nutrition balance, food security, and enhancing economic status of growers in Member States.

(b) Specific (CRP):

- To overcome major constraints in plant regeneration by tissue culture for large-scale multiplication of desirable induced mutants in order to sustain natural and induced fruit tree biodiversity leading to an improved economic viability of growers and nutrition component of their diets.
- To assess the impact of induced mutants on fruit yield and quality components, depending on the fruit tree life cycle, under the field conditions.
- To assess the root stocks of induced mutants, especially those tolerant to abiotic and biotic stresses, for grafting and their impact on yield.

Outputs:

(a) Research:

a) An avocado mutant gene bank with induced mutants was established, which will be very useful in preserving genetic diversity for future uses in tree improvement and molecular biological studies.

b) The usefulness of Simple Sequence Repeats (SSR) and Amplified Fragment Length Polymorphism (AFLP) markers for genotype identification and for the assessment of genetic diversity in cultivated avocado, tangerine, guava, etc. varieties was demonstrated through transfer of techniques for molecular characterisation and cloning of mutated genes between partner laboratories.

c) Optimal irradiation doses have been established for exotic fruits such as; Lichi, Guava, Annona, Pitanga, Jaboticaba and Carambola through technologies transfer of on induced mutations and in vitro culture between partner laboratories.

d) A comprehensive, informative, up-to-date central data base including all the CRP generated data (see resulting publications).

e) An informative and interactive webpage describing the participants and the research programme highlighting the assembled database is available through the IAEA system.
f) The productivity of Tangerine (*C. reliculata*) and pummelo (*C. grandis*), which are regarded as economically important species of citrus in many countries may benefit now from mutated lines produced through the CRP as a basis for breeding purposes.

(b) Others:

**New Mutant Lines**

**Model Crop and First Priority Tree Crops**

Clonal propagation and field evaluation of mutants that exhibit desirable traits such as disease resistance, seedlessness, long shelf-life has been established for fruit trees such as: avocado, guava, and tangerine.

**Second priority tree crops**

a) Development of tissue culture protocols such as somatic embryogenesis could be an interesting alternative for recalcitrant fruit species such as avocado and exotic fruit trees (Litchi, Carambola, and Jobotica).

b) Exotic fruits are ideal for introduction into resource poor farmers programmes and are suitable for intercropping: Carambola – *Averrhoa carambola*, Cherimoya – *Annona cherimola*, Pitanga – *Eugenia uniflora*, and Jaboticaba – *Myricaria cauliflora* have been introduced in a mutation induced breeding programme for the first time for improvement of seedlessness (pitanga and jaboticaba), improved shelf-life and improved fruit set (Annona).

**Effectiveness of CRP:**

(a) In reaching Specific Objective:

The CRP led to the introduction, often for the first time in the participating countries, of radiation induced mutations in their breeding programme. Screening techniques have been designed and tested for: disease resistance (*Phytophthora cinnamomi* for Avocado, for example), dwarfness and seedlessness (Tangerine, Guava). The putative mutant lines are under further field screening before being proposed for certification. The CRP thus fully reached the objective of improving nutrition balance, food security, and enhancing the economic status of growers in Member States.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

As stated in the initial document this CRP was created to allow research groups to establish a scientific basis to close the gap between the limited mutant resource and the full range of phenotypes that is essential to fully exploit tropical and subtropical tree crops. Many fruit trees that were “unknown” to researchers are now fully integrated in breeding programmes in different countries and will surely participate in increasing food and economic security by ensuring sustainable crop production and increase in yield and quality.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Even though some of the specific objectives, which appeared quite ambitious have not been fully achieved, the CRP established the scientific background for further research in molecular characterisation and/or genes discovery by initiating genetic variability in several fruit species directed to specific traits, the genes of which may later on be researched by comparison to model plants.

**Impact of the CRP:**

- Increased fruit yield and raised fruit quality.
- Improved clonal propagation and mass multiplication systems.
- More rapid recovery of useful mutants displaying bacterial and/or fungal disease resistance.
- Production of disease-free planting stocks.

Appendix E.5
Relevance of the CRP:

- The use of tropical and sub-tropical fruit trees as a tool for economic development and political stability involves the removal of a number of obstacles, including biotic and abiotic stresses, and post-harvest losses. Biotic stresses are probably one of the most important factors limiting the expansion of tropical and subtropical tree crops in the developing world. Diseases caused by *Fusarium*, *Phytophthora* and *Colletotrichum* combined with insect and nematode pests account for significant losses of produce, and/or trees.

- To increase the impact of these crops on local consumption, increased nutritional value is highly important. The use of mutation induction and molecular characterisation of the newly developed mutant lines may have a great impact in the rapid expansion of these industries through the development of more appropriate propagation techniques.

Recommended future action by Agency:

- The Agency should continue to support participating countries on further research and evaluation of the mutants generated from this CRP, especially for nutritional quality and acceptability by consumers.

- The Agency should also continue to support the development of adequate mechanisms for the release of the improved varieties that might result from these efforts should also be established to allow a large dissemination of these results.

- Many of the researchers involved in this CRP have now acquired solid skills in mutation induction and screening technologies, therefore it is recommended that the Agency assist in human resource development activities to allow the dissemination of know-how and benefit researchers from various Member States.

Resulting Publications:

A book including the contributions from all participants in the CRP is being published.
CRP No. 1280 (D32021)

CRP Evaluation Report

Title of the Co-ordinated Research Project:
Developing, Validating and Standardising Methodologies for the Use of PCR and PCR-ELISA in the Diagnosis and Monitoring of Control and Eradication Programmes for Trypanosomosis

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 2000-11-15 through 2006-02-28

Total Cost: € 401 598.92

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To assist African countries to more effectively monitor and progressively control or eradicate tsetse flies and trypanosomosis.

(b) Specific (CRP):
To developing, validate and standardise methodologies for the use of PCR and PCR-ELISA in the diagnosis and monitoring of control and eradication programmes for trypanosomosis.

Outputs:

(a) Research:
The use of ITS primers for the diagnosis of trypanosomoses was successful and validated protocols for the entire test (sample taking, processing and testing) are available. A large amount of data was produced on the epidemiology of trypanosomes in man and animals, using specific primers. A Trypstick test was developed allowing PCR product detection without the need to run samples on gels.

(b) Others:
A network of laboratories with increased awareness and use of quality control was set up.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The CRP was most effective in producing agreed validated methods.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The use of ITS primers for the routine diagnosis of trypanosomoses is established. This will greatly help routine surveillance of trypanosomiasis in a single test and also monitoring of the effect of interventions, e.g., in Tsetse eradication programmes.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
Initial needs to refurbish some laboratories. Failure of technology transfer of the ELISA antibody tests produced by IAEA. Need for staff to improve skills.
Impact of the CRP:

Technology transfer of molecular techniques was complemented greatly. Agreement on methods and quality control issues was greatly improved.

Relevance of the CRP:

Highly relevant. Validated tools are provided to assess control programmes.

Recommended future action by Agency:

Support for trypanosomal diagnosis should be maintained, particularly in the light of the SIT work made at the Agency where methods for assessing the impact of intervention in populations are needed.

Resulting Publications:

TECDOC 1559 ‘Developing Methodologies for the Use of Polymerase Chain Reaction in the Diagnosis and Monitoring of Trypanosomosis’ (2007).


4. CLAES, F., RADWANSKA, M., URAKAWA, T., MAJIWA, P., GODDEERIS, B., BÜSCHER, P. Variable surface glycoprotein RoTat 1.2 PCR as a specific diagnostic tool for the detection of Trypanosoma evansi infections, Kinetoplastid Biology and Disease 3, 1-6 (2004).

5. CLAES, F., RADWANSKA, M., URAKAWA, T., MAJIWA, P., GODDEERIS, B., BÜSCHER, P. Variable surface glycoprotein RoTat 1.2 PCR as a specific diagnostic tool for the detection of Trypanosoma evansi infections, Kinetoplastid Biology and Disease 3, 1-6 (2004).


Title of the Coordinated Research Project:
Enabling Technologies for the Expansion of SIT for Old and New World Screwworm

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 2001-08-01 through 2007-03-31

Total Cost: € 278 296.90

Objectives of CRP:
(a) Overall (Agency Project towards which CRP directed):
To enhance the efficiency of the implementation of SIT for screwworms and to reduce risk associated with the introduction of screwworm into new areas.

(b) Specific (CRP):
To establish genetic relationships between populations of Old and New World screwworms.
To identify the origins of new outbreaks in order to improve quarantine regulations.
To develop a genetic sexing strain for New World Screwworm.

Outputs:
(a) Research:

1. Development and optimisation of new genetic markers for OWS and NWS
An optimised suite of molecular genetic markers that include: mitochondrial and nuclear DNA sequence markers, associated RFLP analysis, and microsatellite loci have been developed for these two species.

2. Population genetics of NWS
NWS populations from across the range of the species, from Uruguay in the south to Cuba in the north, have been subjected to molecular analysis. Populations have been analysed by microsatellite analysis, and by sequence/RFLP analysis of three gene markers (COI+II, Control region/12S rRNA, EF1alpha) in two separate laboratories, UNICAMP, Campinas, Brazil and University of Exeter, UK.

3. Analysis of E3 OP resistance gene in NWS
In an additional study, part of the E3 gene in NWS (ChaE7) was isolated and characterized. This region contains the gene responsible for resistance to organophosphorous insecticides in Lucilia cuprina. A PCR-RFLP assay therefore provided a fast, reliable DNA-based method for identifying NWS individuals with a mutation in this gene.
4. DNA database for OWS populations world-wide enabling improved risk assessment protocols for potential new outbreaks to be developed.

Initial cladistic analyses of mitochondrial DNA sequences of OWS gave strong support for recognizing two races of OWS, one from sub-Saharan Africa and the other from the Gulf region and Asia. The latter race could be further sub-divided into two lineages, i.e., one from mainland Asia (from the Gulf to the Malay Peninsula) and the other from two islands of Papua New Guinea.

5. Better laboratory strains of the OWS

Laboratory colonies were developed in Iraq, Iran and Indonesia. These were able to routinely produce up to 20-30,000 adult OWS per generation (Iraq/Indonesia).

6. Genetic transformation of NWS

Transformation was achieved in the NWS at the ARS Midwest Livestock Insects Lab in Lincoln, Nebraska, (see Allen et al. Med. Vet. Entomol., 18:1, 2004). A P95 wild lab-strain of NWS was the host for transformation with a piggyBac vector marked with polyubiquitin-regulated enhanced green fluorescent protein (EGFP) (pB[PUb-nls-EGFP]).

7. Fitness of transgenic lines

The fitness of eight transgenic strains of NWS with comparison to the wild-type parental laboratory strain (P95) in colony was examined.

8. Genetically marked NWS

The existing transgenic strains marked with EGFP may be considered for release, but fluorescent protein markers can now be introduced with new transgene vectors that can be stabilized by deletion of terminal sequences.

9. Remote sensing and NWS eradication

Satellite imaging was used to select preferred habitats of screwworms which were discovered on the island of Aruba where ground release stations for sterile insect releases were then located. The screwworm infestation was eliminated in less than 9 months.

10. Diffusion model for movement of sterile NWS

Sterile flies, marked with fluorescent powder, were released from an airplane in a flight-line perpendicular to the center of a 10 km trap-line, with data showing that the current release rate and pattern were correct for continued use in the barrier but that the width of the barrier-zone could be reduced.

11. NWS as vectors for highly contagious viral diseases

Viruses were not detected on the screwworms when reared in the normal larval media containing formalin as the antibiotic. These results help ensure that when developing new strains of screwworm that highly contagious diseases will not be moved to new areas.

13. Improvements to NWS rearing

Cellulose fiber was tested and shown to be superior to previous gelling agents used in the larval medium. Cellulose fiber was adopted by the mass rearing facility and the optimum level of blood protein was determined which, when fed to adults, optimized egg production.

14. Genetic maps for NWS

Six mutant strains of screwworm were characterized by crosses to wild-type strains. These strains were used in backcrosses (test crosses to the male mutant) and then subjected to genetic analysis using Amplified Fragment Length Polymorphism. Results indicated four linkage groups.
15. Polytene chromosome maps for NWS

Polytene chromosome maps have been developed for NWS and will be an essential component of the development of a genetic sexing system based on classical genetics.

(b) Others:

- Enhanced collaboration among and between South American, European, and North American laboratories

- Capacity building in South America

- Fellowship support and two young researchers have started their PhD studies at participating institutes.

- Focused international attention on the contribution of genetics to efficacious area-wide screwworm fly control

- Research studies of genetic diversity, behaviour and control of *Wohlfahrtia magnifica* in the Mediterranean Basin. Stimulation of the write up of past studies of NWS trap development.

- Recruitment of new workers into the screwworm fly community

Effectiveness of CRP:

(a) In reaching Specific Objective 1: To establish genetic relationships between populations of Old and New World screwworms.

Overall, research focusing on genetic relationships between populations of New World screwworm flies suggests moderate to high genetic variability across the current range of the species.

For OWS, specific, geographically isolated haplotypes were identified that can be used to indicate the origin of some potential movements of OWS, either by natural dispersion or, more likely over long distance, by human activity (e.g. livestock shipments).

Specific Objective 2: To identify the origins of new outbreaks in order to improve quarantine regulations

The tools developed and the results obtained to date provide a framework for potential epidemiological tracking of flies from their population of origin to new areas.

Specific Objective 3: To develop a genetic sexing strain for New World Screwworm.

The genetic analysis of male linked translocations and selectable markers could not be carried out. However, work on developing transgenic techniques for screwworms was enhanced as was work in developing understanding of genetic linkage through other contracts and collaborations.

(b) In contributing towards Overall (i.e. Agency Project) Objective: To enhance the efficiency of the implementation of SIT for screwworm and to reduce risk associated with the introduction of screwworm into new areas.

Studies of OWS population genetics demonstrated geographical populations that could rapidly identify the source of introductions of screwworm, thereby enabling action to be taken to close down the route of introduction, reducing the risk of potential introductions to other uninfested areas through the same route.
The question of genetic compatibility of released, sterile mass reared flies and their wild conspecifics has not been investigated directly, but genetic studies of natural populations do not in general show high levels of population structure.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Problems in coordinating sampling support early in the project were encountered but largely resolved after the 3rd meeting by the appointment of an IAEA consultant.

It quickly became apparent that we needed political and administrative support for sampling from all relevant countries, e.g. Argentina. In future, ideally the Agency would provide support to talk directly to relevant personnel (e.g. national veterinary coordinators, health service administrators) within all countries not directly represented in the CRP.

Some difficulties were experienced in Indonesia with inadequate levels of staffing over certain periods to collect samples from the field, as there was no replacement of staff during their secondment on training. As a result of the breakdown in security in Iraq and problems with the electricity supply, the colony level has presently been reduced to a minimal level of about 500 adults.

Impact of the CRP:

1) Improved decision making for future NWS SIT programmes in South America through an assessment of patterns of genetic variability in contemporary field populations.

2) Successful genetic transformation in NWS opening up the way for a variety of strategies for improved SIT and biocontrol using recombinant DNA. Fundamental genomics analysis will also be possible in NWS.

2) Cryopreservation enables transgenic germ plasm to be stored for future use avoiding expense and fitness costs associated with rearing, and the loss of genetic resources during transitions in rearing capabilities.

3) Demonstration that some NWS transgenic strains have fitness equivalent to the non-transgenic host laboratory strains.

4) Several new vectors systems are now available for testing in NWS that should allow more highly efficient and ecologically safe SIT and conditional-lethal based strategies for biocontrol.

5) Sufficient progress on transgenic research has stimulated the potential of collaboration between the ARS-Screwworm Research Unit and ARS-U.S. Livestock Insects Laboratory in Kerrville, TX.

Relevance of the CRP:

The CRP succeeded in focusing attention of investigators on the necessity of understanding the genetic basis of parasite populations and collecting relevant baseline data to inform the management of subsequent SIT control programmes.

Recommended future action by Agency:

Training

The establishment of reciprocal fellowships between South American institutions could greatly facilitate interest in the screwworm fly problem to further institutional capacities and scientific progress. Specifically, we recommend establishing a programme to support the training of personnel in the ecology and population dynamics to support and direct the interpretation of genetic data. The programme would cover both theory and practice.
A. Field techniques

- Geographic information systems
- Mark-release-recapture training
- Representative sampling and analytical procedures
- Equipment, software and resources necessary to accomplish the foregoing

B. Laboratory practice

- Microsatellite library development, use of high-throughput automated microsatellite analysis, including training in multiplex design and interpretation of electropherogram outputs, primer design and DNA sequencing
- Exercises in phylogenetics and population genetic statistics using a range of current software

Capacity building: regional centres and human resources

Support is required for personnel to undertake microgeographic studies across the range of the NWS. Ideally, three studies would be undertaken at the extremes of the range, e.g. in Cuba, mid-West Brazil, Uruguay. Such microgeographic studies would allow a range of population characteristics to be investigated: temporal stability, population structure and population dynamics. At present, the definitive interpretation of population genetics data is being held back by a lack of knowledge concerning these factors. Each study would require a dedicated scientist to undertake and coordinate the research; funding would be necessary for these personnel and all associated equipment, software and consumables.

Establishment of a central database

To facilitate sharing and dissemination of information, all data generated by the activities of the CRP (and continuing activities) should be coordinated and maintained on a central database.

Continuing support for population genetic analysis

While coverage of NWS populations has been adequate to gain an insight into broad patterns of genetic variation within the species, a number of key areas remain to be sampled and analysed, e.g. central Brazil, northern and western South America, particularly regions west of the Andes.

Movement of biological material

Shipping biological materials, such as DNA, ethanol-preserved screwworm flies and cryopreserved materials, is becoming extremely difficult. We therefore recommend the agency keep scientific collaborators and applicators appraised of rules and laws regarding GM organisms and work to lessen shipping problems.

A new CRP is required

For all the foregoing reasons, a new CRP would greatly encourage and support progress in the control and eradication of New World Screwworm fly. It would do so by providing research and outreach focus on obtainable goals, disseminating fundamental scientific knowledge, new scientific applications, and, above all, encourage technology transfer from ‘rich’ countries to South American countries directly affected by this parasite.

Resulting Publications:

The results of the CRP will be published as full papers in the journal Medical and Veterinary Entomology. The following is a list of papers published during the course of the CRP.


Carvalho, R. A., T. T. Torres and A. M. L. Azeredo-Espin A survey of mutations in the Cochliomyia hominivorax (Diptera: Calliphoridae) esterase E3 gene associated with organophosphate
resistance and the molecular identification of mutant alleles. *Veterinary Parasitology*, 140: 344-351


Title of the Coordinated Research Project:
Evaluating the Use of Nuclear Techniques for the Colonization and Production of Natural Enemies of Agricultural Insect Pests

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 1999-08-01 through 2005-05-31

Total Cost: € 357 522.88

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To increase the cost-effectiveness, trade and safety in the use of biological control agents of insect pests of agriculture.

(b) Specific (CRP):
To assess the potential roles nuclear techniques can play in improving production, and facilitating trade and use of quality biological control agents in integrated pest management.

Outputs:

(a) Research:
The wide range of research performed during the CRP was aimed at exploring the potential of using nuclear techniques in facilitating the various applications of biological control agents against insect pests in agriculture.

Specific outputs achieved:
1. Procedures developed for production of three biological control agents using irradiation.
2. Procedures developed for facilitating shipping of two natural enemies using irradiation.
3. Procedures assessed for using in the field sterile hosts of two insect pests to supplement natural enemies.
4. Procedures assessed for integrating in the field SIT/inherited sterility and biological control for two insect pests.
5. Procedures under development for evaluating under natural conditions two exotic biological control agents for confirmation of host specificity.

(b) Others:
Enhanced networking and collaboration among and between natural enemy researchers, and laboratories and institutions working on enhancing biological control of pest insects.

Capacity building in the biological control of insect pests.

Fellowship support for some researchers to obtain specific training in other Member States.

Focused international attention on the recruitment of new researchers into the use of nuclear techniques in biological control.
Various degrees and postdoctoral positions resulted from students/research groups participating in this CRP.

**Effectiveness of CRP:**

(a) In reaching Specific Objective:
The CRP successfully met its specific objectives. Many potential roles were identified and investigated including (1) improving rearing media/host and utilising by-products of mass rearing facilities, (2) addressing some shipping-related problems concerning live hosts for natural enemies, (3) using of sub-sterile or sterile hosts or prey in the field as supplemental food to natural enemies, (4) facilitating the complementary and integrative use of biological control with the SIT or inherited sterility, and (5) exploring the potential for using reproductively inactivated exotic agents for confirmation of host specificity of potential biological control agents, and for exploration and collection of new natural enemies.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The overall objective was met. Nuclear techniques investigated during the CRP have been established in practical application to reduce the cost of pest biological control, reduce the dependency of insecticides, and increase the effectiveness and safety in the use of natural enemies. Producers of natural enemies, industry, growers, scientists, and regulatory agencies are adopting many of these techniques.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

1. Appropriateness of the CRP:
The CRP covered the very broad field of biological control. Nevertheless, this was appropriate in view that it was the first CRP in this field and the use of nuclear technique in relation to natural enemies is a largely unexplored topic with only a limited amount of basic references available.

2. Formulation of the CRP:
The CRP was largely based on the recommendations of a consultants meeting. It was well formulated and the challenge to properly address a very broad new subject area was met by developing sub-groups, which focused respectively on the main areas of potential application of nuclear techniques in biological control.

3. Management problems during implementation of the CRP:
   Location and Timing: Two RCM had to be redirected and held in Vienna in view of unforeseen circumstances (problems to secure host country agreement in one case and war in neighbouring country in another). There was also some delay in holding the RCMs because of the location problems.

4. Intellectual, financial and other inputs from participants:
There were considerable inputs from most of the various participating institutions.

**Impact of the CRP:**

1. Demonstrated the utility of sub-standard and excess material produced in mass-rearing facilities for rearing biological control organisms, thus increasing the cost efficiency of rearing operations and improving the control options and potential of area-wide management programmes.

2. Demonstrated the potential of irradiation to extend the suitability of host material for exposure to parasitoids and predators.

3. Increased efficiency of biological control programmes by eliminating the need to separate non-parasitized host material from parasitoid emergence containers.

Appendix E.18
4. Provided an additional host specificity-testing tool (use of F1 sterility) to assess the safety of lepidopteran species being considered for release in classical biological control.

5. Demonstrated the utility of irradiation to suppress, and thus elucidate, host immune responses, and to take advantage of immuno-suppressed hosts to facilitate and improve the production of natural enemies and allow the use of easier to rear factitious hosts.

6. Demonstrated the benefits of supplementation of irradiated hosts early in the season to build up natural enemy populations, or during critical periods to facilitate the survival of biological control agent populations.

7. Developed a basic tool for studying complex host-natural enemy interactions.

8. As a result of the CRP, this area of applied entomology has been added to a university curriculum.

9. Policy-makers have been made aware of the potential and benefits of this technology.

**Relevance of the CRP:**

*New emerging thrust area*

Nuclear techniques have been found to be very relevant to this until now unidentified area. It has been recognized as an emerging thrust area.

*Application in biological control (production, trade, and conservation)*

The results offer great practical application in production, trade, and conservation of natural enemies. Using radiosterilized hosts offers a means for eco-safe (risk free mode) of transport and release of natural enemies. Radiosterilized host/prey (pest) insects are environmentally safer and more effective for both inundative and inoculative releases of natural enemies. In addition, low doses of radiation can be used in enhancing production and the efficiency of natural enemies.

*Tool in basic science*

Irradiation has been shown to be a useful tool in developing an in-depth basic understanding of pest - natural enemy interactions.

**Recommended future action by Agency:**

*Follow-up Activities*

Certain related and pertinent emerging research topics have been identified that merit further investigation. It is recommended that some of these new areas related to biological control and nuclear techniques be considered for developing a future CRP.

There is the need to explore various possibilities of using alternative and more cost-effective sources of irradiation to facilitate in the future the application by end-users of radiation in biological control.

*Training and Capacity Building*

The Agency should continue critically important training programmes for related insect radiation biology studies. Efforts should continue to pursue opportunities of holding RCMs in conjunction with relevant training workshops and/or international meetings.
Resulting Publications:

1. Research Results Initially Published:


Appendix E.20


Appendix E.21


2. The final results of the CRP were peer-reviewed and published in 2006 as full papers in a dedicated issue of the respected UK journal BIOCONTROL SCIENCE AND TECHNOLOGY. The following manuscripts are included:


J. Cancino, L. Ruiz, and P. López. Irradiation of different aged larvae of Anastrepha spp. and Ceratitis capitata (Wiedeman) (Diptera: Tephritidae) as hosts for Diachasmimorpha longicaudata (Ashmead) and Diachasmimorpha tryoni (Cameron) (Hymenoptera: Braconidae): Implications for quality control in parasitoid mass rearing.

J. Cancino, L. Ruiz, J. Pérez and E. Harris. Irradiation of Anastrepha ludens (Loew) Eggs for the Rearing of the Fruit Fly Parasitoids, Fopius arisanus (Sonan) and Diachasmimorpha longicaudata (Ashmead) (Hymenoptera: Braconidae).

J. Cancino, L. Ruiz, J. Sivinski, F.O. Gálvez, and M. Aluja. Rearing of five hymenopterous larval-prepupal (Braconidae, Figitidae) and three pupal (Diapriidae, Chalcidoidea, Eurytomidae) native parasitoids of the genus Anastrepha (Diptera: Tephritidae) on irradiated A. ludens larvae and pupae.


B. Fatima, N. Ahmad, M. Bux, R.M. Memon and M. Sattar. Use of nuclear techniques for economical production of parasitoids and their application for area-wide control of sugarcane borers. (will be published in two separate papers).

N.P. Genchev, R.Y. Milcheva and M.I. Velichkova. Use of gamma radiation for suppression of the hemocytic immune response in larvae of Galleria mellonella (Lepidoptera) against Venturia canescens (Hymenoptera).

N.P. Genchev, N.A. Balevski, D.A. Obretenchev, and A.D. Obretencheva. Stimulation effects of low gamma radiation doses on the parasitoids Habobracon hebetor (Braconidae) and Venturia canescens (Ichneumonidiae).

M. Hamed, S. Nadeem, and A. Riaz. Use of gamma radiation for improving the mass production of beneficial insects.


B. Hepdurgun, T. Turanli and A. Zümreoglu. Four-year experiment in Turkey in the control of olive fruit fly (Bactrocera oleae (Gmel.) by means of mass trapping and parasitoid release (Psyttalia concolor Szepl.).

G. Hoch, R.C. Marktl and A. Schopf. Gamma radiation-induced pseudoparasitization as a tool to study interactions between host insects and parasitoids in the system Lymantria dispar (Lep., Lymantriidae) - Glyptapanteles liparidis (Hym., Braconidae).

G. Saour. Effect of early oviposition experience on host acceptance in Trichogramma (Hymenoptera: Trichogrammatidae) and application of F1 sterility and T. principium to suppress the potato tuber moth (Lepidoptera: Gelechiidae).

R.K. Seth, T.K. Barik and S. Chauhan. Interaction of entomopathogenic nematode, Steinernema glaseri (Rhabditida: Steinernematidae) derived from irradiated host with F1 Sterility towards management of a tropical pest, Spodoptera litura (Fabr.) (Lepidoptera: Noctuidae).

C.D. Tate and J.E. Carpenter. Role of Inherited Sterility in risk assessment of biological control agents of weeds: Influence of radiation treatment on Cactoblastis Cactorum (Lepidoptera: Pyralidae) host preference for oviposition.

A.S. Tuncbilek, U. Canpolat and A. Ayvaz. Parasitization efficiency of Trichogramma evanescens on irradiated host Mediterranean flour moth, Ephesta kuehniella Zeller and Angoumois grain moth, Sitotroga cerealella (Olivier) and biocontrol potential of parasitoid derived from irradiated host.

A.S. Tuncbilek, U. Canpolat and F. Sumer. Use of radiation in extending the duration of host suitability for managing Ephiesta kuehniella and Sitotroga cerealella by egg-parasitoid, Trichogramma evanescens.

E. Wang, D. Lu, X. Liu, and Y. Li. Evaluating the use of nuclear techniques for colonization and production of Trichogramma chilonis in combination with releasing irradiated moths for control of cotton bollworm, Helicoverpa armigera.

M.C. Zapater, C.E. Andiarena, G. Perez-Camargo and N. Bartoloni. Use of irradiated Musca domestica pupae to optimize the mass rearing and commercial shipments of the parasitoid Spalangia.

M. Zúbrik and J. Novotný. Impact of gamma radiation on the developmental characteristics of the gypsy moth (Lymantria dispar L., Lep.: Lymantriidae) larvae.

Appendix E.23
Title of the Coordinated Research Project:
Quality Control of Pesticide Products

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 2000-12-01 through 2006-09-30

Total Cost: € 299,535.60

Objectives of CRP:
(a) Overall (Agency Project towards which CRP directed):
To assist national pesticide control agencies to control and assure the quality of pesticide products and hence support legislation concerned with food quality and environmental protection.

(b) Specific (CRP):
• Elaborate and validate GC and HPLC separation and detection conditions suitable for the analysis of a number of pesticides singly or in combination.
• Test the applicability of uniform instrumental analytical conditions for selected pesticides which are used in the countries of the participating laboratories.
• Introduce appropriate internal quality control measures for assuring reliable results.
• Compare the results obtained with pesticide multi-methods with those obtained with commonly used CIPAC/AOAC procedures.
• Validate the new procedures according to the criteria of the AOAC Peer Verified Method Programme.

Outputs:
(a) Research:
Multi-pesticide methods were elaborated and validated for about 20 pesticide formulations manufactured by various companies. Analytical quality assurance and quality control (QA/QC) procedures were established and introduced in the participating laboratories as standardised procedures. This improved the technical and management capabilities of the laboratories and facilitated implementation of legislation by national authorities.

(b) Others:
Analytical methods and procedures were introduced in the participating laboratories towards simplifying and rationalizing widely used CIPAC/AOAC methods. After the 3rd RCM, the running time of the CRP was extended to conduct an interlaboratory comparison in order to evaluate newly developed methods in the daily laboratory practice by comparing the results obtained by the CRP participants.

Effectiveness of CRP:
(a) In reaching Specific Objective:
The main targets and specific objectives of the CRP were accomplished. Despite the fact that several laboratories did not participate continuously during the overall CRP, a number of
satisfactory and good results were obtained which will serve as the basis for considering a TECDOC and separate publications, respectively.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The safe use of agrochemicals and its control and surveillance are essential requirements for the protection of health both on the application side as well as for the consumer of agricultural produce. The results of the CRP contribute in the set-up and facilitation of pesticide registration, formulation control and surveillance by governments.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
The original CRP work plan was affected by unforeseen adverse events, i.e., as a consequence of the 2001 terrorist attacks, the planned distribution of synthesized pesticide impurity compounds to be used for interlaboratory comparison became impracticable. These had been synthesized by one of the CRP participants but could not be shipped to the other participants due to severe restrictions in air transportation.

Impact of the CRP:
The results of the CRP enable pesticide control laboratories to apply multi-method approaches in pesticide formulation analysis, resulting in saved time, reduction of the consumption of expensive solvents and reference materials. Analyses can be done at an equivalent level of quality and reliability compared with the peer validated but laborious CIPAC/AOAC methods commonly used so far.

Relevance of the CRP:
The outcomes of the CRP provide economical alternatives for pesticide control laboratories to use alternative analytical methods. They can be applied for several compounds at a time instead of performing analysis on a single compound approach. This is relevant in particular for laboratories in developing countries which have limited access to laboratory material, like high purity solvents and standards, and high tech analytical equipment.

Recommended future action by Agency:
There is no immediate further action recommended as a direct follow-up of this CRP. However, the problem of pesticide control continues to create serious problems in many Member States. As already realized in certain TCPs, the Agency in the future should help MS in need of setting up a registration and control system for chemicals used in agriculture. Also the application of radionuclides in such projects is particularly useful in terms of the development and validation of analytical methods.

Resulting Publications:
Data derived from the CRP have been synthesized. Components of the results are intended to be published in line with the compilation of the results towards the respective TECDOC.
Title of the Coordinated Research Project:
Irradiation to Ensure the Safety and Quality of Prepared Meals

Section/Division: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Period Covered: 2001-11-23 through 2006-05-22

Total Cost: € 256 376.66

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To evaluate the effectiveness of irradiation as a method to ensure the microbiological safety and extend the shelf-life of prepared meals, stored under ambient, chilled or frozen conditions, and to evaluate the sensory quality of the treated products.

(b) Specific (CRP):
To use validated procedures for irradiation treatment and process control, and to use validated methods for assessing the microbiological safety and quality as well as the sensory quality of prepared meals, mainly of ethnic origin.

Outputs:

(a) Research:
The efficacy of radiation processing for microbiological safety and quality of more than 50 prepared meals was studied.

Most of these meals (more than 30) were prepared with beef, chicken, pork, mutton or prawns as a major component. The optimum gamma radiation doses were found to be in the range of 2 to 4 kGy for a majority of these meals to achieve microbiological safety and desired sensory quality. In general, the shelf-life of the meals was extended from one week to more than three weeks at chilled temperatures depending upon the characteristics of the meals.

Prepared meals based on vegetables and /or fruits and other miscellaneous meals were also investigated. For instance, studies on two of the most popular vegetarian meals consumed in India, concluded that these meals treated with 2 kGy were microbiologically safe, with a shelf-life of a month. Other meals, such as vacuum packaged frozen soups, treated with 5-7 kGy were preserved for 3 months without impairing sensory quality.

In addition to the general achievements, some participants carried out studies on the following issues: 1) Predictive microbiological modeling; b) Hazard Analysis Critical Control Point (HACCP); 3) consumer studies and 4) studies with immunocompromised patients; in fact, studies carried out with fruit salad, custard and bread pudding showed that radiation processing could be used as a decontaminating process for meals to be consumed by this type of patients.
Effectiveness of CRP:

(a) In reaching Specific Objective:
Most of the participants used internationally recognized standard methodologies such as the methodologies adopted by the Association of Official Analytical Chemists (AOAC), American Society for Testing Materials (ASTM), published by the Food and Drug Administration in the USA (Bacteriological Analytical Manual), as well as others.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The overall objective was met. The work done is now supporting scientifically the application of irradiation technology as an effective method to ensure microbiological safety of a wide variety of prepared meals. This application has an important potential in the near future due to the increasing trend in the consumption of prepared meals in developed and developing countries, including ethnic meals.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
None

Impact of the CRP:
The CRP demonstrated that radiation processing of prepared meals results in safer food by eliminating pathogens and extends the shelf-life by decreasing the number of spoilage organisms without significantly jeopardising the overall quality. However, the work also highlighted the complexity and technological challenges of using radiation processing for multi-component food systems such as prepared meals.

The safety of radiation processed products was demonstrated using challenge tests / inoculated pack studies with various pathogenic test organisms or their surrogates. Such products could satisfy or fulfil several niche markets. However, proper storage temperature and maintenance of the “cold chain” is a crucial factor of food safety and stability. Oxidative changes are sometimes enhanced by radiation treatment but counteracting such changes by proper packaging conditions and using efficient antioxidant additives has been demonstrated.

The implementation of a HACCP substantially reduced microbial counts; however, some potential pathogens survived. Although the HACCP plan requires that the ready meals were held at 0 to -5°C in order to suppress growth of survivors, the latter could proliferate during temperature abuse when power outages occur. Strict hygienic practices during the manufacture of prepared meals are also a prerequisite for the successful application of irradiation in order to ensure the safety, quality and extended shelf-life of the prepared meals.

Relevance of the CRP:
In view of the increasing trend in consumer demand for safe prepared foods, the importance in using irradiation technology as a pasteurization process is likely to increase in the future. This was confirmed by the consumer studies carried out in the USA, the results of which were reported during the course of this CRP. Provision of information about the nature of food irradiation increases consumer acceptance and willingness to pay a premium for enhanced product safety and quality.

This technology could potentially be advantageous for consumers, food manufacturers, and traders world-wide as the foods are safer, have an extended shelf-life and high quality. The use of this technology would also make it possible to give a safer and wider variety of meals to specific target groups such as immunocompromised patients.
Radiation treatment thereby offers the opportunity of a wider utilisation and marketing of such high quality meals, including many ethnic food products. If the irradiation technology is applied at commercial scale could produce an impact from the public health point of view because in this way it would be possible to avoid many food-borne diseases.

As it was aforementioned the new trends on consumption, and other factors such us the use of new packaging materials are producing or delivering “new products” to the market, like the prepared meals including ethnic meals, but this type of products are also producing “new” public health problems. This CRP showed that the irradiation technology is very effective and has enormous advantages in comparison with alternatives technologies.

**Recommended future action by Agency:**

**Resulting Publications:**

Book *Irradiation to Ensure the Safety and Quality of Prepared Meals (T. Rubio Cabello, NAFA)* to be published.
Title of the Coordinated Research Project:
Doctoral CRP on Management of Liver Cancer using Radionuclide Methods with Special Emphasis on Trans-Arterial Radioconjugate Therapy and Internal Dosimetry

Section/Division: Division of Human Health

Period Covered: 2000-09-01 through 2005-12-31

Total Cost: € 379,488.32

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

(b) Specific (CRP):

- to develop a cost-effective radiopharmaceutical (Re-188 Lipiodol) for loco-regional therapy of non-operable hepatocellular cancer (HCC);
- to determine its (Re-188 Lipiodol) safety (Phase-I study);
- to determine its (Re-188 Lipiodol) efficacy (Phase-II Study);
- to determine the overall response rate, progression-free and overall survival (“utility”) of loco-regional radiopharmaceutical therapy using Re-188 Lipiodol in non-operable hepatocellular cancer;
- to develop a strategy for the effective management of hepatocellular cancer;
- to educate and train medical doctors, technologists and scientists from the participating centres in the field of radionuclide therapy;
- to assist at least one professional from each participating centre obtain a PhD, MD or equivalent post-graduate degree from the local Universities.

Outputs:

(a) Research:

- formation of a network of participating institutes;
- availability of a ready to use standardised procedure for labelling Re-188 with Lipiodol, treatment;
- dosimetry protocols for Re-188 Lipiodol therapy;
- a report on the safety and efficacy of Re-188 Lipiodol therapy for HCC.

(b) Others:

- publication of results in journals;
- presentation of the work at National and International scientific meetings and conferences;
- award of PhD or equivalent degrees by the respective local universities to the scholars from participating centres on the basis of their research work carried out under the thematic CRP.

Effectiveness of CRP:

(a) In reaching Specific Objective:

The Phase I study to determine the safety of trans-arterial Re-188 lipiodol in the treatment of patients with inoperable hepatocellular carcinoma (HCC) was conducted at few selected sites. These included Vietnam, Colombia and Singapore. The Rhenium-188 Lipiodol conjugate was
prepared by the Radiopharmacists using a HDD (5-Hexadecyl-tetramethyl-dithia-
diazacyclodecane) kit from Korea and lipiodol purchased from local markets.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

The CRP was the first Doctoral CRP of the IAEA combining research and development with the higher education programmes of the participating universities in the Member States. Besides developing a new cost-effective therapeutic radiopharmaceutical for treating HCC, and assessing its safety and efficacy; the second major objective of the CRP was to develop human resources in the field of radionuclide therapy through establishment of a link between the CRP activities of IAEA and the post-graduate medical education and training programmes in the IAEA Member States. The CRP has achieved most of its objectives, namely; development of Re-188 Lipiodol and standardization of the labeling procedure, development of Re-188 Lipiodol internal dosimetry protocol, evaluation of its safety for use on humans (Phase-I study), evaluation of its efficacy in the treatment of HCC, producing at least one PhD thesis per participating institute during the period of the CRP. Extreme cost-effectiveness, on site availability and safety of the radiopharmaceutical make Re-188 Lipiodol therapy an attractive option for routine clinical use anywhere in the world. In a recently published biological dosimetry study a research group in Germany has in fact validated the Agency’s work on Re-188 Lipiodol in the treatment of liver cancer, and reported that Re-188 Lipiodol therapy yields a significantly lower cytotoxicity effect and lower radiation exposure for an expected higher tumour killing effect (Ruyck KD et al. Journal of Nuclear Medicine 2004; 45: 612-618). This report makes the Agency’s work all the more important and relevant.

Agency’s efforts in meeting the challenges of Liver cancer in developing countries is a truly global effort with the following principal players: 1. IAEA: NAHU-NMS responsible for coordination of the entire Research & Developmental activities, Protocols and multi-centre Studies; 2. IAEA: Department of Technical Cooperation, responsible for the transfer of technology, human resources development, fellowship training, group training, expert services and supply of radiopharmaceuticals; 3. Department of Energy, USA – responsible for the supply of Re-188 generators at subsidized price to IAEA (US$ 7800 instead of 14,000), expert advise, Fabrication of accessories etc., 4. Memorial Sloan Kettering Cancer Centre, New York responsible for developing the clinical and dosimetry protocols; 5. Seoul National University Hospital, responsible for developing the Re-188 Lipiodol; 6. Centre Eugene Marquis, Rue de la Bataille Frandres-Dunkerque, Rennes-Cedex, France – responsible for Clinical Protocols; 7. Singapore General Hospital, acting as core centre for the Clinical Studies, and 10 Centres from 10 developing countries, 6 centres from 5 developed countries and 9 Universities from 9 developing countries: Making it a truly global venture.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None

Impact of the CRP:

In the Phase-II efficacy study 185 patients were treated with Re-188 Lipiodol. The level of radio-conjugate administered was based on radiation absorbed dose to critical normal organs, calculated following a "scout" dose of radio-conjugate.

Relevance of the CRP:

Hepatocellular carcinoma (HCC) is a malignant epithelial tumour arising from parenchymatous liver cells. It is one of the world’s most common malignancies, causing almost one million deaths annually. About 315,000 new cases of HCC are reported per year which constitutes 5.6% of all cancers among males and 2.7% of all cancers among females. Control strategies to prevent occurrence of HCC are sub-optimal; this is evident by the rising incidence of HCC even in developed nations like the USA, where the prevalence of the disease is one of the lowest in the world.
Currently, patients with HCC have an extremely poor prognosis with a five year survival rate of less than 5%. However, morbidity and mortality in such patients are not determined by the presence of HCC alone, but are also influenced by the activity of the underlying liver disease, as well as the functional status of the liver. The stage of the tumour (size, number, vascular invasion, extra hepatic spread) has been consistently documented to be an important determinant of the natural course of the disease. These factors are major variables that influence various therapeutic strategies directed against this tumour in recent times. Therefore, therapy in HCC needs to be optimized depending upon the above mentioned influences on the final outcome of the disease.

Various forms of therapy such as surgical resection, orthotopic liver transplantation (OLT), percutaneous injection to induce coagulative necrosis of the tumour using agents like ethanol, acetic acid, hot saline, microwave and laser have been considered as radical treatment of HCC, aiming at curing the disease. The understanding of pathology, pathogenesis, natural course and risk factors of HCC during the last three decades has resulted in the development of multiple therapeutic approaches with promising yet varying results.

Most patients with hepatoma from the developing countries at the time of their presentation to the doctor fall into the intermediate/inoperable category, and for these, radionuclide methods to deliver high radiation doses to tumour must be considered. Uncontrolled studies using radioisotopes like I-131, Y-90, Ho-166, Re-186 conjugated to monoclonal antibodies, lipiodol or chemical compounds have shown promising results. However due to lack of prospectively designed randomised trials, their efficacy is yet to be optimally evaluated. There have also been reports (from one study only) on the usefulness of radionuclide therapy as an adjuvant treatment following resection of “curable” HCC. It has been shown that patients given a single administration of 1GBq. Of I-131 Lipiodol have significantly greater survival and less recurrence than those not treated. It is important that the results of this study be verified and confirmed by reproducing the results in another prospective trial.

It may be noted that the disease is most prevalent in those communities with least resources for setting up clinical trials. Hence the role of the International Organizations like IAEA and WHO are extremely important in assisting them in setting up such trials and coordinating them. Currently the only commercially available radiopharmaceutical for the treatment of liver cancer, I-131 Lipiodol, has been found to be prohibitively expensive, and it is virtually not practical to use this radiopharmaceutical on a routine basis in the poor and developing countries of the world. For nuclear medicine and the IAEA-WHO to develop a cost-effective therapeutic procedure and play a key role in the treatment of HCC, new methods must be evolved, tested and standardized in full random controlled trials.

Recommended future action by Agency:

Resulting Publications:


Scientific Presentations at National & International Conferences:

Results of the various aspects of the CRP have been presented at a number of national, regional and international conferences. These include:

1. World Congress, WFNM&B, 2002 (Santiago, Chile);
2. EANM, Vienna, 2002;
3. SNM, Annual Meeting, New Orleans, USA, 2003;
4. EANM, Amsterdam, 2003;
5. Colombian Association of Nuclear Medicine Congress, Cali, Colombia, 2003;
6. ARCCNM, Annual Convention, Dhaka, Bangladesh, 2003;
7. IAEA International Symposium on Nuclear Oncology, 2004-05-13;
8. Rajiv Gandhi Institute International Conference on Cancer, Delhi, India, 2004-05-13;
9. SNM Annual Meeting, Philadelphia, USA, 2004;
10. First International Conference on Radiopharmaceutical Therapy (ICRT-2005), Limassol, Cyprus, 2005;
CRP No. 774 (E13022)

CRP Evaluation Report

Title of the Coordinated Research Project:
Harmonization of Radionuclide Procedures and Protocols in the Management of Neonatal Hydronephrosis

Section/Division: Division of Human Health

Total Cost: € 198 275.02

Period Covered: 2001-08-01 through 2006-07-17

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
This CRP was directed towards the Agency’s project on Applying in vivo diagnostic nuclear medicine procedures in the management of childhood diseases, cancer, coronary artery disease and degenerative disorders.

(b) Specific (CRP):
This CRP aimed to analyze the strategic options of management of asymptomatic hydronephrosis that are proposed, and to evaluate the role of medical imaging, in particular the radionuclide approach.

Outputs:

(a) Research:

a) Better understanding of the natural history of neonatal hydronephrosis:
It became clear that congenital urinary tract obstruction is a common cause of renal failure accounting for up to 20% of end-stage renal disease cases. Intratuterine obstruction often results in parenchymal loss and renal dysfunction. Signs suggestive of urinary obstruction in the newborn may include an abdominal mass, hypertension, oligoanuria/polyuria, urosepsis, and hyperchloremic acidosis. The combination of renal ultrasound, diuretic renal scans, and voiding cystourethrogram are the main diagnostic modalities in infants with hydronephrosis. Obstruction complicated by infection is dangerous and requires prompt intervention. Any newborn with a urinary tract infection, regardless of sex, should be presumed to have urinary obstruction or reflux until proven otherwise.

b and c) Production of a diagnostic algorithm/software:
A software for automated analysis of renal scans have been produced and made available to the nuclear medicine community in MSs.

d) Widespread use of the technique: it has been introduced in the 10 MSs participating in the project and has been presented at several regional; and subregional NM conferences.
Effectiveness of CRP:

(a) In reaching Specific Objective:

The project has clarified that the goal of all therapeutic strategies in the management of newborn hydronephrosis is to select all infants with severe obstructive dilatation during serial follow-ups and to perform surgical repair before irreversible deterioration and functional renal damage occurs. Interdisciplinary cooperation between experienced pediatric urologists, nephrologist and radiologists is the basis for optimal decision making.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

The strategy of management of children with hydronephrosis has considerably changed as a result of the development of ultrasound techniques, allowing a prenatal detection. Congenital ureteropelvic junction anomaly, vesicoureteral reflux, posterior urethral valves, and duplex kidney will be successively considered. Multicystic dysplastic kidney disease, although not classified as hydronephrosis, may be mistaken for hydronephrosis.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None

Impact of the CRP:

As a result of this CRP, the nuclear medicine community has a better understanding of the role of radionuclide imaging in this type of disease and a new software tool for renal scans analysis is now available. Paediatricians and paediatric surgeons can now count on a new standardized technique to investigate their patients.

Relevance of the CRP:

Results of this CRP clarified that the postnatal management of the antenatally detected ureteropelvic junction obstruction relies on several factors, including the degree of hydronephrosis detected postnatally, the renogram washout curve, and the degree of renal function. It is imperative for the urologist to review all renal scans because of the inherent pitfalls in performing and interpreting these studies.

It was also found that variability in classifying drainage patterns based on half-time requires that practitioners be circumspect when applying this parameter for managing asymptomatic hydronephrosis. It also necessitates the availability of quantitative methodology, as provided through the software which was developed under the scope of this CRP.

Recommended future action by Agency:

None specifically

Resulting Publications in:


Appendix E.34

Appendix E.35
Title of the Coordinated Research Project:
Radiopharmaceutical Imaging to Predict and Evaluate the Response of Breast Cancer to Neoadjuvant Chemotherapy

Section/Division: Division of Human Health

Period Covered: 2001-08-01 through 2005-11-30

Total Cost: €162,127.60

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To assess the efficacy of Tc-99m-MIBI scintigraphy in the prediction and evaluation of tumor response to neoadjuvant chemotherapy in patients with stage III breast cancer

(b) Specific (CRP):
1. To determine the role of washout ratio of Tc-99m-MIBI for predicting chemotherapeutic response of breast patients with stage III.
2. To verify the role of tumor uptake ratio of Tc-99m-MIBI for monitoring therapeutic efficacy in breast cancer patients with stage III.

Outputs:

(a) Research:
Breast cancer is one of the major causes of death of women aged 30-60 in most countries of the world. In particular, in developing countries, advanced breast cancer patients frequently occur due to late consultation of medical doctors. The cancer is commonly treated with various combinations of surgery, chemotherapy, endocrine therapy and radiation treatment. Recently the neo-adjuvant therapy, which is a pre-operative chemotherapy, has acquired an expanding role in therapies for locally advanced breast cancer patients since several courses of chemotherapy can reduce the tumor size. Therefore a smaller surgery than expected can be undertaken. However, chemotherapy is not always effective for all patients since some have a biological resistance to chemotherapy. It was recently proposed that for some breast cancers the retention of Tc-99m-MIBI in tumor cells may be a predictor of response to chemotherapy. The radiopharmaceutical retains in tumor cells but it fails if specific transmembranous proteins such as P-glycoprotein and multi-drug resistance related protein exist in the cell membrane. Therefore, the scintimammography with Tc-99m-MIBI was expected to be of importance for selecting advanced breast cancer patients (stage III) who are sensitive to chemotherapy before commencing neo-adjuvant therapy.

No substantial role of washout ratio of Tc-99m-MIBI in the lesions of breast cancer patients with stage III for predicting chemotherapeutic response could be shown in this study: No significant difference in washout ratios between the pre-chemotherapy and post-chemotherapy was noted (0.35 +/- 0.11 (means +/- standard deviation) vs. 0.28 +/- 0.11, p>0.05).

The role of tumor uptake ratio of Tc-99m-MIBI 120 min after injection for monitoring therapeutic efficacy in breast cancer patients with stage III was demonstrated in this study. The means of the uptake ratios in the mid-chemotherapy and the post-chemotherapy significantly decreased compared with that in the pre-chemotherapy (2.14 +/- 0.75, 1.97 +/- 0.76 vs 2.70 +/- 1.19, p<0.05).
**Discussion:** It was demonstrated in this CRP that the washout ratio of such radiopharmaceutical in cancer lesions cannot predict the chemotherapeutic response. Currently, it is well known that several factors affect the dynamics of Tc-99m-MIBI in breast cancer lesions. In addition, it was speculated that various components of a lesion (viable cancer cells, necrosis, inflammation) could affect the tumor uptake of Tc-99m-MIBI. On the other hand, a reduced uptake of Tc-99m-MIBI was found following chemotherapeutic response in this study. The sensitivity was 75.0% and the specificity was 70.0%. The results were a bit better than mentioned in a report of another researcher (Mankoff DA, et al. Monitoring the response of patients with locally advanced breast carcinoma to neoadjuvant chemotherapy using Tc-99m-sestamibi scintimammography. Cancer 1999; 85:2410-2423).

**Conclusions:** Scintimammography with Tc-99m-MIBI is not able to predict chemotherapeutic responses of breast cancer patients with stage III but it has potential for a limited role in monitoring tumor response to chemotherapy.

**Effectiveness of CRP:**

(a) In reaching Specific Objective:

1. Scintimammography with Tc-99m-MIBI is not able to predict chemotherapeutic response in breast cancer patients with stage III.
2. Scintimammography with Tc-99m-MIBI has a limited potential in monitoring tumor response to chemotherapy.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

Results related to overall objectives were not satisfactory.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Low number of patients enrolled for the project:
High drop-out rate: at the beginning of the project, 11 countries participated. In the 3rd project year, 3 countries dropped out due to their insufficient achievements. At the end, further 3 countries left the CRP.

**Impact of the CRP:**

Results did not confirm the expected role of scintimmaography with Tc-99m-MIBI. In addition, it was recognized that, following an initial enthusiasm for the technique, current practice sees a limited role of scintimammography for clinical cancer management of advanced cancer patients.

**Relevance of the CRP:**

The relevance was low. A precise predication of chemotherapeutic response could not be demonstrated.

**Recommended future action by Agency:**

The IAEA should look for a different modality (possibly PET) for improving clinical management of advanced breast cancer patients.
Resulting Publications:


Title of the Coordinated Research Project:
Nitrate Augmented Myocardial Imaging for Assessment of Myocardial Viability

Section/Division: Division of Human Health

Period Covered: 2002-09-01 through 2005-12-31

Total Cost: € 162799.39

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To enhance the competence of developing Member States in the management of childhood diseases, cancer, coronary artery disease (CAD) and degenerative disorders through effective use of appropriate in vivo nuclear medicine procedures.

(b) Specific (CRP):
The overall objective of the CRP is to ascertain the value of nitrate-augmented myocardial imaging study for the assessment of myocardial viability and risk stratification of patients with coronary artery disease and left ventricular (LV) dysfunction.
- To establish the accuracy of nitrate augmented myocardial SPECT for myocardial viability detection by using global and regional wall function improvement after revascularization as gold standard.
- To analyze the prognosis of the patients who undergo revascularization compared to patients who will receive only medical therapy in whom viability is demonstrated by nitrate augmented SPECT.
Additionally, depending on single Institutions capabilities:
- To compare nitrate-augmented Tc-99m sestamibi myocardial imaging and FDG metabolic imaging by dedicated PET where possible.
- To compare multi-gated acquisition (MUGA) with echocardiographic assessment of wall motion.
- To compare wall motion assessment with Gated-SPECT with MUGA.

Outputs:

(a) Research:
Availability of standardized protocol for myocardial viability assessment for routine clinical use. Establishment of a cost-effective non-invasive technique for assessment of myocardial viability and risk stratification of coronary artery disease for routine clinical use.

(b) Others:
Identification of the most convenient radiopharmaceutical for myocardial viability detection.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The belief that viability assessment is clinically useful is largely based on the fact that LV dysfunction is reversible after revascularization in many patients with CAD, and
revascularization procedures entail some risk. As such, the goal of viability assessment has been to prospectively differentiate patients with potentially reversible LV dysfunction.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
This CRP contributed to the overall Agency’s Programme in providing new knowledge on resource-sparing strategies for the management of coronary revascularization in selected patients (those with already compromised heart function) in developing countries

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Impact of the CRP:
The main impact of this study has been demonstrating the vasodilating effects of nitrates (NTG) in coronary arteries. It has been hypothesized that nitrates dilate flow-limiting obstructions in coronary arteries and there is also the vasodilating effect of nitrates on coronary collaterals, which explains the improvement in 201Tl uptake after NTG administration in regions with hypoperfusion related to totally occluded coronary arteries but with well-developed collateral circulation. Previously, the increase in coronary blood flow is considered to be responsible for reversibility of 201-T1 perfusion defects when myocardial SPECT performed after nitrate administration. This vasodilator effect has also been confirmed with 99mTc-sestamibi scintigraphy.

Relevance of the CRP:
This study was focused on the analysis of myocardial segments with severe reduction of myocardial uptake in which the detection of reversible hypoperfusion was of interest. In clinical practice, it was generally believed that 99mTc-labelled compounds can be effectively employed for myocardial perfusion studies since resemble thallium in the detection of coronary artery disease. However, they may underestimate the presence and extent of viable myocardium since, unlike Tl-201 which is a potassium analogue and shows a myocardial uptake that parallels the integrity and viability of myocites, those compounds have no specific metabolic behaviour and they were therefore considered only flow tracers rather than viability tracers.

Results proved that Tc99m-labelled compounds are as effective as Tl-201 to identify myocardial viability in infarcted patients candidate to revascularization. This finding makes Tc-labelled compounds suitable for this application, overcoming many of the logistic and dosimetric limitations of Tl-201. In addition, adoption of Tc99m labelled compounds will make myocardial SPECT less expensive than current practice in developing countries, where Tl-201 is still very much in use.

Recommended future action by Agency:
The Agency should continue to provide support to projects related to application of nuclear medicine techniques in cardiology.

Resulting Publications:
Results from this study have been presented by individual Chief Scientific Investigators at major Nuclear Medicine Meetings (EANM; SNM).
Title of the Coordinated Research Project:
Comparative Evaluation of Radiopharmaceuticals for Radiosynovectomy

Section/Division: Nuclear Medicine Section, Division of Human Health

Period Covered: 2002-10-15 through 2006-12-04

Total Cost: € 260 518.57

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To introduce new, clinically safe and cost-effective radio-pharmaceuticals for performing Radiosynovectomy.

(b) Specific (CRP):
1. To conduct a comparative study of efficacy and toxicity of various radiopharmaceuticals.
2. To explore the clinical safety and efficacy of the radiotracers used to alleviate inflammation and pain in patients suffering from inflammatory disease of the joints, namely, Rheumatoid arthritis.
3. To explore the clinical safety and efficacy of the same radiotracers in preventing knee joint bleeding in patients suffering from Haemophilia (an inherited sex-linked clotting disorder of the blood).

Outputs:

(a) Research:
1. Two radio-colloids were developed and tested clinically; one was labelled with P-32 and the other with Re-188. These tracers were employed as an alternative to the standard product Y-90 radio-colloid.
2. Both tracers, Re-188 and the P-32 labelled colloids, proved safe for use in humans.
3. In Rheumatoid Arthritis, both tracers showed adequate efficacy in reducing inflammation and pain for a period up to 6 months, similar to published data using Y-90 radio-colloid.
4. In ninety-six Haemophilia patients, recurrent episodes of knee-joint bleedings were prevented following radiosynovectomy for a time period lasting more than 6 months.
5. Dosimetry studies in a subgroup of patients applying the Re-188 tin-colloid indicated that blood and bone marrow exposure is very well within the safety limits for both adult and paediatric patients. Due to the shorter physical half life of Re-188 the corresponding radio-colloid resulted in a lower radiation exposure to blood than the P-32 radio-colloid and is therefore better suited to be used in the paediatric population of Haemophilia patients.

(b) Others:
- Improving the technology for producing higher quality Re-188 generators.
- Improving the access to this type of Radioisotope generators for other types of therapeutic applications in Nuclear Medicine.
• Contributing to a better level of inter-disciplinary networking (Physicians-Physicists and Radiopharmacy research and production facilities).

Effectiveness of CRP:

(a) In reaching Specific Objective:
This CRP was successful in reaching all specific objectives.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The CRP contributed to promoting the use of nuclear techniques in medicine. It promoted the use of novel radiopharmaceuticals for therapeutic applications of unsealed radioisotopes in Medicine.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
None

Impact of the CRP:

• Treatment options for Haemophilia patients suffering of post traumatic joint bleeding in developing Member States were improved. Significant reduction or cessations of knee joint bleeding in over 90% of the patients receiving this treatment were demonstrated.
• An efficacious and safe Re-188-based radio-colloid for performing Radiosynoviorthesis in patients suffering from Haemophilia was introduced.
• Radiopharmacy and isotope production:
  o Improved accessibility to Re-188 Generators at an affordable cost.
  o Problems and drawbacks related to handling the Re-188 generator were detected, reported, and corrected. Thus the current available improved generator provides highly concentrated activity, lesser manual manipulation and therefore significantly lower radiation exposure to operator’s fingers.

Relevance of the CRP:

• Transferring useful knowledge and providing access to effective radiopharmaceuticals to treat this unique medical condition that, if left untreated, leads to debilitation.
• Improving the performance level of involved Nuclear Medicine departments and raising the public awareness to effective therapeutic applications.
• Strengthening at both national and regional levels the cooperation of different non-clinical and clinical disciplines for improving the level of health care.
• In an indirect manner, as a result of the feedback of the end-user, this CRP led to improving the design of the Re-188 generator, thus reducing significantly doses to the fingers of radio-pharmacists and radio-chemists caused by manipulation of the activity.

Recommended future action by Agency:

• Medical applications involving targeted radioisotopic therapy require special training and guidance by highly trained experts in the field to guarantee qualitative transfer of knowledge to medical specialists implementing these techniques in developing Member States. The IAEA should continue to play a leading catalytic role in facilitating and overseeing this process.

Appendix E.42
Resulting Publications:

This CRP produced four publications provided herewith, covering issues referred to under “specific objective” of the CRP

CRP No. 1325 (E24013)

CRP Evaluation Report

Title of the Co-ordinated Research Project:

Development of procedures for quality assurance for dosimetry calculations in radiotherapy

Section/Division: DMRP/NAHU

Period Covered: 2004-04-01 through 2007-12-06

Total Cost: € 86 157.92

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

To create a set of simple and practical acceptance and commissioning tests of dosimetry calculations, defined in a dedicated protocol, to assist hospitals with limited resources to perform the characterization, validation and testing of algorithms used in treatment planning systems (TPSs).

(b) Specific (CRP):

1. To develop recommendations to be provided to the TPS manufacturers for dose calculation algorithm verification tests, to be completed and documented prior to installation, and recommendations for tests to be included in manufacturer-guided acceptance test procedures at the hospital that are based on International Electrotechnical Commission (IEC) standards.
2. To provide recommendations for commissioning tests to be performed by the hospital users and to formulate guidelines for periodic checks of TPS.
3. To conduct on-site trials of the commissioning tests of dosimetry calculations.

Outputs:

(a) Research:

As an output of the CRP, two specific guidance documents were prepared and published as IAEA TECDOCS. The first document uses the International Electrotechnical Commission (IEC) standard IEC 62083 as its basis and addresses the procedures for specification and acceptance testing of TPSs to be used by both manufacturers and users at the hospitals. The second document deals with the verification of the dose calculations through commissioning tests that cover typical treatment techniques and provide recommendations for periodic checks.

(b) Others:

The phantoms suitable for clinical commissioning were studied. The standardized procedures that cover a wide range of typical clinical situations and follow the logistic chain of the treatment planning process, starting from CT scanning, anatomical modelling, treatment planning and MU calculation were developed and tested through a pilot study for selected phantoms.
Effectiveness of CRP:

(a) In reaching Specific Objective:
The practicality of the guidelines has been confirmed through trial use in clinical facilities of varying size. Reduction of extensive QA recommendations to a feasible QA programme in hospitals with limited resources is achieved without loss of comprehensiveness by appropriate and optimal division of effort between TPS manufacturers and hospital staff. Prior to publication, the acceptance testing document was distributed to TPS manufacturers and their comments and suggestions were included in the final version.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The developed guidelines for implementation of QA measures will increase the confidence that each patient receives radiation treatment as planned and that no errors will occur in the process of using the TPS.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
None

Impact of the CRP:
The guidance documents developed under the CRP will be distributed to the users in Member States. Dose computation verification that will be performed in a reasonable amount of time should help a user in a hospital to avoid severe errors in the treatment planning process.

Relevance of the CRP:
The implementation of the QA procedures will help to improve the safe use of TPS in radiotherapy hospitals.

Recommended future action by Agency:
The IAEA should conduct a new CRP to extend the testing of TPS for more advanced treatment techniques.

Resulting Publications in PC:

Title of the Coordinated Research Project:
Aspects of Radiobiology Applicable in Clinical Radiotherapy - Increase of the Number of Fractions per Week

Section/Division: Division of Human Health

Total Cost: €170,673.10


Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To assist radiotherapy departments in developing countries in evolving more practical and more effective radiation treatment techniques in head-and-neck cancer. To establish procedures for introducing new techniques and research findings in radiobiology into clinical radiotherapy practice, with the aim of improving the therapeutic gain and decreasing morbidity following radiotherapy.

(b) Specific (CRP):
To study the clinical effect of increasing the number of weekly fractions for locally advanced head-and-neck cancers by a multi-institutional prospective randomized trial. The primary endpoint is to clarify whether six fractions per week protocol has a greater effect on survival, as compared to a conventional five fractions per week protocol.

Outputs:

(a) Research:
The results showed a benefit in 3-year loco-regional control (47% vs. 36% p=0.005) for the 6 vs. 5 fractions-per-week arm. The effect of overall treatment time occurs in the tumour site (52% vs. 42%) whereas the response in the neck nodes was not significantly different. The benefit in tumour control resulted in a significantly better disease-specific survival (54% vs. 42%), whereas there was no significant difference in overall survival. Acute morbidity in the form of severe mucositis was significantly more frequent in the 6 fractions-per-week group, but there were no differences in late radiation side effects.

(b) Others:
Improvement in patient treatment technique, quality assurance, patient compliance and follow-up in participating centres.

Effectiveness of CRP:

(a) In reaching Specific Objective:
This CRP had sought to prove by a prospective randomized trial that modest acceleration of radiotherapy would improve the outcome of patients with cancers of the head-and-neck. The recent analysis showed that this was indeed the case, with tumour control improving markedly (by 32%) at the primary site of cancer.
(b) In contributing towards Overall (i.e. Agency Project) Objective:

The participating centres gained experience on how to improve patient compliance and follow-up of treated patients. The CSIs from India (IND 10344) and Pakistan (PAK 10346) agreed to work together to prepare a guide for future CSIs in this regard. Participating institutions complied with the study guidelines and patient accrual was adequate.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Impact of the CRP:

The participating centres gained experience on how to improve patient compliance and follow-up of treated patients. The positive result from this trial is likely to have significant impact in other MS who may adopt this accelerated schedule.

Relevance of the CRP:

The findings of this prospective randomized trial are significant for the management of patients with head-and-neck cancer in resource limited settings. It is rare indeed in oncology that a novel treatment is not only more effective but also less burdensome for patients and for staff.

Recommended future action by Agency:

Research contract and agreement holders were encouraged to submit research proposals to the Agency as a continuation of this study on advanced head and neck cancer. It is recommended that a new CRP based on the accelerated schedule as the control group be coordinated.

Resulting Publications:

Presented as oral presentation in the Presidential Symposium of the ECCO-13 meeting in Paris. (Wednesday, 2 November 2005). The committee determined that the results were sufficiently important for cancer patients that they should be featured in the Presidential Symposium as one of the "Best of Oncology" presentations. A paper for a peer-reviewed scientific journal was also prepared.
Title of the Coordinated Research Project:
The Role of Teletherapy (TT) Supplementary to Intraluminal High Dose Rate (ILHDR) Brachytherapy (BT) in the Palliation of Advanced Oesophageal Cancer

Section/Division: Division of Human Health

Period Covered: 2002-09-01 through 2006-08-31

Total Cost: € 169,579.26

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To determine if there is a benefit in adding external beam radiation therapy (EBRT) to high dose rate intraluminal brachytherapy (HDR ILBT) in the palliation of advanced oesophageal carcinoma with regard to dysphagia and/or survival.

(b) Specific (CRP):
To determine whether the addition of EBRT to HDR ILBT in patients with advanced oesophageal carcinoma reduces odynophagia, regurgitation, chest or back pain, or improves overall quality of life.

Outputs:

(a) Research:
1. Presentation of the study results at international radiation oncology and oesophageal disease congresses.
2. Publication of the study results in peer-reviewed journals.
3. The CRP, in testing the null hypothesis has:
   • identified and corrected clinical QA/QC procedures in the use of HDR ILBT in participating centres with deficiencies.
   • introduced HDR ILBT for the management of advanced oesophageal cancer into new participating centres.
   • improved institutional experience in the documentation of clinical outcomes and research methodology in clinical radiotherapy.

(b) Others:
4. Resultant saving of resources.

Effectiveness of CRP:

(a) In reaching Specific Objective:
For 219 patients, the average palliative benefits of ILBT+EBRT vs. ILBT alone were statistically significant on single measures of QOL, performance status, weight, and symptoms.
including dysphagia. There were no statistically significant differences in DFE, survival or toxicities.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

This CRP has been effective in determining the added value of external beam radiation therapy to intra-luminal brachytherapy in the palliation of oesophageal cancer dysphagia. It contributed to the overall Agency’s Programme in providing new knowledge on resource-sparing strategies for the management of common cancers in developing countries.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

1. Some centres routinely used oesophageal dilatations before brachytherapy, while others did not. This limited the selection of a number of patients in centres where routine dilatation is not practiced. This will be addressed in the next CRP by recommending dilatations and randomizing patients only after the first brachytherapy application.
2. The QA information from one institute was initially limited. Due to visa problems, a quality audit meeting had to be specially arranged in Vienna VIC. The data on QOL, ECOG performance status raised doubts as to the full understanding of these criteria in that institute when analyzing the data.

Impact of the CRP:

1. The CRP had a positive impact on the participating centres by standardizing their approach to the palliative treatment of oesophagus cancer with radiotherapy and brachytherapy. They developed skills in the use of oesophageal applicators, imaging, dosimetry, patient follow-up and data recording and reporting.
2. We are now in a position to recommend to resource-limited centres to treat cancer-related dysphagia with two HDR applications of 8.0 Gy followed by external beam radiotherapy at 30 Gy in 10 fractions.
3. The results of this study will be published in peer-reviewed scientific journals. It is hoped that the new schedule will be adopted in routine clinical practice in limited-resource centres that treat large numbers of patients with oesophageal cancer.

Relevance of the CRP:

Carcinoma of the oesophagus represents roughly 1% of all cancers in the USA excluding skin and in situ lesions. In South Africa, cancer of the oesophagus is the most common cancer of males -18% of all cancers. Carcinoma of the oesophagus is a very common form of cancer in a number of countries and regions.

It is found in many parts of the world with more variations in incidence than any other tumour. Patients usually present with the disease between 55 and 65 years of age. Perhaps the highest rates in the world are found in Iran and Russia around the Caspian Sea. The prognosis is poor with standard treatments, and most patients require palliation of dysphagia and other symptoms caused by oesophageal obstruction.

This trial confirms that the addition of EBRT to ILBT improves the palliation of patients with squamous-cell oesophageal carcinoma.

Recommended future action by Agency:

It is recommended that a new CRP to determine the role of a shortened external beam schedule (4 Gy x5) compared to the previously tested one (3 Gy x10) be conducted. If equivalence in palliation can be demonstrated, the shortened regimen will be resource-sparing and more convenient to patients and centres.
Resulting Publications:

2. Three articles in preparation:
   1.1 Clinical results of the study.
   1.2 Dysphagia assessment methods.
   1.3 Validation of a Quality of Life tool.
Title of the Coordinated Research Project:
Radiobiological and Clinical Study on Viral-Induced Cancers Response to Radiotherapy

Section/Division: Division of Human Health

Total Cost: € 52,923.20

Period Covered: 2004-08-01 through 2006-07-31

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To test a resource-sparing radiotherapy treatment for cervix cancer, and to gather knowledge of factors that will predict tumor resistance.

(b) Specific (CRP):
   i) To test a 2 vs. 4 HDR brachytherapy fractions regime to treat cervix cancer patients, to compare late effects and locorregional control.
   ii) To test whether the addition of cisplatin to radiotherapy in cervix cancer patients would improve results over that obtained with radiotherapy alone.
   iii) To use antibodies to a range of proteins in tumour sections in order to associate molecular markers with tumor resistance.
   iv) To measure the radiosensitivity of cervix cancer cell lines in oxic and hypoxic conditions, using cell lines infected with characteristic cervical viral oncoproteins.

Outputs:

(a) Research:
Based on 108 patients; no increase in high-grade toxicity with the addition of chemotherapy; some cellular radiosensitivity studies completed, others continuing.

(b) Others:
Improvement in patient treatment technique, quality assurance, patient compliance and follow-up in participating centres.

Effectiveness of CRP:

(a) In reaching Specific Objective:
This CRP had sought to prove by a prospective randomized trial that an additional chemotherapy in limited resources setting improves the outcome of patients with cervical cancers having HIV/AIDS. The recent analysis showed that there is no increase in high grade toxicity in the chemotherapy arm.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The participating centres gained experience on how to improve patient compliance and follow-up of treated patients.
(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Impact of the CRP:
The participating centres gained experience on how to improve patient compliance and follow-up of treated patients. The results from this trial are likely to have significant impact in other MS who may adopt this combined treatment schedule.

Relevance of the CRP:
The findings of this prospective randomized trial are significant for the management of patients with cervical cancer having HIV/AIDS in resource limited settings. The laboratory studies will provide information that may help improve future treatments.

Recommended future action by Agency:
The Chief Scientific Investigators were encouraged to submit research proposals to the Agency as a new study that will continue with this type of treatment. This new study will also include an additional component on adverse event reporting, making thus a completely new CRP study in patients with cervical cancer with HIV/AIDS. Co-ordinate a new CRP based on the accelerated schedule as the control group.

Resulting Publications:
Publications will follow from the follow up CRP E33026.
CRP No. 773 (E43013)

CRP Evaluation Report

Title of the Coordinated Research Project:
Doctoral CRP on Isotopic and Complementary Tools for the Study of Micronutrient Status and Interactions in Developing Country Populations Exposed to Multiple Nutritional Deficiencies

Section/Division: Division of Human Health

Period Covered: 2001-12-15 through 2006-11-23

Total Cost: € 358,838.83

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
Sustainable Strategies to Combat Micronutrient Deficiencies (2.2.1.2.).
Objective: To enhance Member States’ capability to combat micronutrient deficiencies

(b) Specific (CRP):

- To evaluate different strategies to combat micronutrient deficiencies, i.e., food fortification, dietary diversification and supplementation, by stable isotope techniques and other relevant techniques.
- To support post-graduate training in human nutrition in developing countries
- To promote North-South collaboration in human nutrition research.

Outputs:

(a) Research:
1) Four PhD theses and one MSc thesis have been completed;

Ghana: M.Sc. student: Mr. Samuel Tchum
Thesis: “Evaluation of the newly proposed vitamin A regimen and indigenous leafy vegetables as a vitamin A source for post partum mothers” (September 2006)

India: Ph.D. student: Mr. Prashanth Thankachan
Thesis: “Iron status and bioavailability studies in young women” (December 2006)

Mexico: Ph.D. student: Ms. Luz Maria de Regil Velez

Sri Lanka: Ph.D. student: Mr. Manjula Hettiarachchi
Thesis: “Impact of interactions and bioavailability of micronutrients in supplementation and food fortification: an interventional study in Galle District” (December 2006)

Thailand: Ph.D. student: Ms. Siriporn Tuntipopipat
Thesis: “Effect of commonly consumed spices and herbs in Thai diets on human iron absorption” (September 2006)

One PhD student is in the final stages of completing his thesis.

Pakistan: Ph.D. student: Mr. Aziz Jiwani
Contribution to capacity building: The CRP had a strong focus on capacity building and several graduate students were trained in reference laboratories in the North. With financial support from TC, training of 3 post graduate students (Ghana, Sri Lanka and Thailand) in the North and 4 expert visits (North to South) have been organized. In addition, arrangements for training of the Indian Ph.D. student in Switzerland were made independently by the Chief Scientific Investigator. The experience with training in reference laboratories in the North as well as the opportunities for networking by young scientists provided during the training (for graduate students in both the North and the South) and during experts’ visits were highly appreciated by the students benefiting from the training component of this CRP. Five of the six graduate students supported by this CRP have completed their theses. One PhD student (Pakistan) is in the final stages of completing his thesis.

Increased North – South collaboration: The experience with pair-building between contract holders and agreement holders (Ghana-USA, India-Switzerland, Mexico-USA, Pakistan-Switzerland, Sri Lanka-USA Thailand-Switzerland) has been very positive and has resulted in strong commitments to the project. Considerable efforts have been made to ensure successful implementation of the different projects by all participants, in the North and in the South. In addition, the World Health Organization’s contribution to the design of the study in Ghana provided a unique opportunity to evaluate a newly proposed public health strategy. A solid working relationship has been created between the collaborating centers in the North and in the South resulting in expanded collaboration outside the scope of this CRP.

Increased use of stable isotope techniques in nutrition: Stable isotope techniques have been successfully applied in a variety of environments, including field settings, to contribute to the development of strategies to combat micronutrient deficiencies. New data have been generated and has been disseminated in a number of presentations at prestigious scientific meetings and in peer-reviewed publications.

Effectiveness of CRP:

(a) In reaching Specific Objective:

1) To evaluate different strategies to combat micronutrient deficiencies, i.e., food fortification, dietary diversification and supplementation, by stable isotope techniques and other relevant techniques. The CRP has been highly effective in reaching this specific objective.

2) To support post-graduate training in human nutrition in developing countries. The CRP has been highly effective in reaching this specific objective as five of the six graduate students supported by this CRP have completed their theses. One PhD student (Pakistan) is in the final stages of completing his thesis.

3) To promote North-South collaboration in human nutrition research. The CRP has been highly effective in reaching this specific objective as a solid working relationship has been created between the collaborating centers in the North and in the South resulting in expanded collaboration outside the scope of this CRP.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

To enhance Member States’ capability to combat micronutrient deficiencies. The CRP was highly effective in contributing to the overall objective as graduate students in the South have been trained on nuclear and other relevant techniques to generate new, important information relevant to the development and evaluation of strategies to combat micronutrient deficiencies in different settings.
(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None

Impact of the CRP:
Impact of this CRP is very high as the project contributed significantly to capacity building, increased North-South collaboration and increased use in nuclear techniques to address major public health problems in nutrition.

Relevance of the CRP:
The relevance of this CRP to major public health problems is very high. The “Doctoral CRP in human nutrition” clearly highlights the importance of nuclear techniques and other relevant techniques in the development, evaluation and monitoring of nutrition interventions to combat micronutrient deficiencies. The importance of generating evidence-based information for the development of effective nutrition programmes cannot be underestimated and the new information generated within this project will clearly contribute to move the nutrition agenda forward. The importance of involving policy makers and programme managers in this process is essential and was highlighted within this CRP by the close collaboration with WHO in the project in Ghana.

Recommended future action by Agency:

• To continue supporting “Doctoral CRPs in human nutrition”. The overall experience during this CRP was very positive and the participants strongly recommended more emphasis on “Doctoral CRPs in human nutrition” in the future to train young scientists in developing countries in the application of nuclear techniques in nutrition.

• To strengthen the capacity building component of Doctoral CRPs by exploring mechanisms for training fellows individually and in specialized courses to optimize the benefits of this component as well as to invite graduate students to the RCMs as part of the capacity building.

• To encourage and facilitate collaboration and communication between research groups in the North and in the South to increase the potential for successful projects.

• To explore possibilities to increase networking between research groups participating in Doctoral CRPs by encouraging North-South and South-South initiatives.

Resulting Publications:

Ghana


India

Sri Lanka


Thailand

Title of the Coordinated Research Project:
Development of Improved Sources and Imaging Systems for Neutron Radiography

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2003-03-15 through 2006-03-14

Total Cost: € 134,405.76

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
The effective utilization of research reactors is one of the major objectives of the project

(b) Specific (CRP):
• To optimize the neutron beams for radiography using modern simulation techniques.
• To enhance the beam intensity using modern neutron optics, like focusing and beam guides.
• To develop a standardized, low cost, neutron image grabber and analyzer for fast data collection that can be used with low intensity sources.

To improve signal processing techniques used in neutron radiography imaging

Outputs:

(a) Research:
(1) Scattering correction software developed and used for improving radiography image output has been done developing software and implementing on experimental data taken on different beamlines
(2) Phase flow studies carried out
(3) Microtron based neutron source designed and comparative study of simulated and experimental yield has been done. This will be useful for conducting experiments at university centre which will be beneficial to students and researchers
(4) Experimental determination of scattering effect using three well characterised beams was done with correction of contribution of sample holders of different thickness.

(b) Others:
An efficient imaging detector for fast neutron radiography with a cone beam developed
(2) sample holders for liquid specimen were designed, fabricated and tested with and without samples and results from different labs used for data analysis. Collimators designs based on MCNP calculations for improving intensity and resolution was carried out by developing laboratories which will be used for fabrication of the device.

Effectiveness of CRP:

(a) In reaching Specific Objective:
Optimization of instrument is one of the main issues for effective utilization of available neutron radiography facilities in many centers. The activities under the CRP helped design of collimators to improve the intensity and resolution of the incident beam for some instruments through the use of MCNP codes. Fast neutrons are used for radiography and the technique needs good quality detectors. Development of detectors for fast neutrons was one of the activities in this CRP.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The CRP helped in development of new facilities and upgradation of existing facilities in developing laboratories which will be useful to meet the needs of participants in effective

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utilization of research reactor beams. Good collaboration was advantage for developing facilities.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
Nothing affected adversely the CRP, but the procurement procedures at the participants institution end did delay in implementing some of the proposed project plans by some participants.

Impact of the CRP:
Availability of radiography facility with reliable good quality radiographs is essential for extending the technique for application to industrial users. Based on the discussions, communications and exchange of information during the CRP neutron radiography facilities are being developed and some are upgraded. This is useful to attract stakeholders for applications.

Relevance of the CRP:
Neutron radiography is a powerful tool for characterization and testing of materials and has edge over some of the complementary methods used for this purpose. This will also help in enhancement of research reactor utilization.

Recommended future action by the Agency:
A follow up meeting on the application of the technique and support for round robin tests on standard samples for standardization will be beneficial.

Resulting Publications:
The report has been submitted for publication as an IAEA TECDOC. The following publications resulted based on the work carried out under the CRP.


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21. DINCA, M., PAVELESCU, M., Calculation for a Neutron Imaging System Based on a CCD camera, Romanian Journal of Physics, Volume 51, Nos. 3-4, 2006, Bucarest, Romania, pp. 363-370.

22. DINCA, M., PAVELESCU, M., Detector for neutron and gamma radiography based on CCD cameras, 8th World Conference on Neutron Radiography, October 16-19, 2006, Gaithersburg MD, USA.

Appendix E.59
CRP No. 1358 (F12017)

CRP Evaluation Report

Title of the Co-ordinated Research Project:
Development of new techniques and applications of accelerator mass spectrometry

Section/Division: NAPC

Period Covered: 2004-12-15 through 2007-12-15

Total Cost: € 86 830.44

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
- To increase Member State capacities in the development of AMS for application in priority national development areas. This encompasses the increased utilization of ultra-trace radioisotopes for sustainable development, human health, food and agriculture, environment protection, water management, and safety and security.

(b) Specific (CRP):
- To catalyse the development of innovative and more accessible non-radiocarbon AMS technologies.
- To build capacity in applications of AMS in developing countries.

Outputs:

(a) Research:
- The major and most relevant scientific and technical achievements of the CRP can be summarized, as follows:
  - A novel, gas filled time of flight detector was developed for the isobar identification and high discrimination of Cl-36/S-36 at low energies. This approach can be beneficial to a large class of AMS laboratories with low energy electrostatic accelerators, and wishing to more effectively pursue water research programmes utilizing the long-lived isotope Cl-36.
  - A better theoretical description was developed of multiple electron loss collisions that take place between accelerated ions and the residual gas molecules in the high-energy side of a tandem accelerator, and which reproduced experimental measurements. This new knowledge of atomic collisions can be useful for the design and operation of accelerators in which the charge state distribution at the stripper must be known, and for understanding the origin of, and so mitigating, spurious backgrounds in high sensitivity AMS measurements.
  - A new experimental method using a nuclear microprobe was developed for investigating small angle ion-atom scattering processes of interest to AMS. Advantages were taken using technical developments in nuclear microprobe technology and techniques. Results obtained indicated acceptable agreement with conventional computer modeling and simulation routines for the most of studied systems, providing an increased level of confidence in the underlying science and mathematics implemented in the computer algorithms.
  - The participant from Kazakhstan has completed the design, development, and construction of an innovative, AMS accelerator facility for Cl-36 using their indigenous UKP-2-1 1 MV tandem accelerator. A heavy ion AMS beam line has been designed, built, commissioned, optimized, and controlled via a locally designed and built computerized automation system.
This new capacity in AMS will support a radio-ecological monitoring programme of radioisotopes in underground waters in Western Kazakhstan.

(b) Others:
The results of the investigations of problems through this CRP have generated useful data and information of interest to laboratories in several Member States. The participants have improved or developed new methods of AMS applicable to developing countries without access to modern and dedicated accelerator facilities. In general, it was found that all participants involved in the development of non-standard AMS techniques have achieved considerable progress in their research endeavours and reached a high level of mastery of the underlying principles behind precision AMS and concomitantly, putting these into practice.

Educational benefits: 3 Master and 3 PhD theses were contributing to and benefiting from contract holders activities under this CRP.

Effectiveness of CRP:

(a) In reaching Specific Objective:
AMS requires a very high standard of performance of accelerators in terms of stability, efficiency, transmission, etc which can usually only be met by modern accelerators, usually located in advanced countries. This CRP has highlighted to those Member States aspiring to develop a capacity in AMS, which acquisition of special experience and skills not readily obtainable from general industry needs to be developed through long-term investments in institutional and human resources. It is this uniqueness of accelerators and AMS that provides a strong stimulus for innovative thinking in solving technical problems where off-the shelf solutions are not obtainable, and for encouraging a culture of self-reliance.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The achievements attained and technology developed in some cases, and improved in others, can be transferred to other similar groups that did not participate in this CRP. The CRP provided opportunities from persons from geographically remote countries to travel to other research laboratories, and to be in closer proximity to the mainstream scientific community to interchange ideas and information and form and strengthen collaborations and partnerships.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
Willingness to openly share information, and willingness to participate on a cost-free basis, is the two most cited impediments to some advanced countries taking up Research Agreements under this CRP. Technology transfer by way of partnerships between AMS laboratories in advanced countries and developing countries was a key ingredient unable to be established under this CRP.

Impact of the CRP:
This CRP has stimulated and initiated technical developments and improvements in the accelerator laboratories of all participants, as an outcome of a better understanding of the underlying science and technology of accelerator systems and ion beam transport. This CRP has promoted communication and collaborative research among the participants. In particular, development of techniques and devices for identification of ions was a matter of discussion and in turn has reached considerable progress. Furthermore, the CRP has also stimulated training of young scientists and students consolidating in this way, the AMS groups at the different participating laboratories.

Relevance of the CRP:
AMS techniques and methodology have reached a high level of maturity, touching almost all possible application areas. AMS is a very sensitive technique able to trace minute amounts of
long-lived radioisotopes at abundance levels down to $10^{-15}$ now being achieved for some isotopes. This ultra-trace sensitivity opens up previously inaccessible studies of a large variety of complex and little understood processes occurring in nature, ranging from geology to astrophysics, to anthropogenic. With an increased interest in nuclear power and concerns over possible environmental issues associated with potential nuclear emissions from nuclear power plant/ fuel fabrication plant/ reprocessing plant operations and long-term disposal sites, AMS is increasingly being considered for new applications in environmental monitoring and nuclear security applications. Improved methods and/or techniques for high-sensitivity measurements of heavy isotopes will be required to be developed to make AMS more accessible to a larger number of interested Member States, and to build collaboration bridges to state of the art laboratories.

**Recommended future action by Agency:**

The CRP participants noted that knowledge of the “art” and science of accelerators and ion beam transport systems is diminishing worldwide in many accelerator laboratories. To many facility operators and end-users, an accelerator system (AMS or other) has become essentially a “black box” provided by equipment manufacturers, and which should be operated within prescribed specifications. The institutional capacities to change, optimize, and develop improved and specialized systems are considered to be below adequate levels in many accelerator laboratories, both in advanced and developing countries.

The CRP participants have identified areas for future activities that the IAEA may consider for further promotion in its Member States. In particular:

- Support training programs, schools, and interchange of young scientists, particularly in application areas in which high precision measurements are necessary, and for which a deep level of understanding and practical experience of “how to do it” is required to achieve it.
- Promote scientific visits by internationally recognised experts to laboratories geographical remote from the mainstream scientific community.

**Resulting Publications in PC:**

The results of the work done under the CRP have been/will be published in journals and national and international conferences by the participants, some of which are as follows:


Title of the Coordinated Research Project:
Dense Magnetized Plasmas

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2001-12-15 through 2007-04-30

Total Cost: € 198 482.42

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To stimulate and promote investigations of dense magnetized plasmas through synergistic international cooperation. Specific objectives are 1) to coordinate complementary research efforts by experts in developed and developing Member States related to DMPs, 2) to speed progress in DMP applications by sharing knowledge, manpower and costs, 3) to promote technology transfer among Member States, and 4) to contribute to knowledge preservation by involving additional scientists in developing Member States, not yet experts in DMPs.

(b) Specific (CRP):
The specific research objectives of this CRP fall into the following three categories:

i) Comparative Assessment of Driver Technology – Review and summarize the current status of key technologies of DMP devices including energy storage, switches, master trigger, chambers, target fabrication and inserting systems, etc. Being the Dense Plasma Focus (DPF) one of the most promising DMP devices, as for near-term applications, with energy supply system on the level of several kJ, it is supposed to develop the following topics in the frame work of this CRP:

- A new DPF device based on a new technology, possessing a long lifetime and permitting high repetition rate;
- A set of DPF chambers fitted to different nuclear and plasma physics applications exploring the generated beams of neutrons, X-rays, fast electrons ion and plasma streams

ii) Interface Issues – Identify and co-ordinate research in addressing and resolving interface issues between the DPF components and target systems.

iii) New Technologies Appraisals, Approvals, and Assessments. – Investigate possible applications at present level of development and evaluate the environmental, safety and economics aspects of candidate DPF and other devices designs. Recommend pathways, technologies and developments needed to produce an integrated system that meets the goals of developing environmentally acceptable, safe and economically competitive industrial, bio-medical and educational applications.

As part of the Comparative Assessment of Driver Technology and the New Applications Testing, Approvals, and Assessments. (items i and iii), technical requirements will be defined for drivers, chambers and targets (at the component subsystem or system level). Also, near and long term measurable goals will be established to help gauge progress toward economically and technologically attractive applications. Also in the frame of this CRP an exchange of updated pulsed-power technology will be organized

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Outputs:

(a) Research:

The outputs from this CRP cover the construction of several new devices, new testing chambers and innovative diagnostics and the new contributions to fusion and plasma physics science materialized in scientific publications:

- New Devices - Conception, design and construction of several Dense Magnetized Plasma devices (Plasma Focus 6.0, Plasma Focus 10.0, Volume Reflex Plasma Chamber, Positive Ion Source, Plasma Gun, a small and a large Z-pinch Plasma Focus (in construction) and chambers optimized for different applications. Several upgrades of the largest plasma focus operating with DD reaction, PF-1000.

- New Diagnostics - Upgrade and design of various diagnostic systems (fast optical diagnostics, Laser induced photo-detachment diagnostics, X-ray diagnostics, neutron spectrometers, proton track detectors, etc…)

- Material tests - Irradiation, diagnosis and modelling of materials relevant for fusion reactors and biology applications.

- Publications – As listed in the section on Resulting Publications.

Assessment of the work performed

During the first year (2002) the projects were focused in assessing the status of present devices involved in the CRP and develop the requirements for new plasma focus devices to be used in material research for fusion. Designs for new devices and components were developed aiming to upgrade and build new facilities in the laboratories. Initial equipment was manufactured/purchased and was transported to the recipient laboratories. Also a specific action was conducted to gather more participants involved in DMP to join the CRP. The initial 5 contracts were extended to 8 plus 2 agreements.

The second year (2003) was devoted mainly to put into operation two recent devices, the plasma focus 10.0 and the plasma focus 6.0. In parallel, were developed diagnostic systems to measure the plasma properties and control the operation of the devices.

This work was conducted in a strong international collaboration basis with the teams from different laboratories participating actively in the work.

For the third year (2004) the results were obtained in the utilization of the DPF devices to measure properties of fusion grade materials under irradiation of neutrons, x-rays and deuterium plasma jets. Also a contribution for biology by irradiating enzymes was made by one laboratory. Theoretical work on modeling the experimental conditions and interpretation of results was also conducted.

An important result of the experiments in material science was obtained in 2005 year by showing “proof of principle” that DPF can be used to treat materials for fusion applications and improve their specific characteristics, in particular their micro-hardness. This was a topic that called for further investigations.

The CRP also explored other applications for DMP devices. This is for instance the development of very intense ion beam sources and plasma jets for tokamak plasma fuelling and heating. These were conducted under an individual contract and a CRP agreement.

Application of DMPs in support of fusion research was mainly addressed in the extension period of the CRP (2005-2007), where most of the new devices and upgrades could be fully utilized. The activities in this area are summarized below:

- Intense streams of plasma and fast ions generated in Plasma Accelerators (PA) and Dense Plasma Focus (DPF) applied in testing materials intended for use as first wall and/or divertor elements in the existing and future fusion devices. Such tests using DMPs were and are being...
carried out intensively in Russia (DPF, PA), Poland (DPF) and Ukraine (PA). For example, preliminary comparative round-robin tests of low activating steels of various types, tungsten, carbon composites, and other ceramic and optical materials, were performed in 2006 with financial support from the IAEA (TC project POL/1013).

- Intense, short-duration, neutron pulses from DPF used to calibrate neutron diagnostics (activation counters) for existing and planned fusion devices (e.g., W7-X). This kind of activity is performed at present within the frame of EURATOM.
- Plasma gun technology developed for tokamak fuelling and improving initial stage of tokamak discharge. Experimental results already obtained in GLOBUS-M are very positive and promising for scaling up for larger devices.
- Dense plasma sources developed for production of neutral beam systems for application in magnetic confinement devices for plasma heating and current drive.

During the 2005 RCM were introduced two matrixes which helped to classify the working activities performed by the CRP participants. The Individual Activity Matrix (IAM) presented in Table I contains all individual activities planned in the CRP proposal and the Joint Activity Matrix (JAM) depicted in Table II groups the CSIs involved in one particular research topic being investigated in more than one laboratory. The propose of the JAM is to highlight the potential for performing joint research and networking planning in common topics that are being addressed individually in different laboratories and in which it would make sense to have stronger international collaboration.

A list of main topics covering the whole subject's range of the research on the Dense Magnetized Plasmas CRP is presented in annex I. The main topics are divided in sub-topics representing each research activity. All topics and sub-topics are numbered for further reference.

The IAM indicates the outputs of the research performed using the terms of “Y” (Yes) for referring to an activity that as been implemented and “P” (Published) if the results were published in a scientific journal or in a conference proceedings book. New activities that were implemented in addition to the planned ones are indicated between square brackets [new activity number].

The results presented in the Joint Activity Matrix relate only to joint activities where participation of at least two different groups (or more) to study a particular sub-topic was established in particular aiming at delivering new results to be published in a scientific journal or conference proceedings. The most striking output is that 12 of the 14 implemented joint activities (100% implementation rate) have resulted on publication in peer reviewed journals or in conference proceedings. This reveals the enormous benefit of the CRP in stimulating networking planning by finding synergies between CRP participants which resulted in a noticeable amount of joint publications and in established links and mechanisms to promote expertise exchange and international exchange of post-graduated students (by means of international schools, workshops, joint experiments and fellowships). Changes between the planned (in 2005) and the present collaborations' plan are very few indicating that some laboratories have not engage in few specific sub-topics of joint research (strikethrough numbers in Table II) and are not affecting the overall outputs of the planned activities.

The elaboration of a database was discussed during the RCM in 2005. The implementation of this activity was almost zero due to the dedicated effort and financial support required to build up and maintain an updated database. It is an activity that should be strengthened for the future as the participants have recognized.

(b) Others:

- established network among the CRP participating laboratories in planning and implementing research activities
- capacity building through the education of several students (awarding Master and PhD degrees) which participate in the CRP activities
- was an umbrella for organization of several Fellowships (at national and international level), Schools, Joint experiments, and Workshops used to exchange expertise, transfer knowledge, discuss new results and plan combined activities
• established links between CRP and non-CRP members, for instance, the membership on an international consortium established to test candidate materials for fusion in a round Robin experiment approach

• established a plasma focus laboratory at ICTP, Trieste, supported by CRP members, for training purposes.

Effectiveness of CRP:

(a) In reaching Specific Objective:

In summary, there were planned 135 research activities each corresponding to a sub-topic of study. Of the planned, about 6 activities where not addressed during the last two years. However, 19 new additional research activities have been implemented. The balance of planned and implemented exceeds 100% implementation rate due to the introduction of the new activities (overall published in 94 peer reviewed journal publications and 47 proceedings). In the course of the project several students participated in some of the research activities, in some cases receiving Master and PhD titles. About 16 under-graduated and 26 post-graduated students have been working in this CRP. (See text above for further details)

(b) In contributing towards Overall (i.e. Agency Project) Objective:

• Research activities based on the application of Plasma Focus (PF) devices as generators of ion, electron and neutron beams and hard and soft X - rays have large potential for future applications in fusion, medicine, hidden materials detection, semiconductor industry, and others. A recent CRP on "Neutron based techniques for the detection of illicit materials and explosives" is benefiting from some of the technology developed during the "Dense Magnetized Plasmas" CRP

• The CRP contributed to develop the experimental conditions to prepare and award a TC project between 2005 and 2006 to establish a laboratory for material testing based on plasma focus (POL1013).

• The possibility to cross link DMPs with mainstream fusion activities has been enabled by this CRP and has been already initiated and is expected to be enhanced through a new CRP.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

The lack of support to develop a Database for materials tests and results. Lack of networking tools to exchange information more readily and promote on-line real time discussions or remote accompanying of the experiments by all CRP members.

Impact of the CRP:

The main impact that the CRP produced in the community of DMPs can be highlighted as follows:

• state-of-the-art research infrastructure able to support mainstream fusion research has been established throughout the CRP participants

• modern diagnostic systems necessary to carry out advanced experiments have been elaborated and tested in the course of the last CRP

• new knowledge of the involved physical mechanisms occurring in DMP devices and in the irradiation of sample materials has been gained and exchanged within the community

• methodologies and procedures for organizing international experiments have been developed and implemented, starting from the preparatory phase and proceeding through the experiments up to the elaboration of scientific reports

• preparatory activities towards the effective utilization of DMPs in fusion research have been initiated, including the establishment of links to groups working in magnetic and inertial confinement fusion programmes

Appendix E.67
Relevance of the CRP:

The CRP was important to augment the research capability and cohesion of DMPs community. The progress on the CRP activities was awarded by the establishment of new links with other laboratories in the same field, not CRP members, working together in additional projects not foreseen at the start of the CRP.

In addition, some CRP members became members of an International Consortium to carry out comparative investigations of different materials subject to heavy plasma and radiation loads in view of the ITER and beyond ITER (DEMO) as well as ICF(NIF) demands. The laboratories participating in the consortium are:
1/ Sandia National Lab. (US)
2/ Forschunszentrum Juelich, FZK, Germany
3/ Troitsk Institute of Innovation and Fusion Research, Russia
4/ Kharkov Institute of Physics and Technology, Ukraine
5/ IPPLM, Poland

One CRP member developed the capability to propose and be awarded with a TC project (POL1013). One positive side effect worth to mention is that the new international contacts bridged through this TC project have materialized in significant funding from EU for a facility in Karkov, Ukraine (not a CRP member) to strengthen their contribution to the on-going material round robin tests.

Recommended future action by Agency:

The CSIs have recommended a few areas of action where DMP devices can effectively and visibly contribute to the future fusion activities through a new dedicated CRP. Some of the most promising future applications of DMPs for contributing for solving scientific and engineering problems in support of mainstream fusion research are identified for the two main fusion concepts as follows:

<table>
<thead>
<tr>
<th>Magnetic confinement</th>
<th>Inertial Confinement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanosecond time resolved testing and calibration of D-D and D-T neutron diagnostics</td>
<td>Nanosecond time resolved testing and calibration of D-D and D-T neutron diagnostics</td>
</tr>
<tr>
<td>Testing bench for charged fusion products diagnostics</td>
<td>Testing bench for charged fusion products diagnostics</td>
</tr>
<tr>
<td>Compact neutron sources for use in characterization of neutron fields and cross-calibration of MCNP codes</td>
<td>Compact neutron sources for use in characterization of neutron fields and cross-calibration of MCNP codes</td>
</tr>
<tr>
<td>Tests of fusion candidate materials under transient heat loads</td>
<td>Investigate the possibility to develop the PF technology to perform experiments for lithium blanket concepts under representative pulsed neutron fluxes.</td>
</tr>
<tr>
<td>Test of plasma facing and construction materials under plasma and fusion products fluxes</td>
<td>Test of plasma facing and construction materials under plasma and fusion products fluxes</td>
</tr>
<tr>
<td>Fuelling systems</td>
<td>Applications of DMP as intense x-ray sources (backlighting, pellet ignition, etc.)</td>
</tr>
<tr>
<td>Development of plasma sources for fusion applications</td>
<td>DMP as source for proton radiography for hohlraum characterization</td>
</tr>
</tbody>
</table>
Resulting Publications:
List of publications (2002 – 2007)

Peer Reviewed Journals


Appendix E.69


34. M.Sadowski, M.Scholz; Progress in large-scale plasma focus experiments, Problems of Atomic Science and Technology Series: Plasma Physics (10), 2005, 1, 81-85,
37. A.Szydlowski, A.Banaszak, M.J.Sadowski, M.Scholz, J.Wolowski; Advantages of the use of solid-state nuclear track detectors in high-temperature plasma experiments, Radiation Measurements, 2005, 40, 479-482

Appendix E.71
75. V. Gribkov, G. Van Oost, A. Malaquias and J. Herrera (2006) Summary of the 16th IAEA


Appendix E.73


Proceedings


Appendix E.74


Appendix E.75


40. V.K.Gusev et al Overview of the Globus-M Spherical Tokamak Results. Proceedings of the 21th IAEA FEC, Chengdu, China 16 - 21 October 2006 OV/P3


42. V.A. Gribkov (2003) Utilization of powerful beams of penetrating radiation produced by dense plasma focus devices to create ecologically clean technologies of materials treatment to improve their characteristics and to solve applied problems of material sciences. Proc. of the Tallinn University of Social and Educational Sciences, Tallinn 2003, B2: 9-14


Appendix E.76


CRP Evaluation Report

Title of the Coordinated Research Project:

Development of $^{99m}$Tc Based Small Bio Molecules Using Novel $^{99m}$Tc Cores

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2003-03-15 through 2006-03-14

Total Cost: € 127,486.02

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

To generate know how and expertise in participating laboratories for:

- Applying the recent advances in $^{99m}$Tc chemistry such as the $^{99m}$Tc tricarbonyl and $^{99m}$Tc nitrido chemical approaches for $^{99m}$Tc labelling of small biomolecules.
- Develop a few promising $^{99m}$Tc labelled small biomolecules of high purity and stability for further investigations as potential radiopharmaceuticals.

(b) Specific (CRP):

- Development of reproducible and simple methodologies for preparing the $^{99m}$Tc carbonyl and nitrido cores suitable for laboratories in developing Member States for use in further labeling of molecules with $^{99m}$Tc.
- Development of $^{99m}$Tc labeled analogues of a few important small bio molecules using these two new approaches and their evaluation as potential radiopharmaceuticals.

Outputs:

(a) Research:

- Development of know-how and expertise in participating laboratories to apply the new $^{99m}$Tc labelling approaches based on the Tc-tricarbonyl and Tc-nitrido cores to a variety of small biomolecules.
- Methodologies standardized for preparing a few important $^{99m}$Tc biomolecules of potential clinical interest using the new approaches data generated by participants assessing their relative potential for use as radiopharmaceutical.

(b) Others:

- Publication of the Progress reports, Reports to RCM, Publications in symposia and journals.

Effectiveness of CRP:

(a) In reaching Specific Objective:

The preparation, quality assessment and biological evaluations of a large number of $^{99m}$Tc complexes with biomolecules such as RGD peptides, annexin-derived peptides, fatty-acid derivatives, quinazoline derivatives and glucose analogs were achieved by the participants. The biological evaluations of the different radiotracers were conducted in several laboratories, some with promising and most with negative biological uptakes. One notable development was the synthesis of $^{99m}$Tc(N)(Cys2-Anx13) through a collaborative effort between institutes in Hungary and India. This $^{99m}$Tc nitrido complex showed specific binding to cultured apoptotic cells.
Further investigations on this compound may enlighten the mechanism underlying this specific uptake and provide an opportunity for developing a novel radiopharmaceutical targeting apoptotic tissues.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

- Confirming to overall objectives as listed in the CRP proposal, the fundamental chemical methods required for the preparation of the different $^{99m}$Tc cores were efficiently transferred to the various laboratories involved in the CRP.
- Chemical reagents required for the production of the different $^{99m}$Tc cores were shared with various laboratories. Similarly, a considerable number of ligands have been prepared through the application of chemical methods ranging from peptide chemistry to organic synthesis. These ligands were distributed among the various laboratories.
- The CRP was effective in increasing the technological level of the various laboratories. This allowed to obtain reliable experimental data, and led to a number of interesting scientific publications. Further, the various laboratories have been very efficient in assimilating the new technologies and improving their ability in these fields.
- Analysis of the results of the CRP revealed that the new labelling technologies have been fully incorporated into the scientific background of the various laboratories and, therefore, they could be conveniently utilized for pursuing the design and preparation of novel classes of radiopharmaceuticals other than those considered in this CRP.
- The CRP was also helpful for the participants for expanding their scientific relationships and to identify research collaborations, which may allow them to enter scientific projects funded by others sources.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Nil

Impact of the CRP:

The CRP is expected to have very a good impact on further widening the research capabilities of the participating laboratories. Based on the new and novel chemistries of technetium, the participants will be able to develop new Tc-99m complexes that could prove as useful radiopharmaceuticals. The high impact of the CRP can be seen from the large number of publications arising out of this CRP in high impact, peer reviewed scientific journals.

Relevance of the CRP:

Highly relevant as the novel chemistries and the new complexes developed during as well as by extension of the work in the participating laboratories could prove to be useful towards the development of potential diagnostic radiopharmaceuticals.

Recommended future action by Agency:

1. Continue the support towards the development of diagnostic tracers using $^{99m}$Tc.
2. Formulate and support CRPs for developing new radiopharmaceuticals for specific diseases based on the chemistries developed under f.2.20.38.

Resulting Publications:

1. Technical Report Series based on the submissions provided by the participants.
2. Papers in Journals as well as in National and International Symposia as listed below.

Journals


Appendix E.79


**Presentations at National and International meetings**


[34] Rey A.; León E.; Giglio J.; Decristoforo C.; and von Guggenbern, E. “Preparation and characterization of 99mTc-RGDyK-HYNIC peptide as potential Radiopharmaceutical for Nuclear Oncology.” The International Symposium on Trends in Radiopharmaceuticals, Vienna, Austria, November 2005.

[35] Rey, A.; Muslera, C.; Giglio, J.; León, A.; Decristoforo, C.; and von Guggenbern, E. “Nuevos cores de 99mTc en la marcación de péptidos con potencialidad para imágenes de neoangiogénesis tumoral.” The XXCongreso de ALASBIMN” Punta del Este, Uruguay, 4-7 diciembre 2005.


[45] Ellis, B.L.; Gorshkov, N.I.; Lumpov, A.A.; Miroslavov, A.E.; Yalfimov, A.N.; Braddock, R.; Prescott, M.C.; Sharma, H.L.; and Suglobov, D.N. “Pre-Clinical Evaluation of $^{99m}$TcI(CO)$_5$” 52nd Annual Meeting of the Society of Nuclear Medicine, Toronto, June 2005.


Appendix E.83
Title of the Coordinated Research Project:
Controlling of Degradation Effects in Radiation Processing of Polymers

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2003-11-15 through 2006-12-29

Total Cost: € 130,309.58

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To enhance Member State capabilities in applying radiation technology in managing agricultural and industrial waste and effluents and decontamination of biological agents as well as for advanced materials development and natural polymers processing.

(b) Specific (CRP):
To develop procedures and chemical formulations enhancing or preventing degradation effects on polymers, depending on the desired application of the process, and to develop reliable analytical methodologies concerning investigation of degradation effects of radiation on polymers, with emphasis on:

♦ Application of new and advanced analytical methods (optical and mass spectroscopy, chromatography, synchrotron radiation, etc.) for studying radiation effects in polymeric materials.
♦ Performance comparison of application of different techniques in study of the analogues radiation stimulus on the standardized samples.
♦ Development of improved radiation resisted blends for manufacturing of medical products sterilized by irradiation, insulators, etc.
♦ Utilization of radiation degradation of natural polymers for manufacturing of high-value added products such as medical or cosmetic grade cellulose.
♦ Controlling degradation effects by development of new and upgrading of existing radiation processing methods, e.g. irradiation in oxygen-free atmosphere.

Outputs:

(a) Research:

♦ The results reported on the controlled radiation-induced degradation of polysaccharides have shown that the degradation products can be effectively used as soil conditioners and plant growth promoters, as well as preventing infections by some fungi.
♦ The compatibility of gamma irradiated inner tubes with virgin butyl rubber was found to be practically the same as commercially available butyl rubber crumbs used by the tire industry. Recycling of irradiated inner tube waste has been shown to be a technically feasible process.
♦ The participants acquired sufficient knowledge and expertise to establish analytical methodologies for testing of radiation induced changes in polymeric materials.
♦ Advanced techniques for understanding the mechanism of radiation degradation were developed, data on radiation-induced physical and chemical changes were collected.

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and analyzed, and based on these results, the process of the degradation is more reliably controlled.

♦ Controlled degradation was used to achieve desirable polymer properties.
♦ A number of different methods for the suppression of unwanted degradation were proposed.
♦ Highly specialized techniques were applied to study the changes in the irradiated polymers associated with chain scission, oxidation and free volume alteration.
♦ The participants established successful collaborations and benefited mutually from the equipments, techniques and know-how available in collaborating partners.

(b) Others:

Publication of the Progress Reports, Reports on RCM, Publications in symposia and journals.

Effectiveness of CRP:

(a) In reaching Specific Objective:

Participating laboratories developed reliable analytical methodologies for investigation of degradation effects of radiation on polymers, and developed procedures and chemical formulations enhancing or preventing degradation effects.

In addition to the well-known effects of dose rate and irradiation atmosphere, the controlled degradation of marine based polysaccharides was found to be significantly affected by the water absorbed from environmental humidity. Either dry or highly moist samples were found to show the highest susceptibility for degradation.

When typically stabilized polypropylene is subjected to irradiation for sterilization purposes a yellow color may be developed due to chemical changes in phenolic stabilizers.

The advanced techniques developed for understanding the mechanisms of radiation degradation of polymers were: Positron Annihilation Lifetime Spectroscopy, Rutherford Backscattering, Elastic Recoil Detection Analysis, and the preparation of polypropylene having specific Carbon-13 labelling for which analysis of solid and volatile degradation products was accomplished using solid-state NMR spectroscopy and gas-chromatography-mass-spectroscopy.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

♦ The development of reliable analytical methodologies for understanding the mechanisms of radiation degradation of polymers, the use of controlled radiation-induced degradation to achieve desirable polymer properties and the suppression of unwanted degradation in the radiation processing of polymers, were efficiently transferred to the various laboratories involved in the CRP.
♦ The CRP was effective in increasing the technological level of the participants’ laboratories and the participants benefited mutually from the sophisticated equipments and techniques available in collaborating partners. This allowed obtaining reliable experimental data and led to a number of interesting scientific publications. Further, the various institutions participants were very efficient in assimilating the developments and improving their ability in these fields.
♦ The CRP was also helpful for the participants for expanding their scientific relationships and to identify research collaborations, which may allow them to enter scientific projects funded by others sources.
♦ During this CRP, the participants undertook several joint programmes and researcher exchange.
♦ A high number of publications and communications to scientific meetings were presented and accepted during the CRP.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None
Impact of the CRP:

This CRP has favourably impacted the widening the research capabilities of the participating institutions. Based on the results achieved in laboratory, the participants will be able to apply radiation processing to control the effects on degradation of polymers focusing specific application.

Relevance of the CRP:

Highly relevant showing the emerging beneficial applications that make use of radiation-induced chain scission, and had provided information on applications for which the further reduction of degradation effects is crucial. The development of reliable analytical methodologies for understanding the mechanisms of radiation degradation of polymers was an important output of this CRP. This CRP had provided timely visibility to the status, importance and future potential of this phenomenon for a wide range of industrial applications.

Recommended future action by Agency:

- Continue the support towards the development of analytical techniques for understanding the mechanisms of radiation degradation of polymers used in industrial processes.
- Formulate and support CRPs for studies of radiation degradation technology applied in nanostructuring of polymeric materials.

Resulting Publications:

**BRAZIL**


**BULGARIA**


[2] Misheva, M., Djourelov, N., “Positron annihilation lifetime study of biodegradable poly(l-lactide), poly(dl-lactide), poly(l-lactide-co-dl-lactide), and poly(dl-lactide-co-glycolide), before and after gamma irradiation”, to be submitted


EGYPT


KOREA


POLAND


ROMANIA


Appendix E.87
USA


TURKEY


SPAIN


Title of the Coordinated Research Project:  
New Applications of Prompt Gamma Neutron Activation Analysis (PGNAA)

Section/Division:  Division of Physical and Chemical Sciences

Period Covered:  2002-09-01 through 2005-12-31

Total Cost:  € 108,866.14

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To explore new fields of application for prompt gamma neutron activation analysis and to enhance the general perception of its role as a valuable analytical tool in the nuclear community.

(b) Specific (CRP):
To establish new applications of PGNAA particularly in the field of prospecting and processing of minerals at facilities with nuclear infrastructure. To validate analytical results obtained by PGNAA by introduction of results from a previous CRP and inter-comparison of analysis.

Outputs:

(a) Research:
Substantial progress was made in the improvement of existing facilities for enhancing neutron flux and reduced background radiation. Several new applications of PGNAA were presented, such as "analysis of long lived radionuclides in nuclear waste", PGNAA as a possible tool for the cement industry, investigating the fatigue in batteries, analysis of mineral deposits from the ocean floor, multi-element analysis of archaeological materials".

(b) Others:
The results of the MCNP design study for a neutron generator based irradiation facility for NAA and PGNAA were presented and discussed. The results suggest that current DD-NG technology could lead to a neutron source strong enough to enable short lived radioisotope analysis in complex samples independent from a conventional research reactor. Expensive and sensitive isotopic neutron sources can also be substituted if such a device can be made available.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The specific objectives have been fully met. The participant from China has established a new PGNAA facility and has successfully determined mineral content of ocean floor manganese nodules, All participants are using the new PGNAA data catalogue and a PT 'cement' has been performed incorporating also other, non CRP, participants.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
A great number of publications emerged from the CRP participants (more than 30 in international journals). New applications, such as H in Li-batteries, fission products in nuclear waste, B analysis in BNT relevant materials, or trace elements in archaeological figurines, have been successfully demonstrated.
(c) Factors, if any, which adversely affected the effectiveness of the CRP:

A purchase order of Li-plastic shielding material was delayed due to internal reasons, hence, full advantage of this material could not be explored. Other than that, the CRP was carefully planned and executed with timely implementation of meetings and reports.

Impact of the CRP:

The CRP has encouraged participants to explore the potential of and develop further the capabilities of their PGNAA facilities. Sensitivity was enhanced and reliability of results was improved through introduction of the new data catalogue and execution of the proficiency test "cement material". Demonstration of new fields of PGNAA applications will certainly encourage other PGNAA users to adopt these techniques.

Relevance of the CRP:

The demonstration of superior detection capability of PGNAA for some important radionuclides in nuclear waste, such as Tc-99, I-129, U and Th has relevance to nuclear safety and security as well as to nuclear safeguards activities. Exploring PGNAA sensitivities for the cement industry needs was unsuccessful, but hydrogen poisoning of Li batteries can be 'non-destructively' investigated using PGNAA. Here the technique has no other competitor and is of unique use for an important industrial branch.

Recommended future action by Agency:

The high potential of PGNAA for science and industrial applications has been demonstrated. Training and information of interested researchers from MS in PGNAA and its applications is an important IAEA activity that should be pursued through eg. ICTP training courses.

Resulting Publications:


12. English, Gerald A. Firestone, Richard B.; Perry, Dale L.; Reijonen, Jani; Ludewigt, Bernhard; Leung, Ka-Ngo; Garabedian, Glenn; Molnar, Gabor; Revay, Zsolt: The characterization of legacy radioactive materials by gamma spectroscopy and prompt gamma activation analysis (PGAA). Nuclear Instruments and Methods in Physics Research. Section B, Beam Interactions with Materials and Atoms ; VOL. 213 ; ISSUE: 1 (2004) 410-413


Title of the Coordinated Research Project:
Remediation of Polluted Waters and Wastewater by Radiation Processing

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2002-05-01 through 2006-09-30

Total Cost: € 161,291.12

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To enhance Member States capabilities in applying radiation technology in managing agricultural and industrial waste and effluents and decontamination of biological agents as well as for advanced materials development and natural polymers processing.

(b) Specific (CRP):
To develop potential applications of radiation processing treatment in the area of water, wastewater and ground water with emphasis on:

♦ Issues associated with radiation induced disinfection and decontamination of water.
♦ Issues associated with radiation-induced disinfection and decontamination of wastewater for reuse, (e.g. agricultural or ground water injection).
♦ Radiation Processing treatment of groundwater as a source of drinking water
♦ The treatment of highly contaminated groundwater for remediation and eventual uses of the water resource.
♦ Development of alternative methods for assessing the toxicity of treated water, e.g. genotoxicity.
♦ Studies conducted in the laboratory scale to better define potential limitations of the treatment process.

Outputs:

(a) Research:
This CRP contributed to basic scientific and technical information necessary to justify the use of radiation processing in remediation of water quality. The following results were achieved:
♦ Feasibility of implementing radiation processing as an alternative to disinfection process for water treatment.
♦ Collection of data on radiation treatment of real industrial and municipal wastewater.
♦ Comparative assessment of under beam water handling systems to maximize the electron utilization efficiency.
♦ Identification and development of most appropriate toxicological methods for testing radiation processed water.
♦ Development of a reliable and standardized Dosimetry system that can easily be used for flow through radiation processing systems.

(b) Others:
In Korea, on the basis of data obtained from a pilot plant operation, an industrial scale plant was constructed to treat textile dying wastewater.
Effectiveness of CRP:

(a) In reaching Specific Objective:

The current research for the development of potential applications of radiation processing treatment of water, wastewater and ground water demonstrated the effectiveness of ionizing radiation (gamma rays and electron beams) as such, or in combination with other treatment, in the decomposition of refractory organic compounds in aqueous solutions and in the effective removal or inactivation of various microorganisms and parasites. Radiation processing of secondary and tertiary effluents from municipal wastewater treatment plants showed that the destruction of organic compounds, elimination of estrogenic activity and efficient reduction in the number of microorganisms occurs simultaneously. Ionizing radiation at low dose rates demonstrated to increase the efficiency of lagoon treatment systems.

Studies conducted showed that the destruction of selected dyes and pesticides were efficiently removed using radiation processing. The combination of ionizing radiation with oxidants, such as ozone or hydrogen peroxide, further improved the removal efficiency. It was showed that the addition of TiO₂ prior to irradiation improved the destruction efficiency of a pesticide.

Fundamental studies have resulted in the determination of bimolecular reaction rate constants for several pollutants. Complimentary studies had also been conducted on the elucidation of destruction mechanisms of some compounds.

Kinetic models describing the removal of organic compounds, including the formation and destruction of reaction by-products, were formulated. These models appear to predict the formation of reaction by-products and could be used to guide analytical methodology and economic evaluation of the process.

The installation of the first full scale electron beam plant in Daegu, Korea, to treat 10,000 m³ day⁻¹ textile wastewater has demonstrated that the process is a cost-effective technology when compared to conventional treatment. The continuous operation of this facility will provide operational data on reliability and additional data for a detailed economic evaluation.

The electron beam processing of wastewater based on an economic feasibility study in comparing UV and ozonation was showed to be the most cost-effective process for the control of *E. coli* at flows greater than 5,000 m³ day⁻¹.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

- The processes parameters to disinfect and decontaminate the water and wastewater for reuse were established.
- Kinetic models describing the removal of organic compounds, including the formation and destruction of reaction by-products, were formulated and alternative methods for assessing the toxicity of treated water by radiation were developed and transferred to all participants of this CRP and they are able to apply the methodology in their countries.
- The CRP was effective in increasing the technological level of the various institutions participants. This allowed obtaining reliable experimental data, including laboratory and pilot scales demonstration, and led a number of interesting scientific publications. Further, the various institutions participants were very efficient in assimilating the developments and improving their ability in these fields.
- The CRP was also helpful for the participants for expanding their scientific relationships and to identify research collaborations, which may allow them to enter scientific projects funded by others sources.
- During this CRP, the participants undertook several joint programmes and researcher exchange.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Nil

Appendix E.93
Impact of the CRP:

This CRP has had a good impact on further widening the research capabilities of the participating institutions. Based on the results achieved in laboratory and pilot scale demonstrations, the participants are able to apply radiation processing to treat water and wastewater mainly from industrial origin for remediation and eventual reuse. The high impact of the CRP can be seen from the important publications arising out of this CRP in high impact, peer reviewed scientific journals.

Relevance of the CRP:

Highly relevant and demonstrating the radiation processing technology as an alternative safe, technically and economically competitive for the preservation of the environment.

Recommended future action by Agency:

♦ Continue the support towards the process optimization for the treatment of water, wastewater, municipal and industrial wastewater effluents, municipal landfill leachates and other materials that are highly contaminated with recalcitrant compounds such as: pesticides, endocrine disruptors, and surfactants.

♦ Formulate and support CRPs for fundamental studies on the removal of organic compounds from wastewater, to predict the formation of reaction by-products and to be used to guide analytical methodology and economic evaluation of the radiation processing technology.

Resulting Publications:


Title of the Coordinated Research Project:
Nuclear and Isotopic Techniques for the Characterization of Submarine Groundwater Discharge (SGD) in Coastal Zones

Section/Division:
Division of Physical and Chemical Sciences

Period Covered:
2002-08-01 through 2006-07-31

Total Cost:
€ 109 935.01

Objectives of CRP:
(a) Overall (Agency Project towards which CRP directed):
To improve the capability of the Member States for water resources and environmental management of coastal areas.

(b) Specific (CRP):
- To identify and integrate the application of isotope methods appropriate for detection of submarine groundwater discharge in coastal areas.
- To explore application of recently developed nuclear and isotopic techniques suitable for quantitative estimation of various components of SGD.
- To develop a better understanding of the influence of SGD on coastal oceanographic processes and on groundwater regime for better management of groundwater resources in coastal areas.

Outputs:
(a) Research:
In the frame of the CRP the participants have applied their techniques to detect, characterize, and quantify SGD in three reference sites: Sicily, Brazil, and Mauritius. These sites were complemented by selected case studies in Turkey, Australia, and New York.

It is clear that SGD is fairly ubiquitous in the coastal zone. Rates of discharge above 100 cm/day are considered high, while values below 5 cm/day are considered low (or even marginally detectable). In unconfined aquifers measurement strategies should be designed to search for patterns of decreasing SGD with distance from the shore and temporal patterns modulated by waves and tides; not only the diurnal tidal variations but also the spring-neap lunar cycle. Superimposed on these predictable patterns are the effects of storms and other events that may cause large SGD fluxes in a short time. Semi-confined aquifers may discharge many km offshore without a clear pattern. Regardless of location, however, both spatial and temporal variations are to be expected. Preferential flow paths (sometimes revealed as submarine springs) are commonly found not only in karst environments but also in situations that appear reasonably homogeneous and isotropic. Tidal variations generally appear as higher SGD rates at low tide levels (and lower rates at high tides). However, the modulation is not necessarily linear and the relationships are not completely understood. In some situations the rate of SGD seems to change abruptly without an obvious cause. The composition of SGD is often a mixture of fresh and saline groundwater with recirculating seawater accounting for 90% or more of the discharge in some locations or less than 10% in the case of some offshore springs. While each study site must be approached individually, a few generalizations to assist planning could be made. Different measurement techniques applied in the CRP are valid although they each have their own advantages and disadvantages. It is recommended that multiple approaches be applied whenever possible.
addition, a continuing effort is required in order to capture long-period tidal fluctuations, storm-induced effects, and seasonal variations.

The choice of technique will depend, of course, not only on what is perceived to be the "best" approach, but by practical considerations (cost, availability of equipment, etc.) as well. For many situations, it is found that in calm seas not affected by significant waves or strong currents, seepage meters appear to work very well. These meters provide a flux at a specific time and location from a limited amount of seabed (generally ~0.25 m²). Seepage meters range in cost from almost nothing for a simple bag-operated meter to several thousands of dollars for those equipped with more sophisticated measurement devices. However, labour costs to install and maintain seepage meters over a large area for more than a few days are substantial. Seepage meters are subject to artefacts but can provide useful information if one is aware of the potential problems and if the devices are used in the proper manner. This seems to be especially true in environments where seepage flux rates are relatively rapid (>5 cm/day).

Use of natural isotopic and geochemical tracers involves the use of costly equipment and requires personnel with special training and experience. One of the main advantages of the tracer approach is the integration of the SGD signal through the water column so smaller-scale variations, which may be unimportant for larger-scale studies, are smoothed out. The approach may thus be optimal in environments where especially large spatial variation is expected (e.g., fractured rock aquifers). In addition to the spatial integration, tracers integrate the water flux over the time-scale of the isotope and the water residence time of the study area. Depending upon what one wants to know, this can often be a great advantage. For example, stable isotopes of water molecule and that of solutes are useful for characterization of end members and sources of nutrients flowing to the sea through groundwater. Finally, different components of SGD can be recognized and quantified using isotopic tracers. This allows discharge from surficial and semi-confined aquifers to be separated. In all cases conclusions based on isotopic tracers depend on the validity of the models and their assumptions used to interpret the distributions. Mixing and atmospheric exchanges in the case of radon must be evaluated and care must be exercised in defining the end-members. Multiple tracers are recommended when possible.

Simple water balance calculations have been shown to be useful in some situations as an estimate of the fresh groundwater discharge. Hydrogeological, dual-density, groundwater modelling can also be conducted as simple steady-state (annual average flux) or non-steady state (requires real-time boundary conditions) methods. Unfortunately, at present neither approach generally compares well with seepage meter and tracer measurements, often because of differences in scaling in both time and space. Particular problems can be encountered in the proper scaling and parameterizing dispersion processes. Apparent inconsistencies between modelling and direct measurement approaches often arise because different components of SGD (fresh and salt water) are being evaluated or the models do not include transient terrestrial (e.g., recharge cycles) or marine processes (tidal pumping, wave set up, storms, etc.) that drive part of all of the SGD. Isotopic and geochemical tracers as well as seepage meters measure total flow, very often a combination of fresh groundwater and seawater. Water balance calculations and most models evaluate just the fresh groundwater flow.

Although the techniques described here are well-developed, there is no "standard" methodology. If one plans to work in karstic or fractured bedrock environments, heterogeneity must be expected. In this case it would be best to plan on multiple approaches. Rates are likely to be controlled by the presence or absence of buried fracture systems where flow is focused, or dispersed, by the topography of the buried rock surface. In such situations, integrated SGD might be assessed with dispersed tracers or described statistically from many, randomly situated, seepage measurements. In volcanic aquifers, especially young basalts, the radium signal may be low. This was found to be the case in the Mauritius and in other studies in Hawaii. Such a situation might hamper the application of Ra and Rn tracers in these settings. It is suggested in such an environment that one should also confirm the spatial heterogeneity with some preliminary seepage meter deployments and geophysical techniques; and use traditional
modelling approaches with caution as good results will likely require more complex models and significant amount of data.

If one plans to work in a coastal plain setting without an underlying semi-confined aquifer, it is likely that the results will be more homogeneous. Seepage meters often work well in such environments where conditions are calm. These can provide good estimates that can be checked by looking for a distinctive pattern in the results. Such a pattern might, for example, consist of a systematic drop off in seepage rates as a function of distance offshore in unconfined aquifers. Simple modelling approaches (e.g., hydraulic gradients, tidal propagation, thermal gradients) can often be valuable in this type of environment. Tracers also will work very well in coastal plain environments.

Based on experiences during this project, the following suggestions are made to improve the performance of future SGD assessments:

1. Some geophysical surveying (e.g., resistivity profiling, infra-red imaging) should be performed prior to the actual assessments so areas prone to high and low SGD can be mapped out in advance.
2. Point discharge measurements are best recorded in units of cm/day. It is often most useful to design measurements to allow for integrated assessments of groundwater flow per unit width of shoreline, the best way to make comparisons and to extrapolate results. For example, seepage meter transects normal to the shoreline that cover the entire seepage face (which can be mapped with the resistivity probes) would fit this requirement.
3. The experimental design should attempt to incorporate at least two independent techniques.
4. Coordination among groups should ensure that method-to-method intercomparisons can be made. For example, in some experiments data sets from different devices overlapped only for short periods. Extending these overlapping periods would benefit the evaluation process.

(b) Others:
- Assessment of appropriate identification and quantification tools for SGD based on isotopic, geochemical, geophysical and other related techniques.
- Model case studies with application of nuclear and isotopic techniques to SGD that will serve as the guidelines for future investigations in coastal areas.
- Inter-agency coordination between the IAEA and the UNESCO-IOC, the Scientific Committee on Oceanic Research (SCOR), Land-Ocean Interactions in the Coastal Zone (LOICZ) of the International Geosphere and Biosphere Program (IGBP) was established to ensure full integration of the CRP with other programmes in this area. This coordination will be useful for the future projects also.

Effectiveness of CRP:

(a) In reaching Specific Objective:

The CRP has fulfilled its objectives. The common paper and TECDOC resulted from the CRP will be a very useful guide for those who wish to undertake SGD studies in different environments.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

The studies will serve as a guide to the management of coastal water resources.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Impact of the CRP:

This CRP brought together investigators from diverse scientific backgrounds to assess submarine groundwater discharge (SGD) in different geological/hydrological regimes. A combination of isotopic, geochemical, geophysical, and hydrological measurements and models revealed
substantial SGD at each site. The CRP compared different techniques and arrived at a consensus protocol for future SGD studies. This CRP provided an opportunity to test various techniques of estimating SGD in the same location, and also in different environments. It is expected that the products of this CRP will serve as standard reference materials in ongoing studies of SGD.

Relevance of the CRP:

Submarine groundwater discharge (SGD) has been shown to be an important factor in the supply of nutrients and carbon to coastal waters. The natural supply of nutrients by SGD may be necessary to sustain biological productivity in some environments. There is also awareness that in some cases, SGD may be involved in harmful algal blooms and other negative effects. As coastal development continues, changes in the flux and composition of SGD are expected to occur. To evaluate the effects of SGD on coastal waters, it is necessary to know the current flux of SGD and its characteristics.

Recommended future action by Agency:

To guide future studies of SGD, the Agency should provide comprehensive information as well as financial support wherever possible. This information should also be included on the Agency web site. Training sessions on the isotopic measurement techniques and their interpretations should be established and made available to Member States. The training sessions should include practical training in the field, laboratory training for the measurements, and training in the interpretation and modelling of the data. Additionally, the Agency should support efforts to improve the isotopic measurements. These efforts should include workshops on the different methods and the establishment of standard reference materials to calibrate the measurements.

Resulting Publications:

The synthesis of experiments and intercomparisons resulted in a comprehensive paper in the journal 'Science of the Total Environment'. As a result of this CRP as well as the SCOR, IHP, and IOC support, 55 scientific papers have been published. It is anticipated that this list will continue to grow over the coming years. An Agency TECDOC entitled ‘Nuclear and Isotopic Techniques for the Characterization of Submarine Groundwater Discharge in Coastal Zones’ includes the full findings of this CRP.
Title of the Coordinated Research Project:
Improvement of the Standard Neutron Cross Sections for Light Elements

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2002-04-01 through 2006-06-30

Total Cost: €96 880.94

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To improve the methodology for the evaluation of the uncertainty covariance matrix in the R-matrix model fits and to produce R-matrix evaluations of the important light element standards. This work will be used further in a combining process to obtain final evaluations for the light and heavy element standards, with the aim of obtaining their acceptance as the standards set by the international community.

(b) Specific (CRP):
To solve a long-standing controversy between the uncertainties of the evaluated data obtained with the R-Matrix model and the non-model least-squares fits for large numbers of sets of experimental data, and so improve the methods of evaluating the covariance matrices for the uncertainties of the light element standards. The objectives of the CRP were substantially extended at the second Research Coordination Meeting in 2003. Evaluations of the cross-section standards for heavy elements and a combining fit of the resulting light and heavy element standards were added to the objectives of the CRP.

Outputs:

(a) Research:
Biases of the evaluation due to Peelle's Pertinent Puzzle (PPP) in the non-model (cross-sections are fitted parameters) and model (physical or mathematical) were studied for the particular case of the standard reaction least-squares fit. Different technical fixes were applied to reduce the PPP bias, and the Chiba-Smith option was chosen for the standards evaluation.

The origin of the strong reduction in uncertainty for the model fits compared with the non-model fits was explained. This reduction concerns only the variances (or percent uncertainties), and the decrease of variances in the model fits is fully compensated by the increase of covariances close to the diagonal of the matrix of the uncertainties. The uncertainty of the data cannot be judged on the percent uncertainties only - the full covariance matrix of the uncertainties should be analyzed.

Factors reducing the uncertainties in the general least-squares fits were studied. All cross-reaction correlation terms should be accounted for in the construction of the covariance matrices for experimental data.

The methods of determination of the outlying experimental data and introduction of an additional unknown systematic component of the uncertainty to these data were studied and applied in the standards evaluation.

Appendix E.100
A study was made of the possibility of using the microscopic nuclear structure and reaction theory in the evaluation of the standard cross-section for light elements. These studies revealed that this theory can predict the parameters of the R-matrix poles for the low orbital momentum channels in the energy region where reactions are used as standards. The expectation that theory can predict the parameters of the distant poles (used in later R-matrix analysis) were not met.

(b) Others:
Codes used for the least-squares fits were tested, and a bug was found in the GMA code and corrected. Differences in the fits of the same data with the EDA and RAC R-matrix codes were analyzed, and could be mainly explained in terms of the different chi-square expressions in the minimization procedure. The results of the evaluation were believed to be more reliable because of this detailed intercomparison of the codes.

The experimental database used in the evaluation was substantially extended, with the inclusion of the results of a number of accurate measurements undertaken since 1991.

The evaluation of the high-energy fission standards (20 < En < 200 MeV) was carried out by means of a combined fit with all other data, but not as a separate evaluation as done before. This increases the reliability of the evaluated data especially in the region around a few tens MeV.

A combined fit of the light and heavy element standards when the R-matrix fits are treated as pseudo-experimental data was proposed. The resulting covariance matrix of the evaluated data is positive definite.

The uncertainties in the non-model fit were justified by the analysis as proposed by the CSEWG - 2/3rds of all data obtained in the modern experiments fall in the error band of the evaluated data.

Evaluated ENDF-6 formatted files were prepared for all standards. The full version of the standards file includes all reactions used in the combined fit and all non-negligible cross reaction/cross-material covariances.

Effectiveness of CRP:

(a) In reaching Specific Objective:
All specific objectives planned at the beginning of the CRP were implemented, along with additional objectives that arose from the agreed extension. The final results are included in an IAEA TECDOC.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
Results of the CRP including the evaluated data files and related documentation have been provided for loading on the NDS/IAEA web-server for wide public access and retrieval.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
Work overload for some CRP participants led to delays in their specific tasks. If implemented according to the yearly updated plans, this project would have finished earlier.

Impact of the CRP:
The resulting evaluated standard cross-sections will be used by the world-wide community of nuclear experimentalists to obtain absolute cross-sections in measurements relative to these standards.

Results of the CRP are included in the general purpose files of some national nuclear data libraries (ENDF/B-VII.b2 - USA; BROND-3 - Russia).
Relevance of the CRP:

External reviewers (International Nuclear Data Committee, INDC) judged this project to be of a high priority. NDS/IAEA was the focal point for the implementation of this evaluation project by the NEA/OECD and many national nuclear data centres.

Recommended future action by Agency:

Taking into account the high priority of these data, the INDC recommended the continuation of this project in the form of a relatively modest Data Development Project. All future major work for this database should be undertaken at no cost to the IAEA by the interested national institutions. Additional involvement of the IAEA should be to act as coordinator of a series of small biennial meetings organized by the NDS. The first meeting (4 to 5 external participants, 3 days) should be held in 2008 to review the outcomes of using the new standards and assessments of any problems that might occur.

Resulting Publications:

IAEA Technical Report "An International Evaluation of Neutron Cross-Section Standards" has been prepared.
Title of the Coordinated Research Project:
Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2002-11-01 through 2006-02-28

Total Cost: € 126 423.48

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
- To incorporate newly available experimental information into evaluated nuclear data files, which can be processed and used by designers of nuclear plants.
- To activate available human resources and to facilitate interaction and sharing of work to complete the task defined in the previous item in a timely and professional manner.
- To produce improved evaluated nuclear data files that will allow more accurate design calculations of innovative fuel cycle concepts involving the thorium-uranium fuel cycle.

(b) Specific (CRP):
- Critical assessment of the available experimental information with emphasis on new data and renormalization to modern standard cross-sections (if necessary).
- Evaluation of experimental data, derivation of resonance parameters (where relevant), completion of data with the results of nuclear model calculations and formatting of the data in ENDF-6 format.
- Verification of the formatted data to ensure that they are formally correct, internally consistent and that they truly represent the experimental data, from which they were derived.
- Processing of the data into application libraries for validation purposes. Preliminary validation of processed data on existing externally provided benchmark test cases (if available).

Outputs:

(a) Research:
- New evaluated nuclear data files for Th-232 and Pa-231,233 as a collaborative evaluation effort.
- New evaluation for U-232 taken from the Minsk file with modifications.
- Files for U-233,234,236 adopted from ENDF/B-VII project with modifications based on the Minsk file.
- Benchmark specifications for one critical U-233 lattice and one irradiated thorium fuel composition were prepared.

(b) Others:
- Application libraries for all new evaluations, namely the ACE files for Monte Carlo and MATXS files for deterministic transport calculations.
- Full documentation.
- Web page for data distribution.

Appendix E.103
Effectiveness of CRP:

(a) In reaching Specific Objective:
- All foreseen outputs have been delivered.
- Significant improvement in benchmark calculations has been demonstrated with new data.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
- Extended energy range to 60 MeV allows usage of the data for ADS and transmutation.
- Covariance data allow estimates of uncertainties due to nuclear data, which are highly important in the analysis of innovative fuel cycle concepts.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
- Effective co-ordination of activities, distribution of tasks and full co-operation between participants.
- Selection of participants with expertise in experimental work, theoretical nuclear models and integral benchmarking.
- Conducting benchmarking activities in parallel with data evaluation work provided prompt feedback to the evaluators, which could be used immediately to improve the evaluations.

Impact of the CRP:
- Agreement between measured and calculated integral parameters in a variety of benchmarks was greatly improved.

Relevance of the CRP:
- Evaluations for Th-232 and Pa-231,233 were adopted for the US library ENDF/B-VII.

Recommended future action by Agency:
- Continue to support development of nuclear model input parameter database (RIPL).
- Continue to support development and maintenance of evaluation and data visualisation software tools.
- Consider extending the data evaluation activity to other nuclides (e.g. minor actinides and other, as necessary), following the favourable experience of the present CRP.

Resulting Publications:

Nuclear Data Files:
- New evaluated nuclear data files for Th-232 and Pa-231,233 as a collaborative evaluation effort.
- New evaluation for U-232 taken from the Minsk file with modifications.
- Files for U-233,234,236 adopted from ENDF/B-VII project with modifications based on the Minsk file.
Title of the Coordinated Research Project:
Nuclear Data for Production of Therapeutic Radionuclides

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2002-12-01 through 2006-11-27

Total Cost: € 98 187.35

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
- To improve the accuracy and completeness of the data needed for the optimum production of therapeutic radioisotopes.
- To activate available human resources and to facilitate interaction and sharing of work to complete the task as defined in the previous item in a timely and professional manner.
- To produce improved evaluated nuclear data files that will result in the optimum production of therapeutic radioisotopes.

(b) Specific (CRP):

Reactor-produced radioisotopes:
- Compile and evaluate cross sections as a function of the energy in the energy range 0 to 20 MeV to generate pointwise numerical data in ENDF-6 format and graphical data with recommended evaluated cross sections.
- Deduce spectrum-averaged data in the conventional way for thermal neutrons and validate the data by comparison with experimentally measured data from the literature.

Accelerator-produced radioisotopes:
- Carry out new measurements when required.
- Present cross sections as a function of energy up to 40 MeV (except for a few cases where the energy needs to be as high as 100 MeV) by generating pointwise numerical and graphical data with recommended evaluated cross sections.
- Deduce from the microscopic cross sections the integral yield data as a function of incident energy, and generate pointwise numerical and graphical data with recommended evaluated cross sections.
- Compare the deduced integral yields with the experimental thick target yields available in the literature.

Outputs:

(a) Research:
- New recommended nuclear data files in ENDF-6 format for the reactor production by means of neutron capture and decay of the following radionuclides: $^{64}$Cu, $^{166}$Ho (double capture), $^{192}$Ir, $^{114m}$In, $^{177}$Lu (two reactions), $^{186}$Re, $^{188}$Re (double capture) and $^{169}$Yb. Spectrum-averaged data for thermal neutrons have been derived and validated by comparison with experimentally measured data from the literature.
- Evaluation of fission yields for reactor production of $^{90}$Y, $^{131}$I and $^{137}$Cs therapeutic isotopes.

Appendix E.105
- New recommended nuclear data tables, plots and comprehensive decay schemes for reactor production through the (n,p) reaction of the following radionuclides: $^{32}\text{P}$, $^{89}\text{Sr}$, $^{90}\text{Y}$, $^{64}\text{Cu}$ and $^{67}\text{Cu}$.

- New recommended nuclear data tables, plots and integral yield data and comprehensive decay schemes for accelerator production by charged-particle induced reactions of the following radionuclides: $^{64}\text{Cu}$, $^{67}\text{Cu}$, $^{67}\text{Ga}$, $^{86}\text{Y}$, $^{105}\text{Rh}$, $^{111}\text{In}$, $^{114m}\text{In}$, $^{124}\text{I}$, $^{149}\text{Pm}$, $^{169}\text{Yb}$, $^{211}\text{At}$ and $^{225}\text{Ac}$.

(b) Others:
- Documentation is in preparation as an IAEA technical report.
- Web page for data distribution.
- 58 papers published in refereed journals during the course of the CRP.

Effectiveness of CRP:

(a) Specific Objective:
All foreseen outputs have been delivered including production data through 54 pathways for 11 established and 15 emerging therapeutic radionuclides. Four new radionuclides and five production pathways have been included in addition to those originally foreseen.

(b) Overall Objective:
- Newly recommended reaction data, fission yields and comprehensive decay schemes permit the preparation of the highest quality of the final radionuclidic product both in terms of activity and purity for safe therapeutic applications.

(c) Factors which adversely affected the effectiveness of the CRP:
None

Impact of CRP:

- Establishment of a comprehensive database of nuclear data for the production of therapeutic radionuclides.
- The resulting database has been used as a valuable set of benchmarks for the theoretical modelling of nuclear reactions induced by neutrons and charged particles.
- A significant number of new cross-section measurements in charged-particle (especially proton- and deuteron-induced) have been undertaken within this project through a dedicated experimental network covering four MS institutes.

Relevance of the CRP:

- Recommended data for the production of therapeutic radionuclides using accelerators have already been adopted by an independent committee to be included in the “Manual for cyclotron produced radioisotopes” to be published as an IAEA TECDOC by the Industrial Applications and Chemistry Section (Division of Physical and Chemical Sciences).
- Recommended deuteron- and proton-induced cross-section data are highly relevant for the new NDS research project on Nuclear Data Libraries for Advanced Systems: Fusion Devices.

Recommended future action by Agency:

- Convert all recommended reaction database to ENDF-6 format and make available through standard retrieval tools at the NDS website.
- Maintain and update the database and corresponding dedicated website to include new measurements and evaluations for radionuclides of interest.
- Consider extending the data evaluation activity to newly emerging radionuclides.
Resulting Publications:

1. Experimental study of the excitation functions of proton induced reactions on $^{113}$Sn up to 65 MeV
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, In Press, Corrected Proof, Available online 3 April 2006*

2. Activation cross-sections on cadmium: Proton induced nuclear reactions up to 80 MeV
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 245, Issue 2, April 2006, Pages 379-394*

3. Excitation functions of long lived products in deuteron induced nuclear reactions on platinum up to 40 MeV
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 243, Issue 1, January 2006, Pages 20-27*
   F. Ditrói, F. Tárkányi, J. Csikai, M.S. Uddin, M. Hagiwara, M. Baba, Yu.N. Shubin and S.F. Kovalev

4. Validation and upgrading of the recommended cross-section data of charged particle reactions: Gamma emitter radioisotopes
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 240, Issue 4, December 2005, Pages 790-802*
   S. Takács, F. Tárkányi and A. Hermanne

5. Activation cross sections of proton induced nuclear reactions on iridium
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 239, Issue 4, October 2005, Pages 293-302*

6. Experimental studies on excitation functions of the proton-induced activation reactions on yttrium
   M.S. Uddin, M. Hagiwara, M. Baba, F. Tarkanyi and F. Ditroi

7. Cross-section measurement of the $^{169}$Tm(p,n) reaction for the production of the therapeutic radionuclide $^{169}$Yb and comparison with its reactor-based generation
   *Applied Radiation and Isotopes, Volume 63, Issue 2, August 2005, Pages 235-239*

8. Experimental study of the cross-sections of $\alpha$-particle induced reactions on $^{209}$Bi
   *Applied Radiation and Isotopes, Volume 63, Issue 1, July 2005, Pages 1-9*

9. Experimental determination of cross section of alpha-induced reactions on $^{nat}$Pd
   *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 229, Issues 3-4, April 2005, Pages 321-332*
   A. Hermanne, F. Tárkányi, S. Takács and Yu.N. Shubin

10. Experimental studies on excitation functions of the proton-induced activation reactions on silver
    *Applied Radiation and Isotopes, Volume 62, Issue 4, April 2005, Pages 533-540*
    M.S. Uddin, M. Hagiwara, M. Baba, F. Tarkanyi and F. Ditroi
11. Activation cross-sections of long-lived products of proton-induced nuclear reactions on zinc
   Applied Radiation and Isotopes, Volume 62, Issue 1, January 2005, Pages 73-81
   F. Tárkányi, F. Ditrói, J. Csikai, S. Takács, M.S. Uddin, M. Hagiwara, M. Baba, Yu.N. Shubin and A.I. Dityuk

12. Activation cross-sections of light ion induced nuclear reactions on platinum: proton induced reactions

13. Activation cross-sections of deuteron induced reactions on platinum
   F. Tárkányi, S. Takács, F. Ditrói, A. Hermanne, Yu.N. Shubin and A.I. Dityuk

14. Excitation functions of nuclear reactions induced by $^3$He-particles on cobalt
   A. Fenyvesi, F. Tárkányi and S. -J. Heselius

15. Excitation functions of deuteron induced nuclear reactions on natural zinc up to 50 MeV

16. Experimental studies on the proton-induced activation reactions of molybdenum in the energy range 22–67 MeV
   Applied Radiation and Isotopes, Volume 60, Issue 6, June 2004, Pages 911-920
   M. S. Uddin, M. Hagiwara, F. Tarkanyi, F. Ditroi and M. Baba

17. Excitation functions for production of radioisotopes of niobium, zirconium and yttrium by irradiation of zirconium with deuterons
   F. Tárkányi, A. Hermanne, S. Takács, F. Ditrói, A. I. Dityuk and Yu. N. Shubin

18. Experimental cross sections for charged particle production of the therapeutic radionuclide $^{111}$Ag and its PET imaging analogue $^{104m,g}$Ag
   A. Hermanne, S. Takács, F. Tárkányi and R. Bolbos

19. Excitation functions of deuteron induced nuclear reactions on natural tungsten up to 50 MeV
   Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 211, Issue 3, November 2003, Pages 319-330
   F. Tárkányi, S. Takács, F. Szelecsényi, F. Ditrói, A. Hermanne and M. Sonck

20. Validation and upgrading of the recommended cross section data of charged particle reactions used for production of PET radioisotopes
   Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 211, Issue 2, October 2003, Pages 169-189
   S. Takács, F. Tárkányi, A. Hermanne and R. Paviotti de Corcuera
21. New experimental data on excitation functions for practical applications of alpha induced nuclear reactions on Ta up to 30 MeV
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 211, Issue 1, September 2003, Pages 22-32*
F. Tárkányi, S. Takács, A. Hermanne, F. Ditrói, L. Andó, S. -J. Heselius and J. Bergman

22. New data and evaluation of $^3$He-induced nuclear reactions on Cu
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 196, Issues 3-4, November 2002, Pages 215-227*
F. Tárkányi, F. Ditrói, S. Takács, M. Al-Abyad, M. G. Mustafa, Yu. Shubin and Y. Zhuang

23. Excitation functions of proton induced nuclear reactions on $^{nat}$Rb from 30 to 70 MeV. Implication for the production of $^{82}$Sr and other medically important Rb and Sr radioisotopes
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 194, Issue 4, October 2002, Pages 369-388*
Tatsuo Ido, Alex Hermanne, Ferenc Ditrói, Zoltán Szűcs, Imre Mahunka and Ferenc Tárkányi

24. New cross-sections and intercomparison of proton monitor reactions on Ti, Ni and Cu
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 188, Issues 1-4, April 2002, Pages 106-111*
S. Takács, F. Tárkányi, M. Sonck and A. Hermanne

25. Nuclear data for production of the therapeutic radionuclides $^{32}$P, $^{64}$Cu, $^{67}$Cu, $^{86}$Sr, $^{90}$Y and $^{155}$Sm via the (n,p) reaction: Evaluation of excitation function and its validation via integral cross-section measurement using a 14 MeV d(Be) neutron source,
*Applied Radiation and Isotopes, Volume 64, Issue 6, June 2006, Pages 717-724*

26. $^3$He-particle-induced reactions on $^{nat}$Sb for production of $^{124}$I
*Applied Radiation and Isotopes, Volume 64, Issue 4, April 2006, Pages 409-413*
K.F. Hassan, S.M. Qaim, Z.A. Saleh and H.H. Coenen

27. Alpha-particle induced reactions on $^{nat}$Sb and $^{121}$Sb with particular reference to the production of the medically interesting radionuclide $^{124}$I
*Applied Radiation and Isotopes, Volume 64, Issue 1, January 2006, Pages 101-109*
K.F. Hassan, S.M. Qaim, Z.A. Saleh and H.H. Coenen

28. Experimental study and nuclear model calculations on the $^{192}$Os(p,n)$^{192}$Ir reaction: Comparison of reactor and cyclotron production of the therapeutic radionuclide $^{192}$Ir
*Applied Radiation and Isotopes, Volume 63, Issue 1, July 2005, Pages 93-98*
K. Hilgers, S. Sudár and S.M. Qaim

*Applied Radiation and Isotopes, Volume 63, Issue 1, July 2005, Page 147*
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*Applied Radiation and Isotopes, Volume 60, Issue 6, June 2004, Pages 899-909*
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*Applied Radiation and Isotopes, Volume 59, Issues 5-6, November-December 2003, Pages 343-351*


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*Applied Radiation and Isotopes, Volume 58, Issue 1, January 2003, Pages 69-78*


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*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 262, Issue 1, August 2007, Pages 7-12
S. Takács, B. Király, F. Tárkányi and A. Hermanne

43. Evaluated activation cross sections of longer-lived radionuclides produced by deuteron induced reactions on natural nickel
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 260, Issue 2, July 2007, Pages 495-507
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44. Activation cross sections of the $^{169}$Tm(d,2n) reaction for production of the therapeutic radionuclide $^{169}$Yb
*Applied Radiation and Isotopes, Volume 65, Issue 6, June 2007, Pages 663-668

45. Activation cross sections on cadmium: Deuteron induced nuclear reactions up to 40 MeV
*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 259, Issue 2, June 2007, Pages 817-828

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*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 259, Issue 2, June 2007, Pages 829-835
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*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 258, Issue 2, May 2007, Pages 308-312
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F. Tárkányi, A. Hermanne, F. Ditrói, S. Takács, B. Király, M. Baba, T. Ohtsuki, S.F. Kovalev and A.V. Ignatyuk

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*Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 252, Issue 2, November 2006, Pages 160-174
F. Tárkányi, S. Takács, F. Szelecsényi, F. Ditrói, A. Hermanne and M. Sonck

50. Validation and upgrading of the recommended cross-section data of charged particle reactions: Gamma emitter radioisotopes
S. Takács, F. Tárkányi and A. Hermanne

Appendix E.111
51. Excitation functions of long lived products in deuteron induced nuclear reactions on platinum up to 40 MeV
_Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 243, Issue 1, January 2006, Pages 20-27_
F. Ditró, F. Tárkányi, J. Csikai, M.S. Uddin, M. Hagiwara, M. Baba, Yu.N. Shubin and S.F. Kovalev

52. Cross sections of deuteron induced nuclear reactions on iridium
_Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 247, Issue 2, June 2006, Pages 210-216_

53. Experimental studies of the deuteron-induced activation cross-sections on natAg
_Applied Radiation and Isotopes, Volume 64, Issue 9, September 2006, Pages 1013-1019_
M.S. Uddin, M. Baba, M. Hagiwara, F. Tarkanyi, F. Ditroi, S. Takacs and A. Hermanne

54. Evaluated activation cross sections of longer-lived radionuclides produced by deuteron-induced reactions on natural copper
_Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 251, Issue 1, September 2006, Pages 56-65_
S. Takács, F. Tárkányi, B. Király, A. Hermanne and M. Sonck

55. Excitation functions of natGe(p,xn)71,72,73,74As reactions up to 100 MeV with a focus on the production of 72As for medical and 73As for environmental studies
_Applied Radiation and Isotopes, Volume 65, Issue 9, September 2007, Pages 1057-1064_

56. Production of 139Ce by proton-induced reactions on 141Pr and natLa
_Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 255, Issue 2, February 2007, Pages 331-337_
C. Vermeulen, G.F. Steyn, F.M. Nortier, F. Szelecsényi, Z. Kovács and S.M. Qaim

57. Production of no-carrier-added 139Pr via precursor decay in the proton bombardment of natPr
_Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 252, Issue 2, November 2006, Pages 149-159_

58. Excitation functions for the production of 82Sr by proton bombardment of natRb at energies up to 100 MeV
_Applied Radiation and Isotopes, Volume 64, Issue 8, August 2006, Pages 915-924_
E.Z. Buthelezi, F.M. Nortier and I.W. Schroeder

Appendix E.112
Title of the Coordinated Research Project:
Tritium Inventory in Fusion Reactors

Section/Division: Division of Physical and Chemical Sciences

Period Covered: 2002-08-01 through 2006-12-04

Total Cost: € 103 505.84

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To gather and generate new data relevant to the inventory of tritium in fusion reactors. Special emphasis was placed on the interactions of tritium with plasma facing components and in-vessel materials. Data on tritium accumulation in and release from plasma-facing components (PFC) were to be collected. Methods which could be used for detritiation and to purge the system of tritium were to be considered. Data of direct application in the description of tritium transport in other reactor systems (e.g. the blanket) were also be accumulated.

(b) Specific (CRP):
To provide a database relevant to the overall tritium inventory in a fusion reactor. The main materials considered were those proposed for ITER and future fusion devices, primarily carbon, beryllium and tungsten. Due to plasma interactions with materials, mixing of these materials is expected to occur in fusion devices; therefore mixtures of these materials were to be considered. Retention and release mechanisms were to be studied, data on retention and release published and recommendations on the suitability made.

Outputs:

(a) Research:
As a result of research carried out in this CRP the following conclusions were formulated:

The increase of stored energy and pulse duration in ITER coupled with the lack of experience in contemporary tokamaks with the plasma facing materials proposed for ITER make the choice of these materials arguably the highest risk factor for ITER. The tritium inventory is a major source term in accident scenarios. Erosion and tritium retention properties are decisive factors in the selection of plasma facing materials.

It has been determined that of the proposed ITER wall materials, tungsten demonstrates the lowest tritium-inventory risk.

Carbon presents the greatest risk in terms of tritium inventory. For the use of carbon, tritium removal techniques will have to be applied.

Beryllium presents major retention risk through co-deposits in the presence of oxygen. Tritium removal techniques need to be developed and applied for Be.

Limited understanding of possible mixed material effects also increases tritium-inventory risks.
(b) Others:
The CRP participants made specific recommendations on wall materials based on their research:

1. Focus R&D on the effectiveness of tritium removal techniques from Be and BeO co-deposits with carbon and tungsten impurities.
2. There is a need for the capability in the ITER design to make a change of materials in the first wall, due to the concern of unacceptable high tritium inventories with current plasma facing materials.
3. ITER should explore the possibility of using high (400 C or more) temperature for tritium removal and for reduction of tritium inventory.
4. It would be desirable to design a cooled (room temperature) co-deposit collector in the divertor, which is heatable (to >700C) for subsequent hydrogen release and removal.

Effectiveness of CRP:

(a) In reaching Specific Objective:
This CRP completely fulfilled the specific objective in the evaluation of tritium retention and release from proposed wall materials for ITER.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The CRP was very effective in contributing to the overall understanding of tritium inventory in fusion devices. Specific recommendations have been made from the CRP and have been disseminated to the fusion community in published journal articles and IAEA reports.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
There were no adverse factors for this CRP.

Impact of the CRP:
This CRP has already had impact on the knowledge base for fusion devices. It is expected that information from this CRP will have continued relevance to ITER and future fusion devices through information gained on tritium uptake and release from common wall materials.

Relevance of the CRP:
This CRP was of very high relevance to the goal of the Atomic and Molecular Data Unit of establishing databases for fusion energy research. The CRP focused on the stated objectives and carried out appropriate research to achieve the goals of the CRP.

Recommended future action by Agency:
This CRP focused on tritium inventory in wall materials and mainly in the divertor region. The participants recommended that some consideration be given to an additional CRP to focus on blanked issues and permeation barrier development.

Resulting Publications
Summary reports of each RCM were issued as INDC reports.
Individual participants published results in scientific journals throughout the CRP.
All participants have contributed to a summary of the CRP to be published in a scientific journal.
Summary articles from each participant are to be published in volume 15 of the journal “Atomic and Plasma-Material Interaction Data for Fusion”.

Appendix E.114
Resulting Publications:

2. Haasz A.A., Davis J.W.: Tungsten for Use in Fusion Reactors. APID
3. Haasz A.A., Davis J.W.: Carbon for Use in Fusion Reactors. APID

Appendix E.116


Appendix E.117


Appendix E.119


Appendix E.120


CRP No. 1036 (I33010)

CRP Evaluation Report

Title of the Coordinated Research Project:
Intercomparison of Techniques for Pressure Tube Inspection and Diagnostics

Section/Division: Nuclear Power Technology Development Section, Division of Nuclear Power

Period Covered: 1998-12-15 through 2005-12-31

Total Cost: € 125 685.30

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To encourage, within the framework of the TWG-HWR, the exchange of scientific and technical information on, and international cooperation in, advances in heavy water reactor technology for electricity and/or heat production, with emphasis on safety, reliability and fuel utilization.

(b) Specific (CRP):
To validate, verify and improve methodologies and techniques for in-service inspection and diagnosis of pressure tubes via intercomparison of techniques being developed and used by different participating institutes.

Outputs:

(a) Research:
1. To identify the most effective and accurate in-situ NDE methods of:
   - pressure tube flaw characterization,
   - pressure tube blister characterization,
   - determination of hydrogen concentration in pressure tubes;
2. To identify of the most effective and accurate methods of destructive sampling and analysis for pressure tube hydrogen concentration;
3. To recommend advances in techniques or improvement of existing techniques for pressure tube inspection and diagnostics.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The CRP was implemented in the following manner:
- preparation of pressure tube samples containing flaws, blisters and hydrogen;
  carrying out non-destructive or destructive tests in different participating laboratories;
  intercomparison of results; preparation of TECDOC.
The CRP was found to be effective in reaching the original specific research objectives. All the specific research objectives were achieved.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
IAEA convened several Research Coordination Meetings and all participating laboratories were very active in carrying out this CRP.

Appendix E.123
(c) Factors, if any, which adversely affected the effectiveness of the CRP:
As the post of the IAEA project officer for this CRP remained vacant for an extended period of
time, the completion of the CRP was delayed.

Impact of the CRP:
Intercomparison of results has produced a consensus on the strengths and weaknesses of each
technique, leading to recommendations for new techniques or improvement of existing
 techniques.

Relevance of the CRP:
All of the countries that have operating heavy water reactors (Argentina, Canada, China, India,
 Republic of Korea, Pakistan and Romania) will be able to benefit from the results of this CRP.
Thus, topic and scope of the CRP seemed appropriate.

Recommended future action by Agency:
Participating laboratories recommended IAEA to organize a new CRP with pressure tube
 samples with real flaws or deuterium pick-up.

Resulting Publications:
1. IAEA-TECDOC-1499, Intercomparison of techniques for inspection and diagnostics of heavy
2. IAEA-TECDOC, Intercomparison of techniques for inspection and diagnostics of heavy water
   reactor pressure tubes: Determination of hydrogen concentration and blister characterization,
   will be published in 2008.
Title of the Coordinated Research Project:
Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies

Section/Division: Division of Nuclear Power

Period Covered: 2001-12-15 through 2006-12-31

Total Cost: € 151 120.79

Objectives of CRP:
(a) Overall (Agency Project towards which CRP directed):
• To enable the Member States to dispose of precise and well validated methods for desalination cost evaluations.
• To contribute to the IAEA’s efforts to enhance prospects of demonstration and eventually for the successful implementation of nuclear desalination plants in Member States.
(b) Specific (CRP):
• To evaluate economic aspects and to investigate the competitiveness of nuclear desalination under particular site-specific conditions in case studies.
• To identify innovative techniques leading to further cost reduction of nuclear desalination systems.
• To refine economic assessment methods and tools.

Outputs:
(a) Research:
• Collection and analysis of economic and performance data of various existing nuclear desalination installations.
• Determination of economic and technical site specific conditions and conducting of national case studies.
• Update the IAEA’s desalination cost evaluation software, DEEP, through integration of data from operating plants and inclusion of additional desalination/coupling options (e.g. HTRs and other reactors utilising waste heat for desalination).
• Development of a consistent, international approach for economic evaluation of nuclear desalination options, through the analysis of the results of the site-specific case studies.
(b) Others:
• Elaboration of detailed correlations for main RO performance parameters such as the recovery ratio, feed pressure, permeate flux etc as functions of three variables: the feed temperature, the feed flow and the feed salinity. Some correlations which established initially for Filmtec SW30-HR-380 membranes will be generalised to other
membranes and seawater compositions under the Indo-French collaboration agreement and experimentally verified on Indian RO installations.

- Development of an MED plant simulator (under a specific IAEA contract), based on the analytical treatment of thermal-hydraulic phenomena, utilising general energy and mass conservation laws. Thermodynamic parameters calculated by the simulator will then be input into DEEP for more precise calculations of desalination costs.
- Development of an economic method, based on the exergy principle, to remove some elements of arbitrary allocations in the power credit method.
- Egyptian and Syrian participants in the CRP have developed spreadsheet software to estimate the desalted water transport costs, which are included in new release of DEEP versions.

Effectiveness of CRP:

(a) In reaching Specific Objective:
- Results of calculation have shown that nuclear desalination systems are not only technically feasible but economically attractive options in varying site conditions and with a variety of nuclear reactor concepts.
- The cost of desalination by nuclear options, as compared to the most economical fossil fuelled based option, the gas turbine combined cycle plant (CC), could be in some cases 30 to 60% lower, depending upon the gas prices assumed. The overall conclusion is that nuclear options will be competitive as long as gas prices remain above 150 $/toe and discount rates are below 10%. It should be further underlined that all nuclear options considered in this CRP included the cost of safety related components, decommissioning, waste disposal and long term waste storage. Furthermore, calculations were made using the IAEA DEEP software where all specific construction cost is used including cost of land, nuclear island, mechanical island, including all other safety systems, building and constructions …etc.
- Through numerous discussions during the CRP meetings and the studies carried out by the participating Member States, the software package DEEP (version 3) has been considerably improved.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
- The results of the CRP demonstrate that the methodology used in the DEEP software may become an international and consistent approach for desalination cost evaluations of both fossil and nuclear energy based systems. However, more work is required to benchmark and validate DEEP results.
- Several approaches have been proposed and studied in participating countries to reduce the cost of nuclear desalination. The first of these is the use of waste heat from nuclear reactors for desalination. Similarly, the waste heat from the pre-cooler and intercooler exchangers of the new generation HTRs, such as the GT-MHR and the PBMR, can lead to drastic cost reductions in MED systems coupled to such reactors. A third approach to cost reduction would be the use of hybrid thermal/RO systems leading to a considerably enhanced flexibility of the combined system to meet the varying water demands and in which the overall cost of the system is significantly lower. Yet another approach to increase the overall efficiency of the desalination systems would be to extract strategic and valuable materials from the concentrated brine rejected by the desalination plants. This would simultaneously render nuclear
desalination systems relatively more environmentally friendly since no discharges would be made directly to the sea.

- Nuclear desalination costs are strongly influenced by such parameters as the interest and discount rates, the total plant availability, the power costs, the specific water plant base costs etc. In general, it can be stated that RO costs would be in the range of 0.5 to 0.9 $/m³. Desalination costs from thermal systems such as the MED would be slightly higher being in the range of 0.6 to 0.96 $/m³. It should be recalled that the product water salinity by thermal desalination plants is much lower (about 30 ppm) as compared to 300 to 500 ppm from RO plants. The real choice of one over the other would thus be a complex problem, depending upon the specific industrial, agricultural and potable water needs of the countries.

- The water transport costs are an essential part of the global picture. Judging from the results of two reported studies it can be stated that they would be in the range of 0.1 to 0.2 cents/m³/km. These costs should be added to the above production costs to obtain the real cost of desalted water.

Impact of the CRP:
The CRP results and the published report as TECDOC is useful to engineers, scientists and students, as well as decision makers in the Member States, and could influence them to consider or to accelerate the deployment of nuclear desalination plants in their respective countries. Despite the fact that the CRP covered the period of 2002-2006, the methodologies and results obtained are still valid but should be considered in a qualitative and not quantitative manner. The recent increase in fossil fuel especially of oil (US$108/barrel) will enhance the results obtained in the CRP and further demonstrates the competitiveness of the nuclear option.

Relevance of the CRP:
- The CRP on Optimization of the Coupling of Nuclear Reactors and Desalination Systems was completed in 2003 with the participation of 11 Member States. The results of the CRP were published as IAEA-TECDOC-1444 (2005).
- Following recommendations from INDAG, a second CRP (CRP2) on Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies with the participation of 10 Member States was started in 2002 and was completed in 2006.

Recommended future action by Agency:
- It is recommended that the Agency:
  - Initiate further assessment of the possible benefits of cogeneration of water and electricity to the nuclear desalination systems.
  - Continue development and validation of DEEP software through validation, benchmarking and comparison with the actual costs and technical characteristics of operating installations.
  - Initiate comprehensive studies of socio-economic and environmental aspects related to both nuclear energy and desalination.
  - Initiate studies on nuclear desalination cost reduction strategies through innovations.
  - Establish links between major non electric applications of nuclear power such as water desalination, energy production, process heat and hydrogen production.
Resulting Publications:

Title of the Coordinated Research Project:
Accident Severity during Air Transport of Radioactive Material

Section/Division: Division of Radiation, Transport and Waste Safety

Period Covered: 1998-06-01 through 2005-09-30

Total Cost: € 42,233.10

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
In 1996, the IAEA published Safety Series ST-1, “Regulations for the Safe Transport of Radioactive Materials”, which specified requirements for the safe transport of radioactive materials for various transportation modes including the specification of a new packaging type (Type C) to be used for air shipments with enhanced performance requirements. Type C package requirements apply to shipments of radioactive materials by air with an activity greater than specified limits. In 1998, the International Civil Aviation Organization recommended the IAEA secretariat to initiate a CRP to consider research on aircraft accident frequency and severities to validate Type C package test requirements. It further recommended that relevant issues should be identified including data collection, data analysis and treatment of results and that the CRP results be fed into the review process for ST-1.

(b) Specific (CRP):
To collect additional relevant data and analyse it so that the accident forces to which a package of radioactive material might be subjected can be further quantified. This quantified information should make the underlying data for decisions on regulatory test requirements more up to date and reliable.

Outputs:

(a) Research:
- Data on accidents involving the type of aircrafts currently deployed were collected for a period of 11 years.
- The mechanical and thermal impacts and water immersion encountered in the reported accidents were analysed.
- For focusing on relevant impact speeds, a coarse filter (a threshold impact velocity) was agreed upon.
- For simulating the impact test conditions, corrections for the angle of impact and the hardness of the impacting surface were made.
- Similar analysis was made with respect to the thermal and the water immersion tests.
- Frequencies of accidents more severe than the regulatory tests were computed.
Effectiveness of CRP:

(a) In reaching Specific Objective:

The CRP was as effective as the paucity of useful data would permit. The paucity of data is itself an indication of the high degree of safety obtained in air transport.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

The CRP concluded that the current regulatory standards of safety are adequate.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None

Impact of the CRP:

The result of the research shows that the current safety standard for air transport of radioactive material, which is assured by the regulations is adequate and, therefore, no amendment to the regulations is required in light of this research. The ICAO actively participated in the research project and collected, compiled and analyzed the accident data which was used in the research. The wrap-up meeting for the preparation of the draft report of the CRP was organized at the ICAO Headquarters in Montreal. A copy of the report prepared at the meeting was forwarded by the Agency to the ICAO.

Relevance of the CRP:

The results of the CRP assure the regulatory authorities about the adequacy of the current regulatory standards for the transport of large quantities of radioactive material by air.

Recommended future action by Agency:

The CRP report will be published as a TECDOC. Any proposed amendments to the regulatory provisions relating to the safe transport of large quantities of radioactive material by air should be examined against the studies made in this CRP.

Resulting Publications:

A TECDOC reporting the results of the CRP was published.
CRP Evaluation Report

Title of the Coordinated Research Project:
Avoidance of Unnecessary Dose to Patients while Transitioning from Analogue to Digital Radiology

Section/Division: Division of Radiation, Transport and Waste Safety

Period Covered: 2002-11-15 through 2006-05-31

Total Cost: € 41 378.80

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To optimize radiological protection by determining the patient doses that are necessary for diagnostic confidence and assessing the effect that a QA program has on image quality and radiation dose to patients in facilities transitioning from analogue to digital radiography.

(b) Specific (CRP):
To establish methodology to analyse retake rates, image quality and patient dose parameters with particular reference to specific situations and problems in digital radiography. Utilising these methodologies, to obtain data on image quality and patient dose in centres using CR and DR.

Outputs:

(a) Research:
- Methodologies for retake assessment, image quality evaluation and entrance surface air kerma (ESAK) were commonly agreed upon and adopted in the project.
- Specific factors that have potential to contribute to increased patient doses were identified and their contribution assessed.
- The ESAK data were validated through TLD inter-comparisons of dosimeters and was within +/- 10%, which is acceptable.
- Retake rates were in the range of 1.5 to 9% with collimation and positioning contributing highest to the causes. The range of ESAK for a particular examination was wider than explicable through equipment variations and it was found that radiographic technique plays a large factor. However, ESAK values were within the DRLs.
- Use of AEC on the x-ray unit wherever this is available has a significant effect on patient dose - estimating exposure factors can result in high doses, while over- or under-exposures will frequently not be obvious after digital image acquisition.
- This study yet again emphasizes the need for a considered approach to QA in digital radiographic imaging. The transition from film to digital offers a special and important opportunity to optimize dose.

(b) Others:
The results from this project shall be useful for Member States transitioning from conventional to digital imaging radiography.
Effectiveness of CRP:

(a) In reaching Specific Objective:
The success of the project has been in developing a systematic approach to patient dose assessment and dose management through QA actions in digital radiography.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The main focus of the sub-programme on radiological protection of patients is on avoidance of unnecessary radiation doses to patients. In that respect, this project has made direct contribution in analyzing the unnecessary doses and doing cause analysis leading to development of rationale for QA.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
It was an unfunded project (under CAURB). Accordingly some actions had to be curtailed, such as not holding the 3rd RCM and in regarding contract sizes.

Impact of the CRP:
a) Direct impact on improving the image quality and patient dose were seen in a hospital where identification of lack of collimation was rampant and the project helped in remedial actions which automatically has its impact on thousands of patients.
b) The culture of optimization of radiological protection resulted in participating hospitals.
c) The project triggered the development of a phantom for image quality assessment in digital radiography.

Relevance of the CRP:
Digital imaging is the future of radiology and many Member States of IAEA are acquiring digital radiography equipment as the cost of digital imaging systems is coming down. Digital radiography has the potential to offer images with fewer problems of retake in view of image processing and better latitude. However, because of the better latitude, patient exposure is less restricted by the characteristics of the image receptor, with the consequence that dose higher than necessary can remain undetected. If left alone the average dose in many hospitals may increase over time. Systematic study of this type provides guidance to Member States in developing training programme to achieve optimisation of radiological protection.

Recommended future action by Agency:
To develop training material for patient dose optimisation in digital radiography.

Using the website on radiological protection of patients (http://rpop.iaea.org) provide regular updates on newer developments in radiological protection in digital imaging.

Resulting Publications:


Title of the Coordinated Research Project:
Evaluate Quantitatively and Promote Patient Dose Reduction Approaches in Interventional Radiology

Section/Division: Division of Radiation, Transport and Waste Safety
Period Covered: 2002-11-15 through 2006-02-28
Total Cost: € 59 865.72

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To acquire data on dose and image quality and to develop information for physicians that will raise their awareness of skin dose delivered during their fluoroscopically guided procedures. This will provide knowledge and tools necessary to use radiation more effectively with less risk to individual patients.

(b) Specific (CRP):
- To identify and characterize the procedures on the basis of potential for high dose to the patient at specific facilities involved in the research.
- To assess the technical and the image quality capabilities of the equipment used for the research.
- To develop methodologies by which doses to patients from certain complex interventional procedures can be estimated.

Outputs:

(a) Research:

a) 56 patients were found to have maximum skin dose (MSD) exceeding the threshold of skin erythema of 2 Gy, 15 of them exceeding 4 Gy.

b) Contrary to general belief the body mass index of a patient was only weakly related to the risk for high skin dose in the interventional procedures in this project. This means that the size of a patient is far less an important predictor of the dose likely to accrue and the risk of radiation injury than are other factors, such as complexity or difficulty of a procedure. Since the complexity index was used in this study this conclusion was possible to arrive at.

c) Many injuries occur in patients who undergo multiple procedures. Multiple procedures are implicated in this project as being an important contributor to the accumulation of dose in a patient's skin.

d) Monitoring radiation dose to a patient's skin to manage near-term adverse effects is an important aspect of patient care.

e) Monitoring radiation dose to patients with sufficient accuracy is a complex issue. It requires that resources be available to assure a quality and meaningful result.

f) Fluoroscopy time is correlated with dose to the patient but is a poor predictor of it because it does not account for the effects of image acquisition modes and various uses of different beam geometries and output modes of operation.
g) The use of gafchromic media ("film") proved to be highly valuable tool in dose assessment. It provided consistency and reliability in measurement among centers. Use of a dose calibration strip can assist in the real time use of this material, but it must be applied carefully to assure accuracy.

h) Use of small-area skin monitors (like the semi-conductor based systems) posed more difficulty and should not be used for any procedure where the beam will be reoriented during the procedure or where the position of the monitor in the field cannot be continually verified. Skin dose monitors are very useful only in situations where beam orientation can be predicted ahead of time and wherein it will be fixed in that position for nearly the entire procedure.

(b) Others:

The number of patients having maximum skin doses exceeding the threshold for skin injuries surprised participants in the project. The results from this project shall be useful for Member States in realizing the radiation risks in interventional procedures and resorting to dose management.

Effectiveness of CRP:

(a) In reaching Specific Objective:

The project has been successful in raising awareness about higher doses involved in interventional procedures. It has also contributed to knowledge about various dosimetry tools and methodologies, their limitations and merits and what dose management actions can be instituted.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

Avoidance of radiation injuries to patients is one of the most important elements in the sub-program on radiological protection of patients. Interventional procedures are major contributor to deterministic risks and this project made direct contribution in the sub-program.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

None

Impact of the CRP:

a) Monitoring doses delivered during interventional radiotherapy revealed unsuspected and unusually high dose rates from some equipment when used in certain operating modes. Only by monitoring can such events be found, even when quality control is routinely performed, as it was for the facilities in this project.

b) Experience of interventionalists in efficiently completing a procedure is a major factor in dose management. Even under well monitored and controlled training conditions, it was demonstrated that significant increases in dose to the patient result from interventionalists who are less skilled than others.

Relevance of the CRP:

According to ICRP and UNSCEAR, the annual rate of increase in interventional procedures in many countries is in the range of 10 to 20%. Since 1990, hundreds of cases of radiation skin injury from fluoroscopic interventions have been reported in the scientific literature and in legal proceedings. Optimisation and prevention of accidental exposure is crucial to application of Standards. IAEA, in discharge of its responsibility of application of safety standards, has to contribute to gathering information on magnitude of risks involved in such procedures that are carried out in Member States, create awareness about the risks in such procedures, on methods of dose management and provide necessary tools to monitor the radiation doses.
Recommended future action by Agency:

- To work towards sustainability in Member States on information dissemination through professional societies, to develop regulatory and voluntary mechanisms for reporting radiation incidents that cross the threshold for deterministic injuries.

- Use the website on radiological protection of patients (http://rpop.iaea.org) to provide regular updates on deterministic injuries in interventional procedures.

Resulting Publications:


SAENCHON, P., Krisanachinda, A., Wangsuphachart, S., The determination of the average patient skin dose and its factor affecting in cardiac catheterization procedures, ASEAN J. Radiol. (communicated)


Title of the Coordinated Research Project:
Dose Reduction in Computed Tomography (CT) while Maintaining Diagnostic Confidence

Section/Division: Division of Radiation, Transport and Waste Safety

Period Covered: 2002-11-15 through 2006-02-28

Total Cost: € 50 247.92

Objectives of CRP:
(a) Overall (Agency Project towards which CRP directed):
To reduce the dose to the individual patient while maintaining satisfactory diagnostic confidence.

(b) Specific (CRP):
To develop and verify a widely applicable methodology by which CT exposure techniques can be optimised for satisfactory diagnostic confidence with minimum dose to the patients.

Outputs:
(a) Research:
1. The results of this study show that it is possible to reduce CT patient dose for chest and abdominal examinations while maintaining image quality and hence diagnostic confidence.

2. At constant mAs levels, the noise decreases too strongly for small patients and may become excessive for obese patients. To maintain balance between image noise and patient size, individual dose adaptation is therefore warranted. This study shows that it is possible to develop a relationship between image noise and patient weight that can be used to adapt the dose for a specific image quality. However, it is an oversimplification to suggest universally applicable weight-based nomograms for optimized mAs as scanners vary in output (on account of factors such as scanner geometry, detector efficiency and so on).

3. For routine chest and abdomen CT examination in an adult population, it was found that a target noise of 10 was acceptable and can be increased for thicker patients. For pediatric patients and for indications in which contrast resolution has to be high (e.g., evaluation of liver lesions), lower target noise levels may become necessary. For specific indications (e.g., benign diseases such as kidney stones) and obese patients, a much higher noise level can be acceptable.

4. In the chest, noise measurements give variable results and possibly unreliable, but adopting an approach based on reducing abdominal dose requirements by a certain percentage (30% in this study) appears to work in practice.

(b) Others:
The methodologies for image quality and patient dose assessment developed or tried and established in this project are being utilised for the work of TC projects now on-going in all the four regions of IAEA and thus are proving useful to many Member States.
Effectiveness of CRP:

(a) In reaching Specific Objective:

a) The project has successfully developed and verified methodology by which CT exposure techniques can be optimised for satisfactory diagnostic confidence with minimum dose to the patients in CT scanning of abdomen. However, the study has shown that universally applicable weight-based nomograms for optimized mAs are not possible in view of variation in output because of factors such as scanner geometry, detector efficiency and so on.

b) With the demonstration of dose reduction without compromising on diagnostic confidence, the project has contributed towards overall objective.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

CT is the greatest contributor to the population dose and is continuing to increase in all parts of the world. This aspect occupies important place in the sub-program on radiological protection of patients. A recent report demonstrates deterministic injury of loss of hair on the head. The stochastic and deterministic risk being possible particularly with repeat CT scans on the same patient, this work made direct contribution to the overall objective of the sub-program.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Very fast changing technology in the area of computed tomography creates problem in adoption of research outcomes because newer technological development overtake adoption of effective dose management methodologies.

Impact of the CRP:

One paper arising from this project was published in a journal "Radiology" with high impact factor of 3.9.

Modified protocols showing a 22 % CTDIv and a 42 % DLP reduction in abdomen and a 24 % CTDIv and a 15 % DLP reduction in chest CT contributed to patient dose reduction in the participating hospitals.

Direct involvement of radiologists in this project, rather than only medical physicists, created helpful impact in the participating departments on transmission of knowledge and skill in patient dose management.

Relevance of the CRP:

Highest contribution to mankind from manmade ionizing radiation from a single imaging technique comes from computed tomography (CT). UNSCEAR estimated in its 2000 report that globally CT contributes to 34% of the radiation exposure to population as compared to all sources of medical exposures. The contribution to population dose in some developed countries is almost 70% from CT as indicated in this CRP. Thus radiation dose management from CT is most relevant part of the sub-programme on radiological protection of patients.

Recommended future action by Agency:

The results of CRP can be utilised both by users and manufacturers in patient dose management in CT. The Agency can further enhance the actions through TC projects on patient dose management in CT to help users in achieving lower doses. The Agency should strengthen link with International Electrotechnical Commission (IEC) so that IAEA can be part in development of Standards for imaging equipment.

Resulting Publications:


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while maintaining diagnostic confidence: Diagnostic reference levels at routine head, chest and abdominal CT - IAEA coordinated research project, Radiology 240 3 (Sep. 2006) 828-834.

Suwanpradit, P., Krisanachinda, A., Arjhansiri, K., Kitsukjit, W., The effect of the implementation of the quality control program of the computed radiography system. ASEAN J. Radiol. (communicated)


Tsapaki, V., et al., The results of the IAEA project on correlation of noise and image quality in routine CT abdomen and chest examination. World congress on medical physics and biomedical engineering (WC), Seoul, Korea (Sep.2006).
Title of the Coordinated Research Project:

Safety Significance of Near Field Earthquakes

Section/Division: Division of Nuclear Installation Safety

Period Covered: 2002-07-01 through 2005-12-31

Total Cost: € 131,627.34

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

The objectives of this CRP correspond to subjects directly linked to research on and development and practical application of atomic energy for peaceful purposes which are addressed in the IAEA Subprogramme 3.2.4 with respect to the evaluation of external hazards (i.e. earthquakes in this case) affecting nuclear installations. Site evaluation and design of nuclear installations against external hazards are topics covered under the mentioned Subprogramme as well as they are treated in a number of safety standards (safety requirements and safety guides).

(b) Specific (CRP):

(a) To perform a benchmark study on near-field earthquake effects. This study was comprised of three steps: analytical modelling of the scale model French CAMUS tests of a six storey conventional shear wall building subjected to static and earthquake loading conditions; using the analytical models developed for the CAMUS scale model, determine their predicted behaviour when subjected to two recorded motions from Japan (a near-field and a far-field event); and perform sensitivity studies on the impact on floor response spectra of nonlinear structure behaviour for near-field and far-field motions for increasing levels of input motion;

(b) To propose alternative seismic design procedures to better represent the effects of these non-damaging events on engineered structures and their design.

Outputs:

(a) Research:

Twenty-two institutions from 18 Member States were involved in this CRP, which was jointly funded by the IAEA (70%) and the European Union (30%, The Joint Research Centre (JRC), Ispra). A specific Memorandum of Understanding was signed between both institutions. Processing and synthesizing the benchmark outputs delivered by the participating institutes were carried out by the JRC Ispra.

The outputs are: (a) the interim and final research reports produced by all participating institutions, plus (b) the database of all raw and processed results of the benchmark, as developed by JRC Ispra, and (c) the IAEA TECDOC document elaborated as indicated below.

(b) Others:

The CRP was also presented to the international earthquake engineering community, its results and conclusions in a special session of the Structural Mechanics in reactor Technology (SMiRT) 19 International Conference in Toronto, Canada, in August 2007. A CD was prepared as output from this special session.
Effectiveness of CRP:

(a) In reaching Specific Objective:

The available engineering methods were analyzed, investigated and discussed in the CRP in the form of a selection of six typical methods (referred to as M1 to M6), from the simplest (linear spectral approach) to the more sophisticated (time history analyses). An outline and the major features of each method were presented with comments. Comments focus on the philosophy of the method.

The introduction and summary of available methods was followed by a discussion of DBAs, which are becoming more and more popular for the design and evaluation (i.e. the verification of the design) of conventional buildings. Codified methods developed in Europe, New Zealand and the USA were presented and compared. The possible application of these methods to nuclear buildings was also discussed, addressing, in particular, the complexity of nuclear structures, the soil–structure interaction issue and the acceptance criteria.

Finally, other options for the evolution of engineering practice were explored, including full scope time history analysis and modelling simplification techniques such as the macro-element approach. Based on the feedback of experience of well established geotechnical engineering methods, an equivalent linear analysis method was proposed and its outlines presented.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

The scope and objectives of the CRP and its results are within the scope of the NS-G-3.3. and 1.6 safety guides dealing with seismic hazard and seismic design and qualification of nuclear installations.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

As a positive, not a negative comment in this field, it should be mentioned that the organization of the CRP was complemented by a Scientific Organizing Committee that participate actively in all activities, through meetings twice a year using the opportunity of IAEA, JRC or OECD events. This Committee defined the detailed terms of reference of the expected scientific contributions from each participant, reviewed all research reports and produced the synthesis of them, which is finally compiled into the mentioned IAEA TECDOC.

Impact of the CRP:

The impact of the CRP results will be reflected in the upcoming project task of the EBP mentioned above.

Relevance of the CRP:

The CRP has addressed a specific issue of earthquake engineering corresponding to the near field input motions generated by low to medium magnitude seismic events. This specific issue is relevant to nuclear power plants, for both the design and operational stages, since its occurrence can result on the exceedance of the design basis with no safety consequences on structures, systems and components behaviour.

Recommended future action by Agency:

It is recommended that the lessons learned from this CRP will be applied and used in future developments of IAEA safety standards on the seismic safety area as well as to continue the research efforts by the international community. In this regard, the current activities of the Extrabudgetary project (EBP) on Seismic Safety of Existing Nuclear Power Plants is taken due consideration of it (as well as the SMART French benchmark project as part of that project in Working Area 2).

Resulting Publications:

TECDOC on “Safety Significance of a Type of Seismic Input Motions and Consequences on Nuclear Industry Practice”. This TECDOC is a 350 page document including the results of all research contracts and agreements in a CD format.
Title of the Coordinated Research Project:

Assessment of the Interfaces between Neutronic, Thermal-Hydraulic, Structural and Radiological Aspects in Accident Analyses

Section/Division: Division of Nuclear Installation Safety

Period Covered: 2002-12-01 through 2005-11-30

Total Cost: € 125 951.84

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

The CRP was initially proposed in 2001 in line with the objectives of project H.1.01 (Safety Analysis and Accident Management), which were: "to provide guidance on the analysis of design basis, beyond design basis and severe accidents, focusing on verification and application and the promotion of the best practices by means of comprehensive training, services and exercises." At the time of its commencement in 2002, it complied equally with one of the objectives of IAEA Subprogramme J.2 (Development of Safety Assessment Methods and Tools) for the Programme Cycle 2002-2003, namely "to increase the capability of Member States to develop and apply effective methods and tools for safety assessment." Both objectives remain valid up to the present day.

(b) Specific (CRP):

The objectives of this CRP were:

1) To verify IAEA guidance documents related to deterministic accident analysis, concentrating on complex interfaces between various disciplines (neutronic, thermal-hydraulic, structural, radiological), and to research these interfaces providing information for updating the guidance documents.

2) To offer to the Member States involved the opportunity to share the same level of knowledge with regard to the subject of the CRP, to harmonize accident analysis based on advanced computer codes and to contribute to improving the quality and consistency of analysis.

In addition, it was the intention of the CRP to contribute to facilitating the technology transfer from the IAEA to Member States.

Large primary to secondary (PRISE) leakage accidents for WWER-440 reactor were suggested as a reference case for the analyses. In some cases WWER-1000 reactor and different accidents were also considered for comparison. This category of accidents was selected because of their very complex nature, requiring consideration and treatment of interfaces between different disciplines. It was planned to obtain comprehensive information with regard to these accidents, allowing independent evaluation of their consequences and the specification of respective countermeasures.

Outputs:

(a) Research:

1) The methodology for accident analysis described in the existing IAEA guidance documents was verified for a very complex type of PRISE accident, and included the consideration of the interfaces between disciplines. Particular attention was given to the treatment of the interfaces.
2) The experience acquired and results obtained by the participants from the analysis of several accident scenarios for various aspects of the accidents can be used to update the IAEA guidance documents related to accident analysis.

3) Participants' progress reports provided a comprehensive evaluation of large primary to secondary leakage accidents for WWER-440 reactors, covering neutronic, thermal-hydraulic, structural and radiological aspects of the accidents.

(b) Others:

1) Contacts among analysts in the Member States involved were established, which facilitated a harmonization of the approaches used in different countries for accident analysis.

2) The publication of research results can contribute to the broader dissemination of accident analysis methodology.

Effectiveness of CRP:

(a) In reaching Specific Objective:

1) Both best estimate and conservative accident analysis methodologies described in the IAEA guidance documents were applied for the analysis of a large primary to secondary leakage accident, focusing on several safety aspects. The role of each accident analysis methodology was verified. The need to use coupled neutronic/thermal-hydraulic codes to analyse very complex phenomena expected to occur in the core during the accident was confirmed.

2) It was confirmed that different approaches should be adopted for the analysis, focusing on a particular safety aspect of the accident. The IAEA guidance documents will be updated taking into account the findings of the CRP.

3) A comprehensive evaluation of a PRISE leakage accident was obtained. This evaluation can be used for independent checking or improvements of existing design modifications and operational measures for the control of this category of accidents.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

It was confirmed that the IAEA guidance documents related to accident analysis methodologies were also applicable to very complex phenomena such as PRISE leakage events.

Through the comparison of the results of analyses performed by the participants at the same initial and boundary conditions using different accident analysis codes, the CRP contributed towards the harmonization of the different approaches and to the better quality and consistency of accident analysis for NPPs.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

At the first RCM, it was found that the WWER 440 reactors operating in the participants' countries were not the same in design or with respect to the operating procedures. This fact made a direct comparison of the results obtained by the participants difficult.

Impact of the CRP:

Through the evaluation of the PRISE leakage accident from the point of view of the various safety aspects concerned, new insights were gained. Among other things, it became clear to the participants that while some of the safety aspects addressed at the beginning of the CRP might be critical, others might not be of such crucial significance. The emergency operating procedure for this type of accident was revised taking into account the findings of the CRP.
Relevance of the CRP:

The results of the CRP provided important insights relevant to the improvement of the performance of WWER reactors.

Recommended future action by Agency:

IAEA guidance documents related to accident analysis should be updated taking into account the results of the CRP.

Resulting Publications:

1) The results of the CRP were presented at an international conference relevant to accident analysis for NPPs (International Conference on Nuclear Energy for New Europe 2006, in September 2006).

2) Results published as an IAEA TECDOC.
Title of the Coordinated Research Project:
Safety Significance of Postulated Initiating Events for Different Research Reactor Types and Assessment of Analytical Tools

Section/Division: Division of Nuclear Installation Safety

Period Covered: 2002-09-01 through 2006-08-31

Total Cost: € 153,179.50

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To promote activities in the area of safety analysis of research reactors, to encourage and foster the exchange of information among the participants, and to address some of the weaknesses in the safety analysis of research reactors observed during INSARR and other safety review missions.

(b) Specific (CRP):
- To develop and/or adopt numerical tools to cover the scenarios not adequately treated by the available codes;
- To make the attention to accidents commensurate with the safety significance;
- To update the safety analysis of research reactors using the new tools and to incorporate the new requirements for safety of research reactor and modifications in the facilities and/or site evaluation;
- To increase the technical capability to perform safety analysis in institutions in which this activity is based only on the opinion of outside experts.

Outputs:

(a) Research:
The methodologies to perform safety analysis of different types of research reactors for licensing process were discussed and different approaches were identified, compared and summarized, including methods used to identify relevant Postulated Initiating Events (PIEs); rules of conventions for the response of reactor systems; PIEs considered and bounding events; acceptance criteria; and uncertainties considered.

Relevant sets of experimental data that support code assessment were collected which constitute a remarkable output from the CRP. These data included information available from the literature and the results of the experiments performed at the research reactors of the participants' organizations (simulation of fast RIA and LOFA). These data were used to assess the validity of the available computational codes (PARET, RELAP 5, ATHLET, MARS, RETRAC-PC, MERSAT, and COBRA-RERTR) for safety analysis for different types of research reactors. Guidance on the use of these codes was provided including codes' features, limitations, and required modifications.

Another output was the identification of the major physical phenomena that are expected to occur during various transients of research reactors together with the experiments (separate and integral

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effect) that are considered useful in validating a selected computational code for performing safety analysis of research reactors.

The main results and conclusions of these research outputs were incorporated in the IAEA Safety Report on Safety Analysis for Research Reactors.

(b) Others:
The safety analysis for the research reactors at the organizations of some CRP participants was updated, covering a broader range of PIEs than was originally covered.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The objectives of the CRP have been achieved. Detailed guidance was produced on the relevant scenarios to be addressed in the safety analysis for the participants' research reactors. Computer codes to be used in the safety analysis have been selected and an analysis of the models and available correlations and their applicability to participants' research reactors was carried out. Experimental data in suitable forms for code assessment were gathered and compared against the results obtained from the selected codes. Most of participants have considered scenarios with safety significance for their research reactors that were not yet covered in their safety analysis report. One of the outcomes of the CRP was the improvement of the technical capability of the participants in performing safety analyses.

(b) In contributing towards Overall (i.e. Agency Project) Objective:
The CRP has fully met its overall objective. It provided an excellent forum for exchange of information and experience in the area of safety analysis for research reactors and addressed the weaknesses related to the safety analysis identified in INSARR and other safety review missions.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:
The proper formulation of the CRP helped achieving its effective implementation. Dividing the participants into working groups with well defined responsibilities and work plans and with clear interfaces between them ensured an effective follow up of the project progress and helped in achieving the project's overall and specific objectives. Although there was a deviation from the expected results from one of the contractors, the proper selection and distribution of the participants among the groups ensured obtaining the expected results from the group as a whole.

Impact of the CRP:
The exchange of information and experience in the area of safety analysis which was achieved during the conduct of the CRP as well as addressing of the weakness identified during safety review missions contributed toward enhancing the operational safety of the research reactors at the participants' organizations. The CRP is also resulting in a benefit to the whole community of research reactors through publishing its main results and conclusions in an Agency publication.

Relevance of the CRP:
The topics covered by the CRP remain relevant to the Agency programme on enhancing the safety of research reactors. Some of these topics (particularly benchmarking against experimental data involving models for simulation of natural convection and transition in flow regimes) need to be further analyzed and need a continued research support by the Agency.

The subjects of the individual contracts and agreements are relevant to the operational safety of research reactors at the participants' organizations.
**Recommended future action by Agency:**

Based on the results of the CRP, it is recommended to conduct a new CRP that addresses benchmarks on neutronic and thermalhydraulic computational methods and tools to demonstrate, through a formal qualification process, the validity of their application to the safety analysis of research reactors.

**Resulting Publications:**


The following scientific papers were published by the participants in specialized journals and conferences:


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Title of the Coordinated Research Project:
Improvement of Technical Measures to Detect and Respond to Illicit Trafficking of Nuclear Material and Other Radioactive Materials

Section/Division: Department of Safeguards

Period Covered: 15/03/2003 through 14/03/2006

Total Cost: € 509 596.54

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):

Activity area II of the IAEA programme on measures to protect against nuclear terrorism addresses detection of nuclear and other radioactive materials at borders and in the country. The work at the IAEA in this field is divided in two major, closely linked areas. The first is the co-ordination of research and development to improve the technology needed to detect radiation at borders and in the country. The second is the provision of support (advice, documents, training, and equipment) to Member States for their radiation monitoring systems at borders. The work focused on the first topic, the improvement of technology needed to detect illicit trafficking.

(b) Specific (CRP):

To improve portal monitoring systems.

Outputs:

(a) Research:

1. Standardization of border monitoring equipment.

A set of technical specifications for border monitoring instruments was developed. Procedures of various national and international standards ANSI, IEC, ISO, GOST, RADTAP for type test and performance monitoring of fixed radiation portal monitors and hand-held radiation detection instruments were analyzed for conformity. A Unified Test Procedures for testing of radiation detection instrumentations were developed, contributing to the IAEA efforts to standardize border monitoring equipment.

2 Improvement of radionuclide identification device

Specific problems associated with radionuclide identification devices (RID), such as low usability under the field conditions, poor reliability of identification results due to a weak spectroscopic performance and inadequate analysis of row data were addressed by several participants of the CRP.

3 New technologies for nuclear security application

Comparative study of new scintillation materials in application for border monitoring was carried out by the group of researchers from Soltan Institute.
4 Development of new instrumentation

An improved, user friendly hand-held neutron search detector with enhanced sensitivity to match a sensitivity of radiation portal monitors (RPM) and therefore to enable verification of neutron radiation alarm was designed. Monte Carlo optimization and feasibility study of various types of neutron detectors ($^{10}$B, $^{3}$He, $^{6}$Li(Eu), BC-501A, etc) followed by manufacturing of the prototype has resulted in the development of high sensitive neutron search detector with sensitivity of about 20 cm$^2$ and weight of 4.5 kg.

The attractiveness of the lithium iodine detector for detection of nuclear and radioactive material was shown by allowing instrument simultaneous and separate detection of gamma rays and neutrons. Prototype of RID “SIGMA-n” and spectroscopic personal radiation detector (SPRD) “SIGMA-n personal” were built and sent to the Agency for further evaluation.

Two coplanar grid detectors were fabricated with application of the technology developed for the fabrication of pixel and strip detectors.

Energy resolutions achieved were 8.2 keV on 59.9 keV (13.8%); 9.04 keV on 122 keV (6.6%); 11.4 keV on 662 keV (1.72%); 16.0 keV on 1332 keV (1.2%) correspondingly. Sensitivity of the detectors CZT2-4-2 for Cs-137 was ~18 mm$^2$ for irradiation from the grids and ~16 mm$^2$ from the end face.

A feasibility study of a miniature isotope identifying gamma spectrometer for covert detection and categorization of radioactive materials was carried out. Specialized algorithms for radionuclide identification and dose rate linearization were developed.

The form factor of the instrument has allowed its use with a small, cybernetic helicopter (www.airrobot.com) to detect and categorize radiological dispersing devices.

5 Detection of shielded SNM and other radioactive material

The challenges associated with detecting masked or shielded highly enriched uranium using active interrogation methods were addressed by two research groups, which implemented the Pulsed Photonuclear Assessment method and developed an associated particle technique for detection of shielded nuclear materials.

Experimental work using three neutrons detectors for detection of triple (n-n-) and quadruple (n-n-n-) coincidences between neutrons from induced fission of shielded fissioning materials is currently under way.

6 Innocent alarms and fast verification of NORM

A new generation of spectral portal monitors for monitoring pedestrians has been developed and demonstrated. One research group studied detection and fast verification of NORM in tracks and developed a system which incorporated 100×50 mm NaI(Tl) crystal based detector and the appropriate software for the automatic identification of nuclides in the transportation means at stand-still by real-time identification of spectrum from the NaI(Tl) detector. The developed method was tested at several border crossing points in Uzbekistan and found to be sufficient for primary attribute test of NORM in the trucks.

7 Verification of legal shipments and masking

One research group completed a three stage scientific program to experimentally investigate different scenarios that could potentially be used to mask the presence of illicit nuclear materials. The first two stages were concerned with the masking of HEU and plutonium when detected by different types of gamma ray detectors: HPGe, CdZnTe and NaI(Tl). The third stage investigated the comparative performance of the RID and HPGe detector to detect masked material. A variety of test scenarios were formulated which involved the combination of nuclear material with other gamma ray emitters and a combination of different shielding material configurations.

Another research group developed an approach of legal shipment verification. The database of standard shipping containers in combination with HPGe detectors has shown reliability of the verification method for isotopic and quantitative analysis of the radioactive enclosure.

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The most difficult case – activity verification inside unknown shipping container was studied in work by analyzing a shape of Compton continuum of the gamma ray spectrum behind shielding. The approach was tested experimentally with lead, steel and tungsten containers from 3 to 50 mm wall thickness for $^{152}$Eu, $^{137}$Cs, $^{60}$Co, $^{133}$Ba, $^{88}$Y, and $^{22}$Na. The accuracy of the proposed method was found to be sufficient for primary attribute test of the activity.

(b) Others:
Several radiation detection systems developed under the CRP were commercialized and are available on the market.

**Effectiveness of CRP:**

(a) In reaching Specific Objective:
Under the CRP, significant scientific/technical contributions were made by 26 research groups and invited experts from 18 Member States to address the above described problems. The topics investigated were:

- Detection Materials and Detector Response (5 projects)
- New Instrumentation Development (7 projects)
- Testing and Implementation Procedures for Border Monitoring Equipment and Support Facilities (7 projects)
- Verification of contents of sealed shipment containers (involving gamma radiation probes or detection) (3 projects)
- Characterization of a suspected RDD (1 project)
- Verification of contents of sealed shipment containers (involving neutron radiation probes or detection) (3 projects).


(b) In contributing towards Overall (i.e. Agency Project) Objective:
Results of the CRP significantly contribute to the Activity area II of the IAEA programme on measures to protect against nuclear terrorism addresses detection of nuclear and other radioactive materials at borders and in the country. The cooperation and contribution of 26 research groups and participation of the experts from international organizations has resulted in important step forward made in the area of technical support of nuclear security. New IAEA technical guidance for border monitoring equipment was published as Nuclear Security Series; significant improvement of the standard radiation detection equipment reached; new instruments and approaches were developed, tested, built, commercialized and made available for Member States.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

| none |

**Impact of the CRP:**
Besides of the improvement of radiation detection equipment for nuclear security applications, the CRP has helped to identify the challenges of border monitoring equipment implementation to be addresses with the higher priority by scientific and industrial community. The discussions at RCMs have stimulated the development of new generation of the instruments – spectroscopic radiation portal monitors, advanced radionuclide identification devices, personal radiation detectors with real time identification capability.

**Relevance of the CRP:**
The CRP is a logical extension of the Agency efforts in the area of Nuclear Security as it serves to encourage the acquisition and dissemination of new knowledge, technologies and experience in safe, secure and peaceful use of nuclear energy. The CRP addresses many technical issues in the field of radiation detection at the borders, bridging a gap between final user needs and technical performance of the border monitoring equipment.
**Recommended future action by Agency:**

The development of the capability to discriminate real illicit trafficking from the movement of NORM or Medical isotopes is the area that requires the most improvement. This research should not only concentrate on better isotopic identification systems but should also include the development of tools for better information distribution and communication. There is the need to increase the capability of the inspection agents to resolve alarms by developing improved “reach-back” capabilities. The agents desperately need an enhanced capability to acquire help from experts with higher level of training in the use of radiation detection equipment and the interpretation of data from these devices.

As a way forward and logical extension of the previous CRP IAEA established a follow up CRP on “Development and implementation of instruments and methods for detection authorized acts involving nuclear and other radioactive material”.

The main goal of the follow up CRP is to assist Member States to develop and implement effective, efficient and sustainable system to contract nuclear terrorism.

**Resulting Publications:**


CRP No. 1277 (T12014)

CRP Evaluation Report

Title of the Coordinated Research Project:
Data Processing Technologies and Diagnostics for Water Chemistry and Corrosion Control in Nuclear Power Plants (DAWAC)

Section/Division: Division of Nuclear Fuel Cycle and Waste Technology

Period Covered: 2001/03/01 through 2006/03/31

Total Cost: € 139 192.62

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To improve understanding by Member States of the mechanisms of corrosion of core and primary circuit materials in water reactors, including water chemistry impact as well as the ageing behaviour of irradiated core materials.

(b) Specific (CRP):
To improve the data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants. To set up methods for development, the qualification and the nuclear power plant commissioning of Data Processing Technologies for Water Chemistry and Corrosion Control including data collection, data evaluation, diagnostics and assessment, provision of calculation modules and support of expert systems.

Outputs:

(a) Research:
Water chemistry specialists from 18 nuclear utilities and research organizations representing 16 countries exchanged experience in the collection and evaluation of water chemistry and corrosion data in nuclear power plants and in the development of diagnostic and assessment systems to advise the operators on the status of the plant. Technical knowledge was acquired in the following major areas:

- Water chemistry control techniques (grab sampling, on-line monitoring, data collecting and processing, etc);
- Plant chemistry and corrosion diagnostics;
- Plant monitoring (corrosion, chemistry, activity);
- Plant chemistry improvement (analytical models and practices).

(b) Others:
The results of the project are that the 18 participating organizations have improved their knowledge and expertise in the areas of: Water chemistry control techniques where several plants now have improved instrumentation and the necessary feedback mechanisms to restore normal operational status following any deviations; Plant chemistry and corrosion diagnostics are being made using expert systems; Plant monitoring for corrosion, chemistry and activity has been automated in several plants; Plant chemistry improvements are monitored and maintained through new analytical models and practices.
Specific recommendations were made covering best practice:

- Chemistry monitoring should use on-line monitoring rather than grab sampling for important chemistry parameters. Such processes must be carefully reviewed and on-line/grab sampling chemistry monitoring ratio should be optimised with regard to plant design, staffing and necessary external support;
- Architecture of the expert system should allow customisation for particular plant design, current configuration and age;
- System should be designed to allow enhancement of its performance and capabilities by the self learning function;
- There is insufficient experience of the use of chemistry expert systems so far, so no judgement can be made about the best methodology approach, therefore a combination of different methods – fuzzy logic, neural networks, analytic models is preferred;
- Consideration should be given to modifications of chemistry database in order to keep historical data retrievable and compatible with changes of both hardware and software environment due to rapid development of computer technologies;
- The balance between R & D activities in water chemistry monitoring area and actual plant needs should be established. The experience gained in extensive laboratory tests and campaigns at plants should not be lost, but either safely preserved for future needs or incorporated into expert system modules;

A TECDOC has been produced, recording the information collected during the CRP and providing a summary of best practice and recommendations for plant operators.

Effectiveness of CRP:

(a) In reaching Specific Objective:

The DAWAC project considered development and implementation of Data Processing Technologies for Water Chemistry and Corrosion Control at NPPs including data collection, data evaluation, diagnostics and assessment and provision of calculation modules as constituents of water chemistry expert systems. Water chemistry expert systems are expected to perform following major tasks: prompt personnel alerting in case of water chemistry deviation, anomaly cause identification and trends prediction. These systems were found necessary to have full benefit from using on-line sensors in the real-time mode when sensor signals, and other chemistry and operational data, are collected and continuously analysed with data acquisition and evaluation software. Both, data acquisition systems and intelligent water chemistry diagnostic systems have already been installed in some commercial plants.

Current status of chemistry monitoring and associated data processing support

- Low temperature on-line monitors (sodium, conductivity…) for the important parameters are considered as essential for satisfactory plant chemistry surveillance. Their data are supplemented by appropriate grab sample analyses;
- The data collection and evaluation tools are used more and more extensively in nuclear power plants. The main driving factors for their implementation have been cost reduction and more efficient utilisation of the collected data from the process instruments, particularly when a utility is in charge of several units in operation. In this case, a centralized data bank allows gathering all relevant data and comparison between data from one unit to another. Therefore utilisation of such systems should be encouraged for further improvement the chemistry control and can be considered as mandatory requirement for newly commissioned plants;
- Several water chemistry expert systems are under development and some of them are already used by the utilities. Based on the calculated chemistry (alkalinity, redox potential, soluble corrosive compounds concentration, etc.), these systems are helping to the plant staff in operation;
Specific In Situ high temperature monitors are considered preferably as a tool for R & D in order to optimize chemistry condition to be specified in nuclear power plants (NPP), but in some circumstances they can be found very beneficial when used in the NPPs under normal operating conditions.

**Expert system expectations and limitations**

A chemistry expert system consists of several modules, two of them having key roles. The diagnostic module (“the artificial chemistry brain”) contains logic algorithms derived from design, chemistry operating experience, regulatory requirements and complementary plant specific information. The knowledge base module contains different corrosion degradation data bases/design curves, or sophisticated codes. Both modules are periodically updated with new requirements and new information from both R&D and industrial experience feedback. The use of expert system in the future will be preferred mainly by NPPs where:

- Significant data volumes are generated and cannot be easily handled by the plant chemist;
- Staff are not routinely available to define the cause and remedy to any abnormal situation in chemistry;
- The expert system can help to decrease the routine workload of a plant chemist;
- The expert system can support inexperienced or busy staff.

However, expert systems still have limitations due to following reasons:

- Operating experience shows that expert systems are not yet adequate to replace fully experienced chemists in evaluating the origin of some off-normal conditions and taking the appropriate corrective action;
- There can be a lack of sufficient data to allow accurate modelling.

**b) In contributing towards Overall (i.e. Agency Project) Objective:**

The CRP has improved the understanding by Member States of the dynamics and variability of water chemistry regimes in NPPs, and allows improvements in control. This supports the understanding and control of the mechanisms of corrosion of core and primary circuit materials in water reactors which is the main Agency objective in this area. It further provides for the collection and storage of plant data which will underpin investigations into the effects of plant aging and previous chemistry history on irradiated core materials.

**c) Factors, if any, which adversely affected the effectiveness of the CRP:**

None

**Impact of the CRP:**

The CRP results and the published TECDOC are useful to personnel concerned with the operation of water cooled nuclear power plants in Member States, and in particular those with responsibility for the operation of water chemistry monitoring and control. The results enable optimisation of the water chemistry in operating plants, which allows for safer and more reliable operation of the plant and fuel.

**Relevance of the CRP:**

Research on coolant-component interactions was carried out in the framework of the previous CRPs:


Following the results from these CRPs, and on the recommendation of the TWGFPT, the CRP DAWAC was initiated. It is a direct follow-on from the WACOL CRP which described on-line...
monitoring techniques for control of water chemistry parameters and corrosion conditions and firmly demonstrated that in situ monitoring was able to provide additional and valuable information to plant operators, e.g. ECP, high temperature pH and conductivity. Such data can now be obtained promptly, i.e. in real time and with a high degree of accuracy. Reliable techniques and sensor devices are available which enable plant operators to obtain additional information from the response of structural materials in core and coolant circuits to changes in water chemistry. These have the potential for optimization of operational procedures and practices in the future. This development of Expert Systems utilising this information was the target of DAWAC.

Recommended future action by Agency:

The Agency should extend the basic lines of previous water chemistry focused CRPs for current reactor core operational parameters, taking into account high burnup, the use of mixed cores and plant ageing. International cooperation on Optimisation of Water Chemistry to ensure Reliable Water Reactor Fuel Performance at High Burnup and in Ageing Plant could be conducted in the future with consideration of the following issues and remedies:

- Understanding the causes and mechanisms of crud deposition on fuel and its composition, which can cause crud induced power shifts (CIPS, previously called AOA) or localised clad corrosion for high burnups and also for advanced water chemistry regimes (noble metals or zinc addition, etc) and “old” units;
- Materials behaviour at high burnup, also for “old” units, including:
  - Fuel rod claddings,
  - Other materials (Inconel, Stainless Steel);
- Remedies by chemistry optimisation for high burnups, mixed cores and plant ageing:
  - Concentration and type of alkaline reagent,
  - Hydrogen concentration and production mode (direct injection or through NH3),
  - Fuel cleaning (chemical cleaning, ultrasonic cleaning),
  - Decontamination and post-decontamination water chemistry treatment,
  - Enriched boron-10 addition (EBA).

Resulting Publications:

IAEA-TECDOC-1505. Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)
Title of the Coordinated Research Project:
Corrosion of Research Reactor Aluminium-Clad Spent Fuel in Water (Phase II)

Section/Division: Division of Nuclear Fuel Cycle and Waste Technology

Period Covered: 2002-03-15 through 2006-03-14

Total Cost: € 128 358.04

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To improve the management and storage practices and procedures at RR interim spent fuel wet storage facilities through better understanding of the localized corrosion of aluminium cladding and the ranges of water chemistry parameters that provide resistance to corrosion. This objective is in line with the objective of project D.2.0.3 “Addressing Research Reactor Fuel Cycle Issues”: “to strengthen the capability of interested Member States with research reactors to deal with all fuel cycle issues including mitigation of identified health, safety and environmental vulnerabilities associated with spent fuel management”.

(b) Specific (CRP):

• To continue to collect whatever information is available at the participating laboratories from the examination of existing fuels in their current conditions and from records of water chemistry parameters.
• To continue to collect data from currently exposed corrosion coupons given to some of the participating laboratories during the first CRP.
• To establish and validate improved standard practices for corrosion monitoring and surveillance.
• To expand the database on the performance of and durability of aluminium alloy components in wet storage to provide an improved technical basis for extended interim wet storage.
• To improve the database on the ranges of water chemistry parameters that allow safe, reliable and economical storage of aluminium clad RR fuel and provide a corrosion resistant environment.
• To assess the improved resistance provided by various oxide films through corrosion coupon studies.
• To examine in detail the correlation of coupon behaviour.
• To provide a link between the studies proposed during the CRP with studies in the Regional TC Project RLA/4/018 in Latin America.

Outputs:

(a) Research:

• Examination of coupons exposed to water in spent fuel storage basins revealed that pitting was the main form of corrosion and the top surface of horizontal coupons pitted more than the surface facing down;
• Coupon orientation has no noticeable effect on crevice or galvanic corrosion. However, the extent of pitting of vertical coupons was considerably less than that of horizontal coupons,
indicating that pit formation is influenced by, among other factors, settled solids on the coupon surface. The settled solids were analyzed at many sites and found to be mainly, oxides of aluminium, iron, silicon and calcium;

- Aluminium alloy surfaces in contact with stainless steel pitted to a higher extent than surfaces in contact with another aluminium alloy;
- Iron oxide particles that settle as sediments on spent fuel aluminium alloy surfaces, can produce pitting corrosion in waters with low amounts of chlorides, like 6 ppm, even when the corrosion potential is lower than the pitting potential in that environment;
- Galvanic contact with steel strongly influences corrosion susceptibility, by means of increasing the corrosion potential of aluminium to a point in which the pitting process is triggered under the sediments, what would not happen otherwise; and
- In order to preserve the health of the spent fuel stored for long terms in water, it is necessary not only to keep the water clean, but also to take measures to minimize or impede the access of particles of any kind that would settle on the aluminium surfaces.

(b) Others:

Lectures on RR water quality management, based on the findings of the CRP, were delivered at the “IAEA National Training Course on Water Chemistry of Research Reactors”, Indonesia, September 2004. Corrosion surveillance programmes have been implemented in Indonesia as a course follow up activity.

Assistant on water quality management, including corrosion surveillance based on the findings of the CRP, is being delivered to Libya, under a Technical Cooperation project.

Effectiveness of CRP:

(a) In reaching Specific Objective:

As indicated above, all specific objectives of the CRP have been achieved.

(b) In contributing towards Overall (i.e. Agency Project) Objective:

Eight countries participating in the CRP have improved the management and storage practices and procedures at RR interim spent fuel wet storage facilities through better understanding of the localized corrosion of aluminium cladding and the ranges of water chemistry parameters that provide resistance to corrosion.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

Some internal organization problems caused implementation delays in some countries.

Impact of the CRP:

Sustainable corrosion surveillance programmes have been implemented in all Member States participating in this CRP.

Relevance of the CRP:

The clear link between the CRP and corrosion activities under the Regional TC Project RLA/4/018 will be reflected in a future publication, which includes results from both undertakings.

Recommended future action by Agency:

- It is recommended that further international cooperative work on the corrosion of aluminium alloys used in research reactors be supported by the Agency and this includes countries that have not yet participated in this type of activity.
- Prepare a document (through CS and/or TM) on poolside inspection of RR fuel (in reactor core or spent fuel storage basins);
• Prepare a global visual inspection catalogue, including pictures from western and Russian type fuels. This catalogue would be useful to categorize spent fuel degradation for transportation purposes;
• Complete a guideline document, at present under preparation, on “Water Quality Management for Research Reactors”, including wet storage of spent fuel; and
• Organize an International Training Course on Water Quality Management for Research Reactors by end 2007, after the draft Guidelines are available.

Resulting Publications:

A publication (possible TRS) including results of the CRP and the Regional TC Project RLA/4/018 is under preparation.


CRP No. 154 (T24006)
CRP Evaluation Report

Title of the Coordinated Research Project:
Disposal Aspects of Low and Intermediate Level Decommissioning Waste

Section/Division: Division of Nuclear Fuel Cycle and Waste Technology

Period Covered: 2002-09-01 through 2006-08-31

Total Cost: € 146 474.98

Objectives of CRP:

(a) Overall (Agency Project towards which CRP directed):
To promote R&D activities, as well as exchange of information and transfer of knowledge, in order to improve the methodologies and technologies that are important in the planning for the disposal of decommissioning waste through a better understanding of the unique properties and disposal-relevant issues specific to decommissioning waste.

(b) Specific (CRP):
To promote R&D activities relevant to the disposal of waste derived from decommissioning activities and to exchange and discuss information available on the topic in the various participating countries. Based on data about waste types and inventories to assess performance of the disposed of waste streams arising during decommissioning of nuclear facilities.

Outputs:

(a) Research:
Decommissioning waste inventories resulting from a variety of decommissioning activities were estimated, incl. types and classes of waste generated, waste characterization and characteristics. Source-term behaviour was assessed through modelling to predict waste package behaviour and repository performance; specifically corrosion and associated gas generation and its impact on waste package and repository performance was studied.

(b) Others:
Options were presented for the conditioning and packaging of the various types of waste generated, as well as issues related to the large amounts of metallic scrap present in decommissioning. Both developing a conceptual plan for the decommissioning of nuclear facilities in the distant future and planning actual decommissioning to be implemented in the very near future have been discussed by CRP participants.

Effectiveness of CRP:

(a) In reaching Specific Objective:
The CRP resulted in rather exhaustive identification of decommissioning waste streams from different sources, their characterization and in proposing adequate management schemes. The CRP provided a forum where information about technological approaches for managing decommissioning waste was shared.
(b) In contributing towards Overall (i.e. Agency Project) Objective:

The RCMs served as effective mechanisms for the participants to meet each other in person and to discuss their research programmes, activities and results. An important outcome of the meeting was that the participants altered and approved the draft of the introductory (generic) part of the TECDOC and discussed and approved the content of national appendices. Therefore, the TECDOC is ready for editing and submission to the publication committee.

(c) Factors, if any, which adversely affected the effectiveness of the CRP:

The most participants were from countries planning decommissioning activities: the efficiency of the project might have been increased by involving more institution with technical experience from performing these activities (but this is subjected to their willingness to share their know-how).

Impact of the CRP:

The CRP results provide interested Member States a source of information on disposal-relevant issues specific to decommissioning waste. However, as intended, the results do not provide guidance on managing schemes for atypical decommissioning radioactive waste (chemical toxicity, physico-chemical characteristics, size, etc.). This information shall be sought in specialised IAEA documents.

Relevance of the CRP:

The CRP intention was to emphasise the generic aspects of decommissioning waste disposal. In this sense, the CRP outcomes are rather relevant to the needs of numbers of countries starting their decommissioning programmes. The results achieved are important for planning and developing disposal facilities or for extending existing repositories to accommodate decommissioning waste.

Recommended future action by Agency:

Further to publication of the achieved results, the IAEA may consider the development of documents dealing with the management of atypical decommissioning waste (abnormal size/volume, chemical and radiochemical features, chemical toxicity, etc.), with focus on their disposal.

Resulting Publications:

The CRP results published within IAEA TECDOC series.