CO-ORDINATED RESEARCH PROJECTS
(CRPs)

ANNUAL REPORT OF ACTIVITIES

and

STATISTICS FOR 2002

August 2003
Research Contracts Administration Section
Department of Nuclear Sciences and Applications
International Atomic Energy Agency

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Introduction

Article III of the IAEA Statute authorises the Agency 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 research supported by the Agency is within the framework of the Agency's programmes, sub-programmes and projects that are listed in the approved Programme and Budget of the Agency. The research work is normally implemented through Co-ordinated Research Projects (CRPs) that bring together research institutes in both developing and developed Member States to collaborate on the research topic of interest.

Doctoral CRPs, (previously known as Thematic CRPs), meant to complement traditional CRPs, are currently being tested by the Human Health programme. This new, optional type of CRP is designed to strengthen promotion of research on nuclear technologies in developing Member States through CRPs that rest on pair building between agreement holders and contract holders and includes a PhD training programme at the contract holders' institutions.

Further details of the administration of research contracts and general information on CRPs is contained in the Agency's Website at:-

http://www-crp.iaea.org

2. CRP Support to Programmes and Subprogrammes

The CRPs reported in this document are conducted in support of the following Agency programmes/subprogrammes (Ref: GC(45)/8 of August 2001).

Programme A: Nuclear Power
Programme B: Nuclear Fuel Cycle and Material Technologies

Programme C: Analysis for Sustainable Energy Development
Programme D: Nuclear Science
Programme E: Food and Agriculture
Programme F: Human Health
Programme G: Water Resources
Programme H: Protection of the Marine and Terrestrial Environments
Programme I: Physical and Chemical Applications
Programme J: Safety of Nuclear Installations
Programme K: Radiation Safety
Programme L: Management of Radioactive Waste
Programme M: Safeguards

The Sub-programmes supported by the CRPs are listed in Appendix C.

Results of research are available to all Member States, and are disseminated through national, international and Agency scientific and technical publications (TECDOCs). In certain cases the research results are directly relevant to implementation of projects in the Agency's Technical Co-operation Programme.

3. Co-ordinated Research Project Activities

In terms of number of awards and degree of funding, CRPs constitute a significant activity within the Agency's programmes.

1003 contracts and agreements were awarded from the 1364 contract and agreement proposals received by the Agency during 2002. Annex I lists by country the number of proposals received and awards made.

In 2002, $6 329 221 were awarded from the regular budget to institutes under contractual arrangements and to fund Research Co-ordination Meetings (RCMs). Additionally, $122 077 of extra-budgetary contributions was used to fund additional contracts and RCMs. Thus, total awards amounted to $6 451 298. Table 1 summarizes all awards by Programme in 2002. The average award per contract was $5 700.

Table 1: Summary of All Awards by Programme in 2002

	Programme	Regular Budget				External Funding				Total Expenses
		Contracts	CRP Purchases	RCM Expenses	**Total**	Contracts	CRP Purchases	RCM Expenses	**Total**	
		$	$	$	**$**	$	$	$	**$**	**$**
A	Nuclear Power	195 000	0	97 872	**292 872**	0	0	0	**0**	**292 872**
B	Nuclear Fuel Cycle and Material Technologies	60 500	0	81 595	**142 095**	0	0	0	**0**	**142 095**
C	Analysis for Sustainable Energy Development	91 000	0	31 458	**122 458**	0	0	0	**0**	**122 458**
D	Nuclear Science	398 130	0	162 736	**560 866**	0	0	0	**0**	**560 866**
	Major Programme 1	**744 630**	**0**	**373 661**	**1 118 291**	**0**	**0**	**0**	**0**	**1 118 291**
E	Food and Agriculture	1 867 300	123 427	617 530	**2 608 257**	67 500	0	0	**67 500**	**2 675 757**
F	Human Health	1 064 000	9 471	301 943	**1 375 414**	17 500	0	0	**17 500**	**1 392 914**
G	Water Resources	146 100	8 093	35 081	**189 274**	0	0	0	**0**	**189 274**
H	Protection of the Marine and Terrestrial Environments	15 000	0	15 109	**30 109**	0	0	0	**0**	**30 109**
I	Physical and Chemical Applications	318 082	8 858	174 692	**501 632**	0	0	0	**0**	**501 632**
	Major Programme 2	**3 410 482**	**149 849**	**1 144 355**	**4 704 686**	**85 000**	**0**	**0**	**85 000**	**4 789 686**
J	Safety of Nuclear Installations	145 050	0	43 370	**188 420**	16 000	0	0	**16 000**	**204 420**
K	Radiation Safety	96 000	0	30 668	**126 668**	0	0	0	**0**	**126 668**
L	Management of Radioactive Waste	80 700	0	100 096	**180 796**	0	0	21 077	**21 077**	**201 873**
	Major Programme 3	**321 750**	**0**	**174 134**	**495 884**	**16 000**	**0**	**21 077**	**37 077**	**532 961**
M	Safeguards/ **Major Programme 4**	**10 360**	**0**	**0**	**10 360**	**0**	**0**	**0**	**0**	**10 360**
	Total:	**4 487 222**	**149 849**	**1 692 150**	**6 329 221**	**101 000**	**0**	**21 077**	**122 077**	**6 451 298**
	Total Contract/CRP Awards	4 738 071								
	Total RCM Expenditures	1 713 227								
	Total Expenditures	6 451 298								

Figure 1 illustrates the proportion of regular budget and extra-budgetary funding in 2002.

Figure 1: 2002 Resources

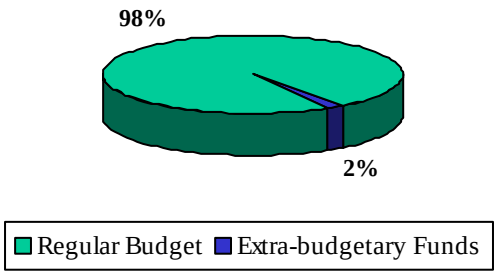
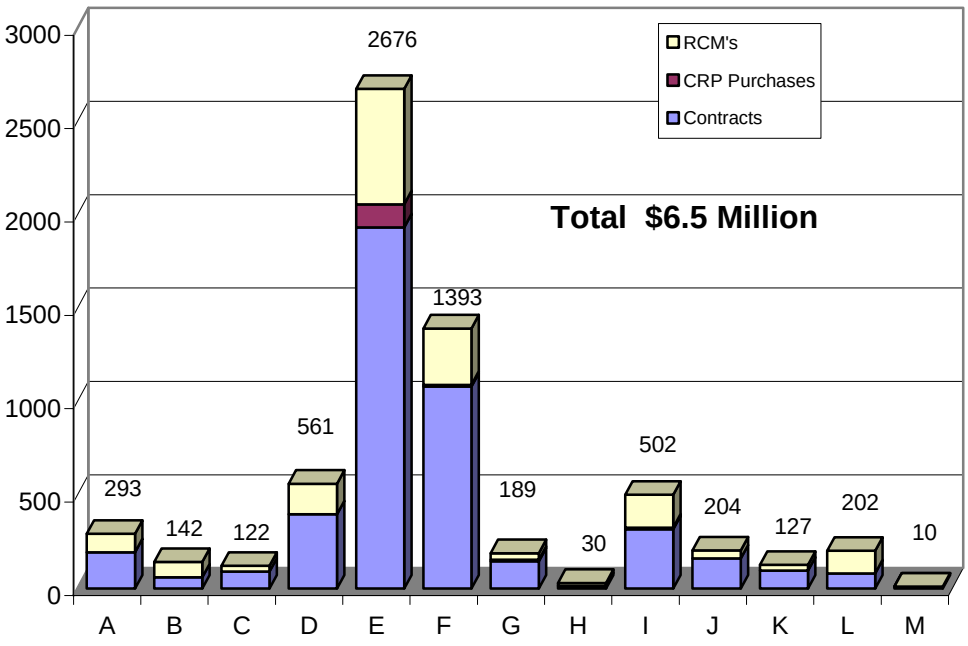


Figure 2 shows the types of awards made by programme.

Figure 2: Distribution of all 2002 Awards by Programme and Type of Activity



Details of resources for 2002 awards by programme and sub-programme and type of award are provided in Table 2. Annex II lists awards by country and programme.

Table 2: Distribution of 2002 Total Funds by Programme

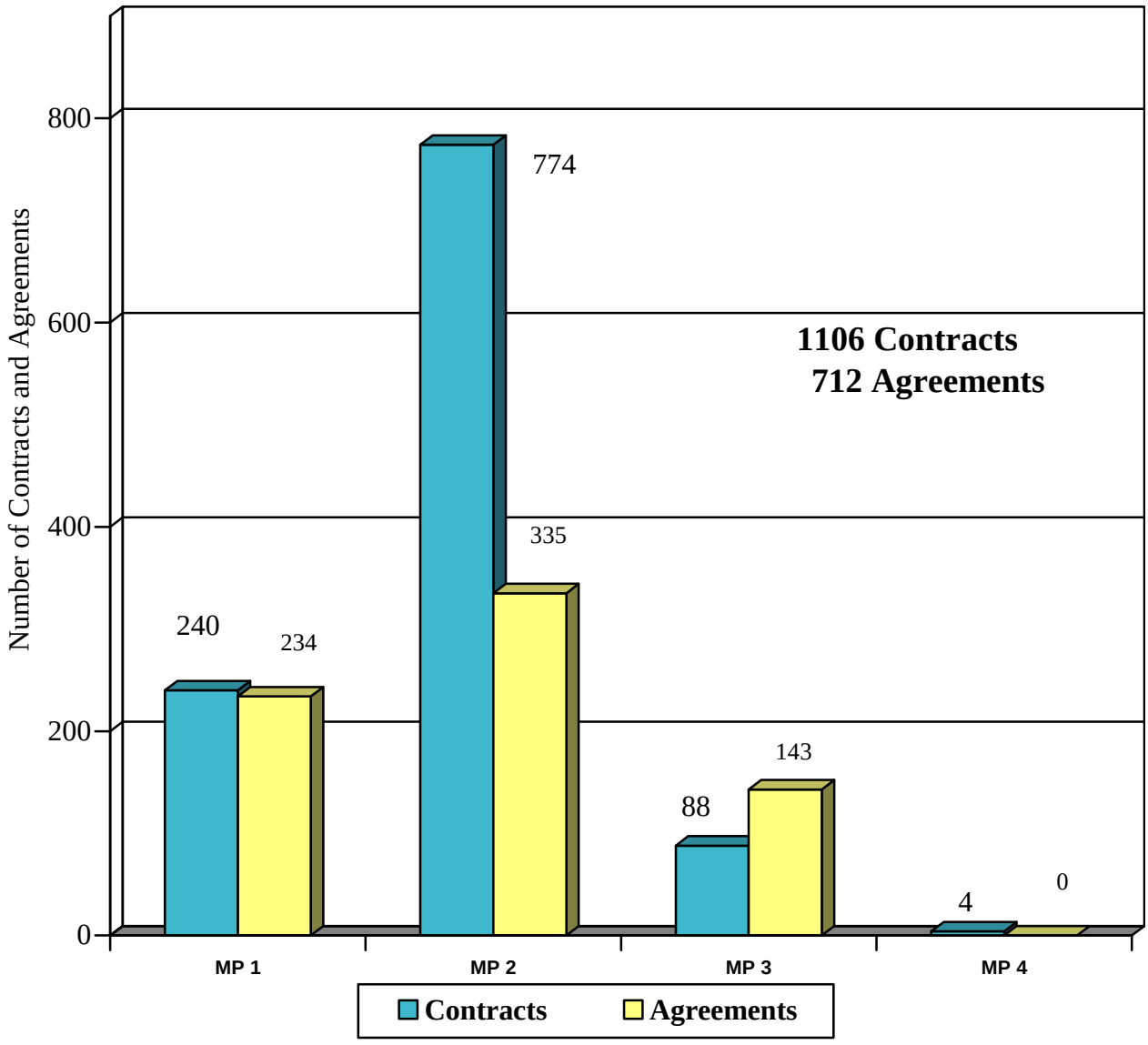
Prog.	Research Contracts		Technical Contracts		Thematic Contracts		CRP Purchases	Total	RCMs		Overall Total
	#*	$	#	$	#	$	$	$	#**	$	$
A1	28	111 000	0	0	0	0	0	111 000	5	56 802	167 802
A2	31	84 000	0	0	0	0	0	84 000	3	41 070	125 070
A	59	195 000	0	0	0	0	0	**195 000**	8	97 872	**292 872**
B2	9	45 000	1	5 000	0	0	0	50 000	3	81 595	131 595
B4	2	10 500	0	0	0	0	0	10 500	0	0	10 500
B	11	55 500	1	5 000	0	0	0	**60 500**	3	81 595	**142 095**
C1	9	46 000	0	0	0	0	0	46 000	1	10 936	56 936
C2	9	45 000	0	0	0	0	0	45 000	1	20 522	65 522
C	18	91 000	0	0	0	0	0	**91 000**	2	31 458	**122 458**
D1	30	141 000	0	0	0	0	0	141 000	4	69 919	210 919
D2	17	81 000	1	10 000	0	0	0	91 000	3	61 812	152 812
D3	33	159 130	1	7 000	0	0	0	166 130	1	31 005	197 135
D	80	381 130	2	17 000	0	0	0	**398 130**	8	162 736	**560 866**
E1	37	270 000	3	28 000	0	0	110 844	408 844	2	50 715	459 559
E2	51	410 000	2	30 000	0	0	0	440 000	3	95 639	535 639
E3	62	431 000	3	28 300	0	0	10 358	469 658	5	172 629	642 287
E4	46	285 000	10	92 000	0	0	0	377 000	5	121 687	498 687
E5	64	339 000	3	21 500	0	0	2 225	362 725	6	176 860	539 585
E	260	1 735 000	21	199 800	0	0	123 427	**2 058 227**	21	617 530	**2 675 757**
F1	71	436 500	1	5 000	8	88 000	9 471	538 971	5	92 615	631 586
F2	23	103 500	6	55 000	0	0	0	158 500	3	39 750	198 250
F3	9	45 000	1	9 000	0	0	0	54 000	2	34 076	88 076
F4	40	259 000	1	5 500	6	75 000	0	339 500	5	135 502	475 002
F	143	844 000	9	74 500	14	163 000	9 471	**1 090 971**	15	301 943	**1 392 914**
G1	11	54 000	0	0	0	0	8 093	62 093	1	15 109	77 202
G2	16	74 100	3	18 000	0	0	0	92 100	1	19 972	112 072
G	27	128 100	3	18 000	0	0	8 093	**154 193**	2	35 081	**189 274**
H1	0	0	1	10 000	0	0	0	10 000	0	15 109	25 109
H2	1	5 000	0	0	0	0	0	5 000	0	0	5 000
H	1	5 000	1	10 000	0	0	0	**15 000**	0	15 109	**30 109**
I1	46	184 000	1	82	0	0	8 858	192 940	4	112 697	305 637
I2	30	134 000	0	0	0	0	0	134 000	4	61 995	195 995
I	76	318 000	1	82	0	0	8 858	**326 940**	8	174 692	**501 632**
J1	4	16 000	0	0	0	0	0	16 000	0	0	16 000
J2	11	54 800	0	0	0	0	0	54 800	1	19 910	74 710
J4	15	41 250	0	0	0	0	0	41 250	1	23 460	64 710
J6	11	49 000	0	0	0	0	0	49 000	0	0	49 000
J	41	161 050	0	0	0	0	0	**161 050**	2	43 370	**204 420**
K1	0	0	1	30 000	0	0	0	30 000	0	0	30 000
K3	0	0	1	10 000	0	0	0	10 000	0	0	10 000
K4	9	38 000	5	11 000	0	0	0	49 000	1	11 033	60 033
K5	2	4 000	1	3 000	0	0	0	7 000	1	19 635	26 635
K	11	42 000	8	54 000	0	0	0	**96 000**	2	30 668	**126 668**
L2	0	0	0	0	0	0	0	0	2	49 807	49 807
L3	12	60 700	0	0	0	0	0	60 700	2	37 816	98 516
L6	4	20 000	0	0	0	0	0	20 000	1	33 550	53 550
L	16	80 700	0	0	0	0	0	**80 700**	5	121 173	**201 873**
M2	1	560	1	9 800	0	0	0	**10 360**	0	0	**10 360**
	744	**4 037 040**	**47**	**388 182**	**14**	**163 000**	**149 849**	**4 738 071**	**76**	**1 713 227**	**6 451 298**

* Includes contracts with multiple fundings.

** Includes one meeting held jointly under subprogrammes G.1. and H.1. Three additional RCM's were also held at no cost to the Agency making a total of 79.

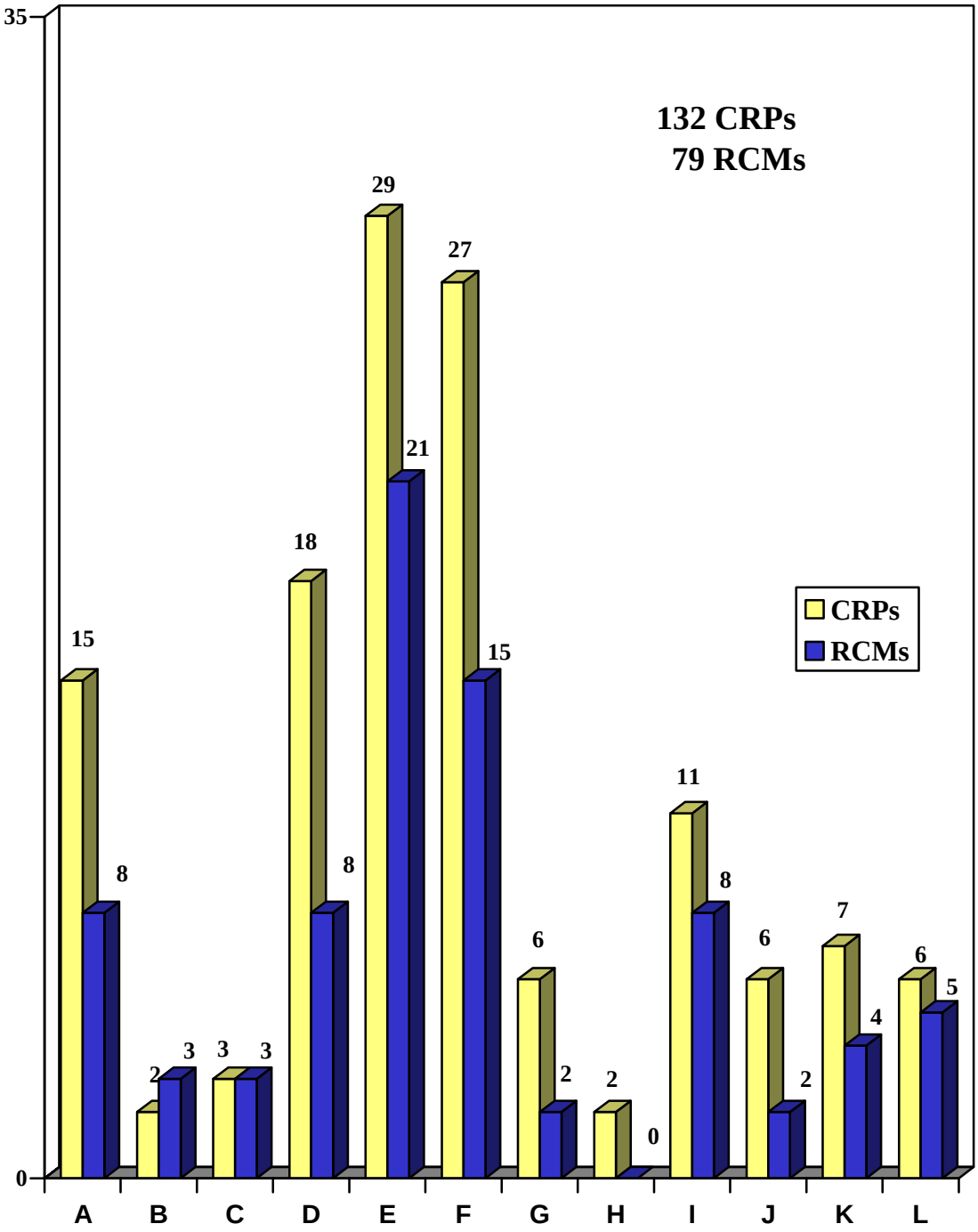
At the end of 2002, there were 1106 contracts and 712 agreements supporting 132 active CRPs (see Appendix A). 79 RCMs (see Annex III) were held in support of these CRPs and an amount of $1 713 227 was spent in support of these meetings. Figure 3 shows the distribution by Major Programme of these contracts and agreements and Figure 4 shows the distribution by programme of the CRPs and RCMs held during the year.

Figure 3: Active Contracts and Agreements by Major Programme at End 2002



MP 1: Nuclear Power; Nuclear Fuel Cycle and Material Technologies; Analysis for Sustainable Energy Development; Nuclear Science
MP 2: Food and Agriculture; Human Health; Water Resources; Protection of the Marine and Terrestrial Environments; Physical and Chemical Applications
MP 3: Safety of Nuclear Installations; Radiation Safety; Management of Radioactive Waste
MP 4: Safeguards

Figure 4: CRPs Active at End 2002 and RCMs Held During the Year



3.1 Member State Participation

The distribution of all contract awards in 2002 is shown by country in Annex IV. 87% of the funds awarded for contracts were made to institutes in developing countries. Table 3 shows the geographical distribution of all contract awards in 2002.

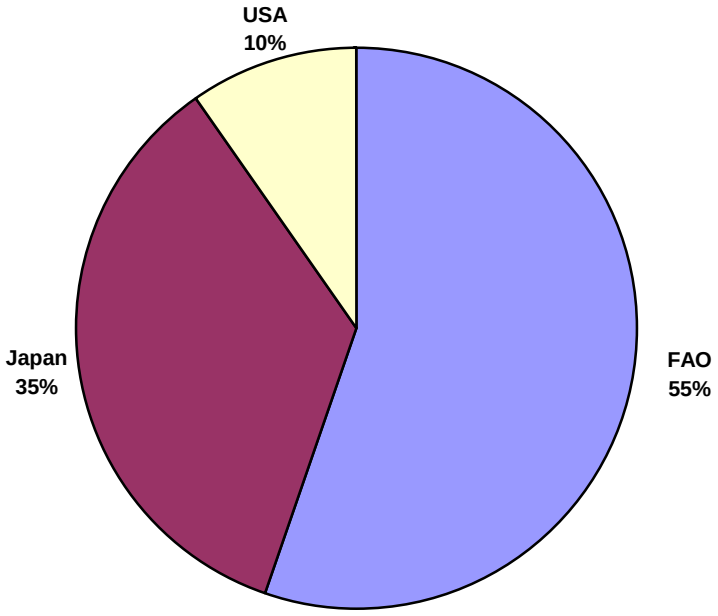
Table 3: Geographical Distribution of Research Contract Awards in 2002

	$	%
South East Asia	1 526 182	33
Eastern Europe	967 710	21
Latin America	910 630	20
Africa	534 900	12
Western Europe	367 800	8
West Asia	170 000	4
North America	111 000	2
Total	4 588 222	100

3.2 Extra-budgetary Funding

In 2002, extra-budgetary funds amounting to $122 077 were used for financing contracts and RCMs. The funds used were from FAO, Japan, and the United States of America, as shown in Figure 5 and Table 4.

Figure 5: Extra-budgetary Funds, Approved in 2002, by Donor



Total Awards $122 077

Table 4: Summary of 2002 Extra-budgetary Funded Awards

Food and Agriculture Organization of the United Nations (FAO)

D1.00.00	Food and agriculture: Soil fertility, irrigation and crop production	4 contracts $32 000
D.3.20.19	Assessment of the effectiviness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay-based technologies for increasing farmyard poultry production in Africa	6 contracts $35 500

Japan

E.4.30.10	Isotopic evaluations in infant growth monitoring – a collaboration with WHO (partly RCA)	1 contract $5 500
J7.10.09	To update and expand the IAEA reliability data for research reactor PSAs	2 contracts $10 000
J7.10.10	Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools	2 contracts $6 000
J9.10.05	The use of selected safety indicators (concentrations; fluxes) in the assessment of radioactive waste disposal	1 meeting $21 077

United States of America

E.4.30.10	Isotopic evaluations in infant growth monitoring – a collaboration with WHO (partlyRCA)	2 contracts $12 000

Total: 17	**Contracts: $101 000**	**Meetings: $21 077**

3.3 Completed CRPs in 2002

22 CRPs were completed in 2002 of which 14 of these CRPs concerned topics in Nuclear Techniques for Development and Environmental Protection, 5 in Nuclear Science and Technology, and 3 in Nuclear Safety and Protection against Radiation. A list of these CRPs is included in Appendix B. Evaluations of these CRPs will be completed by the end of 2003 and included in the next annual report.

4. Accomplishments of Co-ordinated Research Projects Completed in 2001

Co-ordinated Research Projects are fully evaluated about one year after their completion. During 2001, 37 CRPs were successfully completed: 22 of these related to Nuclear Techniques for Development and Environmental Protection, 11 related to Nuclear Science and Technology, and 4 to Nuclear Safety and Protection against Radiation.

Accomplishments of these CRPs are included in Appendix D. Publications and other outputs included 82 Agency and 311 external publications, as well as other outputs such as data bases, software packages, Web sites, presentations at conferences, etc. Detailed listings of these outputs can be seen in Appendix D.

5. External Review of CRP's

An external review of the Agency's CRP activities was undertaken by a panel of seven experts in 2001. The summary of the external review panel report of CRP activities in 2001 can be found in GOV/INF/2002/7. The Panel's overall conclusion is that the programme in co-ordinated research activities is an important, highly visible component of the Agency's overall programme which is well conceived and is very well matched to the Agency's mission.

Total Number of
Proposals Received and Awards Made in 2002

	Proposals Received			Awards*			
Country	Contracts	Agreements	Total	Regular Budget	Extra-budgetary	Agreements	Total
Albania	1	0	1	1	0	0	1
Algeria	5	0	5	5	0	0	5
Argentina	47	3	50	36	0	2	38
Armenia	3	0	3	2	0	0	2
Australia	7	6	13	3	1	6	10
Austria	4	4	8	2	1	5	8
Bangladesh	20	0	20	5	0	0	5
Barbados	1	0	1	1	0	0	1
Belarus	11	3	14	4	0	1	5
Belgium	1	7	8	1	0	5	6
Benin	2	0	2	3	0	0	3
Bolivia	1	0	1	2	0	0	2
Bosnia and Herzegovina	1	0	1	0	0	0	0
Brazil	38	6	44	37	1	5	43
Bulgaria	28	2	30	18	0	2	20
Burkina Faso	3	0	3	3	0	0	3
Cameroon	3	0	3	1	1	0	2
Canada	4	10	14	4	0	9	13
Chile	13	0	13	14	1	0	15
China	70	3	73	58	0	4	62
Colombia	10	0	10	8	0	0	8
Costa Rica	7	0	7	4	0	0	4
Cote d'Ivoire	4	0	4	3	1	0	4
Croatia	11	0	11	7	0	0	7
Cuba	27	1	28	14	0	1	15
Cyprus	1	0	1	1	0	0	1
Czech Republic	19	4	23	15	0	3	18
Democratic Rep. of the Congo	1	0	1	0	0	0	0
Denmark	0	1	1	0	0	0	0
Dominican Republic	2	0	2	0	0	0	0
Ecuador	1	0	1	2	0	0	2
Egypt	17	0	17	6	1	0	7
Estonia	2	0	2	2	0	0	2
Ethiopia	1	0	1	0	0	0	0
Finland	0	3	3	0	0	4	4
France	1	9	10	0	1	7	8
Georgia	1	1	2	0	0	0	0
Germany	2	15	17	3	0	15	18
Ghana	9	0	9	5	0	0	5
Greece	14	2	16	6	0	1	7
Guatemala	1	0	1	0	0	0	0
Hungary	28	3	31	23	0	2	25
Iceland	0	1	1	0	0	1	1
India	68	10	78	60	0	7	67
Indonesia	16	0	16	14	2	0	16
Iran, Islamic Republic of	9	0	9	5	0	0	5
Iraq	1	0	1	0	0	0	0

* Also includes proposals received in previous years.

Total Number of
Proposals Received and Awards Made in 2002

	Proposals Received			Awards*			
Country	Contracts	Agreements	Total	Regular Budget	Extra-budgetary	Agreements	Total
Israel	8	2	10	5	0	2	7
Italy	2	6	8	3	0	6	9
Jamaica	1	0	1	0	0	0	0
Japan	1	10	11	2	0	9	11
Jordan	7	0	7	2	0	0	2
Kazakhstan	10	1	11	10	0	1	11
Kenya	24	1	25	7	0	0	7
Korea, Republic of	26	17	43	21	0	10	31
Lao P.D.R.	1	0	1	1	0	0	1
Latvia	0	0	0	1	0	0	1
Lebanon	2	0	2	2	0	0	2
Libyan Arab Jamahiriya	0	0	0	1	0	0	1
Lithuania	8	2	10	3	0	2	5
Madagascar	1	0	1	0	1	0	1
Malaysia	9	1	10	9	0	0	9
Mali	1	0	1	1	0	0	1
Malta	1	0	1	1	0	0	1
Mauritius	5	1	6	2	0	0	2
Mexico	14	0	14	13	0	0	13
Mongolia	1	0	1	1	0	0	1
Morocco	14	1	15	4	1	0	5
Mozambique	1	0	1	0	1	0	1
Myanmar	8	0	8	3	0	0	3
Namibia	1	0	1	2	0	0	2
Nepal	2	0	2	1	0	0	1
Netherlands	1	3	4	1	0	4	5
Nigeria	5	0	5	7	0	0	7
Norway	1	1	2	1	0	0	1
Pakistan	62	0	62	27	1	0	28
Panama	0	0	0	1	0	0	1
Paraguay	2	0	2	1	0	0	1
Peru	13	1	14	7	0	1	8
Philippines	10	2	12	10	0	1	11
Poland	28	2	30	19	0	1	20
Portugal	7	1	8	7	0	1	8
Romania	34	4	38	17	0	4	21
Russian Federation	41	9	50	44	0	7	51
Saudi Arabia	1	0	1	1	0	0	1
Senegal	0	0	0	1	0	0	1
Serbia and Montenegro	10	0	10	1	0	0	1
Singapore	3	1	4	6	0	1	7
Slovakia	20	5	25	14	0	3	17
Slovenia	12	2	14	10	0	2	12
South Africa	17	6	23	15	0	3	18
Spain	2	2	4	2	0	2	4
Sri Lanka	9	0	9	5	0	0	5
Sudan	7	0	7	2	0	0	2
Sweden	0	3	3	0	0	5	5

* Also includes proposals received in previous years.

Total Number of
Proposals Received and Awards Made in 2002

	Proposals Received			Awards*			
Country	Contracts	Agreements	Total	Regular Budget	Extra-budgetary	Agreements	Total
Switzerland	0	5	5	0	0	2	2
Syrian Arab Republic	11	0	11	10	0	0	10
Thailand	26	0	26	21	0	1	22
The Frmr. Yug. Rep. of Macedonia	1	1	2	1	0	0	1
Tunisia	4	1	5	3	0	0	3
Turkey	48	0	48	20	0	0	20
Uganda	2	0	2	2	0	0	2
Ukraine	22	3	25	11	0	1	12
United Kingdom	8	14	22	6	0	14	20
United Republic of Tanzania	5	0	5	4	0	0	4
United States	10	34	44	7	1	33	41
Uruguay	15	0	15	12	0	0	12
Uzbekistan	2	0	2	1	0	0	1
Venezuela	4	1	5	4	0	1	5
Vietnam	15	1	16	11	2	1	14
Zambia	3	0	3	3	0	0	3
Zimbabwe	1	0	1	0	0	0	0
	1 126	238	1 364	788	17	198	1 003

* Also includes proposals received in previous years.

Distribution of Total
2002 Contract Awards, by Country and Programme

Annex II.1

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	MP 3	M/MP 4	Total
Albania	0	1	1	0	0	0	5 000	**5 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**5 000**
Algeria	3	2	5	3 000	0	0	0	**3 000**	0	5 000	4 000	0	5 000	**14 000**	4 000	0	0	**4 000**	**0**	**21 000**
Argentina	15	21	36	8 000	0	5 000	19 130	**32 130**	95 000	21 000	2 000	0	12 000	**130 000**	9 000	3 000	5 000	**17 000**	**0**	**179 130**
Armenia	2	0	2	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	4 000	0	0	**4 000**	**0**	**14 000**
Australia	2	2	4	0	0	0	0	**0**	26 000	0	10 000	0	0	**36 000**	0	0	0	**0**	**0**	**36 000**
Austria	1	2	3	0	0	0	0	**0**	8 000	0	0	0	0	**8 000**	0	2 000	0	**2 000**	**9 800**	**19 800**
Bangladesh	0	5	5	0	0	0	0	**0**	29 000	7 000	0	0	0	**36 000**	0	0	0	**0**	**0**	**36 000**
Barbados	1	0	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	**0**	**6 000**
Belarus	3	1	4	0	0	0	9 000	**9 000**	6 000	0	0	0	4 000	**10 000**	0	0	0	**0**	**0**	**19 000**
Belgium	1	0	1	0	0	0	0	**0**	0	10 000	0	0	0	**10 000**	0	0	0	**0**	**0**	**10 000**
Benin	0	3	3	0	0	0	0	**0**	14 000	5 000	0	0	0	**19 000**	0	0	0	**0**	**0**	**19 000**
Bolivia	0	2	2	0	0	0	0	**0**	16 000	0	0	0	0	**16 000**	0	0	0	**0**	**0**	**16 000**
Brazil	13	25	38	0	10 500	5 000	20 000	**35 500**	107 000	51 500	11 500	0	14 000	**184 000**	9 000	0	0	**9 000**	**0**	**228 500**
Bulgaria	8	10	18	15 000	5 000	5 000	10 000	**35 000**	33 000	13 400	0	0	0	**46 400**	9 250	0	0	**9 250**	**0**	**90 650**
Burkina Faso	1	2	3	0	0	0	0	**0**	19 000	6 000	0	0	0	**25 000**	0	0	0	**0**	**0**	**25 000**
Cameroon	0	2	2	0	0	0	0	**0**	18 000	0	0	0	0	**18 000**	0	0	0	**0**	**0**	**18 000**
Canada	3	1	4	0	0	0	0	**0**	15 000	13 000	7 000	0	0	**35 000**	0	0	0	**0**	**0**	**35 000**
Chile	5	10	15	0	0	0	0	**0**	38 000	44 000	0	0	0	**82 000**	0	5 000	0	**5 000**	**0**	**87 000**
China	15	43	58	13 000	0	5 000	39 000	**57 000**	144 000	58 500	10 000	0	20 082	**232 582**	4 000	2 000	25 000	**31 000**	**0**	**320 582**
Colombia	2	6	8	0	0	0	0	**0**	11 000	37 500	0	0	0	**48 500**	0	0	0	**0**	**0**	**48 500**
Costa Rica	1	3	4	0	0	0	0	**0**	24 000	0	0	0	0	**24 000**	0	0	0	**0**	**0**	**24 000**
Cote d'Ivoire	0	4	4	0	0	0	0	**0**	28 000	0	0	0	0	**28 000**	0	0	0	**0**	**0**	**28 000**
Croatia	3	4	7	4 000	0	0	13 000	**17 000**	6 000	3 000	5 000	0	0	**14 000**	0	0	5 000	**5 000**	**0**	**36 000**
Cuba	4	10	14	0	0	5 000	10 000	**15 000**	22 000	29 000	0	0	13 000	**64 000**	0	0	0	**0**	**0**	**79 000**
Cyprus	1	0	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	**0**	**6 000**
Czech Republic	5	10	15	10 000	10 000	0	9 000	**29 000**	23 000	7 000	0	0	9 000	**39 000**	14 000	0	0	**14 000**	**0**	**82 000**
Ecuador	1	1	2	0	0	0	0	**0**	6 000	0	0	0	4 000	**10 000**	0	0	0	**0**	**0**	**10 000**
Egypt	1	6	7	5 000	0	0	0	**5 000**	15 000	0	4 000	0	4 000	**23 000**	0	0	0	**0**	**0**	**28 000**
Estonia	1	1	2	0	0	0	5 000	**5 000**	0	5 000	0	0	0	**5 000**	0	0	0	**0**	**0**	**10 000**
France	0	1	1	0	0	0	0	**0**	8 000	0	0	0	0	**8 000**	0	0	0	**0**	**0**	**8 000**
Germany	2	1	3	0	0	0	0	**0**	25 000	0	1 000	0	0	**26 000**	0	0	0	**0**	**0**	**26 000**
Ghana	1	4	5	0	0	0	0	**0**	19 000	12 500	0	0	4 000	**35 500**	0	0	0	**0**	**0**	**35 500**
Greece	1	5	6	0	0	0	0	**0**	11 000	4 000	4 000	0	8 000	**27 000**	0	0	0	**0**	**0**	**27 000**
Hungary	10	13	23	11 000	0	0	34 000	**45 000**	27 000	14 000	0	0	18 000	**59 000**	10 000	0	5 000	**15 000**	**0**	**119 000**
India	21	39	60	16 000	0	10 000	29 000	**55 000**	72 000	128 100	11 500	0	25 000	**236 600**	14 000	8 000	0	**22 000**	**0**	**313 600**
Indonesia	5	11	16	1 500	0	0	0	**1 500**	50 000	3 000	0	5 000	12 000	**70 000**	8 000	0	0	**8 000**	**0**	**79 500**
Iran, Islamic Republic of	2	3	5	0	0	0	0	**0**	13 000	0	0	0	12 000	**25 000**	0	0	0	**0**	**0**	**25 000**

* Includes contracts with multiple fundings

Annex II.2

Distribution of Total
2002 Contract Awards, by Country and Programme

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	MP 3	M/MP 4	Total
Israel	0	5	5	0	0	0	0	**0**	15 000	6 500	5 000	0	0	**26 500**	0	0	0	**0**	**0**	**26 500**
Italy	2	1	3	0	0	0	0	**0**	0	10 000	0	10 000	0	**20 000**	0	2 000	0	**2 000**	**0**	**22 000**
Japan	1	1	2	0	0	0	0	**0**	0	10 000	0	0	0	**10 000**	0	2 000	0	**2 000**	**0**	**12 000**
Jordan	0	2	2	0	0	0	0	**0**	0	0	5 000	0	4 000	**9 000**	0	0	0	**0**	**0**	**9 000**
Kazakhstan	1	9	10	0	0	5 000	20 000	**25 000**	0	0	0	0	16 000	**16 000**	0	0	5 000	**5 000**	**0**	**46 000**
Kenya	2	5	7	0	0	0	0	**0**	43 000	6 000	0	0	0	**49 000**	0	0	0	**0**	**0**	**49 000**
Korea, Republic of	7	14	21	14 000	0	0	14 000	**28 000**	40 000	22 000	0	0	5 000	**67 000**	8 000	0	5 000	**13 000**	**0**	**108 000**
Lao P.D.R.	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	**0**	**5 000**
Latvia	0	1	1	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	0	**0**	**560**	**560**
Lebanon	0	2	2	0	0	0	0	**0**	0	1 000	3 500	0	0	**4 500**	0	0	0	**0**	**0**	**4 500**
Libyan Arab Jamahiriya	1	0	1	3 000	0	0	0	**3 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**3 000**
Lithuania	3	0	3	0	0	5 000	0	**5 000**	0	7 000	0	0	0	**7 000**	0	0	5 000	**5 000**	**0**	**17 000**
Madagascar	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	**0**	**5 000**
Malaysia	4	5	9	0	0	0	0	**0**	44 000	0	0	0	4 000	**48 000**	0	4 000	0	**4 000**	**0**	**52 000**
Mali	0	1	1	0	0	0	0	**0**	4 000	0	0	0	0	**4 000**	0	0	0	**0**	**0**	**4 000**
Malta	1	0	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	**0**	**6 000**
Mauritius	0	2	2	0	0	0	0	**0**	5 000	5 000	0	0	0	**10 000**	0	0	0	**0**	**0**	**10 000**
Mexico	3	10	13	3 000	0	5 000	5 000	**13 000**	40 000	22 500	0	0	8 000	**70 500**	0	0	0	**0**	**0**	**83 500**
Mongolia	0	1	1	0	0	0	0	**0**	0	11 000	0	0	0	**11 000**	0	0	0	**0**	**0**	**11 000**
Morocco	3	2	5	0	0	0	0	**0**	13 500	12 000	5 000	0	0	**30 500**	0	0	0	**0**	**0**	**30 500**
Mozambique	1	0	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	**0**	**5 000**
Myanmar	1	2	3	0	0	0	0	**0**	10 000	5 000	0	0	0	**15 000**	0	0	0	**0**	**0**	**15 000**
Namibia	1	1	2	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	0	0	0	**0**	**0**	**10 000**
Nepal	0	1	1	0	0	0	0	**0**	7 000	0	0	0	0	**7 000**	0	0	0	**0**	**0**	**7 000**
Netherlands	0	1	1	0	0	0	0	**0**	0	7 000	0	0	0	**7 000**	0	0	0	**0**	**0**	**7 000**
Nigeria	1	6	7	0	0	0	0	**0**	30 000	13 000	4 600	0	0	**47 600**	0	0	0	**0**	**0**	**47 600**
Norway	1	0	1	0	5 000	0	0	**5 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**5 000**
Pakistan	12	16	28	3 000	5 000	11 000	5 000	**24 000**	57 000	50 500	14 000	0	12 000	**133 500**	4 000	0	0	**4 000**	**0**	**161 500**
Panama	0	1	1	0	0	0	0	**0**	0	6 000	0	0		**6 000**	0	0	0	**0**	**0**	**6 000**
Paraguay	0	1	1	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	0	0	0	**0**	**0**	**10 000**
Peru	1	6	7	0	0	0	0	**0**	21 000	18 000	0	0	4 000	**43 000**	0	0	0	**0**	**0**	**43 000**
Philippines	2	8	10	0	0	0	0	**0**	27 000	48 500	0	0	0	**75 500**	0	0	0	**0**	**0**	**75 500**
Poland	8	11	19	0	0	5 000	5 000	**10 000**	40 000	21 000	0	0	30 000	**91 000**	0	4 000	0	**4 000**	**0**	**105 000**
Portugal	1	6	7	0	0	0	10 000	**10 000**	20 000	0	5 000	0	5 000	**30 000**	0	0	0	**0**	**0**	**40 000**
Romania	10	7	17	3 000	10 000	5 000	24 000	**42 000**	8 000	8 000	0	0	13 000	**29 000**	10 000	0	0	**10 000**	**0**	**81 000**
Russian Federation	22	22	44	43 500	10 000	10 000	51 500	**115 000**	19 000	11 000	5 000	0	4 000	**39 000**	28 800	0	15 000	**43 800**	**0**	**197 800**

* Includes contracts with multiple fundings

Annex II.3

Distribution of Total
2002 Contract Awards, by Country and Programme

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	MP 3	M/MP 4	Total
Saudi Arabia	0	1	1	0	0	0	0	**0**	0	0	0	0	4 000	**4 000**	0	0	0	**0**	**0**	**4 000**
Senegal	0	1	1	0	0	0	0	**0**	0	5 000	0	0	0	**5 000**	0	0	0	**0**	**0**	**5 000**
Serbia and Montenegro	1	0	1	0	0	0	6 000	**6 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**6 000**
Singapore	2	4	6	0	0	0	5 000	**5 000**	0	35 500	0	0	0	**35 500**	0	0	0	**0**	**0**	**40 500**
Slovakia	6	8	14	11 000	5 000	5 000	9 500	**30 500**	16 000	17 000	0	0	0	**33 000**	11 000	0	0	**11 000**	**0**	**74 500**
Slovenia	2	8	10	0	0	0	15 000	**15 000**	12 000	14 500	10 000	0	4 000	**40 500**	0	0	0	**0**	**0**	**55 500**
South Africa	6	9	15	0	0	0	5 000	**5 000**	77 300	11 000	10 000	0	0	**98 300**	0	0	0	**0**	**0**	**103 300**
Spain	1	1	2	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	2 000	0	**2 000**	**0**	**7 000**
Sri Lanka	2	3	5	0	0	0	0	**0**	23 000	18 500	0	0	0	**41 500**	0	0	0	**0**	**0**	**41 500**
Sudan	2	0	2	0	0	0	0	**0**	0	8 000	0	0	0	**8 000**	0	0	0	**0**	**0**	**8 000**
Syrian Arab Republic	5	5	10	3 000	0	0	0	**3 000**	34 000	0	5 000	0	4 000	**43 000**	4 000	0	0	**4 000**	**0**	**50 000**
Tanzania, United Republic of	1	3	4	0	0	0	0	**0**	11 000	15 000	0	0	0	**26 000**	0	0	0	**0**	**0**	**26 000**
Thailand	9	12	21	0	0	5 000	0	**5 000**	41 000	63 500	0	0	8 000	**112 500**	0	12 000	0	**12 000**	**0**	**129 500**
The Frmr.Yug.Rep. of Macedor	0	1	1	0	0	0	4 000	**4 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**4 000**
Tunisia	0	3	3	2 000	0	0	0	**2 000**	17 000	0	0	0	0	**17 000**	0	0	0	**0**	**0**	**19 000**
Turkey	8	12	20	0	0	0	0	**0**	57 500	31 000	4 000	0	13 000	**105 500**	2 000	3 000	0	**5 000**	**0**	**110 500**
Uganda	1	1	2	0	0	0	0	**0**	18 000	0	0	0	0	**18 000**	0	0	0	**0**	**0**	**18 000**
Ukraine	4	7	11	23 000	0	0	4 000	**27 000**	13 000	0	0	0	0	**13 000**	0	0	10 700	**10 700**	**0**	**50 700**
United Kingdom	3	3	6	0	0	0	0	**0**	41 500	0	0	0	0	**41 500**	0	32 000	0	**32 000**	**0**	**73 500**
United States	2	6	8	0	0	0	0	**0**	47 000	19 000	0	0	0	**66 000**	0	10 000	0	**10 000**	**0**	**76 000**
Uruguay	5	7	12	0	0	0	0	**0**	16 000	27 000	0	0	16 000	**59 000**	0	5 000	0	**5 000**	**0**	**64 000**
Uzbekistan	1	0	1	0	0	0	5 000	**5 000**	0	0	0	0	0	**0**	0	0	0	**0**	**0**	**5 000**
Venezuela	1	3	4	0	0	0	4 000	**4 000**	15 000	7 000	0	0	0	**22 000**	0	0	0	**0**	**0**	**26 000**
Vietnam	5	8	13	0	0	0	4 000	**4 000**	39 000	31 000	0	0	0	**70 000**	8 000	0	0	**8 000**	**0**	**82 000**
Zambia	0	3	3	0	0	0	0	**0**	17 000	0	0	0	0	**17 000**	0	0	0	**0**	**0**	**17 000**
Total	290	515	805	195 000	60 500	91 000	398 130	**744 630**	1 934 800	1 081 500	146 100	15 000	318 082	**3 495 482**	161 050	96 000	80 700	**337 750**	**10 360**	**4 588 222**

* Includes contracts with multiple fundings

Research Co-ordination Meetings Held in 2002

A. NUCLEAR POWER

Engineering and Management Support for Competitive Nuclear Power

A1	I2.10.12	Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials
	I2.10.14	Verification of WWER steam generator tube integrity
	I2.10.15	National approaches to correlate nuclear power plant performance targets and O&M costs
	I2.10.16	Evaluation of radiation damage of WWER reactor pressure vessels using the IAEA database on reactor pressure vessel materials
	I2.70.01	Information management solutions for SAT applications (SAT-IM)

Nuclear Power Technology Development and Applications

A2	I3.10.12	Evaluation of high temperature gas cooled reactor performance
	I3.20.04	Studies of innovative reactor technology options for effective incineration of radioactive waste
	I3.50.02	Economic research on, and assessment of, selected nuclear desalination projects and case studies

B. NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

Nuclear Fuel Performance and Technology

B2	T1.20.13	Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys
	T1.20.14	Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)
	T1.20.15	Improvement on the models used for fuel behaviour simulation (FUMEX II)

C. ANALYSIS FOR SUSTAINABLE ENERGY DEVELOPMENT

Energy Modelling, Databanks and Capacity Building

C1	I1.10.02	The impact of infrastructural requirements on the competitiveness of nuclear power
	I1.10.04	Historical evolution of indicators of sustainable energy development (ISED) and the use of this information for designing guidelines for future energy strategies in conformity with the objectives of sustainable development

Energy-Economy-Environment (3E) Analysis

C2	I1.40.04	Cost effectiveness of nuclear power compared to CO2 capture and sequestration from fossil fuel power plants

D. NUCLEAR SCIENCE

Nuclear and Atomic Data

D1	F4.10.16	Fission product yield data required for transmutation of minor actinide nuclear waste
	F4.10.19	Improvement of the standard cross sections for light elements
	F4.20.04	Update of X- and gamma-ray decay data standards for detector calibration
	F4.30.13	Tritium inventory in fusion reactors

Research Co-ordination Meetings Held in 2002

Research Reactors

D2	F1.20.13	Development and practical utilization of small angle neutron scattering (SANS) applications
	F2.30.21	New applications of prompt gamma neutron activation analysis (PGNAA)
	T1.30.10	Corrosion of research reactor aluminum-clad spent fuel in water (Phase II)

Nuclear Research Facilities and Instrumentation

D3	F1.30.07	Comparison of compact toroid configurations

E. FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

E1	D1.50.06	Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques
	D1.50.07	Integrated soil, water and nutrient management for sustainable rice-wheat cropping systems in Asia

Plant Breeding and Genetics

E2	D2.30.21	Molecular characterization of mutated genes controlling important traits for seed crop improvement
	D2.30.22	Mutational analysis of root characters in annual food plants related to plant performance
	D2.30.23	Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology

Animal Production and Health

E3	D3.10.21	Use of nuclear and colorimatric techniques for measuring microbial protein supply from local feed resources in ruminant animals
	D3.10.23	Integrated approach for improving small scale market oriented dairy systems
	D3.20.19	Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay-based technologies for increasing farmyard poultry production in Africa
	D3.20.20	The use of non-structural protein of foot-and-mouth disease virus (FMDV) to differentiate between vaccinated and infected animals
	D3.20.22	The development of strategies for the effective monitoring of veterinary drug residues in livestock and livestock products in developing countries

Insect and Pest Control

E4	D4.10.12	Enhancement of the SIT through genetic transformation of arthropods using nuclear techniques
	D4.10.17	Development of improved attractants and their integration into fruit fly SIT management programmes
	D4.10.18	Improvement of codling moth SIT to facilitate expansion of field application
	D4.20.08	Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barrier systems used in tsetse control/eradication campaigns
	D4.20.09	Enabling technologies for the expansion of SIT for old and new world screwworm

Research Co-ordination Meetings Held in 2002

Food Quality and Safety

E5	D5.20.34	Alternative methods to gas and high performance liquid chromatography for pesticide residue analysis in grain
	D6.10.19	Determination of profiles of human bacterial pathogens in foods for export by introduction of quality-assured microbiological assays
	D6.10.20	Irradiation as a phytosanitary treatment of food and agricultural commodities
	D6.10.21	Evaluation of methods of analysis for determining mycotoxin contamination of food and feed
	D6.10.23	Testing the efficiency and uncertainty of sample processing for analysis of food contaminants
	D6.20.07	Irradiation to ensure the safety and quality of prepared meals

F. HUMAN HEALTH

Nuclear Medicine

F1	E1.10.13	Development and validation of an Internet based clinical and technical study communication system for nuclear medicine
	E1.10.14	To compare clinical application software between nuclear medicine laboratories by software phantoms developed by the Agency and COST B2 project.
	E1.30.18	Study of the relationship between recurrent lower respiratory tract infection, gastroesophageal reflux and bronchial asthma in children
	E1.30.24	Improvement in the treatment of acute lymphoblastic leukemia (ALL) by the detection of minimal residual disease (MRD)
	E1.30.25	Nitrate augmented myocardial imaging for assessment of myocardial viability

Applied Radiation Biology and Radiotherapy

F2	E3.30.13	Randomised clinical trial of radiotherapy combined with Mitomycin C in the treatment of advanced head and neck tumours
	E3.30.17	Regional hyperthermia combined with radiotherapy for locally advanced cancers
	E3.30.21	The role of teletherapy (TT) supplementary to intraluminal high dose rate (ILHDR)brachytherapy (BT) in the palliation of advanced oesophageal cancer

Dosimetry and Medical Radiation Physics

F3	E2.40.09	Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water
	E2.40.12	Development of TLD-based quality audits for radiotherapy dosimetry in non-reference conditions

Nutrition and Effects of Contaminants on Human Health

F4	E4.10.11	Validation and application of plants as biomonitors of trace element atmospheric pollution, analyzed by nuclear and related techniques
	E4.10.13	Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities

Annex III.3

Research Co-ordination Meetings Held in 2002

	E4.30.11	Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependant diabetes) in ageing
	E4.30.13	Thematic CRP on Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies
	E4.30.14	Application of isotopic and nuclear techniques in the study of nutrition-pollution interactions and their impact on the nutritional status of human subjects in developing country populations

G. WATER RESOURCES

Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

G1	F3.30.14	Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones*

Reference Isotope Data and Analysis for Hydrologic Applications

G2	F3.20.03	Design criteria for a network to monitor isotope compositions of runoff in large rivers

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENTS

Measurement and Assessment of Radionuclides in the Marine Environment

H1	F3.30.14	Nuclear and isotopic techniques for the characterization of submarine groundwater Discharge (SGD) in coastal zones*

I. PHYSICAL AND CHEMICAL SCIENCES

Radiochemical Applications

I1	F2.20.32	Development of kits for Tc99m radiopharmaceuticals for infection imaging
	F2.20.33	Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides
	F2.20.36	Development of radioactive sources for emerging therapeutic and industrial applications
	F2.20.37	Comparative laboratory evaluation of therapeutic radiopharmaceuticals
	F2.30.18	Development and validation of speciation analysis using nuclear techniques

Radiation Processing, Radiography and Radiotracer Applications

I2	F2.30.19	Integration of residence time distribution (RTD) tracing with computational fluid dynamics (CFD) simulation for industrial process visualization and optimization
	F2.30.20	Corrosion and deposit determination in large diameter pipes, with and without insulation by radiography testing
	F2.30.22	Remediation of polluted waters and wastewater by radiation processing

J. SAFETY OF NUCLEAR INSTALLATIONS

Development of Safety Assessment Methods and Tools

J2	J4.50.02	Development and application of indicators to monitor NPP operational safety performance

* Meeting held jointly under subprogrammes H.1. and G.1.

Research Co-ordination Meetings Held in 2002

Engineering Safety of Existing Nuclear Installations

J4	J4.10.05	Safety significance of near field earthquakes

K. RADIATION SAFETY

Safety of Transport of Radioactive Material

K2	J1.30.10	Radiological aspects of package and conveyance non-fixed radioactive contamination (Two meetings)

Radiological Protection of Patients

K4	J1.70.06	Exploring the possibility of establishing guidance levels for interventional radiology

Safety of Radiation Sources

K5	J1.70.05	To investigate appropriate methods and procedures to apply probabilistic safety assessment (PSA) techniques of large radiation sources

L. MANAGEMENT OF RADIOACTIVE WASTE

Safety of Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal

L2	J9.10.05	The use of selected safety indicators (concentrations; fluxes) in the assessment of radioactive waste disposal
	J9.10.06	Application of safety assessment methodologies for near surface waste disposal facilities (ASAM)

Technologies for Disposable Radioactive Waste Management

L3	T2.10.20	Anthropogenic analogues for geological disposal of high-level and long lived radioactive waste
	T2.10.21	Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions

Technologies for the Decommissioning of Installations and Restoration of Sites

L6	T2.30.14	Technologies and methods for long term stabilization and isolation of uranium mill tailings

Research Co-ordination Meetings Held in 2002

Locations:

Argentina
Australia
Brazil (5)
Bulgaria
Canada
Chile (2)
China
Croatia
Czech Republic
France
Germany (2)
Hungary
India (2)
Italy (2)
Japan
Mauritius
Mexico (2)
Poland (3)
Portugal (2)
Romania
Russia
Slovakia
South Africa (3)
Spain (2)
Sweden
Thailand
Turkey (2)
Uganda
USA
Vietnam

Headquarters (33)

Total 2002 Contract Awards, by Country

Country	Total US$
China	320 582
India	313 600
Brazil	228 500
Russian Federation	197 800
Argentina	179 130
Pakistan	161 500
Thailand	129 500
Hungary	119 000
Turkey	110 500
Korea, Republic of	108 000
Poland	105 000
South Africa	103 300
Bulgaria	90 650
Chile	87 000
Mexico	83 500
Czech Republic	82 000
Vietnam	82 000
Romania	81 000
Indonesia	79 500
Cuba	79 000
United States	76 000
Philippines	75 500
Slovakia	74 500
United Kingdom	73 500
Uruguay	64 000
Slovenia	55 500
Malaysia	52 000
Ukraine	50 700
Syrian Arab Republic	50 000
Kenya	49 000
Colombia	48 500
Nigeria	47 600
Kazakhstan	46 000
Peru	43 000
Sri Lanka	41 500
Singapore	40 500
Portugal	40 000
Australia	36 000
Bangladesh	36 000
Croatia	36 000
Ghana	35 500
Canada	35 000
Morocco	30 500
Cote d'Ivoire	28 000
Egypt	28 000
Greece	27 000
Israel	26 500
Germany	26 000
Tanzania, United Republic of	26 000
Venezuela	26 000
Burkina Faso	25 000
Iran, Islamic Republic of	25 000
Costa Rica	24 000
Italy	22 000

Total 2002 Contract Awards, by Country

Country	Total US$
Algeria	21 000
Austria	19 800
Belarus	19 000
Benin	19 000
Tunisia	19 000
Cameroon	18 000
Uganda	18 000
Lithuania	17 000
Zambia	17 000
Bolivia	16 000
Myanmar	15 000
Armenia	14 000
Japan	12 000
Mongolia	11 000
Belgium	10 000
Ecuador	10 000
Estonia	10 000
Mauritius	10 000
Namibia	10 000
Paraguay	10 000
Jordan	9 000
France	8 000
Sudan	8 000
Nepal	7 000
Netherlands	7 000
Spain	7 000
Barbados	6 000
Cyprus	6 000
Malta	6 000
Panama	6 000
Serbia and Montenegro	6 000
Albania	5 000
Lao P.D.R.	5 000
Madagascar	5 000
Mozambique	5 000
Norway	5 000
Senegal	5 000
Uzbekistan	5 000
Lebanon	4 500
Mali	4 000
Saudi Arabia	4 000
The Frmr.Yug.Rep. of Macedonia	4 000
Libyan Arab Jamahiriya	3 000
Latvia	560
Total	4 588 222

Active Co-ordinated Research Projects
at end 2002

A. NUCLEAR POWER

Engineering and Management Support for Competitive Nuclear Power

I2.10.11 Scientific basis and engineering solutions for cost-effective assessments of software-based I&C systems

1 Contract 7 Agreements 99/10/1 03/04/28

Argentina(A)[1], China(C)[2], Czech Republic(A), Finland(A), Germany(A), Korea, Republic Of(A), Norway(A), United States of America (A)

I2.10.12 Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials

7 Contracts 6 Agreements 99/12/1 02/12/31

Bulgaria(C), Czech Republic(C), France(A), Hungary(A), India(C), Netherlands(A), Russian Federation(C) (2), Slovakia(C), Ukraine(C), United Kingdom(A), United States of America (A) (2)

I2.10.13 Surveillance programmes results application to reactor pressure vessel integrity assessment

2 Contracts 21 Agreements 99/11/10 03/11/9

Argentina(A), Brazil(A), Bulgaria(A), Czech Republic(A) (2), Finland(A), Germany(A) (2), Hungary(A), India(A), Japan(A), Korea, Republic Of(A), Mexico(C), Netherlands(A), Romania(A), Russian Federation(A) (2)Russian Federation(C), Slovakia(A), Spain(A), United States of America (A) (3)

I2.10.14 Verification of WWER steam generator tube integrity

7 Contracts 6 Agreements 01/3/1 04/12/31

Croatia(C), Czech Republic(C), Finland(A), France(A), Germany(A), Hungary(A)Hungary(C), Russian Federation(C) (2), Slovakia(C), Spain(A), Ukraine(C), United States of America (A)

I2.10.15 National approaches to correlate nuclear power plant performance targets and O&M costs

7 Contracts 2 Agreements 99/11/15 04/10/31

Argentina(A), Brazil(C), Hungary(C), India(C), Korea, Republic Of(C), Mexico(C), Slovakia(C), Ukraine(C), United States of America (A)

I2.10.16 Evaluation of radiation damage of WWER reactor pressure vessels using the IAEA database on reactor pressure vessel materials

7 Contracts 2 Agreements 01/9/15 05/9/14

Bulgaria(C), Czech Republic(C), Finland(A) (2), Hungary(C), Russian Federation(C), Slovakia(C), Ukraine(C) (2)

I2.70.01 Information management solutions for SAT applications (SAT-IM)

3 Contracts 6 Agreements 00/6/1 04/5/31

Bulgaria(C), Hungary(A), India(C), Russian Federation(A)Russian Federation(C), Slovakia(A), Spain(A), Ukraine(A), United States of America (A)

Nuclear Power Technology Development and Applications

I3.10.12 Evaluation of high temperature gas cooled reactor performance

2 Contracts 8 Agreements 97/11/1 05/2/28

China(C), France(A), Germany(A), Indonesia(C), Japan(A), Netherlands(A), Russian Federation(A), South Africa(A), Turkey(A), United States of America (A)

I3.10.13 Conservation and application of HTGR technology: Advances in HTGR fuel technology

6 Agreements 00/11/1 05/12/31

China(A), Germany(A), Japan(A), Korea, Republic of(A), Russian Federation(A), United States of America (A)

[1] (A) Research Agreement

[2] (C) Research Contract

I3.20.04 Studies of innovative reactor technology options for effective incineration of radioactive waste

4 Contracts 14 Agreements 01/12/15 05/12/31

Belgium(A), China(A)China(C), Czech Republic(C), France(A), Germany(A), Hungary(A), India(C), Japan(A), Korea, Republic Of(A), Netherlands(A) (2), Poland(A), Romania(A), Russian Federation(A) (2)Russian Federation(C), United States of America (A)

I3.20.05 Updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects

2 Contracts 7 Agreements 99/10/1 04/9/30

China(C), France(A), Germany(A), India(A), Japan(A), Korea, Republic Of(A), Russian Federation(C), United Kingdom(A), United States of America (A)

I3.30.10 Intercomparison of techniques for pressure tube inspection and diagnostics

7 Contracts 1 Agreement 98/12/15 03/12/14

Argentina(C), Canada(A), China(C), India(C), Korea, Republic Of(C) (2), Romania(C) (2)

I3.30.11 Establishment of a thermophysical properties data base for LWRs and HWRs

7 Contracts 2 Agreements 98/10/22 03/8/31

Canada(A), China(C), Czech Republic(C), France(A), India(C), Korea, Republic Of(C) (2), Russian Federation(C) (2)

I3.50.01 Optimization of the coupling of nuclear reactors and desalination systems

8 Contracts 1 Agreement 98/5/15 03/5/14

Argentina(C), China(C), Egypt(C), India(C), Korea, Republic Of(C), Libyan Arab Jamahiriya(C), Morocco(A), Russian Federation(C), Tunisia(C)

I3.50.02 Economic research on, and assessment of, selected nuclear desalination projects and case studies

10 Contracts 3 Agreements 01/12/15 06/12/31

Algeria(C), Argentina(C), Canada(A), China(C), Egypt(C), France(A), India(C), Korea, Republic Of(C), Libyan Arab Jamahiriya(C), Pakistan(C), Russian Federation(C), Syrian Arab Republic(C), United States of America (A)

B. NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

Nuclear Fuel Performance and Technology

T1.20.14 Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)

4 Contracts 14 Agreements 01/3/1 06/3/31

Bulgaria(A), Canada(A), China(A), Czech Republic(C), Finland(A), France(A), Germany(A), Hungary(A), India(A), Japan(A), Romania(C), Russian Federation(C), Slovakia(C), Sweden(A), Ukraine(A), United Kingdom(A), United States of America (A) (2)

T1.20.15 Improvement on the models used for fuel behaviour simulation (FUMEX II)

4 Contracts 10 Agreements 02/9/1 07/8/31

Belgium(A), Bulgaria(C), Canada(A), China(A), Czech Republic(C), Finland(A), Germany(A) (2), India(A), Japan(A), Korea, Republic Of(A), Norway(C), Romania(A), Russian Federation(C)

C. ANALYSIS FOR SUSTAINABLE ENERGY DEVELOPMENT

Energy Modelling, Databanks and Capacity Building

I1.10.02 The impact of infrastructural requirements on the competitiveness of nuclear power

4 Contracts 1 Agreement 99/10/1 03/9/30

China(C), Kazakhstan(C), Pakistan(C), Russian Federation(C), Turkey(A)

I1.10.04 Historical evolution of indicators of sustainable energy development (ISED) and the use of this information for designing guidelines for future energy strategies in conformity with the objectives of sustainable development

7 Contracts 02/4/1 06/3/31

Brazil(C), Cuba(C), Lithuania(C), Mexico(C), Russian Federation(C), Slovakia(C), Thailand(C)

Energy-Economy-Environment (3E) Analysis

I1.40.04 Cost effectiveness of nuclear power compared to CO2 capture and sequestration from fossil fuel power plants

9 Contracts 3 Agreements 02/5/15 06/5/31

Argentina(C), Australia(A), Bulgaria(C), China(C), India(C) (2), Korea, Republic Of(A), Pakistan(C), Poland(C), Romania(C), Russian Federation(A)Russian Federation(C)

D. NUCLEAR SCIENCE

Nuclear and Atomic Data

F4.10.16 Fission product yield data required for transmutation of minor actinide nuclear waste

4 Contracts 6 Agreements 97/10/1 03/3/31

Belarus(C), China(C), Germany(A), Japan(A), Kazakhstan(C), Netherlands(A), Russian Federation(A), Ukraine(C), United Kingdom(A), United States of America (A)

F4.10.18 Development of a database for prompt gamma-ray neutron activation analysis

4 Contracts 3 Agreements 99/4/1 03/4/30

China(C), Hungary(C), India(C), Korea, Republic Of(A), United States of America (A) (2), Vietnam(C)

F4.10.19 Improvement of the standard cross sections for light elements

3 Contracts 6 Agreements 02/4/1 06/3/31

Austria(A), China(C), Germany(A), Japan(A), Korea, Republic Of(C), Russian Federation(C), United States of America (A) (3)

F4.10.20 Evaluated nuclear data for the Thorium-Uranium fuel cycle

2 Contracts 3 Agreements 02/11/1 05/12/31

Belarus(C), Bulgaria(C), United Kingdom(A), United States of America (A) (2)

F4.10.21 Nuclear data for production of therapeutic radionuclides

4 Contracts 02/12/1 06/11/30

Brazil(C), Hungary(C), Russian Federation(C), Slovakia(C)

F4.30.11 Atomic and molecular data for fusion plasma diagnostics

3 Contracts 9 Agreements 01/7/15 04/6/30

Austria(A), China(C), Germany(A) (2), Netherlands(A), Russian Federation(C), Spain(A), The Frmr.yug.rep. of Macedonia(C), United Kingdom(A) (2), United States of America (A) (2)

F4.30.12 Data for molecular processes in edge plasmas

3 Contracts 8 Agreements 01/8/1 04/7/31

Austria(A), Belgium(A), Czech Republic(C), France(A), Germany(A), Italy(A), Japan(A), Russian Federation(C), Slovakia(C), Sweden(A), United States of America (A)

F4.30.13 Tritium inventory in fusion reactors

3 Contracts 8 Agreements 02/8/1 06/7/31

Canada(A), Germany(A) (2), Japan(A), Russian Federation(C) (2), United Kingdom(A), United States of America (A) (3), Uzbekistan(C)

Research Reactors

F1.20.13 Development and practical utilization of small angle neutron scattering (SANS) applications
8 Contracts 4 Agreements 00/8/25 03/8/31
Austria(A), Brazil(C), France(A) (2), Germany(A), Greece(C), Hungary(C), India(C), Korea, Republic Of(C), Portugal(C), Russian Federation(C), South Africa(C)

F2.30.21 New applications of prompt gamma neutron activation analysis (PGNAA)
5 Contracts 4 Agreements 02/9/1 05/12/31
Argentina(C), China(C), Germany(A), Hungary(C), Korea, Republic Of(A), United States of America (A) (2), Venezuela(C), Vietnam(C)

T1.30.08 Ageing of materials in spent fuel storage facilities
3 Contracts 5 Agreements 99/10/1 03/9/30
Argentina(C), Australia(A), Germany(A), Kazakhstan(C), Romania(C), Russian Federation(A), United Kingdom(A), United States of America (A)

T1.30.10 Corrosion of research reactor aluminium-clad spent fuel in water (Phase II)
5 Contracts 4 Agreements 02/3/15 06/3/14
Argentina(C), Brazil(A), Czech Republic(A), Hungary(C), Kazakhstan(C), Poland(A), Romania(C), Serbia And Montenegro(C), Thailand(A)

Nuclear Research Facilities and Instrumentation

F1.10.08 Development and applications of alpha particle spectrometry
8 Contracts 6 Agreements 00/7/1 03/6/30
Algeria(C), Bulgaria(C), China(C), Cuba(C), Finland(A), India(C), Kazakhstan(C), Korea, Republic Of(A), Mexico(C), Norway(A), Russian Federation(A), Slovenia(C), Spain(A), Sweden(A)

F1.10.09 In-situ applications of X-ray fluorescence (XRF) techniques
10 Contracts 3 Agreements 00/7/10 04/7/9
Albania(C), Argentina(C), Belgium(A), China(C), Ghana(C), Hungary(C), Italy(A), Mongolia(C), Pakistan(C), Poland(C), Romania(C), Slovenia(C), United Kingdom(A)

F1.10.10 Development of distance learning (DL) modules on troubleshooting of nuclear instruments
5 Contracts 1 Agreement 01/11/1 04/12/31
Argentina(C), Brazil(C), Cuba(C), India(C), Israel(A), Vietnam(C)

F1.20.14 The use of ion beam techniques for analysis of light elements in thin films, including depth profiling
7 Contracts 3 Agreements 00/8/1 03/7/31
Brazil(C), China(C), Croatia(C), Finland(A), France(A), Hungary(C), Mexico(C), New Zealand(A), Portugal(C), Slovenia(C)

F1.30.08 Elements of power plant design for inertial fusion energy
8 Contracts 9 Agreements 00/12/15 05/12/14
Czech Republic(C), Germany(A), Hungary(C), India(C), Japan(A) (2), Korea, Republic Of(C), Poland(C), Russian Federation(C) (2), Spain(A), United States of America (A) (5), Uzbekistan(C)

F1.30.09 Dense magnetized plasmas
8 Contracts 1 Agreement 01/12/15 05/12/31
China(C), Estonia(C), Italy(A), Poland(C) (2), Romania(C), Russian Federation(C) (2), Singapore(C)

E. FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

D1.20.07 Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry systems

9 Contracts 5 Agreements 98/12/1 05/12/31

Australia(A) (2), Benin(C), Chile(C), China(C), Costa Rica(C), France(A), Kenya(A)Kenya(C), Malaysia(C), Nigeria(A), Sri Lanka(C), Uganda(C), Zambia(C)

D1.50.06 Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques

9 Contracts 4 Agreements 99/10/15 04/12/31

Australia(C), Benin(C), Brazil(C) (2), Burkina Faso(C), Cuba(C), Germany(A), Kenya(A), Mexico(C), Nigeria(A)Nigeria(C), United States of America (A), Venezuela(C)

D1.50.07 Integrated soil, water and nutrient management for sustainable rice-wheat cropping systems in Asia

7 Contracts 3 Agreements 01/10/1 06/9/30

Australia(A), Bangladesh(C), China(C) (2), India(A)India(C) (2), Nepal(C), Pakistan(C), Philippines(A)

D1.50.08 Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides

14 Contracts 7 Agreements 02/11/1 07/12/31

Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(A), Chile(C), China(C) (2), India(C), Japan(A), Morocco(C), Netherlands(A), Pakistan(C), Poland(C), Romania(C), Russian Federation(C), Turkey(C), United Kingdom(C), United States of America (A) (2), Vietnam(C) (jointly with Programme G)

Plant Breeding and Genetics

D2.30.20 Genetic improvement of underutilized and neglected crops in low income food deficit countries (LIFDCs) through irradiation and related techniques

11 Contracts 4 Agreements 98/12/1 03/11/30

Bolivia(C), Costa Rica(C) (2), Ecuador(C), France(A) (2), Germany(A), Ghana(C) (2), India(C), Indonesia(C), Slovakia(C), South Africa(C), Syrian Arab Republic(A), Thailand(C)

D2.30.21 Molecular characterization of mutated genes controlling important traits for seed crop improvement

12 Contracts 6 Agreements 99/7/7 05/7/6

Brazil(C) (2), Bulgaria(C), Canada(A), China(C) (3), India(A), Korea, Republic Of(C) (2), Philippines(C), Poland(C), Portugal(C), Turkey(C), United Kingdom(A) (2), United States of America (A) (2)

D2.30.22 Mutational analysis of root characters in annual food plants related to plant performance

10 Contracts 9 Agreements 99/9/1 04/8/31

Argentina(C), Australia(A) (2), Belgium(A), Brazil(C), China(C) (2), Cuba(C), Germany(A), India(C), Israel(A), Poland(C), South Africa(C), Switzerland(A), Turkey(C), United Kingdom(A), United Republic Of Tanzania(C), United States of America (A) (2)

D2.30.23 Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology

11 Contracts 3 Agreements 00/8/1 05/7/31

China(C), Cuba(C), India(C), Indonesia(C), Iran, Islamic Republic Of(C), Israel(A), Malaysia(C) (2), Pakistan(C), Philippines(C), South Africa(C), Thailand(C), United Kingdom(A), United States of America (A)

D2.30.24 Physical mapping technologies for the identification and characterization of mutated genes contributing to crop quality

10 Contracts 4 Agreements 02/9/2 07/8/31

Argentina(C), Bulgaria(C), China(C) (2), Czech Republic(C), Germany(A), Iceland(A), Pakistan(C) (2), Poland(C), Ukraine(C), United Kingdom(A), United States of America (A), Vietnam(C)

Animal Production and Health

D3.10.22 Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage

6 Contracts 3 Agreements 98/7/1 04/6/30

Australia(A)Australia(C), Bangladesh(C), Brazil(C), Canada(A), Indonesia(C), Tunisia(C), Turkey(C), United Kingdom(A)

D3.10.23 Integrated approach for improving small scale market oriented dairy systems

11 Contracts 4 Agreements 01/11/1 06/12/31

Bangladesh(C), Cameroon(C), Malaysia(A), Pakistan(C), Paraguay(C), Peru(C) (2), South Africa(C), Sri Lanka(C), Tunisia(C), United Kingdom(A), United Republic Of Tanzania(C), United States of America (A), Uruguay(A), Venezuela(C)

D3.20.17 To develop and validate standardised methods for using polymerase chain reaction (PCR) and related molecular technologies for rapid and improved animal disease diagnosis

8 Contracts 4 Agreements 97/1/1 03/3/31

Cameroon(C), Cote D'ivoire(C), Ethiopia(C), France(A), Kenya(C), Korea, Republic Of(C), Mali(C), Pakistan(C), South Africa(A), Sweden(A), United Kingdom(A), United Republic Of Tanzania(C)

D3.20.18 The monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays

12 Contracts 3 Agreements 97/11/15 03/3/31

Botswana(C), Cote D'ivoire(C), Ethiopia(C), France(A), Ghana(C), Kenya(C), Mali(C), Namibia(C), Nigeria(C), Sweden(A), Uganda(C), United Kingdom(A)United Kingdom(C), United Republic Of Tanzania(C), Zambia(C)

D3.20.19 Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay-based technologies for increasing farmyard poultry production in Africa

13 Contracts 6 Agreements 98/4/1 04/3/31

Cameroon(C), Cote D'ivoire(C), Denmark(A), Egypt(C), Ghana(C), Kenya(C), Madagascar(C), Mauritius(C), Morocco(A)Morocco(C), Mozambique(C), Netherlands(A), Nigeria(A), Sudan(C), Uganda(C), United Republic Of Tanzania(A)United Republic Of Tanzania(C), United States of America (A), Zimbabwe(C)

D3.20.20 The use of non-structural protein of foot-and-mouth disease virus (FMDV) to differentiate between vaccinated and infected animals

14 Contracts 5 Agreements 99/1/15 04/5/31

Argentina(C) (2), Australia(C), Brazil(A)Brazil(C), China(C) (2), Colombia(C), Denmark(A), Italy(A), Lao P.d.r.(C), Malaysia(C), Myanmar(C), Peru(C), Philippines(C), South Africa(C), Thailand(C), United Kingdom(A), United States of America (A)

D3.20.21 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

11 Contracts 5 Agreements 00/11/15 05/11/14

Belgium(A), Bolivia(C), Brazil(C), Burkina Faso(C), Chile(C), China(C), Cote D'ivoire(C), Germany(A), Kenya(C), Netherlands(A) (2), South Africa(C), Thailand(C), Uganda(C), United Kingdom(A), Vietnam(C)

D3.20.22 The development of strategies for the effective monitoring of veterinary drug residues in livestock and livestock products in developing countries

14 Contracts 3 Agreements 02/1/1 06/12/31

Barbados(C), Brazil(C), Cyprus(C), Germany(A)Germany(C), Indonesia(C), Kenya(C), Korea, Republic Of(C), Malta(C), Namibia(C), South Africa(C), Sri Lanka(C), Sweden(A), Thailand(C), Turkey(C), United Kingdom(A)United Kingdom(C)

Insect and Pest Control

D4.10.16 Quality assurance of mass produced and released fruit flies for SIT programmes

13 Contracts 6 Agreements 99/10/1 04/12/30

Argentina(A)Argentina(C) (2), Australia(A), Chile(C), Costa Rica(C), France(A), Guatemala(C), Israel(C) (2), Japan(A), Lebanon(C), Mexico(C) (2), Peru(C), Philippines(C), Portugal(C), South Africa(A), United States (A)

D4.10.17 Development of improved attractants and their integration into fruit fly SIT management programmes

15 Contracts 5 Agreements 00/4/1 05/3/31

Argentina(C), Brazil(C) (2), Colombia(C), Costa Rica(C), France(A) (2), Greece(C), Honduras(C), Israel(C), Kenya(C), Mauritius(C), Mexico(C), Pakistan(C), Portugal(A), Spain(A)Spain(C), United Kingdom(A), United States (C) (2)

D4.10.18 Improvement of codling moth SIT to facilitate expansion of field application

9 Contracts 5 Agreements 02/5/1 07/4/30

Argentina(C) (2), Armenia(C), Brazil(C), Canada(A)Canada(C), Chile(C), Czech Republic(C), Russian Federation(C), South Africa(A), Switzerland(A), Syrian Arab Republic(C), United States of America (A) (2)

D4.20.05 Genetics application to improve the SIT for tsetse control/eradication

3 Contracts 6 Agreements 97/1/1 03/1/30

Belgium(A), Canada(A), Cote D'ivoire(C), Greece(C), Italy(A), Kenya(C), United States of America (A) (3)

D4.20.09 Enabling technologies for the expansion of SIT for old and new world screwworm

6 Contracts 4 Agreements 01/8/1 05/7/31

Brazil(C), Indonesia(C), Iran, Islamic Republic Of(C), Sweden(A), United Kingdom(A)United Kingdom(C), United States of America (A) (2), Uruguay(C), Venezuela(C)

D4.30.02 Evaluating the use of nuclear techniques for the colonization and production of natural enemies of agricultural insect pests

15 Contracts 3 Agreements 99/8/1 04/7/31

Argentina(C), Austria(A) (2), Bangladesh(C), Bulgaria(C), China(C), India(C), Indonesia(C), Mexico(C), Pakistan(C), Poland(C), Slovakia(C) (2), Syrian Arab Republic(C), Turkey(C) (2), United States (A)United States (C)

Food Quality and Safety

D5.40.03 Quality control of pesticide products

14 Contracts 3 Agreements 00/12/1 05/11/30

China(C) (2), Cuba(C), Greece(A), Hungary(C) (2), India(C), Korea, Republic Of(C), Myanmar(C), Nigeria(C), Philippines(C), Thailand(C), Turkey(C), United States of America (A) (2), Uruguay(C), Vietnam(C)

D5.50.01 The classification of soil systems on the basis of transfer factors of radionuclides from soil to reference plants

11 Contracts 3 Agreements 98/11/1 03/12/31

Australia(A), Brazil(C), Bulgaria(C), Chile(C), China(C), Greece(C), India(C), Japan(A), Russian Federation(C), Syrian Arab Republic(C), Turkey(C), Ukraine(C), United States of America (A), Vietnam(C)

D6.10.21 Evaluation of methods of analysis for determining mycotoxin contamination of food and feed

14 Contracts 4 Agreements 98/11/1 03/9/30

Argentina(C), Brazil(C), Canada(A)Canada(C), China(C), Cuba(C), Egypt(C), Ghana(C), India(C), Indonesia(C), Italy(A), Malaysia(C), Philippines(C), South Africa(C), United Kingdom(A)United Kingdom(C), United States of America (A), Uruguay(C)

D6.10.22 Use of irradiation to ensure hygienic quality of fresh, pre-cut fruits and vegetables and other minimally processed food of plant origin

11 Contracts 4 Agreements 01/4/1 05/3/31

Argentina(C), Brazil(C), Canada(A), Chile(C), China(C), Egypt(C), Hungary(C), India(C), Malaysia(C), Pakistan(C), Portugal(C), Turkey(C), United Kingdom(A), United States of America (A) (2)

D6.10.23 Testing the efficiency and uncertainty of sample processing for analysis of food contaminants

12 Contracts 4 Agreements 02/4/1 07/3/31

Argentina(C), Australia(A), Belarus(C), China(C), Colombia(C), Costa Rica(C), Croatia(C), Hungary(C), India(A)India(C) (2), Malaysia(C), Netherlands(A), Slovenia(C), Thailand(C), United Kingdom(A)

D6.20.07 Irradiation to ensure the safety and quality of prepared meals

11 Contracts 3 Agreements 02/1/1 06/12/31

Argentina(C), China(C), Ghana(C), Hungary(C), India(C), Indonesia(C), Israel(A), Korea, Republic Of(C), Malaysia(C), South Africa(C), Syrian Arab Republic(C), Thailand(C), United Kingdom(A), United States (A)

F. HUMAN HEALTH

Nuclear Medicine

E1.10.13 Development and validation of an Internet based clinical and technical study communication system for nuclear medicine

8 Contracts 1 Agreement 98/12/15 03/12/14

Argentina(C), China(C) (2), Greece(C), India(C) (2), United Kingdom(C) (2), United States of America (A)

E1.10.14 To compare clinical application software between nuclear medicine laboratories by software phantoms developed by the Agency and COST B2 project.

8 Contracts 2 Agreements 99/12/15 03/12/14

Argentina(C), Austria(A), Chile(C), China(C), Cuba(C), Hungary(C), India(C), South Africa(C), Thailand(C), United Kingdom(A)

E1.20.16 Radioimmunoassay of advanced glycation end products (AGEs) in the long term management of diabetes mellitus

4 Contracts 2 Agreements 00/9/1 04/8/31

China(C), Greece(C), India(C), Thailand(C), United Kingdom(A), United States of America (A)

E1.30.18 Study of the relationship between recurrent lower respiratory tract infection, gastroesophageal reflux and bronchial asthma in children

9 Contracts 1 Agreement 99/12/15 03/12/14

Chile(C), China(C), Colombia(C), India(A), Pakistan(C), Philippines(C), Poland(C) (2), Thailand(C), Turkey(C)

E1.30.19 Thematic CRP on Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radioconjugate therapy and internal dosimetry

10 Contracts 8 Agreements 00/9/1 05/8/31

Australia(A), Austria(A), China(C), Colombia(C), France(A), India(A)India(C), Korea, Republic Of(C) (2), Mongolia(C), Philippines(C), Singapore(C), Slovenia(A), Thailand(C), United Kingdom(A), United States (A) (2), Vietnam(C)

E1.30.20 Intravascular radionuclide therapy (IVRNT) using liquid beta-emitting radiopharmaceuticals to prevent restenosis following percutaneous transluminal coronary angioplasty

13 Contracts 4 Agreements 00/11/15 03/11/14

China(C), Colombia(C), Cuba(C), Cyprus(C), Germany(A), Hungary(C), India(C), Iran, Islamic Republic Of(C), Korea, Republic Of(A)Korea, Republic Of(C), Poland(C), Singapore(C), Thailand(C), Turkey(C), United States of America (A) (2), Uruguay(C)

E1.30.21 Comparative evaluation of ictal brain SPECT, magnetic resonance imaging (MRI) and X-ray computerized tomography (CT) of brain in the management of patients with refractory seizures

8 Contracts 3 Agreements 00/12/1 03/12/31

Argentina(C), Belgium(A), China(C) (2), India(C), Italy(A), Korea, Republic Of(A)Korea, Republic Of(C), South Africa(C), Thailand(C), Turkey(C)

E1.30.22 Harmonization of radionuclide procedures and protocols in the management of neonatal hydronephrosis

10 Contracts 3 Agreements 01/8/1 04/7/31

Algeria(C), Chile(A)Chile(C), China(C), Colombia(C), Cuba(C), Estonia(C), India(C), Iran, Islamic Republic Of(A), Pakistan(C), Peru(C), Slovakia(C), Spain(A)

E1.30.23 Radiopharmaceutical imaging to predict and evaluate the response of breast cancer to neoadjuvant chemotherapy

11 Contracts 1 Agreement 01/8/1 04/7/31

Argentina(C), Chile(C), China(C), Colombia(C), Croatia(C), Cuba(C), India(C), Italy(A), Korea, Republic Of(C), Poland(C), Singapore(C), Thailand(C)

E1.30.24 Improvement in the treatment of acute lymphoblastic leukemia (ALL) by the detection of minimal residual disease (MRD)

6 Contracts 2 Agreements 02/10/24 05/12/31

Chile(C), India(C), Myanmar(C), Pakistan(C), Sudan(C), United Kingdom(A) (2), Uruguay(C)

E1.30.25 Nitrate augmented myocardial imaging for assessment of myocardial viability

8 Contracts 4 Agreements 02/9/1 05/12/31

Australia(A), Bulgaria(C), China(A), Cuba(C), India(A)India(C), Lithuania(C), Pakistan(C), Philippines(C), Singapore(A), Thailand(C), Uruguay(C)

E1.30.26 Comparative evaluation of radiopharmaceuticals for radiosynovectomy

10 Contracts 2 Agreements 02/10/15 06/12/31

Argentina(C), Chile(C), Colombia(C), India(C), Philippines(C), Poland(C), Singapore(C), Slovakia(C), Thailand(C), United States of America (A), Venezuela(A), Vietnam(C)

E1.50.18 The significance of viral load and virus type in Hepatitis B and C for Pathogenesis and treatment efficacy

7 Contracts 1 Agreement 99/10/1 03/1/1

Argentina(C), China(C), India(C), Korea, Republic Of(C), Malaysia(C), Russian Federation(C), United Kingdom(A), Uruguay(C)

Applied Radiation Biology and Radiotherapy

E3.30.13 Randomised clinical trial of radiotherapy combined with Mitomycin C in the treatment of advanced head and neck tumours

5 Contracts 4 Agreements 95/4/15 03/4/30

Bulgaria(C), Denmark(A), India(C), Italy(A), Japan(A), Pakistan(C) (2), Turkey(C), United States

E3.30.18 Aspects of radiobiology applicable in clinical radiotherapy - Increase of the number of fractions per week

7 Contracts 2 Agreements 98/9/15 06/3/31

Chile(C), Denmark(A) (2), Estonia(C), India(C) (2), Lebanon(C), Pakistan(C) (2)

E3.30.21 The role of teletherapy (TT) supplementary to intraluminal high dose rate (ILHDR) brachytherapy (BT) in the palliation of advanced oesophageal cancer

6 Contracts 2 Agreements 02/9/1 06/8/31

Brazil(C), Canada(A)Canada(C), Croatia(C), India(C), South Africa(C), Sudan(C), United States of America (A)

E3.50.07 Comparative assessment of teletherapy modalities

11 Contracts 01/8/1 03/7/31

Brazil(C), China(C), Croatia(C), Cuba(C), Greece(C), India(C), Indonesia(C), Netherlands(C), Pakistan(C), Peru(C), South Africa(C)

Dosimetry and Medical Radiation Physics

E2.10.03 Dosimetry in X-ray diagnostic radiology. An international Code of Practice

5 Agreements 00/12/1 05/11/30

Germany(A), Malaysia(A), Sweden(A), United Kingdom(A), United States of America (A)

E2.10.04 Development of techniques at SSDLs for the dissemination of absorbed dose to water standards

4 Contracts 2 Agreements 01/4/1 04/3/31

Algeria(C), Argentina(C), France(A), India(C), Norway(A), Thailand(C)

E2.40.12 Development of TLD-based quality audits for radiotherapy dosimetry in non-reference conditions

7 Contracts 2 Agreements 01/12/15 06/12/31

Algeria(C), Argentina(C), Austria(A), Belgium(A), Bulgaria(C), China(C), Cuba(C), India(C), Poland(C)

Nutrition and Effects of Contaminants on Human Health

E4.10.12 Health impacts of mercury cycling in contaminated environments studied by nuclear techniques

7 Contracts 4 Agreements 99/10/1 04/9/30

Brazil(C), Canada(A), China(C), Germany(A), India(C), Japan(A), Philippines(C), Slovenia(C), Sweden(A), United Republic Of Tanzania(C), Venezuela(C)

E4.10.13 Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities

11 Contracts 3 Agreements 01/12/15 06/12/31

Brazil(C), Canada(A), China(C), Czech Republic(C), Ghana(C), India(C), Nigeria(C), Peru(C), Russian Federation(C), Slovenia(C), South Africa(A), Sweden(A), Uzbekistan(C), Vietnam(C)

E4.30.10 Isotopic evaluations in infant growth monitoring - a collaboration with WHO (partly RCA)

3 Contracts 2 Agreements 99/11/1 03/10/31

Brazil(C), Chile(C), Pakistan(C), United Kingdom(A), United States of America (A)

E4.30.11 Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependant diabetes) in ageing

9 Contracts 3 Agreements 98/12/15 03/9/30

Brazil(C), Chile(C), China(C), Cuba(C), India(C) (2), Jamaica(C), Mexico(C), New Zealand(A), Nigeria(C), United Kingdom(A), United States of America (A)

E4.30.12 Use of isotopic techniques to examine the significance of infection and other insults in early childhood to diarrhoea morbidity, mal-assimilation and failure to thrive

9 Contracts 1 Agreement 99/12/15 03/12/14

Argentina(C), Belgium(A), Benin(C), Chile(C), Cuba(C), India(C), Indonesia(C), Mexico(C), Pakistan(C), Senegal(C)

E4.30.13 Thematic CRP on Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies

8 Contracts 7 Agreements 01/12/15 07/12/31

Bangladesh(C), Ghana(C), India(A)India(C), Indonesia(C), Mexico(C), Netherlands(A), Pakistan(C), Sri Lanka(C), Switzerland(A), Thailand(C), United Kingdom(A) (2), United States of America (A) (2)

E4.30.14 Application of isotopic and nuclear techniques in the study of nutrition-pollution interactions and their impact on the nutritional status of human subjects in developing country populations

8 Contracts 3 Agreements 01/12/15 05/3/31

Bangladesh(C), Brazil(A), Chile(C), China(C), India(C), Kenya(C), Korea, Republic Of(A), Morocco(C), Peru(C), Sweden(A), Vietnam(C)

G. WATER RESOURCES

Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

F3.30.11 Isotope response to dynamic changes in groundwater systems due to long term exploitation

7 Contracts 6 Agreements 99/6/1 03/5/31

Australia(A), Denmark(A), Germany(A) (2), India(C), Israel(C), Jordan(C), Philippines(C), South Africa(C), Switzerland(A), Tunisia(C), Turkey(C), United States of America (A)

F3.30.12 Origins of salinity and impacts on fresh groundwater resources: Optimization of isotopic techniques

7 Contracts 6 Agreements 00/8/1 05/7/31

Australia(A), China(C), France(A), Israel(C), Italy(A), Jordan(C), Korea, Republic Of(C), Morocco(C), Pakistan(C), Sweden(A), Tunisia(C), United Kingdom(A), United States of America (A)

F3.30.13 Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection

7 Contracts 3 Agreements 00/12/15 03/12/14

Austria(A), China(C), Germany(C), India(C), Pakistan(C), Slovenia(C), South Africa(C), Syrian Arab Republic(C), United Kingdom(A), United States of America (A)

F3.30.14 Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones

4 Contracts 6 Agreements 02/8/1 06/7/31

Brazil(C), France(A), India(A), Italy(C), Japan(A), Russian Federation(C), Slovenia(C), Sweden(A), United States of America (A) (2) (Jointly with Programme H)

Reference Isotope Data and Analysis for Hydrologic Applications

F3.10.02 Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate

10 Contracts 5 Agreements 00/6/15 04/6/14

Algeria(C), Austria(A), Croatia(C), Egypt(C), France(A), Greece(C), Israel(A), Italy(A), Lebanon(C), Morocco(C), Portugal(C) (2), Slovenia(C), Spain(A), Turkey(C)

F3.20.03 Design criteria for a network to monitor isotope compositions of runoff in large rivers

8 Contracts 8 Agreements 02/3/22 06/3/31

Argentina(C), Australia(A), Austria(A), Brazil(A)Brazil(C), Canada(C), China(C), Germany(A), India(C), Israel(A), Japan(A), Nigeria(C), Pakistan(C), South Africa(C), United States of America (A) (2)

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENTS

Transfer of Radionuclides in the Marine Environment

K4.10.08 Nuclear applications to determine bioaccumulation parameters and processes used for establishing coastal zone monitoring and management criteria

1 Contract 1 Agreement 02/12/15 05/12/14

Australia(A), Indonesia(C)

Measurement and Assessment of Radionuclides and Non-radioactive pollutants in the Terrestrial Environment

G4.10.03 Radiochemical, chemical and physical characterisation of radioactive particles in the environment

4 Contracts 4 Agreements 00/12/1 05/11/30

Denmark(A), Finland(A), Hungary(C), Kazakhstan(C), Norway(A), Russian Federation(C), Ukraine(C), United States of America (A)

I. PHYSICAL AND CHEMICAL APPLICATIONS

Radiochemical Applications

F2.20.32 Development of kits for Tc99m radiopharmaceuticals for infection imaging

9 Contracts 3 Agreements 00/6/15 03/6/14

Argentina(C), China(C), Hungary(A), India(C), Indonesia(C), Mexico(C), Netherlands(A), Pakistan(C), Poland(C), Thailand(C), United States of America (A), Uruguay(C)

F2.20.33 Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides

7 Contracts 4 Agreements 00/10/1 03/9/30

Argentina(C), Belgium(A), China(C), Hungary(A), Indonesia(C), Iran, Islamic Republic Of(C), Kazakhstan(C), Romania(C), Russian Federation(A), Saudi Arabia(C), United States of America (A)

F2.20.35 Development of radioimmunometric assays and kits for non clinical applications

8 Contracts 4 Agreements 01/8/1 06/7/31

China(C), Cuba(C), Greece(C), Hungary(A), India(A), Indonesia(C), Iran, Islamic Republic Of(C), Poland(C), Thailand(C), United Kingdom(A), United States of America (A), Uruguay(C)

F2.20.36 Development of radioactive sources for emerging therapeutic and industrial applications

9 Contracts 3 Agreements 02/4/1 05/3/31

Belarus(C), China(C), Hungary(A), India(C), Indonesia(C), Iran, Islamic Republic Of(C), Kazakhstan(C), Korea, Republic Of(A), Peru(C), Poland(C), Russian Federation(C), United States of America (A)

F2.20.37 Comparative laboratory evaluation of therapeutic radiopharmaceuticals

9 Contracts 6 Agreements 02/8/1 05/7/31

Brazil(A), Cuba(C), Czech Republic(A), Greece(C), Hungary(C), India(C), Italy(A), Korea, Republic Of(A), Mexico(C), Pakistan(C), Poland(C), Romania(C), United Kingdom(A), United States of America (A), Uruguay(C)

F2.30.18 Development and validation of speciation analysis using nuclear techniques

5 Contracts 3 Agreements 01/3/1 04/3/31

Argentina(C), Austria(A), Belgium(A), Brazil(C), China(C), Ghana(C), India(A), Slovenia(C)

Radiation Processing, Radiography and Radiotracer Applications

F1.10.07 Application of nuclear techniques to anti-personnel landmines identification

7 Contracts 7 Agreements 99/10/1 03/12/31

Australia(A), Canada(A), Croatia(C), Egypt(A), Hungary(C), Italy(A), Netherlands(A), Russian Federation(C), Slovakia(C), Slovenia(C), South Africa(C), Sweden(A), United States of America (A), Vietnam(C)

F2.20.34 Radiation synthesis of stimuli-responsive membranes, hydrogels and adsorbents for separation purposes

6 Contracts 4 Agreements 00/12/15 04/12/14

Egypt(C), France(A), Germany(A), Hungary(C), India(C), Japan(A), Kazakhstan(C), Korea, Republic Of(A), Poland(C), Turkey(C)

F2.30.19 Integration of residence time distribution (RTD) tracing with computational fluid dynamics (CFD) simulation for industrial process visualization and optimization

6 Contracts 5 Agreements 01/3/1 04/3/31

Australia(A), Brazil(C), Cuba(C), Czech Republic(C), France(A), Germany(A), India(C), Korea, Republic Of(C), Norway(A), Poland(C), United States of America (A)

F2.30.20 Corrosion and deposit determination in large diameter pipes, with and without insulation by radiography testing

10 Contracts 2 Agreements 02/6/1 05/5/31

Algeria(C), Canada(A), Germany(A), Hungary(C), India(C), Iran, Islamic Republic Of(C), Malaysia(C), Pakistan(C), Romania(C), Syrian Arab Republic(C), Turkey(C), Uruguay(C)

F2.30.22 Remediation of polluted waters and wastewater by radiation processing

7 Contracts 3 Agreements 02/5/1 06/4/30

Austria(A), Brazil(C), Ecuador(C), Hungary(C), Jordan(C), Korea, Republic Of(A), Poland(C), Portugal(C), Turkey(C), United States of America (A)

J. SAFETY OF NUCLEAR INSTALLATIONS

Development of Safety Assessment Methods and Tools

J4.20.04 Assessment of the interfaces between neutronic, thermal-hydraulic, structural and radiological aspects in accident analyses

6 Contracts 4 Agreements 02/12/1 05/11/30

Bulgaria(C), Czech Republic(C), Finland(A), Hungary(C), Italy(A), Russian Federation(C) (2), Slovakia(A) (2)Slovakia(C)

J4.50.02 Development and application of indicators to monitor NPP operational safety performance

4 Contracts 8 Agreements 99/10/1 03/9/30

China(A), Czech Republic(C), India(C), Lithuania(A), Netherlands(A), Pakistan(C), Slovakia(A) (2), Spain(A), Sweden(A), Ukraine(C), United Kingdom(A)

J4.60.01 Round-robin exercise on WWER (water-cooled and -moderated reactor pressure vessel)-440 RPV weld metal irradiation embrittlement and annealing

5 Contracts 4 Agreements 96/10/1 03/12/31

Belgium(A), Finland(A), France(A), Hungary(C), Norway(A), Russian Federation(C) (3), Slovakia(C)

Engineering Safety of Existing Nuclear Installations

J4.10.05 Safety significance of near field earthquakes

12 Contracts 9 Agreements 02/7/1 05/6/30

Armenia(C), Bulgaria(C), Canada(A), China(C), France(A) (3), India(C), Italy(A), Japan(A), Korea, Republic Of(C) (2), Pakistan(C), Portugal(A), Romania(C), Russian Federation(C), Slovakia(C), Spain(A), Turkey(C) (2), United States of America (A)

Research Reactor Safety

J7.10.09 To update and expand the IAEA reliability data for research reactor PSAs

7 Contracts 4 Agreements 01/3/15 04/3/14

Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(A), Czech Republic(C), India(C), Indonesia(C), Korea, Republic Of(A), Romania(C), Vietnam(C)

J7.10.10 Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools

8 Contracts 4 Agreements 02/9/1 06/8/31

Algeria(C), Argentina(A)Argentina(C), Brazil(C), Czech Republic(C), Germany(A), Indonesia(C), Italy(A), Korea, Republic Of(A), Romania(C), Syrian Arab Republic(C), Vietnam(C)

K. RADIATION SAFETY

Safety of Transport of Radioactive Material

J1.30.09 Accident severity during air transport of radioactive material

8 Agreements 98/6/1 03/04/26

Canada(A) (2), France(A), Germany(A), Ireland(A), Sweden(A), United Kingdom(A), United States of America (A)

J1.30.10 Radiological aspects of package and conveyance non-fixed radioactive contamination

7 Agreements 01/9/1 04/8/31

France(A), Germany(A), Japan(A), Sweden(A), United Kingdom(A) (2), United States of America (A)

Radiological Protection of Patients

J1.70.06 Exploring the possibility of establishing guidance levels for interventional radiology

6 Contracts 02/5/21 06/5/31

Austria(C), Chile(C), Italy(C), Spain(C), United Kingdom(C), Uruguay(C)

J1.70.07 Avoidance of unnecessary dose to patients while transitioning from analogue to digital radiology

4 Contracts 1 Agreement 02/11/15 06/12/31

Australia(C), Austria(C), Malaysia(C), Thailand(C), United Kingdom(A)

J1.70.08 Evaluate quantitatively and promote patient dose reduction approaches in interventional radiology

4 Contracts 2 Agreements 02/11/15 05/11/14

India(C), Italy(A), Japan(A), Malaysia(C), Thailand(C), Turkey(C)

J1.70.09 Dose reduction in computed tomography (CT) while maintaining diagnostic confidence

3 Contracts 2 Agreements 02/11/15 05/11/30

Germany(A), Greece(A), India(C), Poland(C), Thailand(C)

Safety of Radiation Sources

J1.70.05 To investigate appropriate methods and procedures to apply probabilistic safety assessment (PSA) techniques of large radiation sources

5 Contracts 2 Agreements 00/6/27 03/6/30

Argentina(C), Canada(A), China(C), Cuba(C), Japan(C), Mexico(C), United States of America (A)

L. MANAGEMENT OF RADIOACTIVE WASTE

Safety of Disposable Radioactive Waste: Managing Non-reusable Radioactive Materials and Arranging for their Disposal

J9.10.05 The use of selected safety indicators (concentrations; fluxes) in the assessment of radioactive waste disposal

1 Contract 9 Agreements 00/2/15 05/2/14

Argentina(A), Brazil(A), China(A), Cuba(A), Czech Republic(A), Finland(A), Japan(A), Sweden(A), United Kingdom(A)United Kingdom(C)

J9.10.06 Application of safety assessment methodologies for near surface waste disposal facilities (ASAM)

27 Agreements 02/8/27 05/12/31

Belarus(A), Belgium(A) (3), Brazil(A), Bulgaria(A), Cuba(A), Czech Republic(A), Hungary(A), Kazakhstan(A), Korea, Republic Of(A), Lithuania(A) (2), Peru(A), Philippines(A), Romania(A) (2), Russian Federation(A) (3), Slovenia(A), South Africa(A) (2), Spain(A), Ukraine(A), United Kingdom(A), Viet Nam(A)

Technologies for Disposable Radioactive Waste Management

T2.10.21 Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions

4 Contracts 10 Agreements 98/12/15 04/2/28

Argentina(A), Australia(A), Belgium(A), China(C), Croatia(C), Czech Republic(A), France(A), India(A), Japan(A), Korea, Republic Of(C), Russian Federation(A)Russian Federation(C), Spain(A), United Kingdom(A)

T2.10.20 Anthropogenic analogues for geological disposal of high-level and long lived radioactive waste

5 Contracts 2 Agreements 99/7/15 03/10/14

Argentina(C), China(C) (2), Czech Republic(C), Korea, Republic Of(A), Ukraine(C), United States of America (A)

T2.40.06 Disposal aspects of low and intermediate level decommissioning waste

6 Contracts 7 Agreements 02/9/1 06/8/31

Argentina(C), Canada(A), China(C), Hungary(C), India(A), Korea, Republic Of(A), Lithuania(C), Russian Federation(C), Slovakia(A), Sweden(A), Ukraine(C), United Kingdom(A), United States of America (A)

Technologies for the Decommissioning of Installations and Restoration of Sites

T2.30.14 Technologies and methods for long term stabilization and isolation of uranium mill tailings

4 Contracts 9 Agreements 00/2/15 04/2/14

Brazil(A), Canada(A), China(C), Czech Republic(A), France(A), Germany(A), Kazakhstan(C), Korea, Republic Of(A), Poland(A) (2), Russian Federation(C), Ukraine(C), United States of America (A)

CRP's Completed in 2002

B. NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

Nuclear Fuel Performance and Technology

T12013 Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys

Spent Fuel Management

T13007 Spent fuel performance assessment and research (SPAR)

D. NUCLEAR SCIENCE

Nuclear and Atomic Data

F41017 Nuclear model parameter testing for nuclear data evaluation (Reference input parameter library: Phase II)

F42004 Update of X- and gamma-ray decay data standards for detector calibration

Nuclear Research Facilities and Instrumentation

F13007 Comparison of compact toroid configurations

E. FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

D12006 Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production

Animal Production and Health

D31021 Use of nuclear and colorimatric techniques for measuring microbial protein supply from local feed resources in ruminant animals

Insect and Pest Control

D41012 Enhancement of the SIT through genetic transformation of arthropods using nuclear techniques

D42008 Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barrier systems used in tsetse control/eradication campaigns

Food Quality and Safety

D52034 Alternative methods to gas and high performance liquid chromatography for pesticide residue analysis in grain

D61019 Determination of profiles of human bacterial pathogens in foods for export by introduction of quality-assured microbiological assays

D61020 Irradiation as a phytosanitary treatment of food and agricultural commodities

F. HUMAN HEALTH

Nuclear Medicine

E15015 Molecular typing of mycobacteria strains in multi-drug resistant tuberculosis

E15016 Genotype/phenotype correlation in thalassemia and muscular dystrophy

E15017 Development of an improved serological kit for Chagas diagnosis using radionuclide methods

Applied Radiation Biology and Radiotherapy

E33012 Clinical application of radiosensitizers in cancer radiotherapy

E33017 Regional hyperthermia combined with radiotherapy for locally advanced cancers

Dosimetry and Medical Radiation Physics

E24009 Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water

Nutrition and Effects of Contaminants on Human Health

E41011 Validation and application of plants as biomonitors of trace element atmospheric pollution, analyzed by nuclear and related techniques

J. SAFETY OF NUCLEAR INSTALLATIONS

Engineering Safety of Existing Nuclear Installations

J71008 Safety of RBMK type Nuclear Power Plant in relation to external events

K. RADIATION SAFETY

Safety of Transport of Radioactive Material

J13008 Development of radiological basis for the transport safety requirements for low specific activity materials and surface contaminated objects

Radiological Protection of Patients

J17004 Image quality and patient dose optimisation in mammography in Eastern European Countries

IAEA 2002 Programme/Sub-programme and CRP Codes

MAJOR PROGRAMME 1: NUCLEAR SCIENCE AND TECHNOLOGY

		CRP Code
Programme A:	**Nuclear Power**	
A1	Engineering and Management Support for Competitive Nuclear Power	I2
A2	Nuclear Power Technology Development and Applications	I3
Programme B:	**Nuclear Fuel Cycle and Material Technologies**	
B2	Nuclear Fuel Performance and Technology	T1
B3	Spent Fuel Management	T1
B4	Nuclear Fuel Cycle Issues and Information Systems	T1
Programme C:	**Analysis for Sustainable Energy Development**	
C1	Energy Modelling, Databanks and Capacity Building	I1
C2	Energy-Economy-Environment (3E) Analysis	I1
Programme D:	**Nuclear Science**	
D1	Nuclear and Atomic Data	F4
D2	Research Reactors	F1, F2, T1
D3	Nuclear Research Facilities and Instrumentation	F1

MAJOR PROGRAMME 2: NUCLEAR TECHNIQUES FOR DEVELOPMENT AND ENVIRONMENTAL PROTECTION

Programme E:	**Food and Agriculture**	
E1	Soil and Water Management and Crop Nutrition	D1
E2	Plant Breeding and Genetics	D2
E3	Animal Production and Health	D3
E4	Insect and Pest Control	D4
E5	Food Quality and Safety	D5, D6
Programme F:	**Human Health**	
F1	Nuclear Medicine	E1
F2	Applied Radiation Biology and Radiotherapy	E3
F3	Dosimetry and Medical Radiation Physics	E2
F4	Nutrition and Effects of Contaminants on Human Health	E4
Programme G:	**Water Resources**	
G1	Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources	F3
G2	Reference Isotope Data and Analysis for Hydrologic Applications	F3
Programme H:	**Protection of the Marine and Terrestrial Environments**	
H1	Measurement and Assessment of Radionuclides in the Marine Environment	F3
H2	Transfer of Radionuclides in the Marine Environment	K4
H4	Measurement and Assessment of Radionuclides and Non-radioactive Pollutants in the Terrestrial Environment	G4
Programme I:	**Physical and Chemical Applications**	
I1	Radiochemical Applications	F2
I2	Radiation Processing, Radiography and Radiotracer Applications	F1, F2

IAEA 2002 Programme/Sub-programme and CRP Codes

MAJOR PROGRAMME 3: NUCLEAR SAFETY AND PROTECTION AGAINST RADIATION

Programme J: Safety of Nuclear Installations

J1	Regulatory Infrastructure for Nuclear Energy	J7
J2	Development of Safety Assessment Methods and Tools	J4
J4	Engineering Safety of Existing Nuclear Installations	J4
J6	Research Reactor Safety	J7

Programme K: Radiation Safety

K2	Safety of Transport of Radioactive Material	J1
K3	Occupational Radiation Protection	J1
K4	Radiological Protection of Patients	J1
K5	Safety of Radiation Sources	J1

Programme L: Management of Radioactive Waste

L2	Safety of Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal	J9
L3	Technologies for Disposable Radioactive Waste Management	T2
L6	Technologies for the Decommissioning of Installations and Restoration of Sites	T2

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **D14008** **The use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation**

Participating Countries: Australia(A), Bangladesh(C), Belgium(A), Brazil(C), Brazil(C), Chile(C), China(C), Egypt(C), Ghana(C), India(A), Malaysia(C), Mexico(C), Morocco(C), Sierra Leone(C), Sri Lanka(C), United Kingdom(A), United States (A), Vietnam(C)

Total Cost: **$505 945**

Duration: 1995-12-15 — 2001-07-01

CRP Overall Objectives

To increase crop production through management of soil organic matter and nutrient inputs.

CRP Specific Objectives

(i) To increase the quantity of nutrients available to crops from organic sources and from more effective recycling.
(ii) To enhance the efficiency of use of nutrients by crops and minimise losses through improved synchrony between nutrient supply and crop demand.
(iii) To improve process level understanding of carbon and nutrient flows through the use of isotopic techniques so that the management recommendations can be extrapolated to a wide range of environments using models.

Research Outputs

The results of this CRP provided valuable information on residue management practices for a wide range of cropping systems in different agro-ecological regions. There is an increasing need for such information as in many countries new legislation has been introduced to ban the on-site burning of crop residues, mainly because of environmental implications. The results of this CRP showed that addition of crop residues did not significantly affect crop yields. Crop residue had limited effect on the mineralization of labelled nitrogen from soil organic matter. A large variability was observed in the recovery of nitrogen from the residues among the different sites mainly due to differences in soil temperature and moisture. The results also highlighted the need for investigating non-nutrient benefits of residue incorporation as bio-physical properties of soil improved when residues were incorporated. However, long-term experiments are needed to evaluate the effects of these parameters on soil fertility and crop production. Some of the contract holders will be continuing the field work initiated through this CRP from local funds. The overall effects of residue management practices on recovery of nitrogen and crop yields were evaluated using a predictive model. The 15N studies showed that approximately two thirds of fertilizer nitrogen is lost irrespective of the residue management practices adopted. Most of the losses occurred during the first season suggesting that more work needs to be done on nitrogen fertilizer management to minimize losses. The results also demonstrated the need for further studies on the effects of residue management practices on carbon sequestration and weed and pest management of different cropping systems.

CRP Outcome (Effectiveness; Impact; Relevance)

Valuable information was provided on (i) use efficiency of nitrogen fertilizers under different crop residue management practices in varying agro-climatic regions (ii) synchronization between nutrient release from fertilizers and crop residues and nutrient uptake by crops for identification of improved fertilizer and crop residue management practices (iii) a descriptive model for analysis of data generated from various crop rotation experiments under varying environmental conditions.

The participants of this CRP gained experience in the use of 15N techniques for investigating the efficiency of applied N fertilizers and crop residues in different crop rotations over several seasons. The acquired skills such as labelling (15N) of crop residues for field experiments and implementation of field experiments with appropriate treatments to quantify the uptake of nitrogen by crops from different sources (soil, fertilizer and residues) will be useful for planning future research activities at their local institutes aimed at restoring and sustaining soil fertility for increased crop production. The results of this CRP will be disseminated to scientific community through research publications and to Member States through a TECDOC.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

The use of nuclear techniques (13C isotope shifts) will be useful to quantify Carbon stocks and balances in selected agro-ecological zones and farming/cropping systems, which would be a logical follow up of this CRP.

CRP Published Results

Internal:
One TECDOC submitted to publication committee.

External:
Journal and conference papers published by the participants.

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**D15005**	**The assessment of soil erosion through the use of Cs-137 and related techniques as a basis for soil conservation, sustainable agricultural production and environmental protection (Joint CRP with F3.10.01)**
Participating Countries:	Argentina(C), Australia(A), Australia(C), Brazil(C), Canada(A), Chile(C), China(C), China(C), Greece(C), Morocco(C), Romania(C), Russian Federation(C), Slovakia(C), Thailand(A), United Kingdom(A), United Kingdom(C), United States (A), Zimbabwe(C)	
Total Cost:	**$415 362**	
Duration:	1995-12-15 — 2001-10-14	

CRP Overall Objectives

To develop guidelines for estimating soil erosion and sedimentation for sustainable agricultural production and environmental protection.

CRP Specific Objectives

i) To refine (including validation and standardization) relevant methodologies for documenting soil erosion and sedimentation using the Cs-137 technique across a range of environments which can then be used to test and calibrate existing models of soil erosion.
ii) To evaluate the effect of specific land use management on soil erosion for providing data to underpin the selection of soil conservation strategies.

Research Outputs

The Cs-137 technique was proven to work well in a wide range of environments and scales in the course of this CRP. Standardized methods and protocols for the application of the technique were developed and will be disseminated through the publication of a handbook. These developments include a suite of approaches for site selection and field sampling, selection criteria for reference sites, guidelines for sample preparation and analyses by gamma spectrometry and quality assurance of the results. An updated map of the global distribution of Cs-137 reference inventories was prepared and a model to estimate these for a study area was developed. Also, in the quest for standardisation of the technique, a suite of calibration models for converting Cs-137 measurements to estimates of soil re-distribution rates on cultivated and uncultivated soils (including software and a technical manual) were developed and tested by the participants. Further refinement of exsiting models to better suit local conditions was also made. The correct application of the technique provided reliable soil erosion and sedimentation data integrated over a medium term (~40 years) period. These erosion/sedimentation rates obtained with the Cs-137 technique have been validated with independent estimates provided by erosion plots, instrumented catchments and soil profile interpretation as well as local experience.The data on soil erosion/sedimentation rates and spatial redistribution have provided directly comparable and representative information in a wide range of environments. Values ranged from 0-100 t/ha/year and demonstrated in general the land use exerts a more important influence on these rates than climate or lithology and soil type. However, the influence of the latter can be readily distinguished. The potential use of the Cs-137 measurements for validating erosion prediction models and distributed soil erosion and sediment delivery models was demonstrated by the studies undertaken within the CRP. As the efficacy and the value of the technique was increasingly recognised, the participants exploited the potential of the technique in a wide range of studies, including further applications such as the role of tillage in soil erosion, relationship between soil redistribution and topographic controls, relationship between soil quality parameters and rates of soil loss, relationship between Cs-137 derived soil redistribution and soil organic carbon distribution patterns and the relationships between on-site soil erosion and nutrient export and off-site impacts.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been effective in refining and harmonizing the application of the Cs-137 technique in a range of environments and scales. Reliable data on soil erosion/sedimentation rates and their spatial redistribution have been obtained. The use of standardized methods and protocols for the application of the technique enabled the evaluation of the relative influence of the factors affecting soil erosion. As the participants became experienced with the application of the technique, several other

potential applications of the results have been made. A better understanding of the soil erosion procesess will enable the participants to provide a set of guidelines for selecting soil conservation technologies.

The development, refinement and calibration of the Cs-137 techniques has provided a universal tool to quantify soil redistribution rates in a range of natural and agroecosystems, and has paved the way for the wider application of the technique as well of other radionuclides to assess the effectiveness of soil conservation technologies.

This CRP has demonstrated that reliable erosion and sedimentation rates integrated over a medium-term period of 40 years could be obtained in a range of environments and spatial scales through use of the fallout radionuclide Cs-137 as a tracer. Standardised methods and protocols for the application of the technique were successfully developed, and will be disseminated through the publication a handbook. Other potential applications of the Cs-137 technique such as the relationships between rates of soil loss and soil quality, soil carbon and nutrient redistribution and the fate of agrochemicals and other environmental contaminants have been explored. There is demand for the publications emanating from this CRP, in particular the standardized methods and protocols for the correct application of the technique.

Land degradation in the form of water and wind erosion is a serious threat to global food security, representing an irretrievable loss of the basic soil resource. More than three quarters of the surface land area affected by erosion is in developing countries of Africa, Asia and Latin America, with about one-half of the total occurring in Asia. The information generated from this CRP will be useful to further develop other environmental radionuclides methodologies for the assessment of soil conservation technologies.

Recommended Future Action by Agency

Further research and development using other fallout radionuclides such as Lead-210 and Beryllium-7 is required to assess short-term erosion and sedimentation rates. These new and refined methods will allow systems of land use and management and the effectiveness of specific soil conservation technologies to be rapidly evaluated in a cost-effective manner. The new techniques will also provide an improved understanding of the relationships between rates of soil loss and soil quality, soil carbon and nutrient redistribution and the fate of agrochemicals and other environmental contaminants. A new FAO/IAEA Co-ordinated Research Project will be launched in 2003 to further develop radionuclide methodologies and to pilot test soil conservation strategies tailored to local conditions and resources.

CRP Published Results

Internal:
Five technical reports, IAEA-TECDOC-828 and IAEA-TECDOC-1028

External:
One special issue in Acta Geologica Hispanica, vol 35 (2000) and another special issue in Soil and Tillage Research (In preparation)

Other Outputs:
130 journal and conference papers generated by the participants.
Map and model to estimate fallout Cs-137 inventories for study areas.
Technical manual and sofware for the application of calibration models to convert Cs-137 measurements to estimates of soil redistribution rates on cultivated and uncultivated soils (available on the IAEA website).

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**D23019**	**Cellular biology and biotechnology including mutation techniques for creation of new useful banana genotypes**
Participating Countries:	Belgium(A), Belgium(C), Belgium(C), Brazil(C), Cameroon(A), Colombia(C), Cuba(C), Czech Republic(C), France(A), Germany(A), Ghana(C), Guyana(C), Israel(A), Malaysia(C), Mexico(C), Philippines(C), Sri Lanka(C), Thailand(C), United States (A), Vietnam(C)	
Total Cost:	**$517 780**	
Duration:	1994-11-01 — 2001-10-29	

CRP Overall Objectives

To make bananas and plantains a more stable and profitable crop especially for small land holders and to reduce excessive pesticide use, thereby improving the quality of the environment in the producing countries.

CRP Specific Objectives

i) To integrate radiation-induced mutations and in vitro culture methods into conventional breeding of bananas; ii) To promote the development of methods for large-scale rapid multiplication of the resulting mutants/segregants; iii) To develop molecular markers for rapid characterization of genotypes; iv) To develop rapid methods for genome ploidy-level manipulation, in vitro screening of mutants, validate the use of toxins for early selection of banana resistant to black sigatoka disease; and v) To facilitate field-testing in different climatic conditions and regions.

Research Outputs

The desirable banana variants/putative mutants have been identified for release or for further confirmation trials in Cuba, Malaysia, Philippines and Sri Lanka. Nine promising mutants induced by gamma irradiation of SH 3436-L9 (AAAB), mainly with reduced height, are being field tested in Cuba. "Novaria" a mutant banana variety with desirable traits has been commercialized in Malaysia with early flowering, short stature, high yield, strong fruit pedicel, good flavour and pulp texture. By inducing in vitro polyploidy, autotetraploid Pisang Mas (AAAA) has been produced and is being further evaluated. Success has been achieved in developing in vitro culture techniques, e.g. somatic embryos, Agrobacterium transformation, and shoot tip culture; molecular cytogenetic and cytometric techniques, e.g. flow cytometry for cytochimera dissociation, GISH and FISH; molecular marker techniques, e.g. PCR-based simple sequence repeat (SSR), AFLP, MSAP; and screening techniques such as in vitro screening for resistance against nematode, Yellow and black sigatoka, viruses and Fusarium wilt. Flow cytometry is a highly efficient system for monitoring cytochimera disscociation. The multi-apexing technique is a more effective micropropagation method to dissociate chimerism than the shoot tip culture method. Flow cytometery also indicated that of four Musa accessions previously considered as natural acuminata x balbisiana tetraploids, two were triploids. Somaclonal variation is a problem in banana, which stems from activation of transposable elements."Cpia-like" retro-transposable element is transcribed after a long duration of banana clones in tissue culture. Whens compared to conventionally propagated banana plants, DNA methylation polymorphisms were detected in micropropagated banana plants and they were relatively hyper-methylated. Three cryopreservation techniques were developed for a long-term conservation of meristem and embryogenic cell suspension. INIBAP technical guidelines for cryopreservation of banana were published. Agrobacterium-mediated transformation and particle bombardment methods were developed for banana genetic transformation.

CRP Outcome (Effectiveness; Impact; Relevance)

Significant progress was achieved in most of the participating countries in implementation of mutation techniques and in vitro techniques well integrated into conventional banana breeding to generate desirable variation.

Banana can be multiplied by micropropagation for large scale plant multiplication. Several putative banana mutants with desirable traits have been isolated. These mutants are either at the begining of or already under field trials. Banana mutant varieties will be released to the farmers after field trial completion on multi-location sites. By flow cytometry, disassociation of chimerism and ploidy level were studied. Cell suspension culture system was helpful in radiosensitive test and plant regeneration. Furthermore, somatic embryogenesis system is being worked out for clonal propagation. An in vitro selection system for Fusarium wilt and black sigatoka diseases has been developed.

Accomplishments of CRPs Completed in 2001

Banana can readily be multiplied in large numbers by micropropagation throughout the year, providing a continuous supply to the growers. In Sri Lanka, farmers were trained to use microprogated banana plants. Banana growers have improved their economic status and rice growers are replacing rice with banana. In Malaysia, private companies have commercialised banana mutant lines.

Banana is an essential fruit crop in tropical and subtropical countries, ranking 4th in total world food production (standing 4th after cereals), and still has possibilities for yield improvement. This CRP is relevant for producing new mutant varieties, especially resistant to Fusarium wilt, black sigatoka, pests like nematodes, abiotic and biotic stresses. Through this CRP, scientists from developed countries understand the problems of banana growing in developing countries.

Recommended Future Action by Agency

Even though this CRP has produced some excellent results, further work is still required to obtain more desirable mutants and results of their field evaluation trials. It takes longer to conduct field tests at different locations. Farmers need to be educated in other participating countries to use micropropagated banana mutant cultivars. This project should further be continued to support continuation of mutation work for producing more mutants, bioreactor technology, molecular characterisation of mutants, genomics and genetic mapping.

CRP Published Results

List of publications of this CRP

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Accomplishments of CRPs Completed in 2001

CRP Number and Title: **D32016** **Rinderpest seromonitoring and surveillance in Africa using immunoassay technologies**

Participating Countries: Benin(C), Burkina Faso(C), Cameroon(C), Central African Republic(C), Chad(C), Cote d'Ivoire(C), Egypt(C), Eritrea(C), Ethiopia(C), France(A), Ghana(C), Guinea(C), Kenya(C), Mali(C), Mauritania(C), Niger(C), Nigeria(C), Senegal(C), Sudan(C), Uganda(C), United Kingdom(A), United Republic of Tanzania(C)

Total Cost: **$428 068**

Duration: 1997-12-01 — 2001-01-10

CRP Overall Objectives

To support the activities of the Pan-African Rinderpest Campaign (PARC) and its follow up programme the Pan-African programme for the Control of Epizootics (PACE), in the eradication of rinderpest through the establishment and use of immunoassay based technologies for the diagnosis of rinderpest.

CRP Specific Objectives

To use immunoassay based techniques for the diagnosis of rinderpest.

Research Outputs

A laboratory capacity for the diagnoses of rinderpest and the epidemiological surveillance of rinderpest resulted in 21 African countries.

CRP Outcome (Effectiveness; Impact; Relevance)

The diagnostic technologies and methodologies are fully established on a sustainable basis in 21 African countries.

Rinderpest is eradicated from all of Africa except for a small focus in Southern Somalia.

The information and the surveillance results from the CRP and the laboratory capacity established as part of the CRP were instrumental in eradicating rinderpest from most of Africa and in the last three years of the CRP the diagnostic capacity and the results produced by the Research Contract holders were the basis of the national confidence to stop vaccinations against rinderpest in all countries of Africa except for Southern Somalia and Northern Kenya. The capacity for the diagnosis and surveillance of rinderpest which was established as part of the CRP continues to be the basis for the preparation of the national dossiers for the OIE certification processes to declare the countries internationally free of rinderpest.

The CRP was highly relevant to the efficient implementation of the national vaccination programmes against rinderpest and later to the cessation of vaccination. The expertise and the laboratory results which are based on the capacities established as part of the CRP are now the basis for the preparation of the national OIE dossiers.

Recommended Future Action by Agency

After the eradication of rinderpest, other transboundary animal disease such as peste des petits ruminants (PPR), contagious bovine pleuropneumonia (CBPP) and foot and mouth disease (FMD) remain significant constraints to livestock production and to livestock trade in Africa. The development of integrated disease surveillance and reporting networks would represent a significantly complement the acitivities of other programmes such as PACE.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **D41015** **Molecular and genetic approaches to develop sexing strains for field application in fruit fly SIT**

Participating Countries: Argentina(C), Australia(A), Bangladesh(C), Brazil(C), Greece(C), Guatemala(C), Italy(A), Philippines(C), United States (A)

Total Cost: **$261 159**

Duration: 1994-12-15 — 2001-10-22

CRP Overall Objectives

To promote the use of genetic sexing strains in fruit fly SIT programmes.

CRP Specific Objectives

i) To optimize genetic sexing strains (GSS) as regards their genetic composition, productivity and application.
ii) To develope third generation GSS using nuclear and molecular methods.
iii) To develope of GSS in fruit flies other than medfly.

Research Outputs

i) Competitive medfly GSS has been demonstrated
Many medfly GSS have been evaluated in field cages in competition with wild insects. In no case has a GSS performed less well than any other mass reared strain. The genetic changes used to construct the GSS do not impact negatively on the fitness of the strain. Much of this work was done in collaboration with participants in CRP D.4.10.12.

ii) All male releases were more effective than the release of males and females
Studies following the open field release of both bisexual and all male sterile medflies have shown that the release of males only is 3-5 times more effective at inducing sterility in the field population. Sterility induction in the field females is the key determinant of the efficiency of an SIT programme.

iii) Genetic instability during mass rearing of medfly GSS was analysed and solved
Two types of instability have been documented during the large scale rearing of GSS. They have different origins and impact in specific ways on the pattern of instability. An understanding of the genetic and cytological basis of the instability has enabled improved strains to be designed. It is impossible to mimic one of these types of event in the laboratory as it is exceedingly rare. In addition the introduction of the Filter Rearing System has provided added security to the mass rearing of these strains.

iv) New selectable genes and chromosomal rearrangements were isolated in medfly and B. tryoni In medfly, there are now three mutations being used to develop GSS. Two of them are being used in operational programmes whilst a third is undergoing evaluation. The latter could be used to isolate female larvae for the production of parasitoids. Inversions have also been induced and studied in medfly for the first time. One of these rearrangements has already been introduced into a GSS and is undergoing evaluation for competitiveness and mass rearing profile. Other inversions have been used to construct a balancer chromosome that will be very useful in the isolation of new mutations. In B tryoni, several translocations and 2 selectable markers have been studied. In addition a potential GSS has been developed in B. dorsalis using a white pupal colour mutation.

v) In situ hybridisation of genes to polytene chromosomes and the development of DNA markers for B. tryoni was achieved. In medfly, many DNA sequences both coding and non-coding have been hybridised to polytene chromosomes and their positions mapped. This, together with the genetic data, has confirmed that there is a great deal of conservation of the organization of the genome in flies. Fluorescent in situ hybridisation (FISH) has been developed for medfly and used in the analysis of transformed lines. Polytene chromosome analysis and in situ hybridisation was also developed for B. tryoni. In B. tryoni a collection of DNA microsatellites has been isolated and they are currently in use to identify the origin of outbreaks and help improve SIT interventions.

Accomplishments of CRPs Completed in 2001

CRP Outcome (Effectiveness; Impact; Relevance)

Specific Objective 1. To optimize the composition, productivity and application of GSS
The first three research outputs listed above have been essential in reaching this objective. GSS were shown to be competitive in field the analysis of stability has been used directly to improve GSS for field operations.
Specific Objective 2. To develope 3rd generation GSS using nuclear and molecular methods
Many transformed lines are now available in medfly and have been studied in relation to this objective. The biological reagents required for medfly transformation are now available. The demonstration that there are mobile elements in field populations of medfly has injected a note of caution into this approach.
Specific Objective 3. To develope GSS in fruit flies other than medfly
The last 2 outputs listed above have made a major contribution to this objective. In B. tryoni and B. dorsalis potential GSS have been isolated. There is still however some way to go before these strains can be considered as bona fida sexing strains.

All medfly rearing facilities, with the exception of the plant in Tapachula, Mexico, are now using GSS and there are plans being made to convert Tapachula to GSS rearing in the near future. This development has come about because GSS are competitive, they provide increased efficiency to SIT programmes and the strains themselves can be effectively and predictably mass reared. The first 3 outputs listed above have contributed directly to achieving this objective.

Improved medfly GSS have resulted in increased effectiveness of SIT operational programmes as evidenced by the wide take up of the technology. This will contribute to the wider use of the SIT and perhaps to its commercialization. The expansion of GSS technology for other pest species will follow closely that developed for medfly.

There are still several areas where GSS for medfly will need improvement based on their increasing use in operational SIT programmes. It is very important that the Agency maintains its leading role in the field. This can be done by continuing research in this area at the Seibersdorf Laboratory and by following some of the recommendations given below. In other insect control programmes where SIT currently plays a role and where the use of GSS would be advantageous, The Agency can collaborate on the development of these strains as is currently the case with a new CRP on genetic sexing in the screwworm.

Recommended Future Action by Agency

The use of molecular techniques to further enhance the usefulness of medfly GSS should be encouraged, especially in the following two areas:
Use genetic transformation systems to develop new GSS and evaluate stability of transformation strains,
Develop genetically or molecularly marked GSS for medfly and improve stability.

For other fruit flies where SIT programmes are being carried, it will be important that the following activities are supported:
Transfer of current medfly technology to other species of fruit flies and support of field testing and mass rearing of alternative medfly GSS.
Evaluation of all male releases in other fruit fly species, initially using field cage evaluation.

The following general activities need to be supported in relation to improving the use of GSS:
Evaluation of the optimal radiation dose when all male releases are used in SIT.
Use the filter rearing system to introduce desired traits mass rearing.
Support the development of cryo-preservation for strain maintenance.

CRP Published Results

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Other Outputs:
- Transfer of GSS technology from medfly to Queensland fruit fly and other Bactrocera through increased networking.
- Positive impact of participation in the CRP in relation to other funding applications.
- Provision of opportunities for two-way interaction between operational activities and academic research.
- Development of increased skills following exchange of staff and scientific discussions.
- Fellowship support and the provision of essential supplies.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **D42006** **Automation in tsetse fly mass-rearing for use in sterile insect technique programmes**

Participating Countries: Austria(C), Austria(C), Austria(C), Burkina Faso(C), Czech Republic(C), Kenya(C), Nigeria(C), United Republic of Tanzania(C)

Total Cost: **$321 797**

Duration: 1994-11-01 — 2001-12-31

CRP Overall Objectives

To develop and utilize automated and other methods for improved, upgraded, standardized and more efficient tsetse mass rearing.

CRP Specific Objectives

To reduce labour-intensive fly handling components and streamlining/standardizing quality sensitive aspects of tsetse mass rearing. Particular emphasis was on a) automated or mechanized holding and feeding of tsetse colonies; b) methods for automated sex separation of tsetse flies, allowing a reduction or discontinuation of labour intensive young fly handling; and c) the development of methods for emergence of flies directly into production cages.

Research Outputs

The use of inserts in production cages was shown to increase holding capacity for G. austeni at TTRI, Tanga and Seibersdorf. Mating regime appropriate for automated mass rearing and direct loading of production cages was developed. The mating system using resident males was initially tested with G. austeni using ratios of 1 male to 4 females and was shown not to affect survival and production. The procedure has now been tested with other species kept at Seibersdorf laboratory. The current mating regime for all species utilizes a sex ratio of 1 male to 3 or 4 females depending on species. The revised procedure saves 17% of time invested in tsetse mass rearing and removes one chilling procedure that was necessary after mating.
Day 0 mating with resident males using predetermined sex ratio was shown to be effective. The procedure involves putting together emergent flies of both sexes in the right sex ratio at the time of emergence in production cages and mating takes place as flies mature. This procedure was adopted for routine maintenance of colonies at TTRI and Seibersdorf. Adult sex separation of flies based on the differences in eclosion time was demonstrated and tested in Ethiopia, Burkina Faso and Tanzania. Seibersdorf has adopted the procedure for G. pallidipes (Ug) colony where chilling separation is no longer applied.
Emergence of flies directly into production cages (self-stocking of production cages or SSPC) was shown to be feasible and an automated sex separation and direct cage loading based on study of emergence behaviour was developed. This system may be used for production of male pupae only or sterile male production.

Three prototype tsetse production unit (TPU) for holding and feeding of colony flies and larval collection were designed, constructed and evaluated.

TPU 1 - A prototype that held fly cages, automatically moved cages to blood source for feeding while larvae and pupae were collected centrally was the first prototype evaluated. The evaluation however, revealed that the prototype was incapable of maintaining a self-sustaining colony of G. austeni. Experience gained lead to the development of a second prototype, TPU 2, a simplified version that could be locally constructed and serviced. TPU 2 prototypes were evaluated in Ethiopia, Kenya and Tanzania, for mechanical and suitability for maintaining colony flies. Although TPU 2 proved suitable for maintaining a colony of tsetse, it was observed that the distribution of light inside the cage was important. Subsequently, the aluminum shelf pupal collector was substituted with clear plexi glass. Since movement was demonstrated to be detrimental to fly performance a further design TPU 3 was constructed and evaluated. In TPU 3 fly cages are held stationary and blood in the feeding system moved on rails is taken to the cage holding frame, raised to make contact with netting of the cages during feeding and thereafter lowered and moved to another set of cages. Two rows of cages are fed at once. TPU 3 is very satisfactory and is comparable with the standard rearing system in terms of production and adult survival.

Accomplishments of CRPs Completed in 2001

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP achieved its objective on improving and upgrading tsetse mass rearing by the development and utilization of automated and other methods within the stipulated time. Simple, efficient, flexible and affordable systems and procedures able to meet requirements for large-scale tsetse mass rearing were developed. The systems and procedures can be adopted to meet the need for large-scale production of sterile males for tsetse eradication on mainland Africa. The prototypes were produced and evaluated and verification took place in target countries. Procedures developed have been adopted by rearing facilities in member states paving way for standardization of tsetse mass rearing. Some of the results have been published in refereed journals and also in conference proceedings. During the early part of the CRP some of the rearing procedures were already used by the Tsetse and Trypanosomiasis Research Institute, Tanga, Tanzania for the production of sterile males released during the Zanzibar Eradication Project. Future sterile male production facilities will benefit from designs of systems and procedures developed during this CRP.

A blue print for factories for tsetse mass rearing was developed through this CRP and therefore the concept of tsetse area-wide approach for tsetse eradication are now brought closer to realization. The area-wide concept was taken up by African member states through PATTEC for integration of SIT in tsetse and trypanosomosis management.

Recommended Future Action by Agency

Although semi-automated tsetse mass rearing is now feasible, the continued research support by the Agency is necessary in the direction of optimization of cages, automation of blood delivery and pupal collection for large colonies. Research should be directed towards expansion of the programme to other economically important tsetse species. It is also important to continue to support collaboration between tsetse eradication projects/programmes intending to integrate SIT to their tsetse and trypanosomosis management.
The current cage used with the semi-automated rearing system is small and has been used for a limited number of species. Investigations should continue to optimize design of fly holding units (cages) for adaptation of the systems to other economically important species. The cage design should maximize use of the feeding surface. Design blood-feeding system for large colonies without need for replenishment during feeding or automatic refilling from reservoir. Develop an automated system for collection of larvae and pupae which is currently done by hand.
Automate SSPC systems for use with TPU 2 or/and TPU 3 (handle cages as units and not individually). Improve facility design, environment control particularly lighting (daylight) and heating system for blood. Carry out large-scale evaluation / verification of TPU 3. Form a network between centers to facilitate sharing of results and information.

CRP Published Results

IAEA TEC- 4451 “automation for tsetse mass-rearing for use in sterile insect technique programmes” A French translation has also been published.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **D52033** **Validation of thin-layer chromatographic screening methods for pesticide residue analysis**

Participating Countries: Argentina(C), Belarus(C), Brazil(C), Ghana(C), Hungary(A), Kenya(C), Lithuania(C), Myanmar(C), Nigeria(C), Romania(C), Sweden(A), Thailand(C)

Total Cost: **$355 662**

Duration: 1996-12-01 — 2001-12-14

CRP Overall Objectives

To utilize analytical methods for risk analysis related to food safety and pesticide management.

CRP Specific Objectives

To validate relatively cheap thin-layer chromatography (TLC) procedures suitable for screening food and environmental samples for pesticide residues that reduce sample numbers for analysis by more elaborate nuclear and related techniques.

Research Outputs

The CRP raised awareness of possibilities of combining TLC with novel detection systems, especially bioassays, and also reinforced the need for a laboratory quality management system and skilled analysts able to utilize low-cost analytical procedures.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP achieved its major objective through a comprehensive initial technical contract and providing "hands-on" training to Contract Holders at RCM meetings.

Codex endorses TLC as a confirmatory method for pesticide residues. However, the full potential of TLC and novel detection systems is yet to be realized in many national laboratories. This may be achieved with three additional technical contracts and by using existing distance learning and information systems to promote transfer of the technology.

Current pesticide residue analytical technology involves the use of sophisticated analytical instruments such as gas and high performance liquid chromatography. Typically these require a variety of injectors and detectors together with large quantities of consumables such as spare parts, high purity solvents and gases. These requirements often cannot be implemented in developing countries who are then unable to take advantage of opportunities created by trade liberalization. TLC and bioassy-based novel detection systems offer a cost-effective alternative to instrumental techniques.

Recommended Future Action by Agency

1 That NAFA disseminates the findings of this CRP both in the scientif literature and its information systems. For example, by producing a distance learning module on TLC and publishing the analyte RRT and MDQ databases under INFOCRIS to provide a range search function.
2. That contract renewals are linked directly to workplan outcomes together with a more transparent implementation of this policy across the subprogramme.
3. That the Agency includes sustainable operation of the laboratory as a precondition for granting contracts to avoid procuring expendable items, wherever possible, and applies cost saving to increasing the value of individual research contracts.
4. That three technical contracts be issued to prepare a database of RRT for pesticides and mycotoxins using two dimensional TLC.

Accomplishments of CRPs Completed in 2001

CRP Published Results

Internal:
Ambrus A. et al. 1996 Development and validation of cost effective screening methods for pesticide residues in vegetables. Technical Contract No: 8908, 100 pages and I-V Appendices.

External:
The Technical Report and the contribution of individual participants and participating Contract Holders from the CRP on Validation of Alternative Methods to Gas and High Performance Liquid Chromatography for Pesticide residue Analysis in Grains will be published in a special issue of J. Environ Sci. and Health Part B.

Other Outputs:
Publication of the RRT and MDQ databases on the web.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **E12015** **Local production and evaluation of primary reagents for the radioimmunoassay of alpha feto protein (AFP)**

Participating Countries: Algeria(C), Argentina(C), Costa Rica(C), Egypt(C), India(C), Indonesia(C), Malaysia(C), Mongolia(C), United Kingdom(A)

Total Cost: **$155 767**

Duration: 1997-12-01 — 2001-12-31

CRP Overall Objectives

To investigate a nuclear technique in the early diagnosis of cancer.

CRP Specific Objectives

1) To raise antibodies to AFP and to locally formulate radioimmunoassay AFP tests, including production of antisera, standards, QC material, solid phases, and tracers for an IRMA of AFP.
2) To ensure that tests are established, validated, optimised and compared to commercially available alternatives.

Research Outputs

It was possible to raise high quality polyclonal antibodies to AFP. Collectively 1.4 litres of high titre antisera which can formulate 5.2 million radioimmunoassay AFP tests (or 1 million tests if immunoradiometric coated tubes format is used). About 20% is required for standards therefore still leaving sufficient for patient use.
The percent binding of the calibration curve showed that locally produced coated tube and bead performed as well as assay using antibody linked to sepharose CL-4B. In the bead format, simultaneous addition of the serum and 125-labelled antibody to the antibody coated substrate gave a higher binding than serial addition. In the coated tube assay the results showed that the buffer used was also important in the antibody immobilisation process. Phosphate buffer performed better than the borate buffer. In the coated tube assay, there was no significant difference in the percent binding between assays using monoclonal anti-AFP antibodies labelled with either chloamine-T or lactoperoxidase methods.
For IRMA based on magnetisable particles, it was found that the optimal assay condition was given by using 4mg magnetic immobilised with anti-AFP antibody in a one step assay.
The performance of coated bead, magnetic particle and sepharose CL-4B IRMA format in Argentina External Quality Assurance Scheme showed biases and coefficient of variations ranged from -1 to 32% and 2.1 to 46.4% respectively.Thus the performance of the indigenous methods were comparable with that of the automated immunoassay black box analysers.

CRP Outcome (Effectiveness; Impact; Relevance)

1) Antibodies were raised to AFP and locally formulated radioimmunoassay AFP tested, including production of antisera, standards, QC material, solid phases, and tracers for an IRMA of AFP.
2) Tests then established, validated, optimised and compared local production to commercially available alternatives.

The locally produced kits are effective in the use of nuclear technique in the early detction of AFP and therefore early diagnosis of liver cancer.

This CRP demonstrates it is possible to raise high quality polyclonal antibodies to AFP. The cost of rabbit polyclonal antibodies is $100 per ml and as shown with this CRP, output would be in litres. This would mean or 100,000's test kits therefore a large potential savings are possible.
In addition, the research findings have significant implications for the future indigenous clinical biotechnology development in developing countries.

It is possible to raise successfully polyclonal antibodies to AFP in developing countries research centres with minimal animal support facilities and formal systematic training in antibody production.
It is possible to formulate quality radioimmunoassay or produce immunoradiometric coated tubes. However quality system

should be put into place.Independent quality checks and comparative evaluation against commercially available tests is vital for both medical-ethical reasons as well as commerical sustainability.
A result of this coordinated approached was that 5 of the 7 laboratories expressed wishes to expand the antibody production activities.

CRP Published Results

International paper:
Co-operative approach to production of immunodiagnostic reagents in developing countries - Is it a feasible option?
Bhupal V, Boucekkine N, Chapman RS, Cheah SH, Ch'ng SL, Darwati S, El-Kolaly MT, Oyunsuren T, Quiroga S and Rodriguez S.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **E13016** **Study of the relationship between vesicoureteral reflux (VUR), Pyelonephritis (PN) and renal scarring in children with urinary tract infection (UTI) using nuclear medicine techniques**

Participating Countries: Chile(C), China(C), India(A), India(C), Israel(C), Korea, Republic of(C), Singapore(C), Slovenia(C), Sweden(A), Thailand(C), Turkey(C), Turkey(C)

Total Cost: **$142 231**

Duration: 1997-07-15 — 2001-07-14

CRP Overall Objectives

To enhance the cost-effectiveness of health care using in vivo nuclear medicine techniques by demonstrating the effective use of appropriate nuclear medicine technology in clinical practice.

CRP Specific Objectives

1. To determine the incidence of permanent renal damage in children suffering from Urinary Tract Infection (UTI) and acute pyelonephritis.
2. To identify its (permanent renal damage) relationship with vesicoureteral reflux (VUR).
3. To collect demographic and clinical data such as age, gender, episodes of UTI and the types of bacterial infection.
4. To understand the effects of ethnic and geographical factors on the final outcome.
5. To create and recommend a diagnostic and therapeutic algorithm for the management of children with UTI.

RESEARCH OUTPUTS

The CRP was conducted as a multi-centre study involving 10 centres from nine countries. Two hundred sixty nine children with acute pyelonephritis were prospectively evaluated by Tc-99m DMSA scans in order to determine the number of patients who would develop permanent renal damage, and to analyze the relationship between the presence of permanent renal damage with age, gender, episodes of urinary tract infection (UTI) and presence of vesicoureteral reflux. There were 147 females and 122 males, with a mean age of 3.5 years (85 children < 1 year, 113 children between 1-5 years and 71 children > 5 years). One hundred and fifty two children were studied after the first proven UTI. Out of 269 children studied, permanent renal damage was observed in 170 children (63.2%). There were no significant difference with respect to gender. With regard to age, permanent renal damage was found in 36.4% of children younger than 1 year of age and in 74.5% of those older than 1 year ($p>0.00000072$). 55.9% of children with first episode of UTI developed permanent renal damage, while in case of recurrent UTI the value was 72.6% (p:0.004). 72% of children with VUR had permanent renal damage, as compared to 52% of children without VUR ($p<0.000$). Our results showed that permanent renal damage in children with acute pyelonephritis is a frequent occurrence, especially when associated with vesicoureteral reflux, recurrent urinary infection and older age. These children require rigorous and aggressive treatment along with strict follow-up schedule.

CRP Outcome (Effectiveness; Impact; Relevance)

Publication of the results in various scientific journals and also their presentation at various scientific congresses resulted in wide-spread application of the technique in a large nember of IAEA member states. Recurrent urinary tract infection is a common clinical condition in children. Its association with vesico-ureteral reflux, acute pyelonephritis and permanent renal damage has been an enigma for the past several years. The results of this multi-centre study have clearly demonstrated positive correlation among them. Permanent renal damage is an important cause of hypertension and end stage renal disease in children and young adults and is to some extent preventable. Although damage associated with severe reflux can be developmental and may occur in utero, there is abundant clinical and experimental evidence that permanent renal damage can be acquired at any stage in childhood and that urinary infection as well as vesicoureteral reflux are important in its pathogenesis. Our data support the fact that in clinical practices, it is very important that in all children with febrile UTI, renal scan must be performed in order to detect renal damage, specially in those children with significant risk factors, such as older age, presence of VUR and recurrence of UTI.

Accomplishments of CRPs Completed in 2001

Tc-99m DMSA scintigraphy is simple. It is a standard accepted procedure in clinical nuclear medicine practice. The CRP has demonstrated that the appropriate and judicious use of a simple technology could lead to more cost-effective management of a very common and potentially life-threatening clinical condition in children, thereby significantly reducing childhood morbidity and mortality.

Throughout the CRP the participants from different parts of Asia, Europe and Latin America worked diligently to enroll cases into the prospective multi-centre study. In order to enroll more patients into the study multiple centres were involved in each participating country. In fact research teams working on urinary tract infection in the participating countries were created and valuable network established among collaborating research centres. The protocol, including selection of patients and timing of imaging was standardized globally and a standard protocol has been recommended by the RCM group for routine use. Presentation of the results of the CRP at EANM, SNM, ALASBMN and various National Congresses of nuclear medicine as well as their publication in a number of peer-reviewed journals has created a general awareness among the medical community world-wide, and especially in the developing countries, where the problems are massive and the resources to tackle them are meagre.Timely detection, early intervention, vigorous and aggressive treatment and meticulous follow-up of children with urinary infection are the key to cost-effective management of such patients. The CRP has demonstrated that radionuclide studies play a very vital role in the management of such children.

Urinary tract infection is common in childhood with a prevalence of 8% for girls and 2% for boys up to the age of 7 years. Acute pyelonephritis is a major cause of morbidity in children with UTI, particularly during infancy, because of its association with irreversible renal parenchymal damage, which carries a risk of subsequent hypertension, toxemia of pregnancy and end-stage renal failure. The ultimate goal of the care of children with UTI is to prevent progressive renal damage. The main role of diagnostic imaging in UTI is to identify children with a high risk for developing renal scarring, i.e: patients who need surgical correction of anatomical anomalies or long-term prophylaxis with antibiotics and follow-up. In the past decade investigations using renal cortical scintigraphy have led to significant changes in our understanding of the epidemiology and pathogenesis of pyelonephritis and subsequent permanent renal damage. The actual etiology of permanent renal damage remains controversial. According to many authors children with acute pyelonephritis are at risk of permanent renal damage. This risk is apparently increased in the presence of gross reflux, a delay of adequate treatment and in case of recurrent pyelonephritis. Others factors, like bacterial characteristics and condition of the urinary bladder, may be important in the development of permanent renal damage, but the practical implications of available data was unclear before the start of the CRP. Renal cortical scintigraphy is today the most sensitive tool for diagnosing renal cortical lesions and also has improved the accuracy of the diagnosis, allowing clinicians to provide appropriate treatment and follow-up. Hence, the aim of this prospective multi-centric clinical study was to determine the incidence of permanent renal damage in children after acute pyelonephritis and establishing its relationship with vesicoureteral reflux (VUR) and various demographic and clinical data such as age, gender, episode of UTI and growth of bacteria.

Recommended Future Action by Agency

The results of this CRP should be disseminated among the scientists in the developing countries through organization of regional training course on nuclear nephro-urology. In fact the Agency has already organised three regional training courses on nuclear nephro-urology, two in the Latin American Region and one in the Europe Region during the past two years, where the results of the CRP were presented, discussed and disseminated.

CRP Published Results

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4. Manual De Normas Y Procedimientos En NEPHROUROLOGIA NUCLEAR. Eds. Padhy AK, Cerquerra AM and Bernal P. RLA6037 (ARCAL-XXXVI).
5. Orellana P, Baquedano P, Cavagnaro F et al. Can acute renal scintigraphy abnormalities predict the evolution of renal damage in children with pyelonephritis? World J. Nucl Med 1 (Suppl.2); 2002: S145

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **E24007 Development of a quality assurance programme for radiation therapy dosimetry in developing countries**

Participating Countries: Algeria(C), Argentina(C), Belgium(A), China(C), Colombia(C), Cuba(C), Czech Republic(C), India(C), Israel(C), Malaysia(C), Philippines(C), Poland(C), Vietnam(C)

Total Cost: **$171 699**

Duration: 1995-12-15 — 2001-12-31

CRP Overall Objectives

To assist Member States to develop national Quality Assurance (QA) programmes based on mailed Thermo Luminescence Dosimeters (TLD) for radiation therapy dosimetry.

CRP Specific Objectives

To disseminate a uniform TLD methodology to Member States where existing resources allowed the set-up of national TLD-based QA audit networks for radiotherapy dosimetry
To develope a common methodology to cover technical aspects of the TLD measurements
To provide guidelines for operation of the national QA networks in participating countries

Research Outputs

The CRP offered a standardized TLD methodology, the same for all participating countries, for the set-up of external audit groups (EAGs), nationally recognized teams of experts in charge of operating external quality audits for radiotherapy dosimetry. The methodology was adapted to the specific conditions in each participating country, which involved scientific investigations leading to new developments at national levels. The countries set up their TLD systems with technical support of the IAEA Dosimetry Laboratory.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP helped the participating countries to establish their national structures for external audits in radiotherapy dosimetry. The calibration of national TLD systems was checked by the IAEA through a serie of TLD comparisons, which provided an external quality control of the performance of the national systems. Standard operating procedures for the TLD system of the IAEA Dosimetry Laboratory were distributed as an example. The methodology for follow-up of discrepancies in dosimetry was also developed

Twelve countries (Algeria, Argentina, China, Colombia, Cuba, the Czech Republic, India, Israel, Malaysia, the Philippines, Poland and Viet Nam) have established their own TLD based national audit systems with the support of this CRP. After its completion in 2001, the methodology was made available to other countries willing to establish national TLD audits. Altogether, the IAEA supported 18 national TLD networks that encompass approximately 1400 hospitals with approx. 900 Co-60 units and 1000 linacs. Owing to the different stages of the implementation of the national systems in these countries, at present about 600 local hospitals are involved in the regular national audit programme. Once the TLD networks are fully operational, the EAGs will be able to expand the number of beam checks in their countries and consider extension to other non-reference conditions and other modalities.

Access for a local hospital to a regular audit programme is now easier and the assistance in resolving problems in dosimetry is now closer at hand and therefore more rapid. All the evidence points to the audit systems being an effective means of detecting problems, which, when rectified, improve the quality of radiotherapy treatment delivery and outcome.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

The audit methodology developed under the CRP E2.40.07 is being extended to non-reference conditions under the CRP E2.40.12. The IAEA Dosimetry Laboratory provides technical back up to the national audit networks, acting as an external QA of their systems

CRP Published Results

The audit methodology developed under this CRP was published in the SSDL Newsletter. The participating institutions presented their work in various local and international conferences; 11 posters and one oral presentation were delivered at the IAEA Dosimetry Symposium in November 2002.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **E24011 Electron Paramagnetic Resonance (EPR) biodosimetry**

Participating Countries: Belarus(A), Germany(A), Italy(A), Japan(A), Russian Federation(A), Russian Federation(A), Ukraine(A), Ukraine(A), Ukraine(A), United States (A)

Total Cost: **$18 553**

Duration: 1998-04-01 — 2001-12-31

CRP Overall Objectives

To review the available methods and current research and development in Electron Paramagnetic Resonance (EPR) biodosimetry technology, which may be of practical use.

CRP Specific Objectives

To investigate the influence of various parameters of EPR biodosimetry with tooth enamel with the aim of providing Member States with up-to-date, and generally agreed advice regarding the most suitable procedures and the best focus for their research and to publish the results as the IAEA TECDOC.

Research Outputs

Individual Institutes participated in the CRP and developed different methods of calibration and computer modelling of EPR spectra and performance protocols for retrospective EPR biodosimetry with tooth enamel.

CRP Outcome (Effectiveness; Impact; Relevance)

Participation in this CRP helped the institutions to facilitate standardization programmes. The establishment of performance standards and quality assurance procedures for EPR biodosimetry with tooth enamel should ensure the tracebility of reconstructed doses to international standards.
Some methods of routine EPR dosimetry for retrospective dose estimation were tested on a small scale. More studies on variation of radiation sensitivity of tooth enamel for different geographical regions are required.
The Co-ordinated Research Project was conducted for four years and the TECDOC presents the results and findings by group of investigators from different countries. A compressive review with recommendations on the use of different methods of radiation dose reconstruction (including the EPR biodosimetry method) is the subject of an International Commission on Radiological Units and Measurements (ICRU) report on Retrospective Assessment of Exposures to Ionizing Radiation. The present IAEA TEDOC is addressed to those who need an introduction in applying EPR tooth biodosimetry and producing dose results. The beneficiaries of the CRP will be both the participating laboratories and all those obtaining the new IAEA report on the unified methods for practical EPR biodosimetry and for related research.
Dose reconstruction can be applied to different radiation events and accidents. It is an essential tool for retrospective assessment of individual doses as a basis for the selection of appropriate countermeasures.

Recommended Future Action by Agency

The Agency should continue to participate in International Comparisons on EPR Tooth Biodosimetry by providing reference irradiation of the samples.

CRP Published Results

The participating institutions have published about 20 publications related to the CRP studies in peer review journals.
IAEA TECDOC -1331

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**E41010**	**Assessment of levels and health-effects of airborne particulate matter in mining, metal refining and metal working industries using nuclear and related analytical techniques**
Participating Countries:	Brazil(C), China(C), Czech Republic(C), Denmark(C), Denmark(C), India(C), Indonesia(C), Kenya(C), Portugal(C), Russian Federation(C), Slovenia(C), South Africa(A)	
Total Cost:	**$285 627**	
Duration:	1996-12-15 — 2001-12-15	

CRP Overall Objectives

To identify the source and evaluate the fate of key non-radioactive environmental contaminants and provide the basis for improved health for human populations by the use of nuclear and related techniques (mainly NAA, PIXE, XRF and ICP-MS).

CRP Specific Objectives

(1) To develop strategies and techniques for sampling of workplace airborne particulate matter (APM), and human tissues and body fluids (hair, blood, etc.) of exposed and non-exposed persons;
(2) To develop suitable analytical procedures for analysis of such types of samples, using nuclear and related analytical techniques;
(3) To carry out workplace and personal monitoring of APM and characterise the health effects of such exposure in terms of the observed elemental concentrations;
(4) To carry out tissue analyses of the workers so exposed for biological monitoring and the health effects studies.

Research Outputs

Strategies and techniques for sampling of workplace airborne particulate matter (APM) and human tissues and/or fluids have been acquired by the participants thus introducing harmonised approach in the participating countries. Appropriate guidelines as to sampling, analytical protocols and experimental design were developed and adopted by the participants. The performance of the nuclear and related analytical techniques used in the CRP has been significantly improved. The techniques have been validated by participation in interlaboratory comparisons organized within the CRP (urban dust, simulated air filters, welding fumes on a filter, elements in freeze-dried urine) and also by additional control analyses of appropriate reference materials. The unique features of the techniques, such as multi-elemental and non-destructive character, an inherent potential for accuracy in case of NAA, a special potential for microanalysis by PIXE and nuclear microprobe techniques, etc. have been exploited and the use of these techniques for occupational health studies has fully been justified. Workplace and personal monitoring of occupational exposure was performed successfully providing input data for the occupational health risk assessment. Several participants initiated studies of occupational exposure on a large scale. Most participants collected total suspended particles (TSP) in the workplace air and nine of them also collected size fractionated APM. Personal sampling was done in four studies; in one of them only TSP was collected, while in three other studies the PM2 (particles smaller than 2um) fraction was also obtained. In total more than 3400 APM samples of the workplace air were collected. About half of them were analysed by nuclear analytical techniques such as instrumental neutron activation analysis (INAA), X-ray fluorescence analysis (XRF), particle induced X-ray emission (PIXE) and radiometric methods; and another half by complementary methods. For monitoring of occupational inhalation exposure, 2648 subjects were examined. In total 287 control subjects were examined; 15 of them were administrative staff of the studied plants and/or enterprises, 8 were workers with other tasks in the same plant/enterprise and 230 were persons not occupationally exposed to metals and/or other xenobiotics. Types of exposure involved: galvanization, iron and steel production, welding of stainless steel, zinc processing, the production of fertilizers, mining and mineral processing including uranium and thorium. Regarding biological monitoring, the following numbers of samples were collected from occupationally exposed and control persons: 617 hair and/or nail samples, 307 blood and/or blood component samples, 479 urine samples and approximately 100 other specimens (mostly teeth). Almost all biological samples were analysed by nuclear methods including also radiochemical neutron activation analysis and nuclear microprobe techniques. Exposure levels were assessed and compared within various industries among different countries/regions.

Accomplishments of CRPs Completed in 2001

CRP Outcome (Effectiveness; Impact; Relevance)

The concluded CRP is an example of a study aimed at providing data by nuclear and related techniques for the occupational health risk assessment. The project has been effective in development of strategies and techniques for sampling of APM and biological samples, development of suitable analytical procedures for analysis of APM and biological samples using nuclear and related analytical techniques, workplace and personal monitoring and the assessment of the associated health risks.

Although the increased awareness of occupational health, hygiene and safety in recent years has resulted in improvements of working conditions and in reducing workers' exposure to toxic agents, substantial hazards remain, making new studies necessary to be able to achieve further improvements. The CRP's outputs proved that nuclear and related techniques are appropriate and competitive for analysing the respirable fraction of APM and human biological material. By means of the technology used exposure levels of critical toxic elements in selected industries were assessed providing the needed data to decision makers, aimed at improving health conditions for the workers.

Improved strategy and technology of APM sampling was implemented. Suggestions for further improvements will influence the future work in this field conducted by the participants and other interested parties. New knowledge was obtained on correlations between the occupational exposure measured and the magnitude of the biological response. Research using nuclear microprobe techniques revealed possibilities to study the health effects of occupational exposure at the cellular level. The knowledge obtained on occupational exposures and health effects will support national authorities in participating countries to formulate necessary codes and regulations to control occupational exposure in the industries concerned. This has already been demonstrated in one participating country.

Experience and expertise obtained within the CRP will certainly be useful for the participating institutions, relevant regulatory bodies and the scientific community concerned with improvements of working conditions and risk assessment in occupational settings. The participants now have the experience to carry out appropriate studies and are capable of transferring this knowledge to other institutes in their countries. It is expected that the Agency will be able to make a significant contribution to health-related studies of this kind also in future.

Recommended Future Action by Agency

Further research on workplace exposure assessment and related health risks is needed for better understanding of risk assessment procedures, as to enable more effective communication with authorities and the media. The CRP generated a large amount of data that was statistically evaluated. However, further harmonisation of protocols for data collection, reduction and evaluation should be implemented in future collaborative studies organised by the Agency.

CRP Published Results

The results obtained were published until now in 37 IAEA reports, conference proceedings, etc., and in 27 papers in refereed journals. One review paper on strategies and techniques for APM monitoring was developed for possible future training of personnel and students. There are still 11 papers in preparation. One participant used the national contribution to this CRP for a Ph.D. thesis. An IAEA TECDOC is in preparation that will contain the final reports from all participants.

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**F12011**	**Application of MeV ion beams for development and characterization of semiconductor materials**
Participating Countries:	Bangladesh(C), China(C), Croatia(C), Czech Republic(C), Hungary(C), India(C), Italy(A), Kazakhstan(C), Poland(C), Russian Federation(C), Slovenia(C), United States (A)	
Total Cost:	**$178 005**	
Duration:	1997-12-15 — 2001-02-26	

CRP Overall Objectives

To promote research and facilitate more extensive and efficient applications and use of low energy ion ion accelerators for development and characterisation of advanced materials.

CRP Specific Objectives

To investigate applications of MeV ion beams for development and characterisation of semiconductor materials with the main focus on the correlation between the structure of investigated materials and their physical properties important for their applications in electronic devices.

CRP Outcome (Effectiveness; Impact; Relevance)

A large amount of research was stimulated by this CRP resulting in numerous publications in scientific journals. For example, the role of grain boundaries in the limitation of charge collection efficiency in CVD (chemical vapour deposition) diamond detectors with respect to natural diamond has been assessed and demonstrated. In addition, conditions for blister formation in GaAs were characterized. Possibilities to create oxygen-enriched layers on the surface of a GaAs single crystal were investigated by implantation of In ions. A ten-fold increase in oxygen atom content was observed in the transparent surface layers. Fabrication and properties of hydrogen and/or erbium containing optical layers in lithium niobate produced by annealed proton exchange were studied. The best electro-optic properties were found with the samples having uniformly distributed lithium atoms and very low content of hydrogen. In addition, this CRP stimulated a number of collaborations between research groups that are expected to last much longer than the CRP itself. This includes associations between persons with very different research backgrounds. Further, a number of participating laboratories have significantly improved their analytical capability for materials characterization. These include developments in Rutherford backscattering spectrometry (RBS), elastic recoil detection analysis (ERDA), nuclear reaction analysis (NRA) and ion beam induced charge/ion beam induced luminescence (IBIC/IBIL) setups.

The CRP was based on applications of MeV ion beams for development and characterization of semiconductor materials with the main focus on the correlation between the structure of investigated materials and their physical properties important for their applications in electronic devices. The materials of concern are those currently used (or contemplated) in semiconductor devices, like CuInSe2 and CuInl-xG~Se2 thin films, InGaAs/JnP heterostructures, GaAs, GaN, LiNbO3, polycrystalline Si, CdTe, CdZnTe, etc. Specific topics include optoelectronic characterization of semiconductor materials and devices by ion microbeams, characterization of thin films, defect transformations in semiconductors, light element analysis in semiconductor materials and microfabrication of semiconductors using ion beams.

CRP Published Results

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Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F12012 Final stage of WIMS-D library update project**

Participating Countries: Argentina(C), Bangladesh(C), China(A), China(C), Cuba(C), Czech Republic(A), India(C), Korea, Republic of(C), Morocco(C), Poland(C), Russian Federation(A), Slovenia(C), United States (A)

Total Cost: **$188 599**

Duration: 1998-12-01 — 2001-12-31

CRP Overall Objectives

To improve of research reactor operation and effective utilization through WIMS-D library updating, aiming at producing working libraries for reactor physics calculations for design and safety.

CRP Specific Objectives

To improve the performance of the WIMS-D with the newly available or revised nuclear data files, by producing a fully updated WIMS-D library compatible with the WIMSD5B code; a user guide for the updated library; documentation for data processing methods and modification of the code for a larger number of energy groups than currently used.

Research Outputs

The CRP achieved:
--Sensitivity of integral lattice results to data processing options.
--Optimization of data processing options for updating the library.
--Analysis of the performance of fully updated libraries based on ENDF/B-VI.8, JEF-2.2, JENDL-3.2 data respectively.
--Development of models for the analysis of benchmark experiments.
--Detailed analysis of more than 200 bench mark experiments including criticality, reactivity temperature coefficient and burn up benchmarks.
--Analysis of specific full core research reactor test case.
--Application of the new library to full scale commercial PWR core design calculation.

CRP Outcome (Effectiveness; Impact; Relevance)

Various benchmarks were identified and analyzed for testing the library.
The calculated reactor parameters were compared with the experimental values and with those from the earlier calculations. The improvement in the agreement with the new calculations provided the performance indicator for the updated library.
CRP has contributed to updated multigroup, neutron cross-section library (WIMSD-IAEA) along with calculations for more than 200 benchmarks and has become available to users.
The knowledge of neutron cross-section library is essential for the calculation of core design of research and power reactors.
The work done during the CRP thus is of relevance to reactor designers and operators.

Recommended Future Action by Agency

Collect feedback on the performance of the library and organize a smaller library updating activity as important revisions of evaluated data files become available

CRP Published Results

A TECDOC is in preparation.

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**F22022**	**Development of agents for imaging central neural systems (CNS) receptors based on Technetium-99m**
Participating Countries:	Brazil(C), China(C), Cuba(C), Germany(A), Greece(C), Hungary(A), India(A), Korea, Republic of(C), Portugal(C), Switzerland(A), United Kingdom(A), United States (A), Uruguay(C)	
Total Cost:	**$217 168**	
Duration:	1995-12-15 — 2001-12-31	

CRP Overall Objectives

To implement research and development on Tc99m labelled compounds with potential for use in imaging CNS receptors.

CRP Specific Objectives

To develope bifunctional chelates containing CNS receptor avid molecules and ligands binding to Tc99m.
To develope radiochemical methods for Tc99m labelling of the bifunctional chelates by different approaches and purity determination.
To develope in vitro receptor binding methods for comparative evaluation of the Tc99m compounds and in vivo biodistribution studies of the most promising ones.

Research Outputs

Reliable and reproducible methods for the derivatization and the labeling of various Tc-based CNS receptor ligands could be achieved, an a series of Tc and Re complexes could be synthesized and characterized at macroscopic amounts.
In general, the complexes showed nanomolar and subnanomolar affinities to the target CNS-receptors in vitro. The affinities of the studied complexes for 5-HT1A receptors were comparable to the lead structures.
Most complexes were successfully synthesized at tracer level (99mTc) and characterized by comparative HPLC studies.
Evaluation in experimental animals of the complexes prepared at tracer level showed a high structure dependent brain uptake in rats. The brain uptake values in rats, of some of these complexes were comparable to reported values of 99mTc-TRODAT.
Although the brain uptake values and affinities were comparable to the lead structures selective localization in brain areas rich in 5-HT1A receptors was insufficient insufficient.
Important data and technology have been compiled serving as a useful base for further rational design of Tc agents for imaging CNS receptors and ultimately developing a useful agent.

CRP Outcome (Effectiveness; Impact; Relevance)

The development of technology for the synthesis, radiolabelling and quality control of potential CNS receptor ligands was successfully achieved by many of the participants. In vivo and in vitro biological techniques, relevant for studying the biological efficacy of receptor imaging agents were also established.

The improvement of the capabilities of the participants groups in all the procedures needed for the development of novel radiopharmaceuticals is considered one of the most important achievements of the CRP. These skills can be applied to the design of potential radiopharmaceuticals for other type of CNS receptors and also to new fields of interest in Radiopharmacy.

The CRP has stimulated research on synthesis, characterisation and evaluation of Tc99m labelled agents for potential CNS imaging. The scientific capabilities in participating laboratories, particularly from developing Member States have been very significantly enhanced so that they can undertake goal oriented research and development of Tc99m labeled compounds for imaging a variety of receptors.

Imaging receptors in the body using Tc99m agents are the current and future areas of research in radiopharmaceuticals. The techniques for labelling and methodologies for evaluation of such high specific activity molecules are unique demanding higher levels of skills. The CRP helped many laboratories particularly from developing Member states to establish such skills thus strengthening the R&D base of their teams.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

With the momentum provided by the CRP, the R&D efforts to develop a useful Tc99m CNS agent is expected to continue in many labs who took part in this programme. CRPs for developing Tc99m infection agents and Tc99m labelling of small bio molecules have been subsequently initiated.

CRP Published Results

Internal: TECDOC under preparation

External:

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Other Outputs:
Meeting reports of 4 RCMs

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F22026 Development of kits for radioimmunometric assays of tumor markers**

Participating Countries: Algeria(C), Canada(A), China(C), Cuba(C), Greece(C), Hungary(A), India(C), Iran, Islamic Republic of(C), Malaysia(C), Thailand(C), Uruguay(C)

Total Cost: **$184 628**

Duration: 1997-09-01 — 2001-05-25

CRP Overall Objectives

To create a technical and manpower base for laying the foundation for production, in sufficient quantity, of radioimmunometric assay kits for tumour markers ultimately leading to early diagnosis and better management of cancer patients, particularly in developing member states.

CRP Specific Objectives

To develope radioimmunometric assays for the tumor markers PSA and free PSA based on two site IRMA methodology , and formulation into kit forms based on where possible, locally developed reagents.

Research Outputs

i) Development and validation of the IRMA methodology based on one common MoAb for solid phase and two different tracer MoAbs for PSA and free PSA.
ii) Development of simple laboratory protocols for purification of PSA from seminal plasma.
iii) Development of methods for I125 radiolabelling of the monoclonal antibodies (MAbs) of required specific activity and quality.
iv) Development of high quality anti PSA MoAbs by three groups and their availability to others.
v) Evaluation and use of indigenous tubes for solid phase and other key reagents.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP assisted participants to develop and validate IRMA methodologies for total and free PSA

They have assimilated adequate expertise in designing assay protocols for tumour marker IRMAs in general, selection and evaluation of assay reagents readily available and in house preparation of reagents not readily and economically available.

Assay of serum PSA (Prostate Specific Antigen) levels is a valuable adjunct to diagnosis and management of patients with prostate cancer which is the second most prevalent cancer in males. Annual PSA tests in conjunction with digital rectal examination is recommended in males above age 50. Local capability to produce PSA assay kits in sufficient quantities and at a reasonable cost is crucial for undertaking such screening programmes in developing countries. The participants through three years of collaborative work under the CRP have developed simple methodology for purification of PSA from seminal plasma, produced anti PSA secreting hybridomas, obtained matched pair MoAbs for use in the assays and produced other key assay reagents including PSA standards, I125 labelled MoAb tracer and MoAb coated tubes. They have developed -IRMA kits for both total and free PSA using the reagents and validated them against imported kits. With the expertise developed under the CRP, the participants will be able to undertake production and supply of IRMA kits for total and free PSA at an affordable cost to meet national and even regional demands. They can also use the expertise to develop IRMA kits for other tumour markers

The CRP it exploited the technical expertise available in many developing member states in RIA development by extending it to IRMA development for PSA assays, and resulted in successful indigenous development of a genuine nuclear technique using radioactive tracer which is very much needed in cancer management.

Recommended Future Action by Agency

The results of the work done by participants constitute a source of technical information for others working on development of IRMA for PSA and hence should be published as TECDOC of IAEA The participants in the CRP have requested that development of IRMAs for breast cancer marker CA15.3 should be taken up as a continuation of this CRP. Since breast cancer

is a common cancer among women this will give the participants capability to indigenously produce reagents and kits for another important tumour marker. Hence continuation of the CRP to develop IRMA for CA 15.3 is recommended.

CRP Published Results

A TECDOC consisting of the reports of R&D work done by participants is being compiled for publication
The participants have also individually published the results in journals and symposia.

1.1. PUBLICATIONS RESULTING OUT OF THIS CRP

INDIA
1. Development of an IRMA for total PSA
Aruna korde, Ketaki Bapat, Archana Shukla, Meera Venkatesh and M.R.A.Pillai
Ann. Conf. Society of Nucl. Med. (India), 1999, Indian J. Nucl. Med., 14, p97, 1999.
2. Monoclonal Antibody for Prostate Specific Antigen : Generation and Characterization
Ketaki Bapat, Aruna Korde, Archana Shukla, Meera Venkatesh and M.R.A.Pillai
XXVI Annual Conference and Symposium on Cancer Immunology in the New Millennium, Mumbai, India, 2000.
3. Development of an Immunoradiometric Assay for total PSA
Archana Shukla, Aruna Korde, Ketaki Bapat, Meera Venkatesh and M.R.A.Pillai
International Conference on Probing in Biological Systems, Mumbai, India 2000.

IRAN
4. Tayebeh Hadizad , Reza Najafi
Development of new PSA IRMA kits based on avidin-biotib method.
Iranian congress of nuclear medicine. Tabriz , Iran, 14-16 October 2000.

URUGUAY
5. Robles, A., Balter, H., Oliver, P., Laiz, J., Berbejillo, J., Gonçalvez, Z., Lopez, A.
Free and Total PSA by IRMA with bulk reagents-XVI Congress of the Latinamerical Association of Societies of Biology and Nuclear Medicine- Iberoamerican Congress on Nuclear Medicine-V Seminar of the Argentinian Association of Nuclear Cardiology-XII
Argentinian Congress Argentino of Biology and Nuclear Medicine. 24-28 October, 1999. Buenos Aires-Argentina.
6. Berbejillo,J., Goncalvez,Z., Lopez,A., Robles,A.
Immunoradiometric assay of free and total PSA. VI Congress of the South
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Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F22029** **Development of radioactively labelled cancer seeking biomolecules for targeted radiotherapy**

Participating Countries: Argentina(C), Austria(A), Brazil(C), China(C), Cuba(C), Finland(A), Greece(C), Hungary(A), India(C), Italy(A), Mexico(C), Pakistan(C), Romania(C), Thailand(C), Uruguay(C)

Total Cost: **$302 008**

Duration: 1997-12-15 — 2001-12-14

CRP Overall Objectives

To develop radiopharmaceuticals based on beta emitting radioisotopes tagged to biomolecules such as peptides and antibodies for potential use in treatment of cancer patients, particularly in developing member states.

CRP SPECIFIC OBJECTIVES

To synthesice of bifunctional agents based on MoAbs and peptides, their labelling with beta emitting isotopes and evaluation of the labelled products in invitro and invivo models.

RESEARCH OUTPUTS

Participants gain the requisite know- how and expertise to prepare and distribute a few peptide or antibody based therapeutic radiopharmaceuticals for use in nuclear medicine centres in their countries. Data of research interest on the preparation, purification and quality control of biomolecules based radiotherapeutic agents was gained.

CRP Outcome (Effectiveness; Impact; Relevance)

The specific objective can be considered to have been achieved.
Synthesis of bifunctional chelating agents and radiolabelling of the biomolecules, particularly with Y90 and Re188 and other radionuclides were developed. Radiolabelling of lanreotide, a peptide specific for somatastain receptors, with 90Y through bifunctional chelating agent was also achieved. The procedure developed is suitable for making clinical doses of 90Y labelled lanreotide. Radiolabelling of peptides, in particular lanreotide, in nanomolar concentration with 188Re was achieved using direct labelling method was developed. This labelling technique could be extended to several other biomolecules. The participants developed several quality control techniques for radionuclides and for labelled peptides, which will be useful for evaluating radiopharmaceuticals based on biomolecules. The participants during the course of the CRP developed in vitro and in vivo biological techniques. These techniques are essential and the knowledge accumulated is relevant for studying the biological efficacy of receptor-based therapeutic radiopharmaceuticals.

The overall objective of the CRP can be considered to have been achieved. Laboratory procedures and protocols for the radiolabelling and quality control of biomolecules with peptides as models and several beta emitting radioisotopes including Re188, Y90, Sm153, Ho166 and Lu177 were optimised with the participation of 15 scientists from selected research institutes in Argentina, Austria, Brazil, China, Cuba, Greece, Finland, Hungary, India, Italy, Mexico, Pakistan, Romania, Thailand and Uruguay. These laboratories, many of them in developing member States, are now in a position to carry on further R&D in developing a range of biomolecules labelled with beta emitters and evaluate them for use as radiopharmaceuticals. Octreotide analogues have been labelled with Re188, Y90 and other beta emitters which have good potential for therapy of neuroendocrine tumours.

Targetted radiotherapy using radiopharmaceuticals has several advantages including the possibility of delivering higher doses to the tumor, treating multiple metastasis not needing. expensive and sophisticated machines and better toleration by patients. Therapy of thyroid carcinoma, bone metastasis, neuroblastoma and arithritis have proved to be very effective. By focusing on the development of therapeutic radiopharmaceuticals based on biomolecules the CRP has shown
the potential of extending such therapy for many other cancers, particularly with the resources available in developing Member States.

Accomplishments of CRPs Completed in 2001

The results of the CRP are very relevant both from the scientific and applications points of view. High specific activity labelling of receptor specific bio molecules such as peptides using bifunctional conjugates and direct labelling methods without losing the biological affinity are challenging. These have been mastered by the participants. In course of time they would be able to propogate this expertise to other national and regional laboratories.
Use of therapeutic radiopharmaceuticals for cancer is a potentially very effective, economical and widespread mode of therapy. During the time of the CRP, a radiolabelled monoclonal antibody was approved in USA and Europe for treatment of lymphoma and has been found very useful in clinic.

Recommended Future Action by Agency

In view of the importance of the field, it is recommended that the Agency should continue supporting R&D efforts in this direction through CRPs and wherever the techniques look promising, through TC programmes It is also recommended that the Agency evolve a mechanism of supporting the participants' continuing the work beyond the life time of the CRP by keeping a stock of specialised key chemicals that are not yet commercially available

CRP Published Results

PUBLICATIONS AND PRESENTATIONS ORIGINATING FROM THE CRP
International publications
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Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**F22031**	**The use of radiation processing for sterilization or decontamination of pharmaceuticals and pharmaceutical raw material**
Participating Countries:	Belgium(A), China(C), Croatia(C), Egypt(C), Germany(A), India(C), Malaysia(C), Poland(C), Romania(C), Switzerland(A), Turkey(C), United Kingdom(A), United States (A)	
Total Cost:	**$135 554**	
Duration:	1998-04-01 — 2001-12-31	

CRP Overall Objectives

To coordinate the research and development programmes carried out in different countries, developed and developing, in use of radiation processing for sterilization or decontamination of pharmaceuticals and pharmaceutic raw materials.

CRP Specific Objectives

To study the radiation effects on drugs of different types and traditonal herbal medicine components (e.g.Traditional Chinese Medicines) for identification of the products of radiolysis and evaluation of their role in changing of biological activity of radiation sterilized pharmaceuticals. Introducing the methods to the manufacturer practice.

Research Outputs

The main outputs are:
- ESR methods for free radicals concentration measurement in solid drugs have been developed
- role of oxygen on the changes induced by radiation has been established
- microbiological decontamination doses needed for the herbal materials have been determined
- trace compunds produced during selected drug irradiation have been identified using HPLC/MS and biological activity changes (including toxity) analyzed

CRP Outcome (Effectiveness; Impact; Relevance)

The analytical and processing procedures were elaborated for selected materials. The collaboration between research and industry established. The new TC projects in the field initiated.

Radiation sterilization has already demonstrated its advantages over conventional (chemical) methods, with the scale of its application rising. The results of the CRP demonstrated new fields of applications and roles of the process in the decontamination of natural medical herbs, which finds increasing usage worldwide. The process application for synthetic pharmaceuthicals sterilization has also been demonstrated.

The CRP has had an impact on the further developments concerning application of radiation processing for drug and natural medicine sterilization. Developed procedures and methods are or will be adopted in a processing manual, and QC systems. Results obtained are the basis for national and international standards elaboration.

Results of the research carried out in the frame of the CRP are important for the pharmaceutical industry. Guidelines will be adopted in its procedures.

Recommended Future Action by Agency

Further activities should concentrate on :
- influence of radiation on materials
- QC(including dosimetry)
- development of new radiation processing lines
- legal issues and standards concerning sterilization or decontamination of pharmaceuticals and pharmaceutical raw materials.

Accomplishments of CRPs Completed in 2001

CRP Published Results

IAEA-TECDOC"Radiation sterilization and decontamination of radiopharmaceuticals and radiopharmaceutical raw materials"(is in preparation).

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**F31001**	**Sedimentation assessment studies by environmental radionuclides and their application to soil conservation measures (Joint CRP with D1.50.05)**
Participating Countries:	Australia(A), Australia(C), Canada(A), China(C), China(C), France(A), Malaysia(C), Morocco(C), New Zealand(A), Poland(C), Romania(C), Spain(A), United Kingdom(A), United Kingdom(C)	
Total Cost:	**$178 507**	
Duration:	1995-12-01 — 2001-11-28	

CRP Overall Objectives

To develop guidelines for controlling accelerated soil erosion and associated soil degradation for sustainable development of agricultural production and environmental protection.

CRP Specific Objectives

i. To refine (including validation and standardisation) relevant methodologies for documenting soil erosion and sediment redistribution using the Cs-137 technique across a range of environments and the establishment of sedimentation rates in lakes and reservoirs.
ii. To test and calibrate existing models of soil erosion and sedimentation.

Research Outputs

1. Standardised protocols of the Cs-137 technique for documenting soil erosion and sedimentation.

2. Reliable data of soil erosion/sedimentation rates using the Cs- 137 technique across a range of environments. Testing and validation of soil erosion models.

3. Strengthening national institutes on soil erosion/sedimentation research through training, workshops and other activities.

4. Publication of protocols and research results. Provision of guidelines for soil erosion/sedimentation control.

CRP Outcome (Effectiveness; Impact; Relevance)

1. The participants of the CRP have made significant progress towards a harmonized application of 137Cs techniques in a worldwide basis.

2. The work of the participants has greatly broadened the range of environments that the technique has successfully been applied and reliable data for erosion and sedimentation rates has been produced for these areas. The spatially distributed 137Cs data produced by the participants has been used to assess the relevance of other erosion models (e.g. tillage redistribution, water erosion models).

3. This CRP had 10 participating institutes, that should be added up to the 16 participants of the CRP on soil erosion (D1.50.05), implemented together with this sedimentation CRP. This makes 26 different institutes with a worldwide distribution, from latitudes higher than 50o N (Canada, Russia) to 40o S (Chile), distributed over all continents. In five of the countries (Russia, Poland, Romania, Slovakia and France), Chernobyl 137Cs fallout was also included in the studies. In all of them, their working capabilities on the subjects of these CRPs were strengthened.

4. As a consequence of this CRP and the associated CRP on Soil Erosion, a book has been published: "Handbook for the Assessment of Soil Erosion and Sedimentation Using Environmental Radionuclides", Kluwer Academic Publishers, 2002 (219 pages). This book contains the standardised protocols of the Cs-137 technique for documenting soil erosion and sedimentation, included as expected output #1 of the CRP.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

As the techniques covered in this CRP are able to assess processes in the long-term, but sedimentation rates are highly variable in time, additional research is needed to use other short-lived environmental radionuclides to allow short-term assessment of sedimentation and soild redistribution.

CRP Published Results

A book has been published by Kluwer Academic Publishers (ISBN 1-4020-1041-9).

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F32002 The use of tracers and stable isotopes in surface water pollution studies**

Participating Countries: Australia(A), Brazil(C), Chile(C), Cuba(C), India(C), Pakistan(C), Peru(C), Poland(C), United Kingdom(A)

Total Cost: **$112 997**

Duration: 1997-12-15 — 2001-12-31

CRP Overall Objectives

To validate the use of specific artificial tracers in heavily polluted water and industrial discharges and to develop appropriate tracer and stable isotopes methodologies to solve problems in the field of surface water pollution and sanitary engineering.

CRP Specific Objectives

i) To study the behaviour and fate of some artificial tracers (mainly Tc-99m and Rhodamine WT) in polluted water and industrial effluents, where their chemical reactivity may affect the tracer's properties.
ii) To develop alternative methodologies with the use of artificial tracers for the measurement of oxygen transfer rate from the atmosphere into polluted surface water, a very relevant parameter for the estimation of the self-purification capacity of water bodies.
iii) To measure "in situ", using artificial tracers, the bacterial die-off rate in existing sewage discharges into coastal water.

Research Outputs

The behaviour of Tc-99m as a tracer in polluted surface water has been studied. The results show clearly that the stability of the tracer, even in reducing conditions, is higher than expected. A field method for labelling fine sediments with Tc-99m has also been developed, with high labelling efficiency and not interfering with the colloidal properties of suspended sediments. This new development allows the use of this tracer to study the dynamics of suspended sediments in polluted waters, a new application in sanitary engineering studies. Rhodamine WT has been shown to be a better tracer than tritiated water when studying the dynamics of sewage treatment ponds, where detention times are in the order of weeks, if no correction for the exchange of tritium with the atmospheric humidity is provided. It was demonstrated that the isotopic composition of dissolved oxygen can be used to quantify the contribution of the different processes responsible for this important parameter in water quality studies. Sampling methods, micro-techniques to handle very low volumes of oxygen and specific measuring techniques have been developed.
For coastal water pollution studies, the N isotopic composition of marine plants can be used as an indicator of exposure to domestic sewage. Two papers have already been published on the use of Tc-99m as water and sediment tracers. Others will follow shortly.

CRP Outcome (Effectiveness; Impact; Relevance)

One of the specific objectives of the CRP, related to the use of artificial tracers to study oxygen transfer in polluted waters, was not accomplished because it was not possible to find groups willing to develop this activity at that time. The field experiments to study sewage dispersion and bacterial die-off in coastal waters are expensive, because of the logistic support costs. This meant that the number of data on "in-situ" measurement of bacterial die-off in marine waters was below expectation.
The main impacts of this CRP are that the conditions under which Tc-99m can be used to trace water and suspended sediments in polluted surface water are now known. This allows its use in developing countries where the importation of short-lived radioactive material may be a problem. The use of oxygen stable isotopes in the dissolved oxygen allows a better understanding of the processes that rule the presence of this important parameter in surface water. These techniques are now available to be applied in developing countries.

CRP Published Results

TEC-DOC is in preparation.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F34008** **Isotope techniques for the assessment of slow moving deep groundwater and their potential application for the assessment of waste disposal sites**

Participating Countries: Australia(A), Austria(A), Brazil(C), Canada(A), China(C), France(A), Germany(A), India(C), Israel(A), Italy(A), Russian Federation(C), Sweden(A), Switzerland(A), Switzerland(C)

Total Cost: **$109 649**

Duration: 1997-07-15 — 2001-12-31

CRP Overall Objectives

To improve the understanding of deep groundwater movement and age distribution especially in low permeable materials with relevance for planning of waste disposal sites.

CRP Specific Objectives

- to provide information and methodologies on the following subjects:
- to decide betwen meteoric and fossil groundwater origin,
- to compare the influence of advective and/or of molecular-diffusive transport,
- to estimate groundwater velocities and fluxes,
- to calculate turnover times for groundwater circulation.

Research Outputs

First successful application of Kr-81 as dating tool for very old (>100,000yrs) groundwater. Good accordance of data with other relevant dating tools (Cl-36, He-4, Ar-40) in a deep aquifer with consistent data interpretation.
Development of new technique for age assessment of groundwater in low-permeable layers by measurements of helium inventory in pore space water and estimation of its accumulation rate through vertical profiles.

CRP Outcome (Effectiveness; Impact; Relevance)

The publications resulting from work of groups participating in this CRP shows clearly the high effectiveness of collaborative work, stimulated by the first RCM of this CRP (resulting in the major field campaign in the Great Artesian Basin starting about three months after conclusion of the first RCM with financial support for logistics and the field work by an IAEA technical contract).

Two key studies improved the understanding of the groundwater turnover time in two groundwater systems (Morsleben, Germany: existing radioactive waste disposal site; and Great Artesian Basin, Australia.)

The CRP has demonstrated the usefulness of an intergrated interpretation of different age dating tracers for very old groundwater and for the first time ever showed consistent data for different tracers applied (Kr-81, Cl-36, He-4, Ar-40). Improvements in both field and analytical methods were achieved and results published, ready for application in further studies.

The CRP has resulted in a major collaborative effort from several leading institutions in a assessment of the residence time of water from deep wells in the Australian Great Artesian Basin. For the first time the radioactive isotope Kr-81 was successfully used for groundwater age assessment of a deep groundwater flow system. This was the second time after an earlier IAEA CRP in the 1980s on very old groundwater conducting a field study in the Canadian Milk River area, that a whole collection of age dating tools covering the respective time horizon were applied. It is the first demonstated example ever, of providing consistent age information from the applied tools within the respective limits of precision.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

Further collaborative work at field sites with deep boreholes was recommended and was already started as one task in a subsequent and related CRP on "Origin of Salinity and Impacts on Fresh Groundwater Resources: Optimization of Isotopic Techniques" (2000-2004).

CRP Published Results

Internal:
The majority of work was published in IAEA Symposia Proceedings (see below).

External:
6 major contributions published, further contributions submitted/ in preparation:
B.E.Lehmann, A.Love, R.Purtchert, P.Collon, H.H.Loosli, W.Kutschera, U.Beyerle, W.Aeschbach-Hertig, R.Kipfer, S.K.Frape, A.Herczeg, J.Moran, I.N.Tolstikhin, M.Groening: A comparison of Kr-81, Cl-36 and He-4 groundwater dating in 4 wells in the Great Artesian Basin, Australia. (accepted for publication-2003) Earth and Planetary Science Letters
P.Collon, W.Kutschera, H.H.Loosli, B.E.Lehmann, R.Purtschert, A.Love, L.Sampson, D. Anthony, D.Cole, B.Davids, D.J.Morrissey, B.M.Sherrill, M.Steiner, R.C.Pardo, M.Paul: Kr-81 in the Great Artesian Basin, Australia: a new method for dating very old groundwater. Earth and Planetary Science Letters 182 (2000) 103-113.
P.Collon, T.Antaya, B.Davids, M.Fauerbach, R.Harkewicz, M.Hellstrom, W.Kutschera, D.J.Morrissey, R.C.Pardo, M.Paul, B.M.Sherrill, M.Steiner: Measurement of Kr-81 in the atmosphere. Nucl. Instr. Method. B 123 (1997) 122-127.
A.J.Love, A.L.Herczeg, L.Sampson, R.G.Cresswell, L.K.Fifield: Sources of chloride and implications for Cl-36 dating of old groundwater, southwestern Great Artesian Basin, Australia. Water Resour. Res. 36(6) (2000) 1561-1574.
J.Lippmann, A.Ruebel, K.Osenbrueck, C.Sonntag, M.Groening: Dating porewater in rock samples from fresh drilling cores: Depth profiles of stable isotopes, noble gases and chloride in hydraulically impermeable geological formations. Proceedings of the IAEA Symposium on Isotope Techniques in the Study of Environmental Change, STI/PUB/1024, IAEA (1997) 465-472.
P.Collon, W.Kutschera, B.E.Lehmann, H.H.Loosli, R.Purtschert, A.Love, I.Sampson, B.Davids, M.Fauterbach, R.Harkewicz, D.J.Morrissey, B.M.Sherrill, M.Steiner, R.C.Pardo, M.Paul: Development of accelerator mass spectrometry (AMS) for the detection of Kr-81 and first application to groundwater dating. Proceedings of the IAEA Symposium on Isotope Techniques in Water Resources Development and Management, IAEA-CSP-2/C (1999), 6 pp.
U.Beyerle, W.Aeschbach-Hertig, F.Peeters, R.Kipfer, R.Purtschert, B.Lehmann, H.H.Loosli, A.Love: Noble gas data from the Great Artesian Basin provide a temperature record of Australia on time scales of 100,000 years. Proceedings of the IAEA Symposium on Isotope Techniques in Water Resources Development and Management, IAEA-CSP-2/C (1999), 7pp.
B.Wallin: Detailed isotope studies of calcite fracture fillings as indicators of paleaohydrology at the Aespoe Hard Rock Laboratory. Proceedings of the IAEA Symposium on Isotope Techniques in the Study of Environmental Change, STI/PUB/1024, IAEA (1997) 881-882.
S.K.Frape et al. (in preparation): Uses and applications of deltaCl-37 isotopes to sources of solutes in old deep groundwater systems.
D.M.Bonotto (submitted): Migration of uranium in Guarany aquifer and implications on the disposal of radioactive wastes

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **F34009 Radionuclide transport dynamics in freshwater resources**

Participating Countries: Austria(A), Belarus(C), Brazil(C), Germany(A), Italy(A), Lithuania(C), Poland(C), Russian Federation(C), Russian Federation(C), Sweden(A), Ukraine(C)

Total Cost: **$114 845**

Duration: 1997-12-15 — 2001-01-31

CRP Overall Objectives

To further improve and enhance isotope methodologies applied to a wide spectrum of hydrological problems encountered as a result of water utilization practices that induce adverse effects on available water resources; and to attain improved water management practices that would minimize water quality degradation due to human activities.

CRP Specific Objectives

To use the environmental releases of radioactivity as a tracer to evaluate the extent of radionuclide migration, and to estimate soil-water radionuclide interaction parameters in a variety of freshwater environments.

Research Outputs

The study focused on ^{137}Cs of Chernobyl origin, although the behaviour of other anthropogenic radionuclides (^{134}Cs, ^{238}Pu, ^{239,240}Pu, and ^{90}Sr) and several naturally occurring radionuclides (^{212}Bi, ^{228}Ac, ^{214}Bi, ^{226}Ra, and ^{40}K) were also investigated in some areas. The study sites included a variety of physiographic, climatic and land use settings to obtain a broad perspective of radionuclide migration characteristics in freshwater environments.

Research conducted within the CRP confirms that mobility of radionuclides through the surface water and the groundwater systems is dependent on the physical and chemical properties of the contaminant, and on the rock and sediment characteristics. Radionuclides such as ^{90}Sr that commonly occur in the aqueous phase were found to be very mobile within the aquatic environment. Other radionuclides such as ^{137}Cs that strongly interact with the particulate matter suspended in water, with the bottom sediments, and with solid particles show comparatively lower levels of mobility.

The experimental studies carried out in the framework of the CRP have also demonstrated that the highest ^{137}Cs migration fluxes at a depth of few decimetres do not exceed 0.005% of the total deposition. Lower infiltration rate is expected for Pu (0.001%), while ^{90}Sr may show infiltration rates one order of magnitude higher than ^{137}Cs. In hydromorphic soils with a well-developed peat layer, the annual infiltration rates of ^{137}Cs at the depth of 0.5m may reach 0.01% of the total deposition.

Vegetation cover and soil microbiota may have a strong seasonal and long-term effect on radionuclide (primarily ^{137}Cs) mobility and vertical migration through the soil. Field data suggest that up to 40% of the total deposition in hydromorphic forest environments may be immobilized in the living biomass (tree vegetation, fungi, mycelium, etc). In automorphic landscapes, the corresponding value is only 13-15%.

Few previous studies have evaluated the direct diffusion of radionuclides from water to sediment. In the present study, this process was found to be significant in lakes with negligible sedimentation rates. “Migration velocity” due to the direct diffusion of ^{137}Cs from the water to lake sediments was estimated at 2.4×10^{-8} to 1.1×10^{-7} m s^{-1}.

New conceptual approaches for modelling the behaviour and the transport of radionuclides through freshwater systems were reviewed within the CRP. Radionuclide migration form a large catchment often tends to reflect an integrated average response based on the “ensemble” of physiographic, climatic and land use types that it comprises. “Statistical aggregation” of processes is one approach that may be further developed to model radionuclide migration in large, complex systems. A review of collective models, which are simple and require only a small number of site-specific parameters, suggests that these models may also be useful and adaptable tools for radiation protection and management of freshwater resources.

Accomplishments of CRPs Completed in 2001

CRP Outcome (Effectiveness; Impact; Relevance)

The pathways and processes of migration of radionuclides from superficial catchment compartments (soil and surface water) to aquifers are not well understood. The investigations undertaken under this project made significant contributions towards the improved understanding of such processes leading to achievement of the envisaged objectives of the CRP.

Freshwater contamination due to environmental releases of radioactivity is an issue of global concern. Comprehensive planning of resource protection strategies requires the characterization of radionuclide migration patterns and processes and an ability to simulate these processes in terrestrial and aquatic environments. The findings of this project will lead to the enhanced understanding of degradation of water resources due to human activities as well as improved water management practices.

The resulting TECDOC provides a synthesis of the different studies and presents detailed scientific findings of the investigations undertaken in the framework of the coordinated research project. It is expected to be useful to scientists, managers and policy makers involved in protection of aquatic and terrestrial resources from radiological contamination. The findings and model simulations will be of significance to the researchers interested in contaminant transport in the terrestrial and aquatic environments.

CRP Published Results

Internal
Research Progress Reports and Reports of Research Coordination Meetings
INTERNATIONAL ATOMIC ENERGY AGENCY (2002): Radionuclide transport dynamics in freshwater resources, IAEA-TECDOC-1314, 161pp.

External
SHCHEGLOV A.I., et al., "Biogeo-chemical Migration of Technogenic Radionuclides in Boreal Forest Ecosystems" Monograph, Moscow: NAUKA, April 2001.
ŠPIRKAUSKAITE N., TARASIUK N., LUJANIENE G., STELINGIS K. (1996) Possibilities of the anthropogenic radionuclide accumulation in the Kaunas reservoir - the part of the Nemunas riverine system. Proceedings of International Symposium on Ionising Radiation Protection of the Natural Environment. Stockholm, Sweden, May 20-24, 1996, 618-622.
TARASIUK N., ŠPIRKAUSKAITE N., LUJANIENE G. (1997) On the question of the cesium-137 seasonal balance in the Nemunas river. Abstracts of the Central Eastern European Conference "Ecotoxicology and Environmental Safety" (SECOTOX'97), Jurmala, Latvia, August 24-27, 1997, Jurmala, 188.
LUJANIENE G., LUJANAS V., TARASIUK N., ŠPIRKAUSKAITE N. (1998) Peculiarities of radionuclides behavior in the atmosphere and the hydrosphere. Proceedings of International Seminar on Use of Isotope Techniques in Marine Environmental Studies, Athens, Greece, 11-22 November, 1996. P. 75-88.
TARASIUK N., ŠPIRKAUSKAITE N. (1998) On the question of 137Cs seasonal balance in the Nemunas river. J. of the Latvian Academy of Sciences, Ser. B., 52, 108-110.
ŠPIRKAUSKAITE N., TARASIUK N. (1998) Lithuanian water systems. Proceedings of the Scientific Conference "Problems of Lithuanian Meteorology and Hydrology on the Eve of XXI century", Vilnius, 24-30.
TARASIUK N., ŠPIRKAUSKAITE N., LUJANIENE G. (1999) The formation of 137Cs concentration in the Nemunas river accumulation zone. Environmental and Chemical Physics, Vilnius, 21, 2, 27-32.
ŠPIRKAUSKAITE N., TARASIUK N., LUJANIENE G., LUKŠIENE B., DRUTEIKIENE R. (2000) On radionuclide contamination of Lithuanian water systems. Environment of Health, Vilnius, 3, 71-76 (in Lithuanian).
V. GOUDZENKO (1997) Artificial radionuclides as a tool for groundwater contamination assessment: Experience following the Chernobyl disaster. In Groundwater in the Urban Environment. Vol.1, Problems, Processes and Environment, Balkema, Rotterdam, 1997 p.141-144.
V. SHESTOPALOV, V. GOUDZENKO, YU. RUDENKO, V. BUBLYAS AND A. BOGUSLAVSKY (1997) Assessment and forecast of ground-water and rock contamination within the Kiev industrial agglomeration influenced by Chernobyl fallout. Ibid, 171-174.
V. BUBLYAS, V. GUDZENKO, I. ONYSHCHENKO, YU. RUDENKO, A. SHEVCHENKO and V. SHESTOPALOV (1999) Hydrogeology and Land Use Management. Proc. of XXIX IAH Congress Bratislava, 1999, 347-352.
V. GUDZENKO and D. KUKHARENKO (2000) Assessment of the urban areas' geological medium permeability by radionuclides. In Proceeding of the Conference "Ecological geology and rationally land use' San-Petersburg, Russia, 349-351 (in Russian).

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **I11001** **Estimating the external costs associated with electricity generating options in developing countries using simplified methodologies**

Participating Countries: Brazil(A), Brazil(C), China(A), China(A), Croatia(A), Croatia(A), Cuba(C), Korea, Republic of(A), Korea, Republic of(A), Lithuania(A), Lithuania(C), Poland(A), Poland(C), Romania(A), Romania(C), Russian Federation(A), Russian Federation(A), South Africa(A), South Africa(C), Switzerland(A), Thailand(A)

Total Cost: **$94 717**

Duration: 1999-04-01 — 2001-12-31

CRP Overall Objectives

To validate and demonstrate the broad applicability of a new analytical tool for environmental and comparative assessment of electricity options - the SIMPACTS model, a simplified methodology for estimating the damage costs associated with electricity generation.

CRP Specific Objectives

- To explore the applicability of the simplified approach to a broad range of analytical needs and case studies;
- To develop default values and parameters on damage costs (external costs).

Research Outputs

This CRP contributed to the validation of the SIMPACTS model and to model enhancement through a series of country-specific test case studies, covering Central and South America, South Africa, East Europe and Southeast Asia . These case studies demonstrated the flexibility of SIMPACTS to do a simple analysis when little information is known, or conversely do a much more sophisticated calculation when more data are available.

CRP Outcome (Effectiveness; Impact; Relevance)

Twelve institutes participated in the field test of SIMPACTS. The great advantage of this CRP was that it permitted testing the simplified approach in different countries, with different environmental agendas, different geographical characteristics, population distribution and meteorological conditions, and different levels of statistical sophistication, data availability and resources devoted to environmental analysis within the context of energy planning. A number of environmental issues were addressed, including power plant siting, comparative assessment of different technologies using the same fuel or across different fuels (e.g., different gas technologies: steam turbine vs. combined cycle; or different fuels: fossil vs. nuclear), cost effectiveness of different pollution mitigation options and analysis of different energy expansion alternatives consistent with national policies aimed at sustainable development.

The main outcome of this project has been the validation and refinement of the SIMPACTS software. This includes the following models: (1) AirPacts for assessing the impacts and damage costs to public health, agricultural crops and building materials from airborne pollution; (2) NukPacts for assessing the health impacts from radiological emissions and accidents; and (3) HydroPacts for estimating the environmental and social impacts and costs of hydropower facilities. The role of these programs is not to replace a detailed analysis, but rather to complement detailed assessments and to obtain estimates in cases when the available input data are insufficient to perform a detailed or complete analysis.

A significant outcome of this CRP has been increased interest on the part of Member States for training in the use of SIMPACTS. Two regional workshops and four national training efforts have been scheduled to date.

The results of this CRP, lessons learnt and development of the SIMPACTS methodology/software, are an important addition to the Agency's existing set of methodologies and computer tools aimed at informing decision-makers about economic and environmental issues concerning long-term energy planning.

Recommended Future Action by Agency

To promote the dissemination and application of the SIMPACTS methodology for informing decision-making regarding

long-term energy planning alternatives consistent with sustainable energy development.

CRP Published Results

A CD including background materials, results of the different case studies performed during the CRP period and the SIMPACTS software is available for distribution to interested Member States.

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**I14002**	**Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies**
Participating Countries:	Argentina(C), Belarus(C), Brazil(C), Bulgaria(C), China(C), Croatia(C), Cuba(C), Egypt(C), Greece(C), Hungary(C), Indonesia(C), Iran, Islamic Republic of(A), Israel(C), Mexico(C), Pakistan(C), Peru(C), Philippines(C), Poland(C), Portugal(C), Republic of Moldova(C), Romania(C), Russian Federation(C), Slovakia(C), Slovenia(C), Switzerland(A), Thailand(C), The Frmr.Yug.Rep. of Macedonia(C), Turkey(C), United States (A), Uzbekistan(C), Vietnam(C)	
Total Cost:	**$463 063**	
Duration:	1996-08-15 — 2001-06-05	

CRP Overall Objectives

To enhance the capabilities of Member States, particularly developing countries, to identify optimized energy mixes for electricity generation that meet environmental protection standards and regulations prevailing in different countries at least cost.

CRP Specific Objectives

To develop Country Specific Databases containing a comprehensive and harmonized set of technical, economic and environmental data for energy chains that use fossil fuels, nuclear power, and renewable energy sources for electricity generation;
To design and carry out national case studies on comparative assessment of different options and strategies for electricity generation in conformity with the objectives of sustainable development;
To demonstrate the application of databases and methodologies established within the DECADES project;
To prepare, publish and disseminate a report on the case studies carried out, highlighting the main conclusions and findings, both technical (about the applicability of DECADES) and substantive (about the role of different electricity generation options in sustainable electricity supply strategies).

Research Outputs

In the participating countries, experts in the fields of electricity system analysis, economics and environmental impact assessment assembled Country Specific Data Bases and conducted national case studies. The participation of countries varied for year to year, but overall some 30 countries did conduct national studies using the DECADES tools, addressing a wide range of issues, including: determining cost-effective strategies for reducing local atmospheric emissions, assessing greenhouse gas mitigation options, incorporating environmental regulations into long-term electricity system expansion planning, and employing multi-criteria decision analysis to identify energy options that are consistent with national objectives and possibilities. In the early period of the CRP, the research conducted by participating country teams constituted in one sense a field test of DECADES databases and tools. Their feedback provided useful inputs to model enhancements and to user interface improvements, resulting in robust, user-friendly and widely applicable tools.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP was a part of the continuing process through which the IAEA is constantly developing and making available analytical tools that reflect changing needs and interests in Member States, and thereby help build local capabilities for elaboration of sustainable energy and electricity strategies. The CRP was initiated at a time when environmental concerns were gradually receiving increased attention in the energy planning and policy making domains, and concerns about sustainable development and external costs were beginning to shape policy discussions. At that point in time, the capabilities in most of the developing MS were lacking for systematically compiling and correlating technical, economic and environmental data on energy facilities and fuel-chains, and using such information for exploring and comparing different energy and electricity supply.
strategies. In this context, the CRP helped remarkably in building local capabilities and fully met its overall as well as specific objectives.
The research effort on case studies highlighted particularly the different implications that enforcement of environmental regulations would have for alternative power system expansion options in terms of investment requirements, operating costs, environmental burdens and external costs of electricity generation. These comparative analyses show that the magnitude of

these impacts is very much dependent on the strategies adopted to comply with the regulations. Some national case studies found nuclear power to be part of an optimal strategy for future expansion of the electricity sector in a sustainable manner.

Recommended Future Action by Agency

CRP participants have provided valuable input into the Agency's on-going efforts on development and enhancement of methodologies for sustainable energy development. Their recommendations for further research and development in this field reflect in large part the changing needs in the wake of technological advancements and restructuring of energy sector. Many of these have already been accommodated in new and advanced tools developed by the Planning and Economic Studies Section. Nonetheless, the newly developed tools will eventually encounter new challenges. Users may request additional features reflecting more detailed energy-economy-environment integration. Policy makers and regulators may need methodologies for monitoring and verifying environmental or economic performance. Hence, the IAEA's efforts on energy models development and enhancement should continue.

CRP Published Results

Internal:
IAEA TECDOC, "Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies", 2003.
IAEA, DECADES Project Document No.3, DECADES Tools User's Manual Version 1.0, 2000.
IAEA, DECADES Project Document No.4. Enhanced Electricity System Analysis for Decision Making - A Reference Book, 2000.

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**I14003**	**The role of nuclear power and other energy options in meeting international goals on greenhouse gas emission reductions**
Participating Countries:	Australia(A), Bulgaria(C), China(C), Croatia(C), Czech Republic(C), Hungary(C), Korea, Republic of(A), Korea, Republic of(C), Lithuania(C), Pakistan(C), Romania(C), Russian Federation(C), Slovakia(C), Thailand(C), United States (A), Vietnam(C)	
Total Cost:	**$174 500**	
Duration:	1999-04-15 — 2001-12-15	

CRP Overall Objectives

To develop new awareness and understanding related to the potential role of nuclear and other energy options in mitigating GHG emissions.

CRP Specific Objectives

i) To enhance the Agency's tools for energy planning and comparative assessment so as to make them better suited for analyzing issues related to GHG mitigation assessment;
ii) To develop methodological guidelines describing the use of Agency tools for GHG mitigation assessment; and
iii) To provide the necessary framework to conduct a series of studies investigating the potential role of nuclear and other energy options in meeting national and international goals for GHG emission reductions.

Research Outputs

The outputs of the CRP in comparison with the stated specific objectives are summarized as follows:

Objective i) Enhance IAEA energy planning tools to make them better suited for GHG mitigation assessment.

a) The WASP model has been upgraded to WASP-IV version with user interface. It was used in national studies by the teams from Croatia, Czech Republic and Lithuania for assessing GHG mitigation options in electric power sectors.

b) The WASP-IV model was also used for analyzing nuclear power for Clean Development Mechanism projects - a flexible mechanism under the Kyoto Protocol - in national case studies of China, India, Pakistan and Vietnam.

c) The new version of ENPEP (ENPEP for Windows) has been developed. It was used in national case studies by the teams from Bulgaria, Romania and Slovakia.

Objective ii) Develop methodological guidelines describing the use of IAEA tools in GHG mitigation assessment studies.

a) A WASP-IV manual has been published by the Agency as "Computer Manual Series No. 16".

b) A document entitled: "Greenhouse Gas Mitigation Analysis Using ENPEP - A Modeling Guide" has been prepared. The document explains the concepts of GHG mitigation assessment, scenario building and abatement cost estimation. In addition, the guidebook demonstrates how to implement a given GHG mitigation option using the ENPEP package. This Modeling Guide has become an integral part of ENPEP and is used in subsequent training courses on the application of the ENPEP model.

Objective iii) To serve as a platform for conducting national studies analyzing the role of nuclear power and other energy options in meeting international goals on GHG emission reductions.

a) All national studies have been completed and the main results were presented during the final RCM.

CRP Outcome (Effectiveness; Impact; Relevance)

The overall objectives were met creating awareness and building national capacities in participating countries to a level such that the results of their work partly contributed to the process of policy making.

The CRP contributed to:

a) Enhancing the capability of Member Countries to conduct their own analyses of GHG mitigation options and to integrate the results into the process of policy formulation for sustainable energy development;

b) Exploring the potential role of nuclear power for sustainable energy development under a variety of different but conceivable futures in Member Countries.

Published Results

a) IAEA, Wien Automatic System Planning (WASP) Package, A Computer Code for Power Generating System Expansion Planning, Version WASP-IV, User's Manual, Computer Manual Series No. 16, IAEA, Vienna, 2001.

b) Slovak Republic (2001) Third National Communication to UNFCCC. Bratislava.

c) Popovici D. and Costea D (2002) Forecast of greenhouse gas emissions from Romania energy sector during the Kyoto Protocol commitment and beyond. Potential role of mitigation options in the achievement of the international goals for emissions reductions. Paper presented at Regional Energy Forum, Romania June 2002.

d) Miskinis V and Galinis A (2000) The role of nuclear power in control of emissions in Lithuania. Latvian Journal of Physics and Technical Sciences 2000 No.2

e) IAEA (2000) Nuclear Power for Greenhouse Gas Mitigation (http://www.iaea.org/worldatom/Press/GreenhouseGas/greenhousegas.pdf)

Accomplishments of CRPs Completed in 2001

CRP Number and Title:	**I32002**	**Intercomparison of analysis methods for seismically isolated nuclear structures**
Participating Countries:	India(A), Italy(A), Italy(A), Italy(A), Italy(A), Japan(A), Korea, Republic of(A), Russian Federation(C), United Kingdom(A), United States (A)	
Total Cost:	**$98 520**	
Duration:	1996-04-15 — 2001-05-31	

CRP Overall Objectives

The overall objective of the CRP is to increase the capability of Member States to develop and introduce advanced fast reactor technology.

CRP Specific Objectives

The use of seismic isolation for structures has been gaining worldwide acceptance as an approach to a seismic design. Seismic isolation to important building such as nuclear power plants would result in reduction of the seismically induced load and hence more economical structural design.
Liquid metal cooled fast reactors operate at high temperature, which induces high thermal stresses during transients. Hence the thickness of the structures have to be minimised to limit the thermal stresses, which approach contradicts the requirements of conventional aseismic design to make the structures more rigid. It is possible to meet these contradictory equirements by adopting seismic isolation.
The objectives of the co-ordinated research project are to verify the numerical analysis methods and computer codes by comparing predictions with the benchmark test data provided by participant organizations, for the force-deformation characteristics of seismic isolation bearings and the response of isolated nuclear structures and to improve the analysis methods on seismic isolation technology.
Experimental data for use in the project were provided by EERC, KAERI and ENEL on high damping rubber bearings (HDRB), by CRIEPI on natural rubber bearings (NRB) and lead rubber bearings (LRB) with both small and large lead core. Shaking – table test results were provided by CRIEPI, for a rigid structure, by ENEL for a flexible model structure and by KAERI for a test on a seismically isolated spent fuel storage pool. The seismic isolation bearings which generally use rubber as the elastomer are constructed from layers of elastomer bonded to steel reinforcing plates, with or without a central hole filled with a lead core.
The participating institutes and chief scientific investigators are:
Indira Gandhi Centre for Atomic Research (IGCAR), India (P. Chellapandi)
National Agency for New Technology (ENEA), Italy (A. Martelli)
ENEL-HYDRO Hydraulic and Structure Centre (ENEL), Italy (F. Bettinaly)
ENEL-HYDRO-ISMES Engineering and Testing Centre (ISMES, Italy (G. Bonacina)
Central Research Institute of Electric Power Industry (CRIEPI), Japan (K. Hirata)
Korea Atomic Energy Research Institute (KAERI), Republic of Korea (B. Yoo)
Research Centre of Fundamental Engineering (RCFE), Russian Federation (V. S. Beliaev)
Tun Abdul Razak Research Centre (TARRC), UK (K. N. G. Fuller)
Earthquake Engineering Research Centre (EERC), USA (J. M. Kelly)
Centre (JRC) of the European Commission, Ispra (V. Rendo)

Research Outputs

Seismic isolation is included in the GE (United States of America) advanced liquid metal cooled fast reactor (ALMR) to decouple the reactor and its safety equipment from potentially damaging ground motions. Flexible isolation elements with high vertical and low horizontal stiffness are used between the building basement and the superstructure to transform high energy seismic input motions into harmonic response cycles with significantly reduced accelerations. This approach is well suited for the low pressure liquid metal reactor system, which has thin-walled components and structures. Some of these components are flexible in the horizontal direction, and reduced accelerations lead to reduced stresses and displacements or enhanced safety margins. The technology programme objective is to demonstrate that the seismic isolation elements perform during earthquakes as designed, with a high reliability throughout their 60-year design life. A testing programme of variously sized seismic isolation bearings indicated that a consistently high horizontal displacement capability can be achieved, and that the bearings have substantial margins for accommodating earthquakes beyond the safety shutdown earthquake. Horizontal seismic isolation

has been adopted for the ALMR design to simplify the reactor and nuclear island design and the in-service inspection programme, and to enhance design margins for beyond-design basis earthquakes. An added economic and licensing benefit of seismic isolation is the ability to achieve reactor design standardization for site locations with different seismic conditions and soil properties. The seismic isolation system decouples the reactor, its safety equipment, and the intermediate heat transport system (including the steam generator) from potentially damaging ground motion by transforming high energy, high frequency seismic inputs into lower frequency response cycles with significantly reduced acceleration. The isolated system responds to horizontal ground motion essentially as a rigid body, with little amplification of the ground acceleration. This limits the inertial loads and increases the structural margins for critical components and structures. Also reduced are relative displacements between components. This is helpful for limiting the potential for seismic interference between the control drives and their guide elements, and for minimizing the forcing function for seismic core compaction. The ALMR nuclear island is supported from a common, seismically isolated platform, with a horizontal isolation frequency of 0.7 Hz and a maximum displacement of 19 cm during a safe shutdown earthquake (SSE) with 0.3g zero period acceleration (ZPA) ground acceleration. The design earthquake was specified to envelop the Nuclear Regulatory Commission's (NRC) Regulatory Guide 1.60 spectra. The selected criteria are expected to apply to over 80% of potential nuclear sites in the USA. Options for siting in seismic zones with higher ground accelerations were investigated and found acceptable. The seismically isolated ALMR system has the capability of accommodating at 0.5g ZPA earthquake. Sixty-six seismic isolators with access and space for in-service inspection and replacement, if necessary, are included. Each isolator is a composite of laminated steel plates and high damping rubber layers encased in rubber. There is a substantial experience base for this isolator design. Performance testing of the isolator bearings has been underway at the University of California (Berkeley) Seismic Engineering Laboratory. A powerful testing machine with a horizontal dynamic load capability of 150t and a vertical capability of 750t was built at the Energy Technology Engineering Center. Tests performed with half-size bearings demonstrated a significant margin to failure (three to seven times the expected SSE displacement). The experimental data have been provided to the CRP participants. A seismic bearing qualification programme has been implemented. This includes: (1) static and dynamic performance tests of bearings; (2) the evaluation of aging and environmental effects, such as temperature, gamma radiation; and (3) seismic isolation system shake table tests to evaluate performance characteristics and margins. The vertically stiff reactor assembly places the vertical natural frequencies of critical structures well above the dominant ground motion frequencies, thereby providing sufficient vertical seismic margins without isolation. In co-operation with Italy's Agency for New Technologies, Energy, and Environment, a proposal for seismic isolation design guidelines for seismically isolated nuclear power plants was developed. Extension of this work is intended to establish a framework of design rules accepted by the American Society of Civil Engineers (ASCE) and the NRC. Seismic isolation is included in the European advanced liquid metal cooled fast reactor (EFR). The reactor building together with the adjacent steam generator buildings, switchgear building and auxiliary building are all on a common basement with bearing pads for effective isolation of horizontal earthquake-induced loads. The reactor vault is additionally separated from the basement by spring to reduce the vertical seismic loads. This last feature is optimal and required only in sites of very high earthquake activity. The isolation assures an essentially common seismic resistant design for a range of site conditions.Seismic isolation technology is relatively new to nuclear power plants and has been investigated only in special, limited applications. Many experimental and numerical studies are required on isolation pads to substantiate the adequacy of design conditions so that they can be used for LMFR applications. The major studies include deformation characteristics and damping of isolation pads. Due to the complexity of the dynamic behaviour of seismic isolation devices, the high cost of their tests and the significant number of devices having excellent potential for NPPs applications, several Member States judged it to be of great interest to extend verification of their numerical models of such devices by the analysis of experimental data obtained by others. The technical challenge in predicting the seismic response of an isolated structure is the need to develop a simple but accurate dynamic model of the isolators that can be combined with the dynamic analysis program that will simulate the rigid and flexible isolated structures. The technical challenge in the analysis of seismic isolation bearing is the large number of mesh elements needed and the fact that a fully 3-D analysis is required to cover all aspects of the bearing behaviour.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has fully met its specific objectives, i.e. code validation and identification of issues requiring further development in the area of seismic isolation of nuclear structures.

Broad participation and open exchange of data and information ensured that the overall Agency objectives in the area of advanced fast reactor technology development were fully met.

High damping rubber bearings (HDRB) or lead rubber bearings (LRB) provide a simple and economical isolation system.They possess the low horizontal stiffness needed and are capable of safely withstanding the large horizontal displacements imposed on them during an earthquake. The need for additional dampers is avoided. In the HDRBs damping is incorporated into the rubber compound. For the LRBs, the damping is provided by a cylinder of lead within the rubber bearing.

Accomplishments of CRPs Completed in 2001

Isolation of structures from horizontal ground motions is gradually becoming a more common method of providing protection from earthquake damage. In contrast to conventional technology, seismic isolation not only upgrades the earthquake resistance of a structure, but also offers the possibility of protecting the contents and secondary structural features of a building or plant because seismic forces transmitted to the structure are reduced. The operability and safety of plant can thus be enhanced. The isolation system functions principally not by absorbing the energy of the ground motion but by providing an interface able to reflect the earthquake energy back into the ground. The natural frequency of the structure mounted on the isolators is made to be below the frequencies of strong ground shaking. Damping is needed to limit the displacement of the isolators and - to control any response at the isolation frequency.

The proper functioning of isolation systems requires bearings with certain characteristics. The principal ones are:
- horizontal stiffness, KH
- vertical load capacity
- horizontal displacement capacity, dmax
- damping.

The isolation frequency is determined by the horizontal stiffness and the gravity load supported. The ability to predict KH and dmax reliably by FEA (finite element analysis) would mean that the isolator design could be verified with a reasonable degree of confidence before the isolators are submitted to a prototype test programme.

Several isolators were analysed within the Project by FE methods to see how well the FEA predicted their force-deformation behaviour. The predictions of individual Partners were compared with the test data from prototype isolators. Those analysed included:
- LRB manufactured and tested in Japan
- HDRB manufactured and tested in Italy
- HDRB manufactured and tested in The Republic of Korea
- HDRB manufactured in Italy and tested in the USA.

In addition to bearing test results, characterisation data for the rubber used in the manufacture was provided; the latter is required by the FE programmes. Again each partner chose the model to fit the data, and carried out the associated analysis to determine the value of the model's parameters.
Within the Project, two other types of isolator:
- low-damping rubber bearing were also analysed. As an adjunct to the FEA of isolators, a benchmark problem - the torsion of a rubber cylinder – was chosen by TARRC to assess how well the results obtained by the FE solvers compared with those based on an exact analytical solution.

The design of isolation systems for critical structures obviously requires confidence in the methods used to predict the responses of the structure and isolation system to earthquake inputs. Factors involved include the adequacy of:
- the model describing the dynamic behaviour of the isolators;
- the model of the structure.

By effectively reducing the seismic input to the structure, and, indeed, allowing the possibility that the response can be kept within the elastic range, the use of isolation may be expected to lead to more reliable analyses.
Within the Project the response of the following seismically isolated structures was investigated: rigid mass
- steel-frame structure (MISS)
- spent fuel pool
- full-scale section of WWER-640 reactor building.

Partners used their own method for analysing the structural response, and also developed the representation of the dynamic behaviour of the isolator necessary for the computations. The results of individual partner's computer predictions were compared with the test observations.

Numerical simulation of rubber bearings by FE code packages such as ABAQUS gives satisfactory results as long as material properties are evaluated properly and a suitable strain energy density function and mesh density is selected. Rubber material can be characterized for FE analysis by forms of the strain energy density: such as the Rivlin strain invariant polynomial or Ogden function. Generally, either provides a fit to the rubber stress-strain data adequate for modeling the horizontal force-deflection behaviour of bearings.

Except for very coarse meshes, the density did not significantly influence the vertical force deflection behaviour in the absence of shear. At shear deflections large enough to produce severe distortions of the rubber near the free surface, a fine mesh, at least in the highly distorted regions, is needed accurately to predict the shear stiffness and the height drop under combined shear and compression.

The analysis of a single layer of the bearing can be used to predict the horizontal deformation of the bearing by scaling up the results. This is significant in the sense that it reduces the computational time greatly. Further, this model can be used effectively to validate the material behaviour. However, more detailed three-dimensional FEM is necessary to analyse the stress distribution within the isolator or to evaluate the behaviour of the bearing at very large deformation.

The achieved results confirmed that overall FE methods are useful tools for both the detailed analysis of elastomeric bearings and improving their. They permit a considerable reduction of the number of validation tests to be performed.

When the same input data was used all codes provided predictions of the horizontal forcedeformation characteristics of all isolators consistent with the test data except at very small deformation.

All predictions of vertical behaviour in the absence of horizontal displacement were consistent with the test data provided the compressibility of the rubber is accounted for. Some deviation of the numerical prediction of vertical displacement when compression loading is combined with shear was found even after allowing for compressibility of the rubber.

The modelling of lead proved to be a problem for all teams as the material is deformed in shear within the isolators, whereas the codes require as input data in tension. Continuing research is needed on the accurate prediction of isolator hysteresis. The benchmark torsion problem proved to be an useful tool for the assessment of the accuracy of the two main computer codes MARC and ABAQUS.

Simplified model of HDRB and LRB have been used successfully to predict the response of two base isolated test structures subjected to earthquake inputs in shaking-table tests. The use of the bilinear model was very accurate in predicting the dynamic response of the rigid mass shake-table model up to the level of design and can be considered reliable for use in design.

For beyond design basis predictions multi-linear, exponential modelling were successfully used, with vertical motion due to rocking incorporated through vertical springs. For the flexible structure the response was accurately predicted if the modelling of the superstructure is accurate. To predict floor responses, an improved model of the isolation system is needed.

The CRP has shown that predicting the force-deflection characteristics of isolators, and calculating the response of isolated structures can often be done with good results. Areas requiring further work have been identified.

The main recommendation derived from the results of the CRP is that the study of isolated nuclear structures should be continued and extended to non-seismic extreme load conditions.

The refinement of the characterization of hyper-elastic behavior of the elastomer is needed to predict multi-directional response under combined loading. The modelling of the flexibility of the reinforced plates and connecting plates should be improved. Investigation of the impact on material characteristics of the special environmental conditions of nuclear facilities is needed. Investigation of the finite element prediction of isolator failure mechanisms is needed.

Simple, accurate, reliable models for the isolator response over a wide range of multidirectional deformation is essential for accurately predicting floor response spectra and other dynamic design quantities. Future research work should also look at the development of alternative seismic protective technologies such as passive, semi-active and active control for the seismic protection of nuclear facilities and components.

The pseudodynamic method to test large scale structures has been validated for base-isolated civil structures and should be extended to isolated nuclear facilities. The influence of vertical ground input on the response of all internal components of an isolated nuclear structure should be investigated.

CRP Published Results

Internal:
TECDOC-1288: Verification of analysis metnods for predicting the behaviour of sesmically isolated nuclear structures.

External:
1) A. Rineiskii, A. Martelli, M. Forni, K.N.G. Fuller, H.R. Ahmadi, F. Bettinali, A. Dusi, K. Hirata, Bong Yoo, G. Bonachina, V.S. Belyaev, R. Ravi, T. Selvaraj, V. Renda, G. Magonette, J.M Kelly: Verification of anlaysis methods for predicting the behaviour of seismically isolated nuclear structures, paper presented in the 7th International Seminar on Seismic isolation, passive energy dissipation and active control of vibrations of structures, Assisi, Italy, 2-5 October 2001.

2) K.N.G. Fuller, et al.: Intercomparison of analysis methods for seismically isolated nuclear structures, paper presented in the OECD Workshop on Seismic, JRC, Ispra, March 2001.
3) A. Martelli, et al.: Presentation in the International Post-SMiRT Conference Seminar, on Seismic Isolation, Passive Energy Dissipation and Active Control of Vibrations of Structures, Cheju, Korea, August 1999, KEERC, Seoul National University.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **I33008** **Potential of thorium-based fuel cycles to constrain Pu and to reduce long-term waste toxicities**

Participating Countries: China(A), Germany(A), India(C), Israel(A), Japan(A), Korea, Republic of(A), Netherlands(A), Russian Federation(C), United States (A)

Total Cost: **$84 085**

Duration: 1995-12-15 — 2001-09-18

CRP Overall Objectives

To implement a series of activities aiming at information exchange and at reviewing the R&D status in the potential of thorium fuelled reactor concepts, as well as at promoting collaborative R&D activities.

CRP SPECIFIC OBJECTIVES

To examine the different fuel cycle options in which plutonium can be recycled with thorium to incinerate the plutonium.

Research Outputs

In order to establish the basis for the inter-comparison of the results, a series of benchmark exercises was defined to compare the methodologies (data and codes) applied in the various institutions participating in the CRP. For the first plutonium incineration benchmark calculations, the PWR-type reactor has been chosen because it is the reactor type that has the largest share in the current production of nuclear energy. The first exercise selected for this benchmark was the calculation of the isotopic composition, cross-sections, and fluxes for a typical PWR-cell loaded with (Pu-Th)O2 - fuel, as a function of the fuel burnup. While for a Pebble-bed HTR, having a nearly homogeneous core structure, a neutronics calculation for the entire core is regarded to be the adequate step following the cell calculation, an additional inter-comparison of the heterogeneous lattice calculation methodology was deemed necessary in case of the PWR. Thus, for the PWR part of the CRP, a second benchmark was established, for which a 17x17 array of fuel ods, including 25 water hole positions was defined. In the following step, the joint research concentrated on the evaluation of the potential of LWRs, HTRs, HWRs, and MSRs for plutonium incineration. The aim of the research during this stage of the CRP was to find fuelling strategies, which are suitable to incinerate plutonium most effectively on the one hand, and to minimize the amount of plutonium to be disposed, on the other hand. In the last phase of the CRP, the participants investigated the effect of plutonium incineration on the radio-toxicity of the nuclear waste to be disposed. The research performed in this stage, aimed at assessing to which degree the incineration of plutonium is an appropriate tool to significantly reduce the hazard potential of the nuclear waste, which in the end remains for final disposal.

CRP Outcome (Effectiveness; Impact; Relevance)

All research goals were attained, the analytical tools were benchmarked, the various concepts were analyzed with regard to both the plutonium incinerating capabilities and the rad-waste toxicity reduction potential, and comprehensive comparisons made.

The CRP has met the overall objective of increasing the capability of Member States to develop and apply innovative nuclear technologies aimed at finding innovative alternative solutions for the back-end of the nuclear fuel cycle.

The CRP has achieved the validation of data and methods used in the respective research institutions of the participating Member States. It has allowed for a comprehensive comparison of the plutonium incinerating capabilities of various reactor concepts. It has advanced the understanding of and the capabilities to simulate reactor cores fuelled with thorium-based matrices.

The results of the research have shown that there is a remarkable potential to effectively constrain the production of plutonium and to reduce existing plutonium stockpiles, by implementing the thorium fuel cycle in a large number of current reactors. This path offers a promising near future plutonium management solution in view of, e.g., the proliferation concerns linked to plutonium. However, the research has also clearly shown that plutonium incineration in thermal reactors is far less effective from the point of view of the reduction of the long-term radio-toxicity of the nuclear waste. A reduction by an order of magnitude or more of the potential long-term radiotoxic hazard of the waste seems not to be achievable by any of the considered plutonium incinerating thermal reactors. Most of the calculations performed for LWR plutonium indicate that the

waste radio-toxicity will be decreased by not more than a factor of 2 to 4, and only for the period between approximately 100 to 10000 years after disposal. The waste radio-toxicity is even increased during the first decades and for extremely long times after disposal.

Recommended Future Action by Agency

It is recommended to maintain activities in the area of thorium-fuelled reactor technology development. Specifically, it is recommended to initiate a CRP on "Assessment based on an unified methodology of thorium fuel in innovative nuclear energy systems".

CRP Published Results

Internal:
IAEA-TECDOC-1349

External:
[1] V. Arkhipov, H.J. Rütten, and A. Galperin Progress Summary of the IAEA Coordinated Research Project on the Potential of
Thorium-based Fuel Cycles to Constrain Plutonium and to Reduce the Long-lived Waste Toxicity,
The Ninth International Conference on Emerging Nuclear Energy Systems, ICENES 1998, Tel-Aviv, Israel, June 28 - July 2, 1998, pp. 647-655
[2] H.J. Rütten, V. Arkhipov, and A. Stanculescu
Second Progress Report on the IAEA Coordinated Research Project on the Potential of Thorium-based Fuel Cycles to Constrain Plutonium and to Reduce the Long-term Waste Toxicity,
The Tenth International Conference on Emerging Nuclear Energy Systems, ICENES 2000, Petten, the Netherlands, September 24 - September 28, 2000, pp. 019.1 - 019.8
[3] H.J. Rütten, and A. Stanculescu
Final Report on the IAEA Coordinated Research Program on the Potential of Thorium-based Fuel Cycles to Constrain Plutonium and to Reduce the Long-term Waste Toxicity, PHYSOR 2002, Seoul, October 7-10, 2002

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **I33009** **Use of Thorium-based fuel cycle in accelerator driven systems (ADS) to incinerate Pu and to reduce long-term waste toxicities**

Participating Countries: Belarus(C), Czech Republic(A), France(A), Germany(A), Italy(A), Netherlands(A), Russian Federation(A), Sweden(A), Switzerland(A)

Total Cost: **$43 850**

Duration: 1996-08-01 — 2001-04-01

CRP Overall Objectives

To implement activities in support of MS research and development in the area of actinide utilization and incineration, specifically, the development of innovative reactor and fuel cycle technologies to this end.

CRP Specific Objectives

To perform analytical benchmarks of accelerator driven sub-critical systems (ADS), and investigate their neutronics properties for various fuels. In its final stage, the CRP has performed also a few experimental benchmarks.

Research Outputs

The first stage of the CRP has focused on simulation calculations of an energy amplifyer like ADS fuelled with thorium and U-233, and cooled by liquid lead. The output of the benchmark calculations was the intercomparison of the main neutronics parameters of this system, i.e. fuel enrichments vs. sub-criticality level, burnup evolution, stability of reactivity level, proton current requirements vs. fuel evolution, void reactivity effect, and long-term activity of the irridiated fuel. The second stage of the CRP focused on the assessment of the neutronics characteristics of a modular fast spectrum ADS designed to transmute radiotoxic waste. The output of this research was the neutronics analysis of sub-critical configurations fuelled with transuranics or minor actinide fuels. The third stage concentrated on experimental benchmarking, specifically, on calculations of the thermal spectrum YALINA sub-critical facility.

CRP Outcome (Effectiveness; Impact; Relevance)

All research goals were attained, comprehensive comparisons among the CRP participants' results were made and analyzed.

The CRP has met the overall objective of increasing the capability of MS to develop and apply innovative reactor and fuel cycle technologies in the area of partitioning and transmutation.

The CRP has contributed towards the validation of data and computer codes used by the various research institutions in the participating MS to simulate sub-critical assemblies driven by a spallation source. The impact of the CRP lies in the broad international intercomparison of data and codes used to simulate ADS, and in the first experimental benchmarking. The relevance of the CRP lies in many detailed findings with regard to the neutronics parameters of ADS. In particular, the discrepancies found have allowed to deepen the knowledge of sub-critical reactor physics, assess the applicability of "standard" neutronics analysis methods, and identify the areas where theoretical and experimental work is needed.

Recommended Future Action by Agency

It is recommended to maintain collaborative research and development activities in the area of ADS. Specifically, it is recommended to initiate a CRP on "Benchmark Analyses on Data and Calculational Methods for ADS Source Related Neutronic Phenomenology with Experimental Validation". The focus of this CRP will be on experimental benchmarks based on ongoing and/or planned experimental programs on the coupling of an external neutron source with sub-critical blankets (e.g., SAD, YALINA, TRADE,...)

CRP Published Results

Internal:
IAEA-TECDOC is in preparation.

External:

[1] I. Slessarev, V. Archipov, Study of the Neutronic Potential of a Modular Fast Spectrum ADS for Radiotoxic Waste Transmutation, Proceedings of ADTTA'99, June 7-11, 1999, Prague, Czech Republic.

[2] W. Gudowski, et al., IAEA Benchmark on Accelerator Driven Systems, Proceedings of AccApp ADTTA 01, November 11-15, 2001, Reno, Nevada, USA.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **J16005 Cytogenetic biodosimetry**

Participating Countries: Argentina(A), Brazil(A), Chile(A), China(A), Cuba(A), Finland(A), France(A), Germany(A), Greece(A), Hungary(C), India(A), Israel(A), Italy(A), Japan(A), Japan(A), Korea, Republic of(A), Netherlands(A), Philippines(A), Russian Federation(A), Russian Federation(C), Spain(A), United Kingdom(A), United Kingdom(C), United States (A), United States (A)

Total Cost: **$47 350**

Duration: 1998-03-01 — 2001-12-31

CRP Overall Objectives

To review the available methods and current findings on bioindicators, which may be of practical use and to identify promising techniques with the aim of providing Member States with up-to-date, and generally agreed advice regarding the best focus of their research and suggestions for the most suitable techniques for practice in biodosimetry.

CRP Specific Objectives

To elaborate of standardized methodology for cytogenetic analysis for radiation dose assessment aimed for comparable procedures enabling comparability of findings, i.e. estimated doses following an accidental radiation exposure. Special attention will be paid to cytogenetic biodosimetry of the partial body exposures and of the prolongated exposures.

Research Outputs

While the previous IAEA publication titled "Biological Dosimetry: Chromosomal Aberration Analysis for Dose Assessment"IAEA Technical Report Series No. 260 published in 1986 described the dicentric chromosome (DC) analysis only, in the Manual produced as a result of the CRP three other newly available, proven cytogenetic techniques have also been presented and discussed. These are the fluorescence in situ hybridisation (FISH), premature chromosomal condensation (PCC) and micronuclei (MN) assays. The Working Protocols added in Annexes are detailed descriptions of all four cytogenetic techniques enabling any cytogenetic laboratory to reproduce these methods for practical biodosimetry following an accidental radiation exposure or suspect for it.

CRP Outcome (Effectiveness; Impact; Relevance)

The Research Co-ordination Meeting held in Budapest, Hungary in June 1998 to review the current status of radiation dosimetry through bioindicators, to present methods used in the participating laboratories and to identify the main tasks (steps and leading laboratories) in elaboration of the unified techniques for biodosimetry was effective in clarifying the advantages and uncertainties of the methods used world wide.
Intercomparisons provided by four biodosimetry laboratories - of the NRPB (UK), IPSN (FRA), LUMC (NET) and CNAEM (TUR) to assess comparability of the results on the same blood samples of ten adults accidentally exposed to ionising radiation (Istanbul accident, 1998), is of practical significance and has been the first ever real life intercomparison using four cytogenetic biodosimetry assays.
The CRP has demonstrated the successful use of different cytogenetic techniques for biological dose assessment.
The CRP confirmed the need of standardization of cytogenetic methods proven and available for biological dose assessment as well as the need for continued research in this field.

CRP Published Results

A new IAEA Manual on the standardized methods proposed for practical cytogenetic biodosimetry and for research of bioindicators was prepared and published in Dec.2001:
IAEA: Cytogenetic Analysis for Radiation Dose Assessment. A Manual. Technical Report Series, No. 405, pp. 127, IAEA, Vienna, 2001

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **J45001 Investigation of methodologies for incident analysis**

Participating Countries: Argentina(C), China(C), Finland(A), Germany(A), Hungary(C), India(C), Korea, Republic of(A), Mexico(C), Russian Federation(A), Slovakia(C), South Africa(C), Spain(A), Sweden(A), United Kingdom(A)

Total Cost: **$165 999**

Duration: 1997-12-15 — 2001-08-15

CRP Overall Objectives

To foster the exchange of information on and develop guidance for the assessment of Feedback of Operating Experience, especially on event investigation (root cause) methodologies and techniques.

CRP Specific Objectives

i) To stimulate the exchange of operating experience in investigating and analysing the event root causes to prevent their re-occurrence, thus improving plant safety.
ii) To review and analyse existing root cause methodologies and techniques, determine their applicability areas and evaluate their strengths and limitations.
iii) To develop a spectrum of root cause methodologies/techniques for particular application areas with corresponding definitions and classifications of direct and root causes.

RESEARCH OUTPUTS

The principal research outputs of this CRP were the following:
i) Various innovative methodologies have been developed such as PSA event based analysis, PRCAP, PORTM, SOL_VE, AEB, etc.
ii) Four IAEA sponsored event investigation training seminars have been held as a direct result of this CRP.
iii) Most countries have had the opportunity through this CRP to familiarise themselves with a wide variety of methodologies.
iv) The widespread use of established RCA (Roots Cause Analysis) methodologies has been confirmed i.e. HPES, ASSET, MORT, etc.
v) Some participants have developed their own utility-specific RCA and Event Investigation manuals by adapting recognised and proven methodologies to suit their own prevailing circumstances.
vi) The acknowledgement that Corrective Action follow-up is as vital as is the effectiveness of the initial Event Investigation process.
vii) The acknowledgement that low level event reporting and trending is an important condition to pro active use of event investigation information.

CRP Outcome (Effectiveness; Impact; Relevance)

Every participant reported on the current situation within his/her organisation regarding the feedback of operating experience with particular reference to the event investigation and RCA techniques presently utilised. In all cases, the situation was considered to be satisfactory and many planned novel and pro-active approaches were discussed. Event selection criteria was also discussed in detail with its obvious relevance to RCA. A thorough review and analysis of event investigation methodologies/techniques which were practised within the participating organisations was undertaken and their applicability areas were determined. Also a subjective evaluation of the strengths and limitations of the various techniques was done on a participant-by-participant experience basis and the results are contained in the Working Material documents produced after each RCM. The range of techniques employed by the participants was discussed at great length within the CRP and various recommendations were made in this regard. a unique glossary of the various terms used when applying RCA was developed and finalised as a direct result of this CRP.

Experience on the use of different Root Caused Analysis methods has been documented in the Final TECDOC Report from the CRP, and as such, will be widely distributed to other interested users in Member States.

· The CRP promoted a high degree of interaction between the international participants.

· Many personal contacts and RCA ideas resulted directly from participation in the CRP.
· An International perspective on how other organisations achieve RCA was gained.
· It provided stimuli to address formalised and structured RCA within the participating organisations.
· Allowed various training initiatives to be undertaken.

There was a necessity prior to this CRP for various organisations to meet to discuss their respective RCA methods employed, exchange experience on the methods employed, promote ideas for the future development of RCA, be exposed to new initiatives such as PROSPER etc. and to reinforce the current overall approach to RCA.
The CRP also made participants aware of the necessity of ensuring that training, and continuos retraining, in RCA techniques is vital to ensure competence.

Recommended Future Action by Agency

Analyse feedback which the IAEA may receive on the TECDOC and if possible, feed this back to all participants.
Ensure the nuclear community is aware of the current status of ASSET and what is planned with respect to PROSPER

CRP Published Results

TECDOC-1278

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **J91002 BIOsphere Modelling and ASSessment methods (BIOMASS)**

Participating Countries: Argentina(A), Czech Republic(A), Hungary(A), Italy(A), Japan(A), Korea, Republic of(A), Lithuania(A), Norway(A), Poland(A), Romania(A), Russian Federation(A), Russian Federation(A), United Kingdom(A), United States (A), United States (A)

Total Cost: **$55 431**

Duration: 1998-04-01 — 2001-12-31

CRP Overall Objectives

To improve ability of Member States to assess radiological impact of the radionuclide releases to the environment on public and biota.

CRP SPECIFIC OBJECTIVES

1. To provide an international focal point in the area of biospheric assessment modelling for the exchange of information and in order to respond to biospheric assessment needs expressed by other international groups (within and outside IAEA).
2. To develop methods (including models, computer codes and measurement techniques) for the analysis of radionuclide transfer in the biosphere for use in the radiological assessments.
3. To improve models and modelling methods by model testing, comparison and other approaches.
4. To develop international consensus, where appropriate, on biospheric modelling philosophies, approaches, and parameter values.

Research Outputs

1. The concept of "Reference Biosphere" developed into a practical system for application to the assessment of the long-term safety of repositories for radioactive waste.
2. The models for the assessment of radiation exposure related to environmental releases tested and compared with regard to their applicability to (i) dose reconstruction for previous releases, and (ii) remediation assessment for historically contaminated areas.
3. The capabilities for modelling the transfer of radionuclides improved in particular parts of the biosphere, i.e. environmental transport of tritium, radionuclide uptake by fruits, and radionuclide migration and accumulation in forest ecosystems.

CRP Outcome (Effectiveness; Impact; Relevance)

The BIOMASS programme reached all its specific objectives:

1. It served as a long-term international focal point in the area of biospheric assessment modeling;
2. By the way of model testing, comparison and other approaches, it promoted improvement of models and development of new methods for the analysis of radionuclide transfer in the biosphere for use in the radiological assessments;
3. It promoted development of international consensus on biospheric modelling philosophies, approaches, and parameter values.

The CRP substantially improved ability of Member States to assess radiological impact of the radionuclide releases to the environment on public and biota.

The BIOMASS programme is relevant to safety of radioactive waste disposal, remediation of land contaminated with radionuclides and to assessment of routine discharges and accidental releases of radionuclides to the biosphere. Its results will be used for numerous practical applications associated with these areas of radiological practice and intervention.

Recommended Future Action by Agency

The following future actions by the Agency are recommended:

1. Publication and wide dissemination of the BIOMASS programme's outputs in form of the IAEA's documents, CDs and scientific papers and presentations;

2. Practical application of the biospheric modelling philosophies, approaches, models and parameter values elaborated in frame of the BIOMASS programme for development and application of safety standards in the area of public protection from hazards associated with radionuclide releases to the environment;
3. Preparation and performance of the follow-up programme covering wider list of radionuclides, other environments and assessment tasks, e.g. remediation assessment of urban environments contaminated with radionuclides due to accidental or intentional radiological events.

CRP Published Results

Modelling the Migration and Accumulation of Radionuclides in Forest Ecosystems (IAEA-BIOMASS-1)

Testing of Environmental Transfer Models Using Data from the Atmospheric Release of Iodine-131 from the Hanford site, USA, in 1963 (IAEA-BIOMASS-2)

Modelling the Environmental Transport of Tritium in the Vicinity of Long Term Atmospheric and Sub-Surface Sources (IAEA-BIOMASS-3)

Testing of Environmental Transfer Models Using the Chernobyl Fallout From the Iput River Catchment Area, Bryansk Region, Russian Federation (IAEA-BIOMASS-4)

*Testing of Environmental Transfer Models Using Data from the Remediation of a Radium Extraction Site

*Modelling the Transfer of Radionuclides to Fruit

*Reference Biospheres for Solid Radioactive Waste Disposal

(*Documents still in production, therefore no IAEA-BIOMASS number available at this time).

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **J91003** **Improvement of Safety Assessment Methodologies for near surface disposal facilities for radioactive waste (ISAM)**

Participating Countries: Argentina(A), Australia(A), Belgium(A), Brazil(A), Bulgaria(A), China(A), Cuba(A), Czech Republic(A), Egypt(A), Hungary(A), India(A), Indonesia(A), Japan(A), Korea, Republic of(A), Lithuania(A), Mexico(A), Romania(A), Russian Federation(A), Slovakia(A), Slovenia(A), South Africa(A), Spain(A), United Kingdom(A), United States (A), Vietnam(A)

Total Cost: **$130 006**

Duration: 1997-09-01 — 2001-03-31

CRP Overall Objectives

To review and improve approaches for post-closure safety assessment for near surface disposal facilities used in Member States.

CRP Specific Objectives

- to provide a critical evaluation of the approaches and tools used in post-closure safety assessment for proposed and existing near- surface radioactive waste disposal facilities;
- to enhance the approaches and tools used; and
- to build confidence in the approaches and tools used.

Research Outputs

The ISAM project has led to:

A review and enhancement of safety assessment approaches and tools for post-closure safety assessment;
The development of a broad consensus on the ISAM methodology, and its application in the evaluation of long-term safety of near surface disposal facilities;
Illustration of the ISAM methodology through three test cases - vault, borehole and Radon facilities;
Confirmation of the importance of the iterative character of safety assessment, and the adoption of multiple lines of reasoning;
The development and illustrative application of the ISAM list if features, events and processes for use in safety assessment of near surface disposal facilities.

CRP Outcome (Effectiveness; Impact; Relevance)

The project has improved and provided a broad consenus on the ISAM methodology for post-closure safety assessment. It has provided a better understanding of the need for systematic, logical and transparent evaluation and documentation of the long-term radiological impact of these facilities and approaches for gaining confidence in the results of such assessments.

Recommended Future Action by Agency

To prepare and initiate a new CRP to investigate the practical application of the ISAM methodology for the purposes of solving practical problems, such as safety reassessment and upgrading the safety of existing facilities; and systematic eview of safety assessment for near surface disposal facilities within the context of a licensing process.

CRP Published Results

The outcomes of the ISAM project were summarised in six working documents which are being consolidated into a final report entitled "Improvement of Safety Assessment Methodologies for Near Surface Disposal Facilities: Results of the Research Coordination Project". The report is currently under review and it is envisaged that it will be published in 2003. The report is presented in two volumes; Volume I describes the ISAM methodology and Volume II presents application of the methodology to three test cases.
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Accomplishments of CRPs Completed in 2001

CRP Number and Title: **T12012** **Modelling of transport of radioactive substances in primary circuit of water cooled reactors**

Participating Countries: Argentina(A), Bulgaria(C), Canada(A), Canada(A), Czech Republic(C), Finland(A), France(A), Germany(A), Hungary(A), India(A), Japan(A), Korea, Republic of(A), Norway(A), Russian Federation(A), Slovakia(C), United States (A)

Total Cost: **$173 123**

Duration: 1996-12-15 — 2001-12-31

CRP Overall Objectives

To improve the quality of activity transport computer codes used for radiation field prediction and water chemistry improvement.

CRP Specific Objectives

To improve the mechanistic understanding of radioactivity transport, to determine the accuracy of existing computer codes and to identify how they could be improved through application of this body of work.
Specifically:
To build a database for selected PWR plants that would contain the design information suitable for their description within a computer code, as well as give the operating history of the plant, which would include the water chemistry data over several efuelling cycles,
To show the contamination of selected out-core surfaces such as the steam generator channel head versus operating history,
To compare the prediction of surface contamination versus time from modern radioactivity transport codes with actual plant data,
To determine how the current codes could be improved,
To encourage the development of accurate new codes in other member countries using the recommendations from the present work.

Research Outputs

- Agreement between the various codes and the plant contamination data was generally good, e.g. with +/- 50%, but some codes agreed better with one dataset than another, illustrating the large effect of the different models within each code on its predictions.
- Material corrosion rate and release rate are among the most important parameters in the models since they determine the source of the corrosion products that enter the coolant. Selection of materials with the lowest possible corrosion rates and release rates combined with material compositions that provide the smallest source of neutron-activatable material will minimize activity transport and radiation field growth on out-core surfaces.
- Purification flow rate to either a filter or to an ion-exchange bed has a negligible effect on the rate of radiation field growth during plant operation. However, high purification flow during surface prefilming before initial start-up is essential to limit the amount of crud available for driving activity transport.
- All codes show the strong effect of water pH on activity transport. The importance of pH arises from its determination of metal oxide solubility and the change in solubility with temperature.
- The change in steam generator material from Inconel 600 to Incoloy 800 and its effect on activity transport is not well-predicted by the codes when compared with plant contamination data.
- Predictions from the simplest code compared as well with plant data as did the most complex codes. The simplest code is built around the transport of dissolved species created by metal oxide dissolution around the heat transport circuit and their removal by precipitation.

CRP Outcome (Effectiveness; Impact; Relevance)

In framework of the CRP, participating organizations (16 participating organizations from 14 countries) presented their experience in the development, qualification, implementation and improvements of computer codes for modelling of transport of radioactive substances in primary circuit of water cooled reactors. Thus, the first specific objective (exchange of information and overview of the state-of-the art in the above mentioned area) was fully met. More than 60 project papers and results of

participants investigations provided a technical basis for understanding how the computer codes could be improved further and which variables might reasonably be changed to effect a dose reduction in new and existing nuclear plants.

The influence of water chemistry on reactor primary circuit corrosion and on radiation fields are the amongst the major objectives of the IAEA project on Nuclear Fuel Performance and Technology, because of the improvement of NPP performance and safety. The CRP assisted to obtaining better knowledge in the majority of nuclear power producing countries in the above-mentioned area and advised on what and how to reach this objective.

The quality of activity transport computer codes used for radiation field prediction and water chemistry improvement has been improved. The first step has been establishing plant design and operation parameters, which in turn are used as input to the codes to predict radiation field growth on primary circuit piping in selected PWRs. A key feature is water chemistry data for each fuel cycle for two 440 MWe VVERs (Loviisa-1, Bohunice-1) and two 900-1300 MWe PWRs (Cruas-1, Gkn-2) over 5-15 fuel cycles. Compilation of all plant data on a CD-ROM has been done. Radiation field predictions from several codes show the observed influence of hot function testing, coolant pH at temperature, and the cobalt impurity content of both in core and out core components. These predictions are being done in exercises where the measured plant values for surface contamination and surface dose rate are not available to the code developers. A sensitivity analysis that was also done for each code can be used to suggest reasons for any major differences between predictions and data. Recommendations to improve code accuracy were made after an expert group review of the benchmarking results. As first step in this improvement, an initial assessment has been done of seven-activity transport codes used for predicting radiation fields and radioactivity transport. This assessment considers the various differential equations derived from mass balances to describe the transport of the various elements and radionuclides in the bulk coolant and their accumulation or release at a corroding surface. A major comment for most codes is their limited validation by experimental data and by plant data to confirm their application. The next generation of codes should be much simpler with limiting cases being used for the processes considered in the mass balances.

Recommended Future Action by Agency

After publication of the TECDOC, entitled "Activity Transport Modelling in Water-Cooled Nuclear Power Reactors" it is necessary to collect and review opinions of leading specialists in this field and to make a decision about new investigation in modelling of transport of radioactive substance.

CRP Published Results

Internal:
60 reports presented in the course of this CRP.

External:
TECDOC is in preparation.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **T13006 Corrosion of research reactor aluminium-clad spent fuel in water**

Participating Countries: Argentina(C), Brazil(A), China(C), Hungary(C), Hungary(C), India(A), Pakistan(C), Russian Federation(A), Russian Federation(A), Thailand(C), United States (A)

Total Cost: **$198 868**

Duration: 1995-12-15 — 2001-11-30

CRP Overall Objectives

To provide the information necessary to improve basin management practices, establish operational limits and predict the lifetime of exposed components. This information, when combined with the results of fuel characterization efforts, will also support the ability to predict fuel behaviour during the long-term, interim storage in water environments.

CRP Specific Objectives

To expose identical, ASTM type, corrosion coupons in the spent fuel storage basins at participating Institutes;
To implement a programme for monitoring, examination and evaluation of the coupons and training of the participants in the monitoring and evaluation methods chosen;
To implement a monitoring programme to assure uniform assessment of basin water chemistry, including training of basin operators in the techniques chosen;
To implement a programme for analyzing and presenting the information collected;
To develop a guidance document for the wet storage of aluminum clad fuel in optimum water chemistry to minimize corrosion.

Research Outputs

The CRP has been extremely effective in specifying optimum wet storage conditions and best management practices. However, it has not succeeded entirely in being able to predict corrosion pitting rates in poor water chemistry.
The methodology used in the CRP has certainly contributed to the overall objective in that a panel of experts in Latin America chose to duplicate it in the Regional TC Project and that there was unanimous agreement that a second CRP on the same topic should be initiated with different participants to continue the research.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has had a significant impact. By communicating optimum water chemistry parameters to the research reactor community many sites have improved their water chemistry and fuel management practices, with a probability that many fuel assemblies have been saved from leaking.
The CRP was initiated at a time when many discoveries of degraded research reactor spent fuel assemblies were made, mainly through the fact-finding missions visiting sites to assess the physical conditions of spent fuel for possible shipment back to the country of origin. With many countries deciding to continue operation of their research reactors after the termination of fuel return programmes and many more that are not eligible for any operative return programme, wet storage of research reactor fuel will continue to be relevant and a challenge for many Member States.

Recommended Future Action by Agency

A second round of the CRP has been initiated. With the termination of the second CRP it is expected that all research reactor facilities in the world will have sufficient information for the safe long term storage of aluminium clad fuel.

CRP Published Results

Internal:
Corrosion of research reactor aluminium-clad fuel in water. Final Report of the CRP. An IAEA paid publication, in press.

External:
Over 20 external publications have reported work first carried out in the CRP or acknowledged support of the CRP.
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[3] P. Brooks and R. L. Sindelar, "Characterization of FRR SN1 in Basin and Dry Storage Systems," Proceedings of the Third Topical Meeting on DOE Spent Fuel and Fissile Materials Management, (Charleston SC, September 1998): p. 542-549.
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[6] J. P. Howell, "Corrosion Surveillance in Spent Fuel Storage Pools," NAC 1: Corrosion," 97, paper 107, (Houston, Texas: National Association of Corrosion Engineers, 1997).
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[15] R. Haddad, A. N. Loberse, C. J. Semino and R. Guasp. -Evaluation of Aluminum-Clad Spent Fuel Corrosion in Argentine Basins", Transactions of the 5th International Topical Meeting on Research Reactor Fuel Management, Aachen.Germany. p. 93-97, April 1-3. 2001.
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Other Outputs:
Proceedings of a Workshop on Characterization, Management and Storage of Spent Fuel from Research and Test Reactors, organized under TC Regional Project Rer/9/058 contained seven papers from participants in the CRP touching various aspects

of the CRP research. These proceedings were widely distributed throughout the research reactor community as Working Material.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **T21018 Combined methods of liquid radioactive waste treatment**

Participating Countries: Belarus(C), Belgium(A), Bulgaria(C), China(C), Czech Republic(C), Hungary(A), India(C), Iran, Islamic Republic of(C), Korea, Republic of(A), Korea, Republic of(A), Malaysia(C), Russian Federation(A), Russian Federation(A), Russian Federation(A), Turkey(A), Ukraine(C), United Kingdom(A)

Total Cost: **$228 900**

Duration: 1997-04-01 — 2001-12-31

CRP Overall Objectives

To outline areas of prospective combination of different waste processing steps, techniques and process materials for improving the overall efficiency of waste processing.

CRP Specific Objectives

To gain practical experience in the development and operation of pilot- and full-scale facilities utilizing combined treatment processes for liquid radioactive waste.

Research Outputs

During the implementation of the CRP it was recognized that sufficient potential exists for employing novel materials with combined properties and functions in waste processing, or in application of combined methods for liquid waste processing. In the framework of this CRP combined methods could be grouped into three categories:
-Application of materials with combined properties;
-Application of different treatment principles in a single stage, and
-Combined multistage treatment processes.
All these options have high potential for application in liquid waste processing.

CRP Outcome (Effectiveness; Impact; Relevance)

The identified overall objective of the CRP was met, e.g. prospective areas and options for application of combined methods for liquid waste treatment were identified and tested at different scales of application. Several combined processes for liquid radioactive waste treatment have been realized on pilot-scale facilities with real radioactive waste.
Implementation of the CRP has contributed towards development and testing several new methods for treatment of radioactive liquid waste with complex compositions, which generally are difficult to process by single conventional methods.

Recommended Future Action by Agency

The Agency should continue to support research and development programmes in most complicated waste management areas through establishing and supporting relevant CRPs.

CRP Published Results

Internal:
TECDOC-1336 "Combined methods for liquid radioactive waste treatment", Vienna, 2003.

External:
Results of CRP implementation were reported at the 14th International Radiochemical Conference held in Marianske Lazne, Czech Rep. in April 2002.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **T21019** **Long term behaviour of low and intermediate level waste packages under repository conditions**

Participating Countries: Argentina(C), Canada(A), Czech Republic(C), Egypt(C), Finland(A), India(A), Korea, Republic of(A), Norway(A), Romania(A), Russian Federation(C), Spain(A), Thailand(C), United States (A)

Total Cost: **$153 750**

Duration: 1997-09-01 — 2001-12-31

CRP Overall Objectives

To promote R&D activities relevant to the performance of low and intermediate waste packages, exchange and discuss information available on the topic in the various participating countries, and to review the research completed during the course of the CRP.

CRP Specific Objectives

To investigate the behaviour and performance of low and intermediate level waste package components under anticipated disposal conditions. The main focus of the experimental programme was on the test methods and approaches applicable to the assessment of waste package behaviour and performance. A secondary focus was to define the link between date collection and performance assessment of waste packages.

Research Outputs

From the range of technical activities carried out under the CRP experimental programme, specific outputs that have a direct bearing on waste package behaviour and performance under repository conditions can be summarized as follows:
- Test methods and approaches that may be applied for the assessment of waste package behaviour and performance
- Factors and conditions which may affect waste form/package performance over time
- Underlying processes controlling the behaviour and performance of the different types of waste forms and packages
- Data requirements, in particular mechanistic data that is amenable to extrapolation and modelling, for waste package performance and source term behaviour
- Long term, in situ field testing of waste packages
- The link between data collection and model development for the assessment of waste packages

CRP Outcome (Effectiveness; Impact; Relevance)

· Given the high degree of variability in the factors, conditions and processes, as well as waste package components and testing methods and approaches, affecting the behaviour and assessment of waste package performance, the CRP was effective in that the various issues summarized above were addressed to varying degrees.
· The CRP was particularly useful in the area of testing methods to derive relevant mechanistic data and modelling to predict waste form/package performance over time.
· It is expected that the CRP will increase the awareness in Member States of the importance of testing methods and approaches for generating meaningful data on waste package behaviour and performance. This is particularly important if waste package data is to be considered and interpreted in the context of repository safety assessment.
· Another important outcome of the CRP is the realization and recognition (by many participants) that the waste package is an integral part of a waste repository and that waste package testing and assessment need to be considered, not in isolation as a discrete activity, but in the context of overall repository safety and performance.

The direct impact of the CRP is that the various participants were exposed to a range of approaches and methodologies applicable to waste package testing and assessment. This, in turn, has a beneficial effect on the national disposal programmes in participating countries.
The CRP has direct relevance to the national disposal programmes of the various participating countries in the sense that waste package assessment is a key component of the repository development process.

Accomplishments of CRPs Completed in 2001

Recommended Future Action by Agency

No further action is needed to this CRP but a specific area not considered in the CRP is being addressed in a new CRP (T2.40.06) entitled "Disposal Aspects of Low and Intermediate Level Decommissioning Waste", launched in 2002.

CRP Published Results

Internal:
TECDOC in preparation.

External:
Dayal, R., "International Co-ordinated Research Project on Low and Intermediate Level Waste Packages", Proc. Global 2001 - Back-end of the Fuel Cycle: from Research to Solutions, 9-13 September 2001, Paris, France.

Accomplishments of CRPs Completed in 2001

CRP Number and Title: **T24005 Decommissioning techniques for research reactors**

Participating Countries: Belarus(C), Belgium(A), Canada(A), Denmark(A), Egypt(A), India(C), Indonesia(A), Korea, Republic of(A), Pakistan(A), Russian Federation(C), Russian Federation(C), Spain(A), United Kingdom(A), United States (A)

Total Cost: **$166 270**

Duration: 1997-07-01 — 2001-12-20

CRP Overall Objectives

To promote the exchange of information on the practical experience gained by Member States in decommissioning of research reactors or operation, maintenance, and refurbishment activities that would be eventually related to the decommissioning. By doing so, to promote progress toward timely planning and implementation of decommissioning.

CRP Specific Objectives

The specific objective of this CRP was the development/adaptation of methods and approaches for optimization of the decommissioning process, with the following specific target areas: design, construction and operational features to assist in final decommissioning; planning for decommissioning, including technical solution assessment; radiological and physical characterization; dismantling and decontamination technology; waste management; restricted and unrestricted site release; costs and financial provisions; decommissioning and refurbishment experience; and lessons learned.

Research Outputs

This CRP investigated practically the whole range of decommissioning-related activities and technologies for research reactors. R&D work was conducted through nine research agreements and four research contracts. Progress and issues were debated and shared by Chief Scientific Investigators (CSIs) in three Research Coordination Meetings (RCMs) held in Mumbai, India (1998), Taejon, Korea (2000), and Kendal , UK (2001). Dissemination of CRP results took place through TECDOC-1273, 2002

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP was effective in exploring practically all of the aspects of decommissioning ranging from theoretical modelling to laboratory, pilot or industrial scale applications. Progress reports circulated at the three RCMs and the final TECDOC were effective in disseminating information and results within and beyond the committee of CSIs. The CRP succeeded in transferring information and know-how from active decommissioning projects to those planning for decommissioning. It is also expected that this project, and in particular the papers collected in TECDOC - 1273, will draw Member States' attention to the need for timely planning for and implementation of decommissioning. The major impact of this CRP was to enhance Member States' awareness of the need to plan for decommissioning in an early, accurate fashion. In addition, through this CRP major factors were highlighted to be taken into account at the planning/implementation stage, in particular when developing new technologies.
This CRP was relevant to the Waste Technology Programme of the IAEA in that decommissioning applies to materials which are or may become radioactive wastes with a particular emphasis on waste minimization, one of the focus areas of this programme.

Recommended Future Action by Agency

The IAEA should continue to expand its decommissioning programme in parallel with the growing awareness by Member States that their aging or shutdown facilities need timely, cost-effective and safe decommissioning. Relevant activities could be developed in further CRPs on decommissioning of nuclear installations.

CRP Published Results

Internal: Interim progress reports

External: TECDOC-1273, 2002