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ESARDA

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16th Annual ESARDA Meeting

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The Sixteenth Annual ESARDA Meeting had a participation restricted to the ESARDA members, i.e. Steering Committee Members, ESARDA Coordinators, ESARDA Working Group Members and Observers, and a few invited specialists. This meeting was based on the results of the work of the ESARDA Working Groups and also had a special session for celebration of the 25th ESARDA Anniversary.
It is customary not to openly circulate the proceedings of the internal meetings, because of delicate items that are preferably reserved to the specialists and not to the general public. Nevertheless, for this particular meeting, the matter discussed is not confidential so that the ESARDA Steering Committee decided to have a free circulation of the results. This special issue of the ESARDA Bulletin containing the papers discussed at the meeting and the final considerations drawn is therefore circulated openly.
The report of the Reflection Group on the Future of ESARDA will be included in the next issue.

The 16th Annual ESARDA Meeting

L. Stanchi
Editor

As announced in the ESARDA Bulletin No. 23, the 16th Annual ESARDA Meeting was held in the historical centre of the city of Ghent, Belgium on 17-19 May 1994. All the room facilities were found in the Pand, an old building belonging to the University of Ghent.

The meeting was mostly based on individual and joint sessions of the ESARDA Working Groups, the programming of the Working Groups' operations and the prospective analysis of the ESARDA activities. After their individual and joint meetings, the six Working Groups presented their conclusions to the Steering Committee in the plenary session. Then the past chairman of ESARDA, Mr Déan, reported on the work of the reflection group.

The afternoon of the last day was devoted to the celebration of the 25th anniversary of ESARDA with a summary of the 25year activitiy by the present ESARDA Chairman, Mr. Cuypers, and addresses of several specialists, authorities and former ESARDA chairman.

A very touching social event occurred in the first evening: we had a musical performance with a piece for two pianos of Ravel and a very exciting execution of Carmina Burana of Carl Orff by the European Commission Choir accompanied by two pianos and percussions. This excellent performance was followed by a rich buffet dinner. We also wish to remember that the meeting was closed by a celebration cocktail in honour of the ESARDA 25th Anniversary.

Programme of the 16th ESARDA Meeting

The programme of the meeting is synthetically reported here:

Session 1 **Opening Session**
Chairman: P. De Regge (CEN/SCK Mol)
Secretary: R. Carchon (CEN/SCK Mol)

Welcome Address
G. Temmerman (Mayor of the City of Ghent)

Opening of the 16th Annual Meeting
M. Cuypers (JRC Ispra, Chairman of ESARDA)

Programme and Organization
R. Carchon (CEN/SCK Mol)

Session 2 **Parallel Sessions**
Session 2.1 DA Working Group
Session 2.2 NDA Working Group
Session 2.3 C/S Working Group
Session 2.4 RIV Working Group
Session 2.5 LEU Working Group
Session 2.6 MOX Working Group
Steering Committee Session

Session 3 **Plenary Session**
Chairman: G. Stein (KFA Jülich)
Secretary: R.J.S. Harry (ECN Petten)

Report of the DA Working Group
P. De Bièvre (JRC Geel)

Report of the NDA Working Group
S. Guardini (JRC Ispra)

Report of the C/S Working Group
B. Richter (KFA Jülich)

Report of the RIV Working Group
M. Dionisi (ENEA, Casaccia)

Report of the LEU Working Group
P. Boermans (FBFC, Dessel)

Report of the MOX Working Group
R. Ingels (Belgonucléaire, Dessel)

Report of the Reflection Group on the Future of ESARDA
G. Déan (CEA, Fontenay-aux-Roses)

Session 4 **Celebration of the 25th Anniversary of ESARDA**
Chairman: M. Cuypers (JRC Ispra)
Secretary: C. Foggi (JRC Ispra)

25 Years of the European Safeguards Research and Development Association
M. Cuypers (Chairman of ESARDA)

Incentives for a Reasonable and Useful Application of Plutonium Stocks in Reactors
C.M. Malbrain (Director General) and **R. Carchon** (CEN/SCK Mol)

ESARDA: The Forum to foster Nuclear Safeguards in Europe
W. Gmelin (Director) and **W. Kloeckner, R. Schenkel** (Euratom Safeguards Directorate, Luxembourg)

IAEA Safeguards beyond the 25th Anniversary of the Nuclear Non-Proliferation Treaty
B. Pellaud (Deputy Director General, IAEA, Vienna)

INMM Present and Future Activities
C. Sonnier (INMM Safeguards Division)

Address at the 25th Anniversary of ESARDA
P. Frederiksen (former ESARDA chairman)

Possible Future Considerations for ESARDA
D. Gupta (former ESARDA chairman)

Action of the European Commission
S. Finzi (former ESARDA chairman)

Opening Address by the Chairman of the Meeting

P. De Regge
CEN/SCK Mol, Belgium

Mr. Mayor,

Mr. Chairman of ESARDA,

Ladies and Gentlemen, Dear Friends and Colleagues, at the opening of the 16th ESARDA Symposium at Ghent, I have the honour and the pleasure to welcome Mr. Gilbert Temmermann, Mayor of this ancient and beautiful city which is hosting our conference.

In this city we found a location like Het Pand which provides the facilities for celebration of the past as well as the quiet serenity for reflection on the future.

On behalf of the Belgian Nuclear Research Centre in Mol, the members of its Board and its general manager Mr. Carl Malbrain, I have the honour to welcome you at the 16th annual symposium of the European Research and Development Association. The Belgian Nuclear Research Centre has been one of the founding members of ESARDA and has supported and participated in many of its activities. The Belgian Nuclear Research Centre is honoured by the mandate from the ESARDA Steering Committee to organise this meeting which will include the celebration of the 25th Anniversary of ESARDA.

I welcome the presence at this symposium of representatives from the Safeguards Authorities, the EURATOM Safeguards Directorate and the International Atomic Energy Agency and from our sister organisation the Institute of Nuclear Materials Management.

Within the European Union I welcome participants from France, Germany, Italy, the United Kingdom, Spain, Luxembourg, The Netherlands, Denmark and Belgium.

Very close to the European Union I welcome participants from Finland, Sweden and Switzerland.

From outside the European Union I welcome our colleagues from the Eastern European countries Hungary and Russia.

Last but not least I welcome our colleagues from farther continents, the United States of America and Japan.

Some years ago the Nuclear Research Centre in Mol went through a restructuration, which was a consequence of the restructuration of the Belgian State.

In the revised statutes issued at the end of 1991, the research and development activities were focused and reoriented towards three main fields:

Reactor safety

Waste and Decommissioning

and Radioprotection.

However, in addition specific responsibilities were explicitly referred to in the terms of reference of the Nuclear Research Centre:

- the first one commends to consolidate and maintain the expertise and to carry out research for the implementation of the nonproliferation treaty in the Belgian nuclear industry;
- the second one commends to preserve and develop the expertise for the measurement and the assay of special nuclear materials.

Support by the Nuclear Research Centre in Mol to activities of interest to ESARDA is therefore fairly well secured in the future and new ideas developed in Mol in this framework will be presented to you by our General Manager during the academic session on Thursday.

I take this opportunity to thank all those who cooperated to organise this meeting and the associated and somewhat special social activities.

In particular I thank our sponsors who supported ESARDA's activities in many instances in the past and again for this meeting were prepared to contribute to its realisation: the European Commission, Canberra Packard Benelux, Belgonucléaire, Franco-Belge de Fabrication de Combustibles and EG&G Ortec.

I also wish to express my appreciation to those who did most of their work already before the symposium and will continue to be available to help you, whatever problem you may have during this meeting, those who had almost no sleep during the last fourteen days and when they did the last revision of the list of participants was certainly haunting their dreams. I wish to thank already now Roland Carchon, Anne Verledens and Ans Vermeulen for the practical organisation of this meeting.

The 16th ESARDA Conference is not formally centred around a particular theme but there will certainly be no shortage of themes for discussion. Allow me to add one thought of reflection for this meeting.

For a while we all thought that, after the cold war, the world's nations were all united in a common civilisation and a collective project of human dignity. We all took for granted a long and rewarding era of worldwide peace with the United Nations growing to a planetary authority watching over social as well as economic order and justice.

Indeed, we are writing important pages of history today, at the turn of both the century and the millennium, and not only in the Middle East or in South Africa.

But we are also witnessing that the world is not growing into a safer and more quiet place to live.

We have witnessed attempts to acquire nuclear weapons in a clandestine way, some of them now confessed openly to be successful. We are witnessing every day the excesses of human behaviour, or maybe of nonhuman behaviour, in Bosnia, in Somalia, in Rwanda. In spite of all good intentions and efforts we seem uncapable to keep the world in control and we witness on our television screens how advanced weaponry is more accessible than food in many places on earth.

By what kind of structure, of controls and of safeguards systems are we going to keep nuclear weaponry away from this scene in the 21st century? I believe it is our mission now to design and start the development of the technical means that will be needed to achieve this.

Welcome Address

G. Temmerman
Mayor of the City of Ghent

Mr. Chairman,
Ladies and Gentlemen,

at the start of your symposium, it is my sincere pleasure to bid you a hearty welcome on behalf of the Ghent Municipality.

We are particularly pleased by the fact that the initiators of this conference have chosen our city as meeting place for your important international company.

The last few years the City of Ghent has made large efforts in order to present itself as a city of congress and it goes without saying that a prestigious meeting like yours largely helps to achieve that goal.

Moreover, we consider it a great honour that the European Safeguards Research and Development Association, ESARDA, which exists 25 years in 1994, is going to celebrate this anniversary in our city at the end of the present conference.

Since the end of World War II fundamental and applied research in nuclear sciences as well as the peaceful use of nuclear energy have been attentively followed by different generations of Flemish engineers, physicists and other academics. Owing to their impact the "Studiecentrum voor Kernenergie" (S.C.K.), the Belgian Research Centre of Nuclear Energy, founding member of ESARDA, has achieved a worldwide renown in the last decades. Within and outside Europe, Belgium is known as a country where a large amount of the demand for electric energy is provided by energy of nuclear origin. The University of Ghent, where a postgraduate of "Engineer in Nuclear Sciences" was established in the academic year 1961-1962, has largely contributed to the renown of Belgian research centres in this sector, as well as to the development of nuclear industry in our country, particularly the nuclear production of electric energy.

Belgium, which is the heart of Europe from a historical as well as from a current and future point of view, has too often, in the course of its history, been the scene of bloody wars between economically competing foreign powers. Consequently, our country was one of the first states to ratify the Nonproliferation Treaty. Even after the Cold War the presence of nuclear arms and the risk to use these weapons of destruction to settle military conflicts remain one of the largest threats to mankind. Research aimed at adequately achieving control on nonproliferation therefore remains of exceptional importance.

In comparison with fossil fuels, the production of electric energy of nuclear origin unmistakably has quite some ecological advantages: the emission of carbon dioxide, one of the main factors causing global warming, and the emission of sulphur dioxide, which results in acid rain, remain absent. In order for nuclear energy to be accepted as a reliable energy source, it is, however, strictly necessary to improve the security of all links of the nuclear chain, also that of the most riskfree component, the nuclear reactor, and that reliable solutions for nuclear waste are developed. We highly appreciate that ESARDA has set itself the task of contributing to a lasting economic development within the sector, without hypothecating the next generations.

We are interestedly looking forward to the final report of your study group, which was established in December 1992, in order to contemplate the future orientations of ESARDA and of the activities of the different working groups. Among other things your research on the cooperation with East European States and the role which the Association can play regarding the security of nuclear military equipment resulting from dismantling nuclear weapons, are vitally important for peace and public security all over the world.

This is all to let you know that we are fully aware of the importance of your meeting, which I wish to be very successful.

I hope that this symposium may give you much scientific satisfaction, as much as I hope that you will retain good memories of your stay in our city.

Opening of the 16th Annual ESARDA Meeting

M. Cuypers
Chairman of ESARDA
EC, JRC Ispra, Italy

Ladies and Gentlemen, it is a great pleasure for me to thank, on behalf of ESARDA, the city of Ghent to host our 16th annual meeting, which occurs at the time of the 25th Anniversary of our Association. This is an important event for all of us because it also coincides with some important changes in the world which could have some impact on future ESARDA activities.

During this meeting we will establish a balance of our activities and reflect how we can contribute to address some of the new challenges of our society.

We are very happy to be in this beautiful city and the venue in this ancient building seems to me very appropriate for reflecting on these important matters. We have to think how R&D people, Plant Operators and Inspectors can progress in the confidence building process, and finally provide assurance and credibility that nuclear energy is an element of further peaceful development of our society and prosperity and not the source of confrontation.

On behalf of ESARDA I like to express my gratitude to SCK (Mr. De Regge and Carchon, in particular) for all the effort made in the preparation of this annual meeting and of the celebration.

I like to welcome all the participants to our annual meeting and wish that the activities, which will be performed in the Working Groups, in the next 3 days will be fruitful. A particular welcome also to our participants outside of the European Union, from IAEA, Canada, Finland, Hungary, Japan, Russia, Switzerland and United States.

A special mention has to be made to the participants from Russia, which have accepted to join us in the discussion of some Working Groups. This is the first time that Russian colleagues participate to those technical meetings and we are looking forward to strengthen our future technical cooperative work.

At many occasions, it has been stated that the ESARDA Working Groups are the main actors of the Association. Through the Working Groups, joint projects are performed, in the field of evaluation of performances, of measurement systems, of standardization, of identification of R&D needs, of establishing inventory of available tools and R&D activities.

These are activities where it is necessary to cooperate, to work together to build up consensus and credibility. So the role of the Working Groups is fundamental for the Association.

However, it appears that the activities and their results are not sufficiently known to the outside world and even to some extent to the ESARDA Steering Committee and the coordinators.

For this reason, in the framework of the ESARDA reflection group established by the Steering Committee, some discussions took place on how to improve this situation. One of the conclusions is that the Working Groups should aim in the future:

- to report periodically (for instance yearly) in a synthetic manner the results of their activities or meetings in the bulletin
- to analyse how the present activities match the identified needs of inspectors or operators or, if not so, how these activities are addressing more long term challenges not yet clearly formulated by potential clients
- to plan more strictly and with 1 to 1.5 year in advance, the main lines of their programme and their meetings including the agendas.

This last point is important in view of attracting plant operators and inspectors by presenting a well documented justification on the validity of the ongoing studies.

Several Working Group convenors have asked at the joint coordinators - convenors meeting held in February, to re-examine in detail the terms of reference and objectives of their Working Groups. This will be one of the main tasks of the secretariat and the Executive Committee in the second half of the year.

At the plenary session on Thursday, we are looking forward to receiving a report from the Working Groups on activities with some indications on future areas of investigation.

I officially open the 16th Annual Symposium of ESARDA.

Report of the ESARDA Working Group for Destructive Analysis (DA)

P. De Bièvre, Convenor of the Working Group, **K. Mayer**
CEC, IRMM, Geel (Belgium)

Terms of Reference of the Working Group

To provide the ESARDA Steering Committee with expert advice on destructive analysis methods suitable for Safeguards purposes which can be used in conjunction with plant measurements to derive material balance data.

To achieve this, the Working Group will:

1. act as a forum for the exchange of information on measurement methods and to recommend the introduction of new and improved methods;
2. communicate Performance Values for uncertainties in measurements of nuclear materials for Safeguards purposes;
3. recommend updated Target Values for Uncertainties in measurements of nuclear materials for Safeguards purposes;
4. maintain a list of analysis methods suitable for accountancy and verification purposes;
5. promote the systematic and correct use of Reference Materials by:
   a) maintaining a list of Reference Materials available within the European Union
   b) maintaining information on their traceability
   c) advising on their distribution and transport problems;
6. objectively determine the reliability of accountancy measurements by continuing interlaboratory measurement evaluation programmes e.g. REIMEP, EQRAIN; in particular the Group will:
   a) identify analytical problems of common interest
   b) define the objectives and the design of the programmes
   c) evaluate the results;
7. consider sampling problems and their significance in accountancy measurements (including sample storage, transport, stability);
8. promote the use of correct and internationally accepted terminology in measurements (International Vocabulary of Basic and General Terms in Metrology - IAEA Safeguards Glossary);
9. observe and support developments in environmental monitoring for Safeguards purposes.

Summary of the Working Group Meeting

The 1994 Spring Meeting of the WGDA was held in the frame of the ESARDA Symposium in Ghent. Sixteen Agenda points had to be discussed in less than two working days. Some major points will be reported here in order to give some insight into the Working Group's activities and enable interaction with interested parties.

A considerable part of the time was dedicated to basic and strategic thinking, especially with respect to the future activities of the Working Group. However, there was time enough for scientific/technical discussions and exchange of information.

The issue of "measurement quality" has triggered several points of discussion:

- Status reports and results of external quality control programmes REIMEP and EQRAIN. These two items regularly appear on the agenda of WGDA, hence enabling the Working Group to permanently follow the evolution and reiterate on performance values and target values.
- Measures to assure the quality of results are a point of interest in all laboratories. A presentation of the "Quality and Data Management System" of the IAEA-SAL highlighted the importance of a well established Q.A. plan for economical (less samples need to be repeated) and scientific/technical reasons (early detection of measurement problems). Three Q.A. models were compared: the "Delvin" system, the "Ratliff" reference model (currently used at SAL) and the ISO-9000 model (which will be considered for the future).
- The problem of quantification of sampling errors was tackled in view of a reduction of the total error of the measurement process, to which the sampling component may contribute a major portion. The calibration of the tank mass/volume of an imput accountancy tank was shown using the example of the new UP2-800 facility at La Hague.
- Traceability of chemical measurements, i.e. the linking of measurement results to the SI system through an unbroken chain of comparisons, is an issue that has been brought to the attention of analytical chemists only recently. It was emphasized that any lack of traceability will lead to results that are actually not comparable. Consequently, and awareness programme is needed to highlight the importance of the problem.
- The presentation and certification of the PERLA standards illustrated how Q.A. measures led to a reliable product and how traceability (to international standards) was established.

Environmental monitoring for safeguards purposes was taken up in the "Terms of Reference" of the Group. The Group will start working on this issue as soon as possible.

Report of the ESARDA Working Group for Non-Destructive Analysis (NDA)

S. Guardini
Convenor of the Working Group, EC, JRC Ispra, Italy

1. Introduction

The ESARDA Working Group on TECHNIQUES AND STANDARDS FOR NON DESTRUCTIVE ANALYSIS, coherently with its terms of reference, has identified its following main tasks:

- Facilitate circulation of information and technology transfer
- Define needs for procedural standards and reference materials
- Design and sometimes produce reference materials
- Assess and contribute to improve the performances of NDA techniques

The group is presently composed by 19 members and 8 observers. Observers come from Japan (PNC), 4 from USA (LLNL, LANL, BNL, ANL), Finland (STUK), Hungary (Technical University Budapest) and IAEA Vienna.

Members are appointed by UK (AEA, BNFL: 2 members) France (CEA: 4 members) Germany (Siemens, WAK, GNS, KFK), Netherlands (ECN), Belgium (SCK/CEN), Spain (ENUSA), Italy (ENEA). The European Commission provides 4 members: one from Euratom Safeguards Directorate (ESD) and three from each JRC laboratory at IRMM-Geel, TUI-Karlsruhe and IST-Ispra.

Members and observers represent plant operators, nuclear industry, R&D laboratories, NDA instrument developers and both safeguards control authorities.

Very good support has permanently been provided to the WG activities by both safeguards authorities, EURATOM Safeguards Directorate (ESD) and IAEA.

The participation and direct involvement of major European plant operators, has always been assured and contributed to the good outcome of the WG activities. Meetings take place twice per year. Special topical meetings are held frequently on items of specific interest, e.g.:

- NDA on nuclear waste materials: SALAMANCA May 1992
- Passive Neutron Workshop: PERLA, April 1993

Later on more details will be given about topical meetings.

The Group has, for some years, appointed subgroups with specific competences and tasks. One example is the subgroup structure given in Annex 1 that was appointed with the task of assessing NDA Performance Values.

2. Activities of the NDA Working Group

Following the main tasks of the Group, as described in the previous section, a number of activities carried out and concluded by the group are now described. They are:

- Intercomparison Exercises (PIDIE)
- Workshops: Waste (Salamanca, May 1992), Passive Neutrons (PERLA, April 1993)
- Performance evaluation: NDA ESARDA Performance Values, IAEA International Target Values (ITV)
- Reference materials
- Varia

For each of the above activities a brief report is given, together with a short description of their outcome, in the attempt to show an overall view of the 'product' of the working group efforts.

2.1 PIDIE: Plutonium Isotopic Determination Intercomparison Exercise

The aim of the PIDIE exercise was to test the recent X/gamma-ray methods for measuring plutonium over a wide range of isotopic compositions, to give an opportunity to improve them and to investigate sources of error. An additional aim was to examine the possible measurement improvement by using CBNM pilot reference samples /1/.

The PIDIE exercise can be considered as a real blind test to confirm the possibilities of X/gamma-ray spectrometry for isotope abundance measurements.

The participants were asked to determine the atomic ratios of seven samples. The participants were also asked to give the 242Pu/Pu ratios derived from isotopic correlations.

They were asked to describe the main characteristics of their instrumentation and the measurement set-up. They had to give information on the methods applied, on peak analysis and efficiency calibration procedures. They also had to report the values of the nuclear data used (half-lives and X- or gamma-ray emission probabilities).

Identical sets of seven plutonium samples were prepared and dispatched by AERE HARWELL of the UKAEA. The sample containers were designed about 12 years ago and the preparation of the samples began not long after, but the final dispatch was delayed due to obstacles encountered in the export of nuclear materials.

PIDIE Samples				
Batch number	Isotopes ratios %			
	238Pu/P*	239Pu/P	240Pu/P	241Pu/P
1	0.01	94	6	0.2
2	0.02	89	10	0.4
3	0.05	85	14	1.0
4	0.1	78	20	1.8
5	0.1	76	21	2.0
6	1.0	69	25	5.4
7	1.3	65	27	6.8

* P=238+239+240+241

Nine laboratories participated in the PIDIE exercise for X/gamma-spectrometry measurements:

- ANMCO HARWELL (UK)
- EC/IRMM Geel (B)
- SCK/CEN MOL (B)
- EC/JRC Ispra (I)
- ECN/PETTEN (NL)
- ENEA CASACCIA (I)
- IAEA Vienna (A)
- LANL (USA)
- LLNL (USA)
- CEA/DAMRI/LMRI (F)

Results and conclusions were presented in a final report /2/.

In the field of Intercomparison Exercises it is worth mentioning that the NDA WG has collaborated with other groups (DA WG in particular) and organizations (e.g. JRC-IRMM) in the definition of specifications, the management and execution of other Exercises. One example is REIMEP /3/, for which studies for the design of the container, the actual NDA measurements and some general NDA, were also discussed in the NDA WG.

2.2 Workshops

The NDA Working Group has shown in past years to be a powerful tool of technology transfer and circulation of scientific information.

In this field we mention here the special workshops organised by the Group with the aim of discussing a specific item, defining the state of the art, assessing performances and indicating future R&D directions. The following meetings were organised directly or indirectly sponsored by the NDA WG:

a. Gamma Spectrometry on Plutonium (PERLA Sept. 1991) /4/
b. Calorimetry on Plutonium and Tritium (PERLA, March 1992) /5/
c. NDA on Waste for Safeguards (Salamanca, May 1992) /6/
d. Passive Neutron Workshop (PERLA, April 1993) /7/

a. Workshop on Performance evaluation of Gamma Spectrometry on Plutonium

The workshop was organised at Ispra by the JRC with the support and the participation of ESARDA laboratories. Safeguards Authorities and US laboratories also participated. The scope was to determine the performances of 4 different spectrum analysis tools from ESARDA laboratories and US tools mostly used in safeguards.

The workshop was an hands-on workshop with topical presentations and measurements on the PERLA Pu standards. Data were analysed with ad hoc statistical tools, properly designed for the experiment. The outcome of the workshop was a very detailed assessment of the performances of gamma spectrometry in field and laboratory conditions. Data have been forwarded to both Euratom and IAEA inspectorates for them to use in their evaluations /4/.

b. Workshop on Calorimetry on Pu and T

This workshop was also sponsored by the ESARDA NDA WG but jointly organised by JRC and EG & G MOUND (US). It had the same scope and was conducted in a similar way to the previous one; i.e. assessing performances of calorimetry applied to Plutonium and Tritium. Laboratory exercises were organised with 5 different plutonium calorimeters at PERLA. About 15 laboratories participated from ESARDA member parties and US.

EURATOM participated intensively also in the organisation phase.

The outcome of the workshop has been reported in /5/, in the form of technical papers, recommendations and future directions on R&D. Particularly interesting have been the discussions concerning the evaluations of effective power in comparison with Pu240 equivalent.

c. Workshop on 'NDA on WASTE'

In 1992 the Working Group was requested by the ESARDA Steering Committee to prepare and organize a workshop on NDA techniques applicable to Safeguarding nuclear material in waste. The workshop was held at Salamanca (Spain) in May 1992.

The objective of the workshop was to review the current status and desired developments of NDA techniques for safeguarding nuclear material in waste with the participation of people in charge of the nuclear material measurements.

Specific objectives were to:

- Identify suitable NDA techniques for safeguarding Special Nuclear Material (SNM) in waste materials
- Review the status of the development and implementation and the performances of present NDA techniques
- Address the technical problems arising in the use of the above techniques for safeguards purposes e.g. authentication of operator systems
- Identify areas for further developments and potential improvements of NDA techniques.

Operators from Enrichment, Fabrication and Reprocessing Plants of the European Community countries were represented, as well as the Euratom Safeguards Directorate and EU development laboratories. Observers from US plants and laboratories (LANL, BNL, LLNL, ANL) and from Japan (PNC) were also present.

Subgroups reviewed the waste arisings from enrichment, fabrication and reprocessing facilities. They discussed the present accountancy and assay systems, evaluated actual performance values and made recommendations for the future.

The workshop then elaborated the main conclusions, derived from plenary sessions (presentation and discussions) and from the work of subgroups /6/ (see also Annex II).

From the presentations given by operators and EURATOM Safeguards Directorate, the main conclusion was that in the field of NDA measurements for safeguards on waste there are no particular problem areas. Some developments to be implemented have been identified, i.e. to improve NDA measurement performance on conditioned waste streams and on samples with unknown and/or heterogeneous matrix: but the actual discrepancies between achieved and required performances were not considered significant.

The reasons for this situation were identified as:

- recent improvements of the performance in NDA techniques
- relatively low quantities of SNM in most waste streams, therefore generally representing very minor contributions to overall balance uncertainty
- improvements in industrial process techniques, so giving rise to lower discards, relative to overall SNM stocks.

d. Passive Neutron Workshop

One of the tasks of the working group is, of course, to follow carefully the developments of the application and the performances of specific and important NDA techniques.

The group constantly dedicates one point of its Agenda to general or specific discussions on assessing and updating NDA performances (see next chapter). For specific techniques, considered particularly important, special topical meetings and/or workshops, are organised.

Concerning Passive Neutron techniques for instance the group had a special meeting in Luxembourg (Sept 1981) to discuss and assess developments, applications and performances of passive neutron techniques which, at that time, were essentially based on Shift Register (SR) devices: time correlation analysis (or multiplicity counting) was just starting to be explored.

A second special meeting was convened at Harwell in May 1984 dealing with the more recent developments at that time.

Recently the WG decided that it was time to define again the state of the art on SRs and their application after some years of use and also analyze the status of development and application of Time Correlation techniques that were gradually coming into use.

For that reason the group organized a third special meeting and first Passive Neutron Workshop at Ispra, PERLA laboratory, in April 1993.

The workshop reviewed the current status of passive neutron assay and made recommendations for further development efforts.

The workshop consisted of presentations, demonstrations, measurements by participants and discussion periods.

Basic technology topics included radionuclides nuclear data (see Annex III), Shift Register based instruments as well as Multiplicity Counters. HRGS measurements, uncertainty propagation models and performance evaluations of various instruments and techniques were also included. Particular reference was given to ESARDA NDA Performance Values and to IAEA international Target Values.

The workshop focused mainly on discussion sessions which provided the opportunity for the participants to evaluate the current status of performances of passive neutron assay and to develop conclusions and recommentations which have been included in the Workshop Proceedings /7/.

2.3 NDA Performance evaluation

The WG has for many years included time in its Agendas for discussion concerning improvement and assessment of the performances of the NDA techniques.

The task is a difficult one since it requires condensation (collapsing) of many parameters, e.g. application of different techniques on different items in different field conditions with different measuring times, etc., in few figures, issued in performance tables.

But the Group succeeded in finalizing a very scientific approach starting from statistical definitions of performance, accuracies and precisions founded on ISO standards and then determining the performances of NDA techniques in different conditions. Field data as well as laboratory tailored experiences were used to prepare tables of Performance Values that were issued /8/ for bulk, process, product U and Pu materials as well as for waste items (see also Annex IV).

Intense collaboration in this area has been given to (and received from) other ESARDA Groups (e.g. DA WG) and to international bodies (e.g. IAEA), that was then finalized in the International target Values /9/.

2.4 Standards and reference materials

This is an area where traditionally since its foundation the NDA-WG has been heavily involved.

The concern of the group was first to identify the requirements for and the needs of reference materials, both for R&D applications and for field monitoring and process control. The 'forum' provided by ESARDA for this kind of analysis is of course quite unique, merging together the experience and the knowledge of developing laboratories, operators, and inspectors (see annex V).

- One of the first and best examples of reference material projects identified, designed and managed by the ESARDA WG was the EC-NRM-171/NBS-SRM-969 U308 CBNM/NBS/ESARDA reference materials /10,11,12/, proposed and specified by the NDA WG, then jointly realized and characterized by US-NBS and JRC-CBNM (now IRMM). KFK and JRC Ispra contributed at various stages of the project with very essential activities.
- Similarly the so called Pu-pilot samples /1/ were proposed and discussed in the NDA WG before they were issued and distributed by JRC-IRMM.
- Also PIDIE samples even though they were never intended as reference materials represent now good sets of well known widely measured samples that are a valid interlaboratory 'link'.

The NDA WG is constantly discussing new needs and eventually the opportunity to launch new projects. At the present we are discussing two possible projects:

- standard drums for calibrating waste assay
- U02 pellets for an intercomparison exercise on U235 abundance techniques

2.5 Varia

There are very many other topics to be mentioned where the group was and is normally engaged:

- Joint meetings

  The frequency of joint sessions with other ESARDA groups has been recently increased: there were meetings with the MOX WG (the first joint meeting, in September 1981) then with the DA WG on many occasions, one meeting with the LEU WG and the last one at Ghent (B), 1994, with the C/S WG. The group strongly supports this kind of management, since it enlarges and integrates the scientific horizons.
- Inhomogeneous Materials

  Since the importance of materials which are not well characterized (like 'scraps') both in safeguards and Nuclear Material Management activities has become more relevant, the Steering Committee charged the NDA WG in 1992 with the task of analyzing the impact and the assay tools of such materials. In consultation and with the contribution of other WGs (MOX and LEU) the NDA WG edited a paper showing the role of inhomogeneous materials and their management and assay in nuclear plants /13/.
- Sampling in NDA

  An action has been started to study the influence of 'sampling' on NDA performances. The study will be supported by experimental results.
- Unattended/integrated systems

  This is the topic that recently has received perhaps the highest attention in the safeguards field. It is in fact the most important technical direction for the future developments of field systems. The NDA WG has therefore proposed amongst other actions a common meeting with C/S WG to develope technical and managerial guide lines for the future.
- 242Pu uncertainty

  It is well known that the impossibility of determing by HRGS (High Resolution Gamma Spectrometry) the 242Pu abundance gave rise to consistent uncertainty in the knowledge of its isotopic abundance, with a relevant impact on the uncertainty of the 240Pu equivalent. Actions have been and are being launched and co-ordinated by the WG to overcome this problem with new technical approaches.
- Visits to nuclear installations

  Often at the occasion of joint meetings but also sometimes at a regular meeting the WG had the chance to visit several nuclear installations. The recent visit to the UK and the visit at Tricastin of few years ago are two impressive examples. These occasions give the members a broader view of the practical circumstances in which the NDA measurements have to be applied. Such contacts with reality are very useful for a good understanding of the different parties in safeguards and the working environment for inspectors.

  We intend to continue to follow this approach, to reinforce it, starting with the next meeting, in September at Helsinki.

3. Future

The NDA WG intends to continue its 'statutary' activities that have been outlined in the previous chapters, in the field of circulation of information, technology transfer and Performance Evaluation. The following are some specific tasks which will be followed with particular attention.

1. Standards, reference materials and intercomparison exercises

Two new proposals (already mentioned) under evaluation at the present are:

- the production of waste 'standards' for an intercomparison exercise on NDA waste assay
- a new gamma spectrometry intercomparison exercise on LEU standard pellets, to determine the performances of improved and new NDA techniques in 235U abundance determination.

2. Unattended/integrated systems

The increase in size of modern plants and the application of updated techniques make the area of integrated systems very important and challenging.

This will require internal coordination of the NDA WG as well as more frequent external contacts with the C/S WG and with the plant oriented WGs.

Therefore this first joint meeting with C/S has to be seen as preparatory to further specific work in the field.

4. Conclusions

In conclusion the NDA WG has had very busy and fruitful activities all along its life time.

The number and quality of 'products' delivered, the scientific and practical support given to inspectors and operators (reference materials, technical improvements, performance assessment, etc.) and the less quantifiable outcomes in the technology transfer field, make the WG an unvaluable tool of scientific progress and support in safeguards.

From a management point of view the group has always been open and is still opening towards non ESARDA countries, US, Japan, EFTA countries and Eastern countries (Hungary, Russia, etc). We intend to continue to enlarge our horizons both in technical and 'geographical' aspects.

We intend, as well, to continue and intensify the 'management by subgroups' approach that worked well with the Performance Assessment, with the workshop organisation and on other occasions. Also the 'tool' of joint meetings with other ESARDA groups and visits to nuclear installations will be reinforced.

Finally the WG will always be open, as it was in the past, to carry on specific and basic activities in support to both Safeguards and Nuclear Materials Management.

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/12/ P. DE BIEVRE et al. - 235U isotope Abundance Certified Reference Material for Gamma Spectrometry; EC-NRM 171 Certification Report, EUR, COM4153, 1985

/13/ M. BICKEL - Scraps in the Nuclear Fuel Cycle Aspects of Safeguards NDA Measurements; Internal report to the ESARDA Board

ANNEX I: ESARDA NDA WG SUBGROUPS DEFINITION FOR NDA PERFORMANCE ASSESSMENT:

UF6

Densitometry (KED-XRF)

Calorimetry

High Resolution Gamma Spectrometry (HRGS) on Pu and U

Low Resolution Gamma Spectrometry

Neutron Coincidence Counting

Spent Fuel Assay

NDA on Waste

Process Monitoring

Rod Scanner

ANNEX II: WORKSHOP ON NDA TECHNIQUES ON WASTE
SALAMANCA, 1992

OUTCOME:

- WASTE TABLES
- PERFORMANCES
- WASTE ARISINGS
- EURATOM SAFEGUARDS REQUIREMENTS AND EXPERIENCE

INSTRUMENTS AND TECHNIQUES

- GAMMA TECHNIQUES
  - γ-spectrometry
  - γ-scanning
- NEUTRON TECHNIQUES
  - passive neutron counting
    - shift registers
    - multiplicity couters
  - active neutron techniques
    - DDA
    - Cf shufflers
- CALORIMETRY

PLANTS CONSIDERED

- ENRICHMENT
- FABRICATION (LEU, MOX)
- REPROCESSING

ANNEX III: ESARDA PASSIVE NEUTRON WORKSHOP

Taken from KRICK LA-UR-88-1301 (1988)

K_1	= 134	
K_2	= 0.381	
K_3	= 1.41	α
K_4	= 0.013	α
K_5	= 0.020	α
K_6	= 26.900	α
K_7	= 10.200	α
K_8	= 2.54	α
K_9	= 1.690	
K_{10}	= 2.062	
K_{11}	= 2.52	Pu-240 eff
K_{12}	= 1.68	Pu-240 eff

Halflife (y) IAEA currently used values

Pu 238	= 87.74
Pu 239	= 24120.0
Pu 240	= 6560.0
Pu 241	= 14.35
Pu 242	= 376300.0
Am 241	= 433.6
Pu 242	= 2.623

KRICK LA-UR-93-1394 (1993) used in multiplicity analysis

SF 1st moment	= 2.154	
SF 2nd moment	= 3.7890	
SF 3rd moment	= 5.2110	
IF 1st moment	= 3.1630	fast neutron induced fission
IF 2nd moment	= 8.2400	fast neutron induced fission
IF 3rd moment	= 17.321	fast neutron induced fission
SF/g/s	= 473.50C	

ANNEX IV: PERFORMANCE EVALUATION OF NDA TECHNIQUES

- HRGS
- Active and passive neutron counting
- Calorimetry
- KED-XRF

Bulk, process, product materials

- U02, Pu02, MOX
- UF6
- Spent fuel
- Waste
- the analysis has now reached a milestone for many of the above points.
- new edition presented at the Esarda Symposium of ROME (1993)

ANNEX V: ESARDA NDA WORKING GROUP STANDARDS AND REFERENCE MATERIALS

TASKS:

- IDENTIFY NEEDS
- COORDINATE PRODUCTION AND11111 CHARACTERIZATION OF RM's

EXAMPLES:

- U308 NBS/CBNM/ESARDA RMs EC-NRM-171/NBS-SRM-969
- IRMM Pu PILOT SAMPLES
- PIDIE (not considered as RMs, but as a good inter-lab link)

FUTURE:

- "STANDARD" DRUMS FOR WASTE ASSAY
- U02 PELLETS

Report of the ESARDA Working Group on Containment and Surveillance (C/S)

B. Richter
Convenor of the Working Group, KFA Jülich, Germany

The ESARDA Working Group on C/S is a forum of communication exchanging information and opinions between ESARDA as well as all relevant and interested partners who strive to enhance the effectiveness and improve the efficiency of safeguards techniques.

The Working Group has 15 members and 6 observers representing developers of safeguards equipment, nuclear plant operators, licensing authorities, and safeguards inspectorates. The European Commission delegates 3 representatives including 2 experts from the Ispra Joint Research Centre and one from the Euratom Inspectorate at Luxemburg. France delegates 2, Germany 4, Italy 1, the Netherlands 1, and the United Kingdom 4 representatives. An observer originates from each one of the following countries and organizations: Australia, Canada, Japan, Russia, USA, and the International Atomic Energy Agency. The Working Group may certainly grow, as Austria, Norway, Finland and Sweden envisage accession to the Euratom Treaty. Finland and Sweden have significant nuclear energy programmes and Support Programmes to the IAEA. While Finland, some time ago, delegated an observer to the NDA Working Group, the official Swedish Statens Kärnkraftinspektion (SKI) expressed its interest in ESARDA when it hosted the C/S Working Group's regular meeting at Oskarshamn in November 1993.

The C/S Working Group holds two meetings per annum, one traditionally in May associated with the ESARDA Symposium or ESARDA Internal Meeting and the second one in autumn. During the past four years the Group took the opportunity to visit the UKAEA laboratories at Harwell, the Euratom laboratories at Luxemburg, the various safeguards related laboratories at Ispra, and, most recently, the Swedish central storage facility for spent fuel CLAB at Oskarshamn.

In 1990, approved by the Steering Committee, the Group restructured its terms of reference (see annex) into "Generic Technology Topics" as well as "Fuel Cycle Topics of Relevance to C/S". They became the basis on which there have been many discussions and working papers contributed from all professional factions within the Group. After four years, there is no reason to drastically change the terms of reference, although some details will be amended to account for the actual needs in the safeguards arena.

Most productive meetings appeared to be the 1990 Special Topical Meeting on 'Optical Surveillance Data Reduction Techniques' and the 1992 Workshop on 'C/S Safeguards Techniques Applicable to Intermediate and Long-term Storage of Irradiated Fuel'. Both these meetings received indispensable and substantial input from the Euratom Safeguards Directorate as well as from plant operators. Above all, this showed that the developers within the Group strived to make practicable recommendations. Moreover, it proved the high standard and progress of Euratom safeguards strategies and cooperation on the plant operators' side.

The topical meeting was essentially technology-oriented discussing the implications of front end versus back end optical data evaluation in video surveillance for safeguards, whereas the workshop covered a larger scope dealing with both facilities and safeguards C/S technologies.

At the workshop the Group discussed safeguards relevant facility design features and basic safeguards concepts for spent fuel storage facilities including both dry and wet storage, established criteria for the development of C/S equipment, identified relevant C/S devices and techniques, and concluded that advanced C/S techniques had a potential for cost savings by substituting on-site inspection effort as well as contributing to the conclusive evaluation of safeguards data. The Group identified four C/S development areas of top priority in order to enhance resource savings on the inspectorates' part: Integrated system techniques, remote data transmission and remote monitoring, data reduction and evaluation techniques, and authentication techniques.

These conclusions led to the first issue of a compendium of C/S devices, a compilation of outline information on a range of products and particular devices which could meet the requirements of specific applications. This compendium will be distributed to all interested parties. Secondly, and more importantly, the Working Group, with great effort, decided to embark on the discussion of the impacts of integrated system techniques and remote data transmission. It was recognized that the topic of integrated systems required the involvement of both the C/S experts and NDA experts.

The 1994 ESARDA Internal Meeting was used as a first opportunity to hold a joint meeting of the C/S and NDA Working Groups in order to intensify and broaden the discussions on the integration of C/S and NDA instrumentation as well as on remote transmission. The questions of whether integrated systems help to reduce on-site inspection effort and make permanent inspection more efficient and effective were discussed under technical aspects.

In the joint Working Group meeting there were seven presentations contributed by persons representing inspectorates, development organizations, and plant operators. Their themes covered

- Euratom's experience with integrated unattended systems,
- networking techniques in general,
- plant-specific safeguards systems and network designs,
- the IAEA Integrated Safeguards Instrumentation Programme.

The groups, in their discussion, looked at two categories of plants: (I) Plants with large inventories, periodical safeguards inspections and instrumentation installed throughout the facility; (II) plants with large throughputs and inventories, but also with automated processes and remote handling of nuclear material. Such plants are permanently inspected and require safeguards instrumentation installed throughout the facility, operating unattendedly including a large number of optical surveillance units, sensors, measuring heads, and possibly on-site sample analysis. Complementary information is necessary for the inspector to verify that no material is diverted from its declared uses. Redundancy is required to ensure the continuity of knowledge.

The Joint Group discussed the issue of integrated safeguards systems and remote transmission on a purely technical level and came to the following conclusions.

Principal Conclusion:

The integration of measuring, sensing, and imaging devices is an important technique capable of reducing on-site inspection effort and making permanent inspection more effective and possibly more efficient.

Complex safeguards systems for unattended operation should be designed to avoid loss of data, e.g. by providing appropriate uninterrupted power supply capability, redundancy, etc.

Conclusion Regarding Plants with Permanent Inspection:

The safeguards advantages of system integration using many different types of measuring, sensing, and imaging devices lie with the automatic correlation of complementary safeguards data enabling a more transparent, i.e. conclusive, and more timely verification of the declared uses of the nuclear materials, thus enhancing the effectiveness of permanent inspection in large automated plants.

Technical Statement:

The digitization of video surveillance data in connection with data reduction/compression enhances the realization of integrated safeguards systems and opens up new possibilities for the data review and remote data transmission.

Data authentication is a requirement.

Conclusion Regarding Plants with Periodical Inspection:

Handling only digital data, integrated systems have a potential for remote transmission of both state-of-health and safeguards data from facilities with no permanent inspection to the Euratom Safeguards Directorate at Luxemburg enabling reduction of on-site inspection effort in such plants. The group, however, took into account that encryption was a precondition for remote data transmission in countries where remote transmission would be acceptable.

By the integration of C/S devices, such as seals and video, the plant operator may perform some safeguards relevant activities, thereby reducing inspection effort.

The integrated data presentation will reduce the overall inspection effort.

Consequences for the Euratom Safeguards Directorate:

The increased use of integrated safeguards systems would allow the Euratom Safeguards Directorate to make more efficient use of inspection effort and increase safeguards effectiveness.

Computer based integrated safeguards systems for unattended operation require different skills which will require education and training of inspectors as well as of technical staff.

Consequences for Plant Operators:

The advantages of integrated safeguards systems and remote transmission for the plant operator would be a reduction of effort in terms of escorting and a greater flexibility in the operation of the plant. It has to be ensured, however, that the safeguards system reliability is high and that the data are conclusive.

Final Notice:

The Group finally stated that the deployment of integrated systems will be a big change and a challenge for developers, inspectorates and operators.

ESARDA WG on C/S Terms of Reference

Fuel Cycle Topics of Relevance to C/S

- Irradiated fuel in AFR-storage (*)
- Reconstitution of fuel at reactor (*)
- Compaction of fuel away from reactor (*)
- Storage of MOX fuel assemblies and PuO_2 powder
  - at reprocessing plant
  - at fabrication plant
  - at stand-alone stores
  - at reactor (f.a. only) (*)
- Includes transportation of MOX fuel and PuO_2 powders
- C/S implications at inaccesible inventories (*)
  - in long-term storage
  - storage of irradiated fuel in containers
- Spent fuel conditioning plant (*)
- Spent fuel final disposal (*)
- Sealing of UF_6 cylinders

(*) topics which have been discussed but not necessarily brought to completion

ESARDA WG on C/S Terms of Reference

Generic Technology Topics

- Integration of C/S systems
  - the combination of C/S devices to enhance the performance of surveillance
- Development of design criteria for C/S systems (*)
- Use of surveillance in more function-specific applications
- Use of intrusion/penetration monitors versus optical surveillance
- How to express C/S assurance/ performance (*)
- Authentication of C/S
  - devices
  - software (validation)
- Remote monitoring (*) (in-plant data transfer)
- Category B C/S systems (Dual C/S systems)
- C/S data interpretation (reviewing of optical surveillance data)

(*) topics which have been discussed but not necessarily brought to completion

Report of the ESARDA Working Group for Reprocessing Input Verification (RIV)

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The RIV Working Group was created in 1982 as an extension of the ICT WG. Its activity deals with problems related to the determination of the input of nuclear materials into the reprocessing plant and to its verification in support to the Safeguards Authorities and also to Operators.

In the past, proposals have been made to enlarge the activities to include all problems of the reprocessing area, but these actions were not followed.

1. Past activities

The Working Group has operated successfully since its creation. Many Organisations from ESARDA members participated to the WG and also many observers (from USA, Japan, IAEA) actively contributed to the effective completion of its objectives.

The activities carried out included:

- exchange of information among participants (Operators, Safeguards Authorities, R&D people);
- experiments in laboratories and in reprocessing plants;
- determination of areas where further research and development were needed;
- research and development of measurement procedures, measurement errors structures, mathematical models, computer programs, data bases.

Several projects have been completed, e.g.:

- ICE experiment at the WAK reprocessing plant;
- RITCEX experiment at the former EUROCHEMIC plant;
- ICT Benchmark Exercise with data of the COGEMA reprocessing plant, the KWU and KWO;
- Seminar on the use of Tracers in Volume Measurement;
- Integral Experiment at the WAK reprocessing plant;
- CALDEX Exercise at the TEKO facility.

All these projects were carried out in close cooperation with the Operators. Both the Operators and the Safeguards Authorities took part in the definition of the scope and in the design of the above experiments with the view to obtaining results which could be useful for their purposes.

The results obtained have opened the way to improvements of the Safeguards measurement systems (instruments, methods and procedures) and therefore to an overall improvement in the practice of the input measurement.

Examples are:

- the increased attention given to the sampling procedure as experienced in the ICE;
- the need for the use of more advanced instrumentation for level measurement and the use of more sophisticated statistical techniques resulted from the RITCEX experiment;
- the awareness of the importance of the systematic error components in the measurement procedures as identified in the CALDEX exercise.

These activities have been found to be extremely fruitful.

The Group has now completed the task which it was assigned.

2. Scenario

The terms of references given to the RIV WG reflects the situation of the early 80's. The situation has now changed.

At present, there is no demand from European Operators of reprocessing plants and EURATOM Safeguards for R&D and for discussion on those Safeguards issues which are dealt with by the RIV WG. There is however a clear and increasing demand for further R&D and for discussion by the IAEA, European R&D people and non European facilities (e.g. Japan and Former Soviet Union). A symptom of this demand is the wide interest in the activities of the TAME Laboratory of the JRC Ispra.

This demand addresses however, in addition to the input of the reprocessing plant, to more general areas related to the back end of the fuel cycle (e.g. isotopic signatures used for Safeguards strengthening purposes, problems related to the conversion of military materials to civilian use, problems related to materials control and fuel management, synergism of Safeguards measures within the fuel cycle and environmental monitoring for detecting clandestine activities).

3. Consequences

The group feels that restricting plant oriented activities to the reprocessing input, as laid down in the present terms of reference, limits the scope and compromizes the existence of the RIV WG.

Consequently, either the terms of reference are adapted to the new Safeguards situation or the WG has limited justification to effectively continue its activity.

The dissolution of the RIV WG would however leave uncovered an area of high interest for Safeguards. If this would be the case, then some new structure should be created to deal with the new situation described above.

The expertise developed within the RIV WG should not be lost. The competence developed in the past should in any case be utilised in the framework of the new structure yet to be defined.

4. Conclusions

The task assigned to the RIV WG has been successfully completed.

To continue the activity the WG should expand and adapt its terms of reference to include the existing or anticipated problems of the modern nuclear fuel cycle.

If this is found not to be possible then the Group could only be maintained as a forum for the exchange of technical information.

The Group believes that this might be too limited a task, and suggests that its expertise should be utilised effectively.

Report of the ESARDA Working Group on Mixed Oxide Fuel Fabrication Plants (MOX)

R. Ingels
Convenor of the Working Group, Belgonucléaire, Dessel, Belgium

1. Introduction

In 1981 the Steering Committee decided to start with a new plant oriented Working Group for the study of mixed oxide (MOX) fuel fabrication plants. It was the third working group, to be established following the formation of the low enrichement uranium (LEU) conversion fabrication plant in 1978 and the reprocessing input verification Working Group also formed in 1981.

The group was established with the participation of the following organisations:

- Industrial facilities
  - Alkem-Hanau - (BRD)
  - BELGONUCLEAIRE-Dessel (Belgium)
  - British Nuclear Fuels plc-Sellafield (UK)
  - Commissariat à l'energie Atomique SFER - Cadarache (France)
  - United Kingdom Atomic Energy Authority - Windscale, Sellafield (UK)
- Inspectorates
  - European Commission, Safeguards Directorate (Luxembourg)
  - Commissariat à l'Energie Atomique, Department de Sureté des matières des matières nucléaires, Fontenay-aux-Roses (France)
- Research establishments
  - Centre d'Etudes Nucléaires - Studiecentrum voor Kernenergie, CEN/SCK, Mol (Belgium)
  - European Commission, Joint Research Centre, Ispra (Italy)
  - Comitato Nazionale per la Ricerca e lo Sviluppo dell'Energia Nucleare e delle Energie Alternative - ENEA, Casaccia (Italy)
  - Forschungszentrum Jülich GmbH (Germany)

The objectives and terms of reference of the MOX fuel fabrication Working Group were defined as follows:

The general objectives of the Working Group are to act as a forum for technical discussion between Plant Operators, Safeguards Authorities and R&D people.

These technical discussions are related to common problems encountered in the use of nuclear material control systems, as developed by plant operators. Through these discussions the plant operators could share experience gained in the implementation of the material control systems.

An important subject which was identified is formulated as follows:

"General exchange of information and analysis of practical plant experience on accountancy and measurement practices for fissile material management and safeguards purposes".

The practical experience gained in the various Working Group meetings shows that the last statement reflects the excellent spirit in which the work was performed. For this reason the Working Group intends to elaborate and propose revised terms of reference to correspond with this last statement.

2. Evolution

- This group did a lot of work during the first years of its existence but in order to understand its evolution the following facts have to be taken into consideration.
- In the early 80's all the industrial facilities were fabricating MOX fuel for Fast Breeder Reactors (FBR), e.g.:
  - CEA-SFER Cadarache produced MOX fuel for Phenix and Superphenix in France;
  - Alkem and BELGONUCLEAIRE were busy with fuel fabrication for the SNR-300 reactor-Kalkar;
  - BNFL produced fuel for the PFR reactor of Dounreay (UK);
  - The United Kingdom Atomic Energy Authority produced experimental fuel for the Dounreay PFR;
- In the mid to late 80's we noticed that due to political reasons, the Fast Breeder programmes changed dramatically. The following important events took place:
  - The SNR-300 project, although completely finished was abandoned
  - The Superphenix project in France as well as the PFR-reactor programme (Dounreay, UK) slowed down. On the other hand Siemens (Ex-Alkem), Belgonucleaire (Dessel) and CEA-SFER Cadarache changed their production programmes. Indeed, the fabrication of MOX-fuel for Light Water Reactor gave a new impulse to these three industrial facilities.
- Between '85 and '93 new plants were developed on the drawing boards.
  - SIEMENS-Hanau planned and constructed a new 100 ton HM plant on its site in Hanau while production continued in the existing plant.
  - BELGONUCLEAIRE-Dessel planned and designed a new 35 ton HM plant in order to doubles its capacities whilst production continued.
  - BNFL/AEA designed and built a MOX Demonstration Facility (MDR) at Windscale.
  - CEA SFER - Cadarache started the production of LWR fuel.
  - COGEMA planned and constructed a new installation in Marcoule with a capacity of 100 tons HM.
  - BNFL stopped the production of FBR-fuel and constructed in collaboration with AEA a demonstration plant in Sellafield. A few weeks ago BNFL started the construction of a 100 ton HM plant called the Sellafield MOX Plant near the THORP reprocessing plant.

Throughout these 13 years from 1981 up to 1994 a lot of things happened. There were difficulties in relation to MOX-plants in most of the countries linked to political problems at local, national as well as international level.

Although and despite all these difficulties, MOX fuel was and is produced and "burned" in a number of European reactors. New plants are ready and will be operational very soon.

It is clear that the MOX-Working Group was influenced by all these changes and events in the MOX field.

The first 6 years a lot of work was done by the group with quite a lot of achievements. Then came a second period of about 3 years were the group searched its second breath. The last 4 years the group has met regularly 2 times per year if possible.

During the first years, Mr. Marc Cuypers, JRC Ispra, our present ESARDA chairman was the convenor. His successor for 4 years was Mr. Le Goff of the CEA (DRI).

Since 1993, Mr R. Ingels (BN-Dessel) has been the third convenor.

The composition of the group also changed because the accent was put more on exchanging information on common safeguards problems.

The members are at present (May 1994):

- 5 operators
  - Atomic Energy Authority, Windscale (UK)
  - British Nuclear Fuels plc Risley (UK)
  - BELGONUCLEAIRE-Dessel (Belgium)
  - Establissement Melox de Marcoule - Bagnols sur Cèze (France)
  - Siemens-Hanau (BRD)
- Inspectorates
  - The Euratom Safeguards Directorate, Luxembourg
  - Commissariat à l'Energie Atomique, Department de Sureté des Matières Nucléaires, Fontenay-aux-Roses (France)
- R&D laboratory
  - European Commission, Joint Research Centre, Ispra
- State organisations
  - Commissariat à l'Energie Atomique, Direction (Paris)
  - Department of Transport and Industry, DRI Safeguards Office (London)

3. Achievements

Contrary to the technically oriented working groups, plant oriented groups are not supposed to deal directly with R&D in the safeguards field. Their tasks are both "upstream" and "downstream" of such R&D activities. "Upstream" in identifying problems which existing safeguards techniques create or are not able to solve in the types of plant considered. "Downstream" in analysing the capability and potential of R&D solutions to these problems.

The achievements of the MOX Working Group are extensively described in the following documents:

- Esarda Symposium - Versailles -1983
- Esarda Internal Meeting - Copenhagen - 1986
- Summary of the 10th Annual Meeting of Karlsruhe - 1988
- Conclusion of the Internal Meeting of Villa Olmo (Como) - 1990

Let me point out some items which were treated:

- Practical plant experience on accountancy and measurement practices
- Analysis of characteristics of MOX fabrication plants
- Review of operators measurement practices
- Analysis of the uncertainty on a physical inventory and a material balance
- Shipper-receiver differences; sampling and analysis procedures on PuO_2 for reducing possible SR Difference
- Safeguards procedures in the frame of the timely detection
- Definition of sampling errors
- Pu level monitoring - assay of Pu nitrate and solution-level monitoring
- Reference plant exercise

and many other interesting themes.

During the last 3 years the Working Group continued its work and the following themes were discussed and summarized in 3 working papers giving the state of practice in 4 MOX plants about:

- Scraps in a MOX Fabrication Plant
- Data Transmission and Communication
- Nuclear Transformation

4. Conclusion and future work

The main objective for the Group is to examine the Safeguards impact of modern large MOX plants which have high throughput, a high degree of automation and restricted access.

The group aims to continue to be a forum for communication and exchange of safeguards related information between its members comprising representatives from fabrication plants, those concerned with nuclear accountancy, control and safeguards, and the safeguards authorities.

The group will go on with its work keeping in mind that real research studies are difficult for the plant operators themselves. Furthermore, the past has taught us that speaking about safeguarding plutonium is not an easy task. It has to be recognized that the MOX business for LWR is up to now only a European business, between 5 MOX plants - 3 located in weapon states and 2 in non-weapon states - and several national and international authorities. Bringing together all these parties is a major achievement.

The creation of the group in 1981 was a sensible decision and without any doubt the Safeguards Authorities as well as the MOX-operators have benefited from the work done during 13 years. The original objective of putting the accent on research has changed more to one of information exchanging and preparing reports on accountancy and control procedures.

But with coming of bigger MOX plants with greater throughputs, new challenges are coming up for all parties. New problems will certainly emerge.

Taking into account the difficulties which were encountered in identifying subjects of common interest that are not industrially sensitive and not related to safeguards strategies, the Working Group will concentrate its activities on the analysis of safeguards techniques and practices including nuclear materials accountancy and continue and exchange views on their applicability to large throughput facilities.

The future topics which will be treated over the next 2 years are:

- The implications of using PC networks for nuclear materials accountancy rather than dedicated mainframe systems
- A re-examination of the development of software to analyse errors in MUF
- Development of the surveillance concept as an aid to safeguarding MOX plants. This will include consideration of the steps necessary for authentication.
- Nuclear materials accountancy aspects and implementation of accountancy rules in a "fongible" MBA (exchangeable).

5. Final remarks

Due to the confidential character of industrial operations the MOX Working Group will always be a restricted group of specialist discussing very particular items for a limited number of interested people who can actively contribute. The bigger the group the more difficult the discussion becomes.

After 13 years of existence and 20 meetings, which took place all over Europe sometimes at the site of the different MOX plants, the group treated a reasonable number of the big items and a great number of small practical problems. The group laid down a network of contacts between the different existing MOX plants.

Report on the Joint Meeting of the ESARDA Working Groups on Non-Destructive Analysis (NDA) and Containment and Surveillance (C/S)

Integrated Safeguards Systems and Techniques

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1. Introduction

In Euratom countries facilities with large inventories and throughputs of nuclear materials are operating, are being taken into operation or are under construction. Examples are bulk handling facilities such as spent fuel reprocessing and mixed-oxide fuel fabrication plants with automated processes, but also item handling facilities for long-term intermediate storage and conditioning of spent fuel.

The Euratom Safeguards Directorate has the task to verify that the nuclear materials are not diverted from their intended uses as declared by the users. To this end, highly automated, unattended safeguards systems comprising both C/S techniques and NDA-devices are being designed and implemented. Huge amounts of safeguards relevant data from different measurement positions, sensors, seals, and video surveillance cameras have to be collected, processed, and evaluated. Some types of facilities require permanent and some types periodical inspections.

In May 1994, the Steering Committee of the European Safeguards R&D Association (ESARDA) had invited all ESARDA Working Groups to convene at Ghent, where they should conduct their regular meetings or carry out joint meetings on special topics.

On the basis of the technological progress, the ESARDA Working Groups on Containment and Surveillance (C/S) and on Non-Destructive Assay (NDA) had arrived at a point where they felt a first joint meeting became desirable. One full day of exclusively technical presentations and discussions was dedicated to the topic of integrated safeguards systems and remote data transmission. The present paper summarizes the discussions on the implications of such techniques.

2. Background

In 1992, the ESARDA Working Group on C/S, at its workshop held in Salamanca, anticipated a need of substituting safeguards techniques for inspection resources /1/. The Group identified two technical approaches capable of meeting this requirement: integrated systems, on the one hand, and remote data transmission and monitoring on the other; signal authentication techniques have to be accounted for, while data reduction and evaluation techniques will also play an important role.

The Group gave some examples on the substitution for Inspection resources:

- Improved data storage and transmission techniques could contribute to reduced inspection frequency.
- Improved data processing techniques can reduce inspector's evaluation time.
- Standardization or improved compatibility between devices could increase the flexibility of integrated C/S system designs and reduce overall equipment requirements and costs.
- Operator performance of some safeguards activities could contribute to reduced inspection frequency and effort.

The workshop also recognised the benefits of multiple C/S systems in ensuring improved reliability and thereby reducing the need for reverification and the consequent costs to operators and inspectors.

Regarding the concept of SSAC (State System of Accounting) or facility operators carrying out some routine operations of inspectors, the workshop stated that the topic had considerable political implications but justified further consideration at the technical level and that implementing such procedures would depend to some extent upon developments in remote monitoring, data transmission and authentication techniques.

In preparing the 1994 joint C/S and NDA Working Groups' meeting at Ghent, the following questions were raised:

- Can integrated systems help to replace or reduce on-site inspection effort?
- Can integrated systems help to make permanent inspection more efficient and effective?

3. Presentations

In the joint Working Group meeting there were seven presentations contributed by persons representing inspectorates, development organizations, and plant operators. Their themes covered:

- Euratom's experience with integrated unattended systems,
- networking techniques in general,
- plant-specific safeguards systems and network designs,
- the IAEA Integrated Safeguards Instrumentation Programme.

Two main categories of plants were identified:

- Plants with large inventories, periodical safeguards inspections and unattendedly operating instrumentation installed throughout the facility,
- Plants with large throughputs and inventories, but also with automated processes and remote handling of nuclear material. Such plants are permanently inspected and require safeguards instrumentation installed throughout the facility, operating unattendedly including a large number of optical surveillance units, sensors, measuring heads, and possibly on-site sample analysis. Complementary information is necessary for the inspector to verify that no material is diverted from its declared uses. Redundancy is required to ensure the continuity of knowledge.

One presentation dealt with a non-European on-load fuelled reactor type to which many of the above safeguards equipment features also apply; in particular, the combination of multi-camera and radiation monitoring systems.

The volume and scope of information resulting from such safeguards instrumentation calls for automatic data handling procedures. Both quantitative and qualitative data may result from measurements on neutron, gamma, and K-edge radiation; from X-Ray Fluorescence (XRF) as well as calorimetry, chemical analysis, weight, density, level, and temperature measurements; localizing and identifiying items containing nuclear material. Generally, multi-camera video surveillance systems are an integral part of safeguards systems.

Some implemented systems correlate sealing or weighing operations with video surveillance, others may correlate the rise of a radiation level, e.g. due to the temporary presence of irradiated fuel, with video surveillance.

In general, the following functional components have to be taken into account when designing integrated systems:

- signal generation
- data processing
- system control
- power management.

A number of basic technical requirements were identified for the data processing in plant-wide integrated systems:

- measuring and sensing
- digitization of analogue signals
- data compression and data reduction
- data authentication
- data encryption
- data collection and evaluation
- remote transmission and networking

While the signals arising from adequate measuring heads and sensors including video cameras are analogue, the processing and correlating of information takes place in digital data streams; i.e. analogue signals are converted into digital data. In addition to the anlogue-to-digital conversion in the measuring and sensor devices, there is authentication and, if necessary, buffering of data. For digitized video images the amount of data has to be reduced using appropriate data compression algorithms; otherwise the data streams cannot be handled (timing and storage capacity). A standard software architecture is established for reliable unattended in-field collection of large amounts of data including an adequate command structure for the instrumentation. The basic command set of the Standard Commands for Programmable Instruments (SCPI) may be a good choice.

The data are fed into a data bus hardware platform such as VXI, which is an open industry standard (mechanical and electrical form factors) widely deployed for scientific instrumentation. The VXI bus leads to a data collection station which may serve as the central in-plant data collection station. The data are stored on digital media. In addition, there has to be a minimum capability for automatic data analysis as well as for diagnostic purposes ensuring the reliable functioning of the system.

In principle, the inspection wants to compare his verification results with the operator's report and records. He may retrieve the data from the respective data carriers for on-site evaluation using a review station; or he may take the data carriers away for evaluation at the Headquarters (HQ). In the future, the data may be automatically transmitted from the plant to the HQ. On-site uninterrupted power management is of paramount importance.

4. Discussion

For the purposes of this paper the following definition of the term "Integrated Safeguards System" is proposed:

An integrated safeguards system is designed to operate unattendedly and to correlate by electronic means complementary safeguards data acquired by using many different measuring, sensing, and imaging devices, sufficient to arrive at conclusive results as regards the verification of the declared uses of the nuclear materials.

The system uses a common hardware platform, data handling procedures, system control, and power management for the data collection and evaluation and may comprise a data logger for remote transmission.

The principal assumption is that technical systems have a potential to outbalance the cost of inspection effort when looking at routine tasks. It is certainly correct to state that the implementation of unattendedly operating integrated safeguards systems may help to reduce the inspector's on-site routine workload giving him the chance to concentrate on non-routine activities within a plant. For example, the review of safeguards data will be facilitated by the automatic correlation of signals from different sensors such as radiation monitoring and video surveillance. This is also an example for a front end data reduction method designed to limit the total amount of recorded data. If the video data are to be remotely transmitted to the inspectorate's headquarters, data reduction will reduce the transmission costs. The remote transmission to the HQ may take place as the data arise or at present intervals, e.g. once a week or once in three months.

Under these aspects, it is also justified to state that permanent inspection becomes more efficient and effective. In plants with periodical inspections integrated systems open applications where the facility operator carries out safeguards relevant activities in the absence of the inspector. One example is the integration of optical surveillance and electronic sealing /2/.

While the degree of complexity of unattended systems in large facilities increases, there are additional aspects other than inspection effort which may be relevant from the inspectorate's point of view. They are, for instance, the skill needed for designing and using the systems, investment and operating costs, maintenance and training efforts. In particular, the routine workload of the inspector is reduced, whereas the maintenance activities of the inspectorate's technical staff may be increased; i.e. there may be a plant specific optimum for system integration when balancing inspetion effort and maintenance effort.

Complex unattended NDA measurement instrumentation as well as system control of large research facilities such as accelerators have been designed using the VXI bus hardware standard. Therefore, it seems justified to assume that the VXI usage has a potential to cut down development costs also for unattended integrated safeguards systems. Furthermore, it should be emphasized that safeguards NDA yields invaluable quantitative data for the independent verification of the operator's declarations on the nuclear materials.

Having in mind that the NDA data are available in digital format, an optimal correlation with surveillance data calls for the digitization of video signals which will improve the review capability and which is also necessary to enable remote transmission of video surveillance data. In comparison to the evaluation of NDA data, the interpretation of video data is a most difficult task from the point of view of data processing. One way of correlating video and NDA data is to merge them. Therefore, the visual review of surveillance data with inserts such as date, time, gamma counting rate, fuel assembly no., etc. is a big improvement with regard to uncorrelated data. Looking at certain types of facilities such as on-load fuelled reactors or spent fuel conditioning plants, where the nuclear material is processed to become inaccessible for reverification by NDA, these considerations gain a great importance. The correlation of quantitative NDA and surveillance may be the best method to independently arrive at conclusive results in a timely maner. It is even conceivable that these data are remotely transmitted to the inspectorate's headquarters, thus rendering unnecessary the presence of an inspector. In order for the inspector to make optimum use of such integration his user interface must be designed appropriately.

Remote monitoring, such as transmission of video data from a facility to the inspectorate, offers the possibility for the inspector not to come to the facility. However, remote monitoring is still a sensitive issue in many states, because the facility operators are mainly afraid to lose commercial information, while the unions may suspect the possibility of "big brother is watching you".

A "starter" could be the remote transmission of state-of-health data out of a facility to the inspectorate's headquarters. Such data are exclusively related to the status of the safeguards system indicating, for example, the functioning of the authentication system, the presence of mains power or failure of certain system functions. Independent of the question of remote transmission such information has to be recorded along with the safeguards data to enable the inspector to assess the validity of the safeguards information.

Integrated systems as well as remote data transmission raise the issues of encryption and authentication. Although authentication methods make use of encryption, the two issues should be clearly distinguished.

Authentication is the indispensable requirement regarding the integrity of safeguards data and, therefore, is the inspectorate's interest; i.e. the authenticity of safeguards relevant information generated in measuring/sensing heads and transmitted all the way to the recording/evaluation unit has to be ensured. In comparison, encryption meets the confidentiality aspect of safeguards data and will be requested by the state/operator in connection with remote transmission of safeguards relevant data out of the facility, where remote transmission is accepted by that state; a Third Party should not be able to read the transmitted data.

Finally, looking at the impacts of unattended integrated safeguards systems on the New Partnership Approach of the Euratom Safeguards Directorate and the IAEA there are requirements for training, replacement/maintenance strategies, and spare parts management; compatibility of devices of different provenience; commonality of operating software and application software. In addition, the techniques should be jointly applicable allowing both inspectorates to arrive at independent conclusions.

For the plant operator it is important to know the installation requirements associated with the development of safeguards systems, while he will be interested in minimizing his overall costs. In the long-term it may be more advantageous to spend money and effort on the installation and operation of unattended equipment (integrated systems) and save resources on escorting, provided the data are reliable and conclusive.

5. Conclusions

The Joint Group discussed the issue of integrated safeguards systems and remote transmission on a purely technical level and came to the following conclusions.

Principal Conclusion: The integration of measuring, sensing, and imaging devices is an important technique capable of reducing on-site inspection effort and making permanent inspection more effective and possibly more efficient. Complex safeguards systems for unattended operation should be designed to avoid loss of data, e.g. by providing appropriate uninterrupted power supply capability, redundancy, etc.

Conclusion Regarding Plants with Permanent Inspection: The safeguards advantages of system integration using many different types of measuring, sensing, and imaging devices lie with the automatic correlation of complementary safeguards data enabling a more transparent, i.e. conclusive, and more timely verification of the declared uses of the nuclear materials, thus enhancing the effectiveness of permanent inspection in large automated plants.

Technical Statement: The digitization of video surveillance data in connection with data reduction/compression enhances the realization of integrated safeguards systems and opens up new possibilities for the data review and remote data transmission. Data authentication is a requirement.

Conclusion Regarding Plants with Periodical Inspection: Handling only digital data, integrated systems have a potential for remote transmission of both state-of-healt and safeguards data from facilities with no permanent inspection to the Euratom Safeguards Directorate at Luxemburg enabling reduction of onsite inspection effort in such plants. The group, however, took into account that encryption was a precondition for remote data transmission in countries where remote transmission would be acceptable. By the integration of C/S devices, such as seals and video, the plant operator may perform some safeguards relevant activities, thereby reducing inspection effort. The integrated data presentation will reduce the overall inspection effort.

Consequences for the Euratom Safeguards Inspectorate: The increased use of integrated safeguards systems would allow the Euratom Safeguards Directorate to make more efficient use of inspection effort and increase safeguards effectiveness. Computer based integrated safeguards systems for unattended operation require different skills which will require education and training of inspectors as well as of technical staff.

Consequences for Plant Operators: The advantages of integrated safeguards systems and remote transmission for the plant operator would be a reduction of effort in terms of escorting and a greater flexibility in the operation of the plant. It has to be ensured, however, that the safeguards system reliability is high and that the data are conclusive.

Final Notice: The Group finally stated that the deployment of integrated systems will be a big change and a challenge for developers, inspectorates and operators.

6. References

/1/ B. RICHTER, F.J. WALFORD "The ESARDA Workhop on C/S Safeguards Techniques Applicable to Intermediate and Long-Term Storage of Irradiated Fuel", J. INMM, Vol. XXI, 1992, pp. 498-500.

/2/ B. RICHTER, G. NEUMANN "The Integration of Optical Surveillance and Electronic Sealing", ESARDA Bull. no. 21, Dec. 1992, pp. 8-10.

Opening of the Celebration Session

M. Cuypers
Chairman of ESARDA, EC, JRC Ispra, Italy

Ladies and Gentlemen, It is for me a honour and a great pleasure to open this second plenary session of the Internal Meeting of ESARDA at Ghent. This session will be essentially dedicated to the celebration of the 25th Anniversary of the Association.

At this occasion, we have asked some distinguished speakers to address the audience.

We are grateful

- to the representatives of the Belgian Government, which has always expressed its interest in the safeguards and NPT issues,
- to the two Inspectorates of EURATOM and IAEA, which are an important point of reference for our Association and, in particular to Mr. Pellaud, Deputy Director General, whom we have the pleasure to welcome for the first time in an ESARDA meeting,
- to the Institute of Nuclear Materials Management (INMM) represented by Mr. Sonnier; INMM is often referred to as the sister organisation of ESARDA,
- to the eminent representative of a research organisation, party to ESARDA, Mr. Malbrain, the General Director of SCK/CEN,
- to Mr. Gupta, a former chairman and an important actor in ESARDA, who will stimulate the audience to look beyond the strict framework of our Association.

It is also a great pleasure for me to welcome a number of guests, invited because of the special role they have played in the past in our Association: the former chairmen.

Some of the chairmen were involved in the creation of ESARDA or acted at important events of the Association. I like in this context to mention, in particular Mr. S. Finzi, who has always been available to ESARDA, to push forward the R&D effort in an area, which he considered as one of the fundamental components for the safe development of nuclear energy. He was appointed last year honorary member of ESARDA.

I also like to welcome those chairmen, who were involved in the adhesion of their respective organisation to ESARDA and finally to all the chairmen, who with their constant work and engagement pushed ahead the Association during their terms of office in order to be able to satisfy all the partners: R&D people, Inspectors and Plant Operators. Some of the past chairmen are not able to participate to our meeting and they have sent their apologies. In particular, M. Bastrup-Birk did address me a letter: Mr. Frederiksen will address the audience with some remarks.

At the occasion of the 25th Anniversary, it seems appropriate to publicly recognise the effort of many other persons: the programme coordinators, who over the years have tried very hard to provide a coherent scientific image of our Association and gave many recommendations for R&D activities of the Association.

Last but not least, the scientific work and joint activities are mainly performed by Working Groups. The Association has in these working groups its most important element of cooperation and integration. A special mention has to be made of the convenors, who need to work hard, and have to use much of their capabilities of conviction to start new activities and to get a maximum of persons involved in their Working Groups.

Finally, an organisation cannot operate properly without an efficient administrative branch. The secretaries of ESARDA have been the elements of continuity in ESARDA, and had to assure in the course of the years that the Association would run smoothly and efficiently.

An important task of the secretariat is the organisation of symposia and edition of our Bulletin, the broad exchange of information and the creation of occasions of informal contacts. This activity has been performed with great competence and engagement by L. Stanchi and this is an occasion to publicly thank him for this excellent job performed since so many years. He was also appointed honorary member of ESARDA last year.

After these introductory remarks, Ladies and Gentlemen, I like to start the series of presentations of this session celebrating the 25th Anniversary by presenting you some reflections on the life of the Association. I have been involved in ESARDA since 1971 and have tried to reconstruct the main events of the Association, which some of you will recall very well. If some of my picture will be perceived as somewhat partial I apologize, in advance, but it is not easy to reconstruct the actions of so many people during a period of 25 years in an area where political, industrial and technical considerations cross each other.

Twenty Five years of the European Safeguards Research and Development Association (ESARDA)

M. Cuypers
Chairman of ESARDA, EC, JRC Ispra, Italy

1. Introduction

The first safeguards co-operation agreement between the European Atomic Energy Community (EURATOM), and the Gesellschaft für Kernforschung mbH (GfK) was signed on December 10, 1969. The agreement started when the basic principles and objectives of NPT safeguards were discussed and the technical basis of international safeguards were been formulated and individual R&D programmes were set-up. Mr. W. Haefele, who was involved in the establishment of the first cooperation agreement, spoke during the luncheon speech at the 11th Annual Symposium of ESARDA at Luxembourg, on the context of the creation of ESARDA in 1969. Quoting Mr. Haefele "If we negotiated INFCIRC 153 in Vienna, then Europe must be heard and EURATOM must be heard, must be present. ESARDA was the principal tool of exchanging ideas on systems analysis as well as instruments and equipment" /1/.

The 1969 agreement formed the framework for the activities of the safeguards research Association, which got its present name "ESARDA" only in 1973.

The objectives of the Association were laid down in Article 1 of the original agreement which is worthwhile recalling: "The purpose of the agreement covers collaboration on research work in the field of safeguards of source and special fissile material. The research programmes of the Contracting Parties, brought up to date annually, shall be submitted to the Steering Committee, which will define the basis for collaboration. Collaboration shall be effected by co-ordination of the research work and by the exchange of information and assistance on the personnel and technical levels and by joint execution of parts of these programmes".

In the renewal of the agreement in 1981, which also coincides with the entrance of the CEA as a party to the Association, the first sentence of Article 2 of the agreement was slightly changed as follows: "The purpose of the agreement is *to facilitate* collaboration on R&D

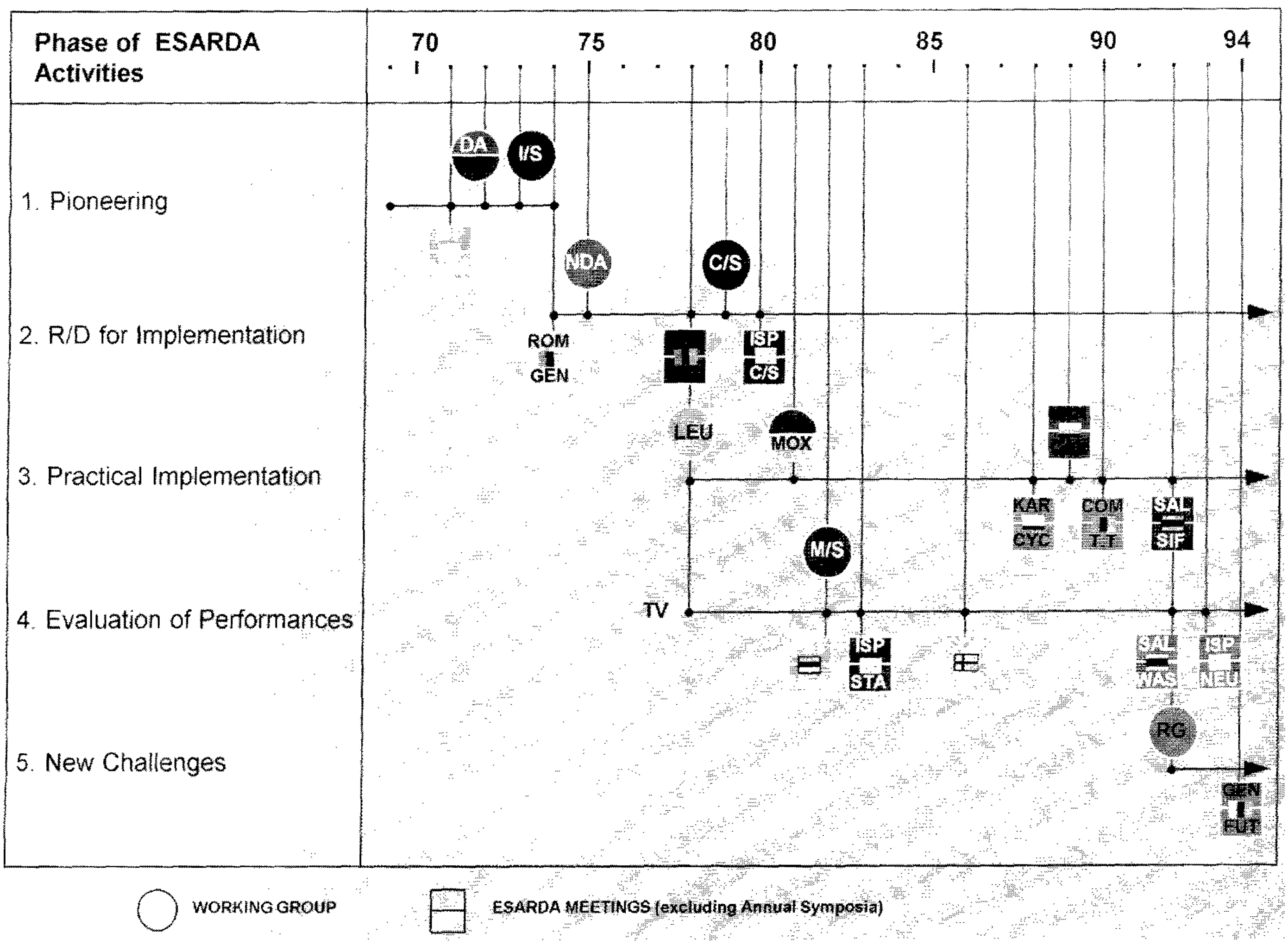

Figure 1: Evolution of Activities of ESARDA

in the field of safeguards and *on the application of such R&D* to the safeguarding of source and special fissile material...".

This change reflects the intention of better putting in evidence the fact that the activities of ESARDA were moving more and more from basic studies and laboratory work to application of techniques in plant conditions. This change in emphasis also had as a consequence that the role of plant operators and their representation in the managerial and executive bodies of ESARDA started to become more important. The 1981 agreement with some minor amendments, is still the basis for the present cooperation between Parties in the framework of ESARDA.

At the 1994 IAEA symposium on international safeguards, a paper on ESARDA was presented /2/. The paper described the ways and means used by the Association to implement the objectives of the agreement, in respect to the exchange of information, coordination of R&D work and the execution of joint activities. The present paper will concentrate more on why and when some activities were performed or initiatives taken and at what stage of the evolution of nuclear safeguards. In other words how did ESARDA contribute to the technical challenges of safeguards in the European Union.

2. Evolution of the Activities of ESARDA

At the first annual symposium of ESARDA at Brussels in 1979, Mr. Gupta presented a paper which reminded the foundation of ESARDA in 1969 and the evolution of the Association's activities during the first decade /3/. During the 11th annual symposium at Luxembourg, C. Fizzotti, reminded the 20th anniversary of the Association and mentioned some highlights of its recent activities /4/. It is worthwhile at the occasion of the 25th anniversary of the ESARDA, to briefly recall some of the statements made in these two papers and to analyse more closely the evolution of ESARDA activities and their present status and to touch upon some of the future orientations.

The activities pursued by the Association over the 25 years of its existence have been going through several phases. Efforts were concentrated on areas, which were conditioned by the general evolution of nuclear safeguards and by non proliferation issues. Following and further elaborating on the scheme proposed by D. Gupta in his paper, one can identify the following phases and categories of activities of ESARDA:

- pioneering R&D on international safeguards,
- R&D on implementation for international safeguards,
- practical implementation,
- evaluation of performances,
- new challenges.

Figure 1 illustrates the evolution of ESARDA, following these different phases.

2.1 Pioneering Phase

As mentioned earlier, ESARDA was founded in 1969, when the IAEA safeguards committee was elaborating the INFCIRC 153 and when it was necessary to demonstrate that the technical conditions foreseen for the NPT safeguards system could be fulfilled. During this pioneering phase, covering approximately the period 1969-1974, ESARDA started to organise itself as an international association and initiated some joint activities and the parties started to formulate their respective R&D programmes. In particular, the JRC established in 1969 its safeguards R&D programme and its technical support activities to the EURATOM Safeguards Directorate.

After the foundation by GfK (which became KfK) and EURATOM, five R&D organisations joined in the following years the Association, namely SCK/CEN (Belgium), CNEN, which became ENEA (Italy), RCN, which became ECN (Netherlands), UKAEA (UK) and AEC, which became ENS (Denmark).

In September 1971 the first international meeting of ESARDA was organised at Ispra on "Non-Destructive Measurement and Identification Techniques in Nuclear Safeguards".

The first Working Groups were established, in particular those in the field of "techniques and standards for destructive analysis (DA)" and "isotopic correlation techniques (ICT)" in 1972 and "identification and sealing techniques (I/S)" in 1973.

During this pioneering phase some feasibility studies were performed for the practical application of nuclear safeguards in facilities. Such studies included integral experiments in reprocessing plants (Mol III-IV experiments at the Eurochemic plant). Also some theoretical studies were conducted to optimise and quantify the safeguards efforts, using statistical and decision theory methodologies, which led to the publication of three ESARDA reports, prepared by W.L. Zijp. Furthermore, several ESARDA activities (creation of DA Working Group and 1971 Ispra international meeting) were oriented to establishing an inventory of techniques of potential interest for safeguards. The evaluation of the performances of analytical techniques and the determination of attainable measurement accuracy under routine operating conditions has been from the beginning a point of major interest in the Working Group of DA (example IDA72). During this period ESARDA started to also investigate the possibilities of identification and sealing techniques.

The EURATOM Safeguards Directorate played an important role for identifying the R&D needs and in the transfer of R&D results to practical implementation.

2.2 R&D on Implementation of International Safeguards Systems

During the second phase, starting approximately in 1974, and coinciding with the introduction and implementation of international safeguards (IAEA) in the European Community, the general studies were gradually replaced by activities with more specific requirements in view of their practical implementation. For this reason it became necessary to intensify the contacts between the facility operators, research organisations and safeguards organisations. In order to respond to this need, the first safeguards symposium of ESARDA was organised in 1974 in Rome. The theme of the symposium was "Practical Applications of R&D in the Field of Safeguards", and the principal objective was to present in a comprehensive manner to a wide audience, in particular plant operators, the basic principles of nuclear safeguards, results of R&D work and the first practical application made mainly by the EURATOM Safeguards Directorate.

ESARDA established in 1975 the Working Group on "techniques and standards for non-destructive assay (NDA)" and in 1979 the Working Group on "containment and surveillance (C/S)" in replacement of the previous Working Group on identification and sealing techniques, which had a more limited scope.

The effort to gather information on techniques of potential interest for safeguards was continued in the existing and newly created Working Groups. In particular, one of the first activities of the NDA Working Group was the establishment of an inventory of NDA measurement techniques and reference materials available in the EU, which resulted in the preparation of two ESARDA reports.

Because of the importance given by Safeguards Inspectorates to use more intensively measurement and monitoring techniques in the implementation of nuclear safeguards in fabrication and reprocessing plants, the need to also apply specific C/S measures was very rapidly identified. In this context the C/S Working Group organised in 1980 at the JRC Ispra the first ad-hoc meeting or seminar on "Containment and Surveillance Techniques for International Safeguards".

The capabilities of isotopic correlations were extensively discussed in the topical meeting, "Isotopic Correlation and its Application to the Nuclear Fuel Cycle", organised in 1978 at Stresa by the ICT Working Group.

The exchange of information in the different Working Groups on the more basic R&D work, performed by research organisations has been since 1974 a continuous activity of ESARDA.

It is also worthwhile mentioning that two research organisations joined ESARDA in 1988 as Parties, namely CIEMAT (Spain) and KFA (Germany), showing that the Association continues over the years to remain a useful forum for discussions between research people on more basic scientific and technical subjects.

2.3 Practical Implementation

The implementation of "modern" safeguards in EU facilities started to raise some practical and technical problems and a stronger interaction of ESARDA partners (at that time mainly R&D organisations) with plant operators was required. Some of the technical problems identified were related to the application of computer based accountancy systems, the installation, calibration and use of measurement equipment in different parts of the nuclear fuel cycle and the procedures for physical inventory taking and verification.

Whereas, in the early stage of interaction with plant operators, the main objective of ESARDA was to provide information on basic principles and potential applications of techniques, in the eighties the main purpose was to investigate in a cooperative manner between inspectorates, operators and R&D people, the optimum use of available technology and to identify areas where improvement was required.

ESARDA started from 1978 on to promote a number of actions with a strong involvement of plant operators.

The first plant oriented Working Group was established in 1978 more specifically in the field of LEU conversion and fuel fabrication.

In 1981, the Isotopic Correlation Working Group, changed its terms of reference to address problems related to the reprocessing input verification and the new RIV Working Group was established.

In 1981 the Mixed Oxide Fuel Fabrication (MOX) Working Group was established, while the discussions on the safeguards approach to be applied on this kind of facilities were still being discussed.

The plant oriented Working Groups gradually developed in an important forum for the exchange of information on safeguards and nuclear management practices and for the better understanding and harmonisation of measurement and accountancy procedures. These Working Groups still continue to provide valuable suggestions to R&D people for developing techniques, adapted to the industrial requirements.

An important event was in 1981 the renewal of the agreement and, as mentioned earlier, the introduction in Article 2 of the words "application of R&D". This was a clear signal of ESARDA that it was orienting its activities not only to the needs of safeguards inspectors but also to those of the operators. The interest of plant operators did grow over the years and the following organisations joined the ESARDA as Parties: in 1981 the CEA (France) with representatives from COGEMA and EDF, in 1986 BNFL (UK). In 1994, the WKK (Germany), representing 20 organisations also applied as a Party to the Association.

ESARDA organised a number of meetings in the following years, aiming at orienting R&D activities more to practical implementation.

In view of identifying needs of R&D at medium and long term, ESARDA started in 1987-88 an analysis of the safeguards features of the nuclear fuel cycle in EU up to the year 2000. The results of the analysis was presented at the 1988 internal meeting of ESARDA at Karlsruhe. In January 1994, the coordinators have decided to review and update this study in order to prepare recommendations for future work of ESARDA Working Groups.

In 1989, the RIV Working Group organised at Hannover the CALDEX (Calibration Demonstration Exercise) workshop on reprocessing plant tank measurements.

In 1992, at the Salamanca internal meeting, the C/S Working Group analysed the application of C/S safeguards techniques applicable to intermediate and long term storage of irradiated fuels, which is an area where at present no specific plant oriented Working Group exists.

One has also to mention that around 1980, several Member States of the EU established technical support programme to IAEA, where the application of R&D is much emphasised. Important parts of their programmes were extensively discussed in the different Working Groups.

In order to promote the exchange of information between inspectors, operators and R&D people, in particular at the initial stage of the implementation of nuclear safeguards, ESARDA decided to organise annual symposia from 1979 on. From 1986, the frequency of these symposia was changed to every two years. This provides the possibility to the Working Groups to concentrate on some more specific themes in the other year during the ESARDA internal meeting. Up to now ten large symposia were organised and five internal meetings.

In the late eighties increasing budgetary difficulties of the Inspectorates and R&D organisations became apparent and led ESARDA to initiate some reflections on the cost effectiveness in the development, procurement and implementation of measurement systems. This subject was extensively discussed at the 1990 internal meeting in Como under the theme, "Technology Transfer in Safeguards".

2.4 Evaluation of Performances

One of the important but difficult issues in nuclear safeguards is the evaluation of its efficiency and effectiveness.

After introducing a large number of measurement systems and the production of many data for material control and verification purposes, two problems came up. One is the evaluation of the quality of data produced and the second one is the data management in field and at headquarters.

ESARDA has never been involved directly in the global evaluation of the effectiveness of safeguards, but it has always had a strong interest and promoted activities aiming at evaluating the performances of measurement techniques and systems.

As was mentioned before, already in the pioneering phase, the first interlaboratory exercises were organised. It is, however, approximately in 1978 that this type of activities started to become important both for the DA and NDA Working Groups.

In 1978, the DA Working Group established the so called "Target values" for analytical measurements and several revisions of these values took place since in 1983, 1987, 1988 and 1994.

In 1992, the NDA Working Group has started similar type of studies, based on the large experience gained by plant operators and inspectors in the application of these techniques in plant conditions and on the better understanding by R&D people of the error components in measurement practices. The internal meeting in 1992 in Salamanca did concentrate on the NDA techniques applicable to safeguarding nuclear waste and the evaluation of their performances was strongly emphasised.

In 1982, on request of different disciple and plant oriented Working Groups, the Mathematical and Statistical Working Group was established. This group contributed to the introduction of the proper statistical methodologies to analyse measurement results and for the evaluation of material balance data.

The Working Group organised in 1983 a workshop in cooperation with INMM on NDA statistical problems.

Two important meetings were organised aiming to promote the studies on the evaluation of performance of measurement techniques. One was the specialist meeting in Petten in 1982. In 1986, at the Copenhagen internal meeting the capabilities and objectives of different techniques were analysed by each of the Working Groups. Another international workshop is worthwhile mentioning, namely the one on "Passive Neutron Coincidence Counting", organised by the NDA Working Group at Ispra in 1993.

One may state that the evaluation of performances of safeguards and nuclear material management techniques is one of the strong points of ESARDA's Working Groups activities and very positive and useful results have been obtained. In fact, this is a typical activity, where one can obtain valuable results only by collective and cooperative actions of different partners involved. It is expected that ESARDA will continue to strongly promote in the future this type of activities.

In order to be able to illustrate the evolution of ESARDA, the past activities were subdivided in different phases and categories. As indicated in figure 1, R&D for implementation, practical implementation and the evaluation of performance are activities which still continue at present. It is to be noted, however, that it becomes more and more difficult to make a clear distinction between the phases. This shows that the present initiatives taken by ESARDA are addressing subjects of interest to all concerned parties and that the role of the integration of ESARDA in particular through Working Group activities is making progress. In other words, the R&D is performed with a better understanding of the requirements from inspectors and plant operators and the implementation of R&D results is taking place, keeping in mind the performances of the technical means put in operation by plant operators and inspectors.

In fact, several Working Groups convene joint meetings (NDA and LEU; NDA and MOX; C/S and NDA; DA and NDA) to discuss subjects of common interest.

3. Present Status of ESARDA

In this chapter we like to describe the present status of ESARDA and more specifically its organisational structure, its way of operation and the cooperative actions it is conducting.

3.1 Organisational Structure

The organisational structure of ESARDA is illustrated in figure 2.

In 1994 ten organisations are *Parties* to the agreement, including nine research organisations and one major industrial company.

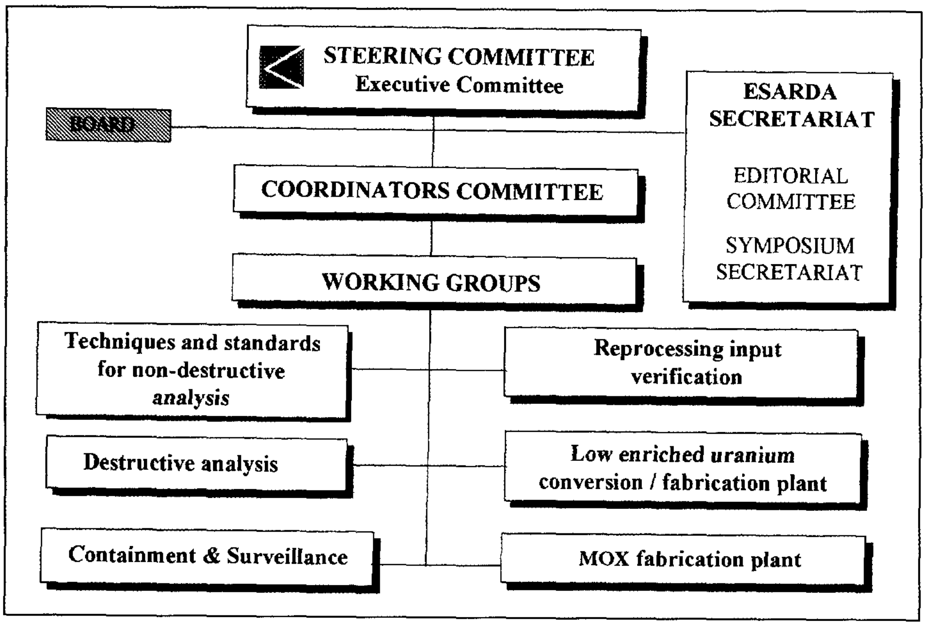

Figure 2: Organisational structure of ESARDA

Table 1: Parties to the European Safeguards Research and Development Association (ESARDA) and Organisations represented in Steering Committee

Parties	Members	Year of Accession
European Atomic Energy Community	DG XII (JRC)/ DG XVII (Dir. C/ESD)	1969
Kernforschungszentrum Karlsruhe GmbH, Germany	KfK/BMFT/GNS	1969*
Studiecentrum voor Kernenergie-Centre d'Etude de l'Energie Nucleaire, Belgium	SCK-CEN BN/EXT. AFF.	1970
Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy	ENEA-ANPA	1971
Stichting Energieonderzoek Centrum Nederland, Netherlands	ECN	1971
United Kingdom Atomic Energy Authority, United Kingdom	UKAEA/DTI	1974
Energistyrelsen, Denmark	ENS	1974*
Commissariat à l'Energie Atomique, France	CEA/COGEMA/EDF	1981
British Nuclear Fuel Ltd., United Kingdom	BNFL	1986
Centro de Investigaciones Energéticas Medioambientales y Technológicas, Spain	CIEMAT	1988
Kernforschungscentrum, Jülich, Germany	KFA/BMFT	1988
Wirtschaftsverband Kernbrennstoff Kreislauf	WKK 29 organisations	1994

* Participation was terminated in 1992 for ENS and in 1994 for KfK.

The decision body of ESARDA is the Steering Committee, which has the responsibility of the ESARDA activities. This committee is presently composed of 24 *members*. Each Party is entitled to select for its representation (members) in the Steering Committee several organisations in its country. These members represent, in practice, ten R&D organisations, seven industrial companies with direct interest in the nuclear fuel cycle, four inspectorates and four governmental bodies. In the near future, an association of utilities and fuel cycle companies in Germany is expected to join ESARDA as a Party. Table 1 provides a list of the Parties to the Association, the member organisations in the Steering Committee and the year of accession. On may state that in the EU, ESARDA is a representative forum for discussions on R&D, technical developments and the application of R&D results in the fuel cycle.

A Board was established in 1981 with one representative for each country, for discussing the management and policy aspects of ESARDA and for streamlining the preparation and decisions of the Steering Committee.

For each country a scientific coordinator is assigned. The coordinator represents its country in the discussions and analysis, for instance, of the nuclear fuel cycle and its safeguards features, of the R&D programmes submitted by the Parties and in the preparation of recommendations on possible joint activities, creation of working or ad hoc groups or special meetings. The coordinators are in charge of the scientific management of the Association.

The scientific and technical activities are performed in the six Working Groups presently operated by ESARDA. Three of these Working Groups, as mentioned earlier are plant oriented, namely on safeguards for LEU fuel fabrication and conversion plants, for MOX fuel fabrication plants and for reprocessing plant input. Three other Working Groups are technical discipline oriented, namely on analytical techniques, on non-destructive assay techniques and on containment and surveillance techniques.

Finally, the general secretariat, held by the Joint Research Centre, assumes the responsibility of the administration of the Association and acts as a focus point for the activities and contacts of ESARDA with external organisations.

3.2 Ways of Operation and Cooperative Activities

As shown before, the modes of interaction and cooperation between ESARDA members and observers are based on:

- the exchange of scientific and technical information,
- joint activities, which consist of the coordination and harmonisation of R&D work performed by the members and the execution of joint technical projects.

3.2.1 Exchange of scientific and technical information

The exchange of information is performed in different ways. Ongoing actions are the organisation of annual symposia and internal meetings, such as the present one in Ghent with all the Working Groups. The next annual symposium is being planned for May 9-11, 1995 in Aachen (Germany).

As mentioned earlier, the exchange of information within the Working Groups on scientific developments and experience gained in the application of measurement and evaluation systems is a permanent agenda point in their meetings. Topical discussions are also held by the Working Groups in ad hoc meetings.

The ESARDA Bulletin remains an important channel for the communication of information on the life of the Association and the presentation of scientific papers.

The recently established Executive Committee is analysing the internal structure of ESARDA to improve the flow of information between Working Groups, coordinators and Steering Committee.

Last but not least, in the margin of the symposia and meetings much informal exchange of information takes place and bilateral discussions are conducted.

3.2.2 The coordination and harmonisation of R&D work

This is the main task of the ESARDA coordinators committee. The implementation of this key element is performed in the following way. The identification of R&D topics of common interest and proposals for cooperation and harmonisation is based on the analysis of:

- ongoing R&D activities of the Parties,
- medium and long term (5 to 10 years) evolution of the nuclear fuel cycle,
- specific (in general short term) needs formulated by potential users of R&D results (Safeguards Inspectorates and Plant Operators)

Additional points considered in the analysis are the existing safeguards approaches and those under discussion as well as the general evolution of technologies of potential interest for safeguards applications.

The critical analysis of the above mentioned input data is facilitated using two data bases, one on safeguards R&D activities and one on the nuclear fuel cycle.

The first data base, called "ESTABANK", has been created for facilitating the handling, processing and use of information provided by the coordinators on the R&D programmes of ESARDA partners. In this data base the activities are labelled according to different criteria, such as the framework in which a certain activity or task is performed, the technical discipline, status of development, potential areas of application, and cooperation partners.

Recent results of the analysis of ongoing R&D activities of partners in the field of containment and surveillance techniques, of non-destructive assay techniques and of analytical techniques, have been published in the ESARDA Bulletin. A similar review and analysis has now been completed on techniques applied or studied for reprocessing plant and fuel fabrication plant safeguards. These analyses provide a good overview of the degree of development and practical implementation of different techniques (laboratory stage - field application - industrial production - implementation for inspection or material control).

The second data base is the one on the nuclear fuel cycle, which includes the list and main characteristics of all the power reactors and industrial nuclear facilities in the EU. These characteristics comprise the location of the facilities, the type of nuclear materials handled or processed, the potential throughput and storage. Special attention is paid to collect data of general interest to safeguards. In 1988 such a data base was established for the EU countries and the horizon of the year 2000. The data base is now being reviewed with the horizon 2020, including nuclear facilities of EFTA countries and to a limited extent of Eastern Countries. The data base is operated by the JRC at Ispra.

The EURATOM Safeguards Directorate participates to all the meetings of the ESARDA coordinators and provides regularly input on its general and specific needs.

The coordinators will initiate at their next meeting also the analysis of the 1995-96 R&D and Implementation Support Programme of IAEA.

3.2.3 Joint technical projects

The joint projects performed in the framework of ESARDA Working Groups aim, in general, at the:

- definition of target and performance values;
- establishment of capabilities and performances of measurement techniques and data evaluation methods;
- development and recommendation of procedures for the application of measurement and data evaluation methods.
- establishment of the status of development of methods and techniques (including reference materials).

Some of the joint projects underway or recently completed are illustrated:

A) Definition of Target and Performance Values

The Destructive Analysis (DA) Working Group of ESARDA established in 1979 the so-called "Target Values" for analytical measurements. They correspond to values of the random and systematic error parameters to be aimed for in elemental and isotopic analyses of the most significant types of materials using common destructive analytical methods. Several revisions (in 1983, 1987, and 1988) of the target values took place. The IAEA has always had a strong involvement in this project. The forum of discussions on target values was also enlarged, including specialised committees of INMM. The January 1994 issue of the INMM Journal and the March 1994 issue of the ESARDA Bulletin published a condensed version of the "1993 International Target Values for Uncertainty Components in Fissile Isotope and Elemental Accountancy for the Effective Safeguarding of Nuclear Materials". These last data include now also target values for bulk measurements and some non-destructive assay methods used as accountancy and verification tools.

A similar action was undertaken by ESARDA in the past to study and establish target values for uncertainty components in sampling. General discussions were held on sampling in different parts of the process lines in LEU and MOX fuel fabrication plants. The 1988 target values did include the random error parameters to be met in the elemental assay as result of sampling.

Recently the NDA Working Group started an action with the objective to establish "performance values" for NDA techniques on different kinds of materials. NDA Performance Values are defined as "knowledge of the overall uncertainty and error sources associated with an NDA measurement system".

A preliminary analysis was also performed on data and information compiled from monitoring of waste materials by NDA techniques, in particular during the last internal meeting held in Salamanca in 1992.

The latest NDA performance values were issued by the Working Group at the ESARDA symposium in 1993 in Rome.

The C/S Working Group has also discussed extensively methodologies to express the assurance/performance of C/S devices and systems.

B) Experimental Determination of Capabilities and Validation of Performances Values for Measurement and Data Evaluation Methods

The results obtained from interlaboratory measurement evaluation programmes, quality control programmes or tailored-made laboratory exercises are an important input to the definition or validation of the performance values of measurement and data evaluation methods. In the framework of ESARDA several exercises have been conducted or are discussed in the different Working Groups. A few of the most recent examples are now illustrated.

- The Regular European Interlaboratory Measurement Evaluation Programme (REIMEP), is organised by JRC (IRMM), Geel, with a very broad participation of laboratories worldwide, including IAEA. In 1992, the programme included the distribution and destructive analysis of MOX pellets, spent fuel solution and plutonium nitrate solution. In 1993, UF6 samples were distributed for destructive and non-destructive analysis. The overall results of the programme are presented to the DA Working Group. The EURATOM Safeguards Directorate is providing a financial support to REIMEP as part of the quality control programme for its network laboratories. Furthermore, the status and results of the EQRAIN (Evaluation de la Qualité du Résultat d'Analyse dans l'Industrie Nucléaire) programme, managed by the French CETAMA, is also discussed in the DA Working Group.
- Two extensive intercomparison exercises were conducted in the past by the NDA Working Group. One corresponds to the plutonium isotopic determination exercise (PIDIE) to test X-ray and gamma spectrometry methods. The second one aimed to the evaluation of the U235 enrichment measurement technique also by gamma ray spectroscopy using U_3O_8 certified reference materials.
- Neutron coincidence counting is one of the basic techniques used in the assay of plutonium. Much experience has been gained for the application of this technique in laboratories, by safeguards inspectors and by plant operators. The NDA Working Group convened in April, 1993 at the PERLA laboratory in Ispra an international workshop on passive neutron counting applied to the assay of plutonium bearing materials. The basic issues discussed were: the evaluation of the applications and performances of well established shift register based instruments and the evaluation and future prospectives of the new generation of passive neutron instruments, based on neutron multiplicity analysis. Demonstration exercises were performed in PERLA and a report with the recommendations of the group have been published.
- A number of measurement methods for volume and mass determination have been implemented routinely by plant operators and safeguards inspectors in pilot facilities of reprocessing plants. The Reprocessing Input Verification (RIV) Working Group participated in an important exercise (managed by DWK/GNS) for intercomparing different calibration and measurement systems on a large size (12 m^3) tank in cold conditions, the so called CALDEX exercise. Eight different measurement devices and five methods have been evaluated. Twelve organisations from Europe, US and the IAEA participated in this exercise. The results were extensively discussed by the Working Group and some of them are now published. An enlarged exercise is being organised at the TAME laboratory at JRC, Ispra on a variety of tanks, including the CALDEX tank, which was transferred from Karlsruhe to Ispra.
- An isotopic correlation technique bench mark exercise has been conducted by the RIV Working Group of ESARDA. This exercise consisted in the intercomparison of the performances of different isotopic correlation techniques for the verification of the input inventory of a nuclear fuel reprocessing plant. To the seven participants of the exercise, COGEMA supplied data (chemical and isotopic analysis and Pu/U ratio) from 53 routine reprocessing input batches made of 110 irradiated fuel assemblies. The results have now been published.

C) Harmonisation of Procedures

One of the results of interlaboratory exercises and discussions in the ESARDA Working Groups is the development of detailed measurement and data evaluation procedures. Ongoing actions in this field are:

- An exercise was originated by the LEU Working Group in order to establish general and easy procedures of weighing, enabling the users to control the accuracy and the precision of their scale system. Standard weights, in the range of 1 to 40 kg were circulated among the plant operators in Europe and the results analysed by the JRC, Ispra and then discussed in the Working Group. On the basis of two measurement campaigns a procedure has been prepared and made available to the plant operators. A new calibration campaign is to be started soon.
- The MOX Working Group studied the practices applied in the different facilities in Europe for the calculation and reporting of nuclear transformation and a common paper is to be issued soon.
- Both the LEU and MOX Working Groups discuss on nuclear material statistical accountancy systems for the evaluation of MUF and VarMUF on reference and real plant data. The goal is to define common calculation procedures and possibly computer packages and make a correct interpretation of the different error components in the material balance evaluation of fuel fabrication plants.

D) State of Development of Methods and Techniques

The Working Groups have a permanent task to remain updated with the latest developments of different techniques and with the experience gained in their practical applications. This is performed during general discussions of the R&D activities of the participants at Working Group meetings and by organising topical meetings in view of establishing the state of the art on a particular subject.

The C/S Working Group organised a specialist meeting on "Optical Surveillance Data Reduction Techniques", where more specifically the implications of front end versus back end optical data reduction in video surveillance for safeguards was discussed. At the Salamanca internal ESARDA meeting on "C/S Safeguards Techniques Applicable to Intermediate and Long Term Storage of Irradiated Fuel", the C/S Working Group discussed safeguards relevant facility design features and basic safeguards concepts for spent fuel storage facilities, established criteria for the development of C/S equipment and identified relevant C/S devices and techniques.

The C/S Working Group has also decided to issue a compendium of C/S devices, a compilation of outline information on a range of products and particular devices which could meet the requirements of specific applications.

The LEU and MOX Working Groups discussed the specific measurement issues of scrap and waste material. The different categories of scrap and waste material encountered in such facilities were defined and the existing measurement capabilities and needs. This information was used by the NDA Working Group for their discussions on performance values and development needs.

In general, the plant oriented Working Groups are interested to be regularly informed by the technique oriented Working Groups on the ongoing developments in order to evaluate, at an early stage, the possible impact of these developments on the nuclear material management and verification practices in their facilities. Several combined meetings were organised between Working Groups such as between MOX and NDA, DA and LEU to promote this type of dialogue.

Because of the need to develop more and more instruments using a combination of different techniques, which have to be integrated, the NDA and C/S Working Groups have decided to organise joint meetings. Similarly the DA and NDA Working Groups meet also periodically to discuss common approaches regarding, for instance, traceability or the definition of target and performance values.

4. Challenges and Future Trends of ESARDA

Nuclear safeguards is confronted with very important challenges, as has been described in several papers at the last IAEA symposium in March at Vienna.

The present level of nuclear safeguards implementation in the EU has to be maintained, continuously improved and adapted to the changes in the nuclear fuel cycle. A stronger cooperation with IAEA and the expected enlargement of the EU are also elements to be taken into account. Furthermore, the strengthening of safeguards, especially regarding the possible detection of undeclared activities, requires the implementation of new techniques. The implementation of an effective and efficient safeguards system in nuclear facilities in the former Soviet Union and the application of safeguards on the nuclear materials coming from the dismantling of nuclear warheads are important issues, which are addressed by several member states of the EU.

The Steering Committee decided in December 1992 to start a reflection on how ESARDA could technically contribute to the solution of some of these problems and on the future orientation of the Association and the activities of its Working Groups. A reflection group was established for this purpose and a number of subjects were discussed and they are now briefly mentioned.

- The need to further study in a Working Group the technical aspects related to the application of safeguards in intermediate storages of spent fuel was assessed.
- The group also exchanged some ideas on the possible criteria that Regional Systems might be expected to fulfil and the technical consequences.
- The R&D requirements for implementing the proposals for the strengthening of safeguards, have been considered (for instance in the area of environmental monitoring).
- The need to involve ESARDA in studies related to verification techniques required for safeguarding ex military nuclear material, coming from weapons dismantlement, has been discussed.
- The possible role of ESARDA was examined in the field of communication and dialogue with non safeguards experts on the features of nuclear safeguards and the experience gained in its implementation in a supranational and international inspection regime. This last point is considered important, because non proliferation and safeguards issues are becoming more and more key elements, in addition to safety, waste management and radiation protection, for the acceptance and safe development of nuclear energy.
- The reflection group did consider the possible enlargement of the Association to other Parties and the cooperation with the FSU (Former Soviet Union) and Eastern Countries.
- Finally, the Steering Committee asked the reflection group to pay special attention to analyse the organisational structure of ESARDA and to make proposals to streamline the internal decision process and working structure.

The reflection group presented its final report to the Steering Committee and to the participants of the this ESARDA Internal meeting here at Ghent. The conclusions of the reflection group will be published in one of the future issues of the ESARDA Bulletin.

In conclusion, I believe that ESARDA is an appropriate forum to address the emerging technical problems of nuclear safeguards and through its present activities the Association demonstrates that it has the willingness and capabilities to tackle these problems.

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Incentives for Reasonable and Useful Applications of Plutonium Stocks in Civil Nuclear Reactors

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1. Introduction

In the last couple of years many important changes, which had considerable impact on the implementation of safeguards of nuclear materials, have taken place in the nuclear world. To mention some of these safeguards problems:

- the clandestine development of nuclear capabilities and activities, recently identified in some countries in the world;
- the final destination of nuclear materials from dismantled nuclear warheads;
- the growing stocks of spent fuel and plutonium from the civilian nuclear fuel cycle.

Some of these problems have resulted in solutions and interventions from the safeguards authorities. In this context, measures for strengthening the effectiveness and improving the efficiency of safeguards have to be considered.

Table 1: World plutonium and HEU inventories (by country at the end of 1990, in tons)

Country	Civilian		Military	
	Pu (a)	HEU	Pu (b)	HEU (b)
Belgium	1			
France	4		6±1.5	10 to 20
FRG	8			
UK	33		2.8±0.7	10?
Japan	2			
CIS	25		125±25	700±150
USA			97±8	550±50
China			2.5±1.5	10 to 20
Total	73	20	233±36	1280±340

(a) Quantities reflect only the separated Pu in store; in addition about 580 tons of Pu are contained in spent reactor fuel and MOX and LMFBR fuel.
(b) Quantities include material both inside and outside weapons
[SOURCE: "World Inventory of Plutonium and Highly Enriched Uranium", Oxford University Press, 1993]

In this presentation, one problem will be looked at in more detail, namely the presence and build-up of large stockpiles of plutonium originating from the civilian fuel cycle. An inventory of plutonium stocks from military applications is also considered in a more general way.

2. The plutonium problem in the world

2.1 Current plutonium inventory (end of 1990)

Military plutonium

Plutonium and highly enriched uranium (HEU) produced by nuclear weapon states (NWS) for military purposes are estimated at about 260 tons and 1320 tons respectively (see Table 1). Of these amounts about 100 tons plutonium and 550 tons HEU were produced in the US and 125 tons plutonium and 700 tons HEU in the former Soviet Union. Dismantling of nuclear weapons has already started and is expected to continue for some ten years. The amounts of weapon-grade plutonium and HEU outside warheads are estimated at 56 tons and 510 tons respectively. (See Table 2.)

This material from nuclear weapons programmes is of high quality, with minimum 93% and up to 99% of fissile isotopes. As associated radiation dose levels are low, fuel fabrication requirements - in case of recycling - will be facilitated.

Table 2: World plutonium and HEU inventories (by NPT status at the end of 1990, in tons)

Inventory	NPT signatory states		Non-NPT countries	Total
	NWS	NNWS		
Civil plutonium				
In spent reactor fuel	297 (a) 366 (b)	218 (a) 148 (c)	17	532
Separated in store	65	7	<0.5	72
In fast reactor fuel cycle	25.3	11.5		37
In thermal MOX fuel cycle	5.8	6.5		13
Total civil plutonium (by ownership)	392	244	18	654
Civil HEU				
In research reactor fuel				20
Military plutonium				
In warheds	178		0.3	178
Weapon-grade outside warheads	56		0.5	56
Fuel and reactor-grade in store	23			23
Total military plutonium	257		<1	257
Military HEU				
In warheads				810
Outside warheads				510
Total military HEU				1320

(a) The figure in the first column includes an estimated six tons of plutonium contained in East European and Finnish spent fuel sent to Chelyabinsk under "take-back" arrangements. The figure in the second column excludes this amount.
(b) Includes an estimated 70 tons of foreign plutonium held in store in France and the UK, in spent fuel or as separated plutonium.
(c) Indicates the amount of irradiated fuel left in NNWS after transfers to France and the UK.
[SOURCE: "World Inventory of Plutonium and Highly Enriched Uranium", Oxford University Press, 1993]

However because of the higher quality and associated lower critical mass of military plutonium, more stringent criticality and safety measures will be required compared to civil plutonium recycling.

Civil plutonium

At the end of 1990, amounts of separated plutonium for civil use were estimated world-wide at around 122 tons. (See Table 2). This amount still represents less than 20% of the total amount of plutonium in discharged spent fuel (654 tons plutonium in 114,740 tons discharged spent fuel at the end of 1990). Of the 122 tons separated plutonium, about 50 tons were recycled in fast reactor and thermal MOX fuel, leaving 72 tons of separated plutonium in store at the end of 1990. Considerable part of this material is stored in the European Union, where major part of the reprocessing activities is taking place. (See Table 1).

Based on IAEA's 1990 annual report, Table 3 gives approximate quantities of plutonium in irradiated fuel, separated and recycled in MOX subject to IAEA safeguards. Overall, at the end of 1990 the IAEA safeguarded 255.6 tons discharged from power reactors in nuclear weapons states (NWS) and nonnuclear weapons states (NNWS) as well as in non-NPT countries. This amount represents only 39% of the world inventory of civil plutonium, and about 28% of the total world plutonium inventory (including military plutonium).

Table 3: World plutonium subject to IAEA safeguards (by NPT status at the end of 1990, in tons)

Inventory	Non nuclear Weapon States		Nuclear Weapon States	Total
	NPT	Non-NPT		
Plutonium contained in irradiatiated fuel	212.4 (a) 154.6 (a)	22.2 16.2	75.0 (b) 74.5	309.6 245.3
Separated plutonium outside reactors	8.5	–	11.6	20.1
Recycled plutonium in fuel elements in reactor cores	1.8	–	–	1.8

(a) Figures in the lower row are net totals after the IAEA's estimated quantities of plutonium in reactor cores (64.3 tons of plutonium) are subtracted on a pro-rata basis from the totals for NPT and non-NPT NNWS given in the upper row. This material is not reported to the IAEA under agreed reporting procedures. A total of 0.5 tons has also been subtracted from the quantity of safeguarded irradiated fuel in the NWS to cover the inventory of plutonium in the Novoronezh reactor cores.

(b) This is assumed to include the 11.6 tons listed as separated plutonium.

[SOURCE: "The Annual Report for 1990", IAEA, Vienna, 1991]

Table 4: Nuclear power units, worldwide. Operable, under construction or on order (by reactor type, as of June 30, 1993)

Reactor type		In operation		Total	
		Units	Net MWe	Units	Net MWe
Pressurized Light-Water Reactors	PWR	205	186,317	242	223,028
Pressurized Water Reactors	VVER	33	22,670	54	40,484
Boiling Light-Water Reactors	BWR	88	72,166	99	83,140
Gas-Cooled Reactors (MAGNOX)	GCR	22	4,059	22	4,059
Advanced Gas-Cooled Reactors	AGR	14	8,340	14	8,340
Heavy-Water Reactors (all varieties)	PHWR	34	18,793	50	26,688
Graphite-Moderated Light-Water Reactors	LGR	15	14,785	16	15,710
Liquid Metal Fast-Breeder Reactors	LMFBR	4	1,178	9	4,908
TOTAL		415	328,308	506	406,357

[SOURCE: Nuclear News, September 1993]

2.2 Future trends in plutonium production (1990 till 2010)

Military plutonium

The production of new weapons grade plutonium has ended in the United States and in the Commonwealth of Independent States (CIS), and the production rate in the other nuclear weapons countries remains low compared to existing stockpiles. Due to the continued dismantling of warheads, total military plutonium outside warheads may increase to 70 tons in the US and 120 tons in the CIS by the year 2000.

If one-third core recycling were carried out in order to process these 190 tons plutonium from dismantled warheads, about 700 G We • years of LWR capacity would be required[1]. Over ten years, this would require almost 25% of total current world LWR capacity, disregarding the capacity needed to dispose of civil plutonium.

Civil plutonium

Future civil plutonium production will largely depend on the future share of nuclear power in electricity production, on the evolution of the different nuclear reactor and fuel types, and on the assumptions made regarding fuel burn-up, fuel reprocessing and plutonium recycling. In the following paragraphs different scenario's will be analysed.

Nuclear power capacity: As of June 1993, a total of 415 nuclear power plants were in operation world-wide, with a total installed capacity of 328 GWe net (Table 4). An additional 91 units or 78 GWe net are under construction or being ordered. (In 1990 nuclear energy covered 6% of the world's primary energy needs and 17% of its electricity generation.) It is assumed that the world nuclear generating capacity of commercial plants would increase with about 25% over the next twenty years from 315 GWe in 1990 to 393 GWe in 2010 (Figure 1). Growth is anticipated mainly in Asia and the Pacific rim, and to a lesser extent in the former Soviet Union. Three burn-up scenarios were considered: low, medium and high.

Assuming a minimum fuel burn-up of 33,000 MWd/tHM (for all reactors using enriched uranium) spent fuel arisings will increase over the next two decades with about 220,000 tHM (Figure 2). A drastic increase in fuel burn-up to 43,000 MWd/tHM (1/4 annual core reload) in 1995 and 53,000 MWd/tHM (1/5 annual core reload) in 2000, may reduce spent fuel arisings by about 50,000 tHM or 23% to 170,000 tHM. Based on more realistic trends in world average burn-up (see Figure 3), spent fuel arisings would

[1] The annual loading of fissile plutonium for 1 GWe LWR operating with one third MOX fuel is about 0.28 tons for a burn-up of 33 GWd/tHM and 0.24 tons for a burn-up of 53 GWd/tHM. Average fissile content of 94% was assumed for weapon-grade plutonium.

still increase by more than 190,000 tHM and reach over 300,000 tHM in 2010.

The corresponding plutonium arisings in the spent fuel would accumulate to 2,200 tons in 2010 in the reference scenario, and resp. to 2,100 and 2,300 tons in the low and high burn-up scenarios. (See Figure 4.) The reduction in plutonium production with increased fuel burn-up is less dramatic (200 tons or only 13%) than in the case of the spent fuel due to the non-linear relationship between net plutonium production and fuel burn-up for the different reactor types (see Figure 5).

Reprocessing capacity: Table 5 gives the design capacity of the world reprocessing plants in operation and under construction. Commercial separation of civil plutonium is undergoing considerable expansion with new facilities recently in operation in France (La Hague) and under construction (India, Japan), but at the same time also increasing public scrutiny and political opposition, with operation of new facilities being delayed (THORP in the UK) or completely abandoned (WAW in Germany). In the high reprocessing scenario, reprocessing reaches a maximum of 4600 tons heavy metal per year in 2005, staying constant till the year 2010. (Figure 2.) In the stretch-out scenario, actual reprocessing gradually declines to little more than 2000 tHM/yr in the year 2000 and 1100 tHM/yr in 2010.

In the high reprocessing scenario about 670 tons of plutonium would be separated in the period 1991-2010, leaving still more than 1,300 tons of plutonium in spent fuel or about 63% of the total amount discharged from reactors. (See Figure 4.) In the more conservative stretch-out scenario, the cumulative amount of plutonium separated would reach about 450 tons in 2010 or about 20% of the plutonium arisings. In both the high and stretch-out reprocessing scenarios, the cumulative spent fuel arisings that cannot be reprocessed, resp. 177,000 and 235,000 tHM, remain considerable. Therefore, there will be a necessity for interim storage of spent fuel and retrievable or final (i.e. irretrievable) disposal of spent fuel will also have to be envisaged.

MOX fuel fabrication capacity: MOX fuel fabrication plant capacities are given in Table 6, both for operating and planned facilities. Although many new facilities are planned, starting dates and actual operating capacities may change due to political circumstances. Two scenarios were considered: moderate and high plutonium recycling. In the maximum recycling scenario MOX fabrication capacity will reach 480 tons per year in 2005. (Based on a 5% plutonium content in the MOX fuel, this corresponds to an annual plutonium consumption of 24 tons. Based on one third MOX cores this would require about 60 GWe[2] or about 17.5% of the world's LWR capacity in 2005[3].) In the moderate plutonium recycling, MOX fabrication capacity will be limited to 300 tons MOX (or 15 tons plutonium) per year in 2005.

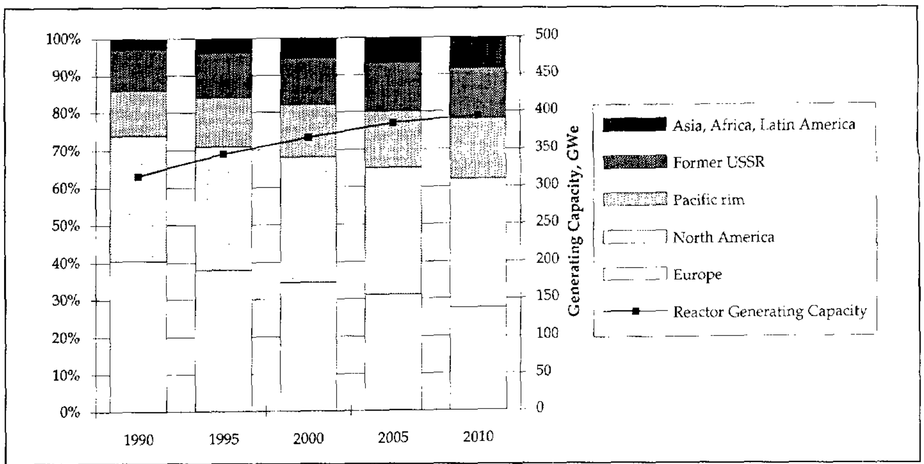

Figure 1: World nuclear power generating capacity - by region

[SOURCE: "Uranium in the New World Market", The Uranium Institute, October 1992]

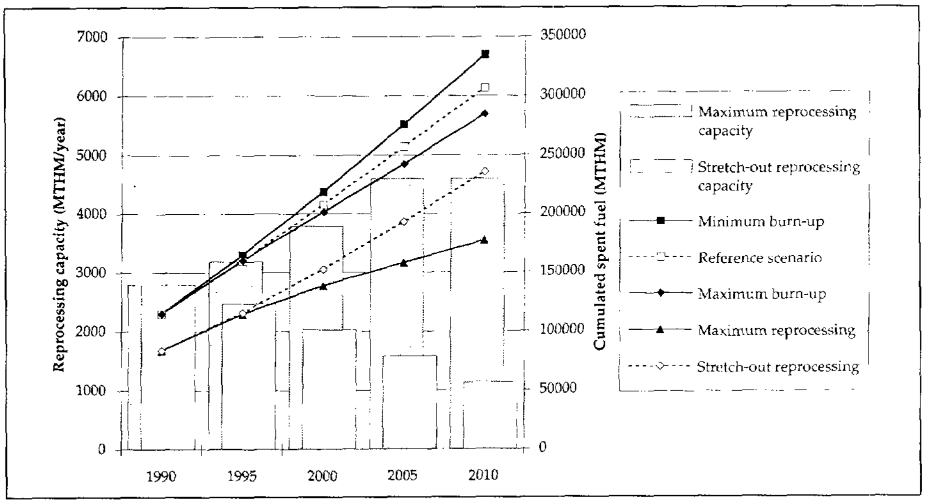

Figure 2: Estimated total world spent fuel arisings

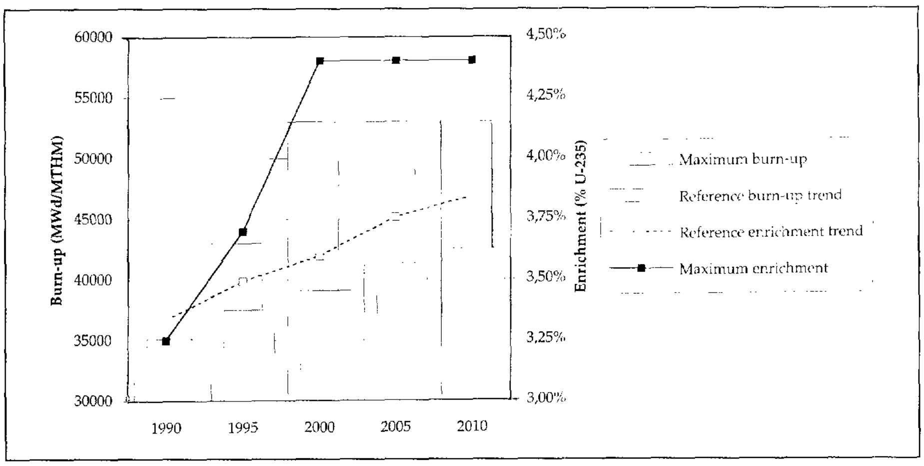

Figure 3: World wide trend of burn-up and enrichment. All reactor types, excluding CANDU/MAGNOX

[SOURCE: "Uranium in the New World Market", The Uranium Institute, October 1992]

2 Fissile content is assumed to be about 70% in reactor-grade plutonium.

3 Based on 384 GWe world nuclear capacity in 2005, of which 90% is assumed to be of LWR type.

In the case of high reprocessing - even with maximum MOX fabrication and maximum MOX fuel burn-up (53,000 MWd/tHM with 8,5% Pu in fresh MOX fuel[4]) - about 500 tons of plutonium can be consumed by the year 2010, leaving a balance of separated plutonium of more than 280 tons. This is four times more (4x) than the balance of separated plutonium in 1990. In the stretch-out reprocessing scenario with moderate plutonium recycling, a balance of separated plutonium of more than 163 tons will still remain in 2010. Only with maximum MOX fabrication and phased-out reprocessing will the balance of separated plutonium actually decrease from 72 tons in 1990 to 34 tons in 2010. A summary of the evolution of world plutonium inventories in spent fuel, separated and consumed for the period 1990-2010 is given in Table 7.

From this study of the fuel cycle evolution, two main problem areas arise:

- the excess of spent fuel in comparison with reprocessing capacity: 140,000 tons in the year 2000 and almost 180,000 tons by 2010, even with maximum fuel burn-up (53 GWd/tHM) and maximum reprocessing capacity (4600 tHM per year starting in 2005);
- the excess of separated Pu in comparison with MOX production capacity: 240 tons separated plutonium by the year 2000 and 280 tons by 2010, in the case of maximum reprocessing and maximum recycling. (Maximum recycling would require almost 10% of total world LWR capacity to use 100% MOX cores.)

To resolve the excess of spent fuel that cannot be reprocessed, interim and final disposal remain to be envisaged. In this case the economic and financial balance has to be made between costs of prolonged interim storage with option of delayed reprocessing and the costs of final (irretrievable) disposal, including the safeguarding of the disposal site.

Some possibilities to resolve the surplus of separated plutonium can be:

- the use of a higher Pu-content in MOX fuel. If burn-up of the MOX fuel is also increased accordingly, a larger LWR capacity base will be required.
- a more efficient use of Pu, possibly in a 100% MOX reactor. This would reduce the number of LWRs recycling plutonium, thereby reducing the safety and safeguards problems. If lower burn-ups are used (20 GWd/tHM) the amount of plutonium could be recycled faster. This would require, however, larger MOX fabrication capacity.

In the past, options have been claimed to embed plutonium in glass and to give the final product a treatment and a follow-up as waste. Taking into account the enormous energy content of plutonium, this proposal is to be considered with caution.

Table 5: Reprocessing plant design capacity (tons of heavy metal per year)

Country	Location	Owner/operator	Facility	Fuel	Capacity HM yr-1	Operated
Belgium	Dessel	Eurochemic		oxide	30	1966-1974
France	Marcoule La Hague La Hague La Hague	Cogema Cogema Cogema Cogema	UP1 UP2 UP3 UP2-800	metal metal + oxide oxide oxide	400 400 800 800	1958-2000 1966-1987 1990- 1993-
Germany	Karlsruhe Wackersdorf	KfK/DWK DWK	WAK WAW	oxide oxide	35 400	1971-1990 p.m.
India	Tarapur Kalpakkam	DAE DAE	PREFRE	oxide oxide	30-150 100-200	1982- 1994?-
Japan	Tokai-mura Rokkasho-mura	PNC JNFS	Tokai Rokkasho	oxide oxide	90 800	1981- 2002?-
Russia	Chelyabinsk-65 Krasnoyarsk	MinAtom	Mayak	oxide oxide	600	1978- p.m.
UK	Sellafield	BNFL	B205 B204/205 THORP	metal oxide oxide	1500 300 700	1964-2010? 1969-1973 1994-
USA	West Valley	NFS		oxide	300	1966-1972

[SOURCE: "Disposition of Separated Plutonium," Science & Global Security, 1992]

Table 6: MOX fuel fabrication plant design capacity (tons MOX per year)

Country	Location	Owner/operator	Facility	Fuel	Capacity t MOX yr-1	Operated
Operating facilities						
Belgium	Dessel	BN	DEMOX-P0	FBR+LWR	35	1973-
France	Cadarache Cadarache	CEA Cogema	ATPu CFCa	FBR FBR+LWR	15 25	1970-1989 1990-
Germany	Hanau	Siemens	BEW1	FBR+LWR	25-30	1974-1992
Japan	Tokai-mura	PNC	PFPF	FBR	5	1988-
Russia	Chelyabinsk-65	MinAtom	Mayak	FBR	35-40 kg	1988-
UK	Sellafield	BNFL		FBR+ATR	15	1970-1989
Planned facilities						
Belgium	Dessel	BN	DEMOX-P1	LWR	35	mid 1990s?
France	Marcoule	Cogema	Melox	LWR	115	1996-
Germany	Hanau	Siemens	BEW2	LWR	80-120	1994?-
Japan	Tokai-mura Rokkasho-mura	PNC JNFS?	PFPF	ATR LWR	40 100?	1993/4 late 1990s
Russia	Chelyabinsk	MinAtom	Mayak	FBR VVER	25-30 100/300?	mid 1990s? late 1990s?
UK	Sellafield	BNFL	MDF SMP	LWR LWR	8 50-70	1993- late 1990s?

[SOURCE: "Disposition of Separated Plutonium," Science & Global Security, 1992]

[4] Higher bum-up would allow to consume about 41 tons plutonium annually in stead of 24 tons. However based on one third MOX cores a larger LWR capacity would be required: about 100 GWe i.s.o. 60 GWe.

The existing and impending surpluses of weapons grade and separated civil plutonium not only present an enormous opportunity as energy resource, but also present some concerns. The concerns that can be mentioned are various in nature: safeguards, safety, security and storage. Some thoughts will be devoted to each of these points in the next sections.

2.3 Safeguards, safety and security aspects

Some ten to fifteen years ago, discussions on plutonium management generally started from a potentially strong increase in plutonium utilisation. At this time concerns were expressed that the IAEA was relatively inexperienced in safeguarding plutonium in reprocessing, fuel fabrication and storage, while the coverage and reliability of international nuclear export controls and physical protection measures were known to be imperfect in certain cases.

These specific concerns have now disappeared as (i) both inspection organisms IAEA and Euratom have gained experience in safeguarding separated plutonium, (ii) nuclear export controls have been updated in an effort to strengthen and streamline safeguards and (iii) their coverage has further been expanded. Existing stocks of separated civil plutonium are subject to IAEA and/or Euratom safeguards, while storage and international transportation are submitted to additional physical protection measures, although the increase in stocks represent a serious challenge to the inspection agencies.

The applied safeguards regime has proven its value and contributes to keep these problems under control. What remains, however, are the specific risks inherent to the presence of plutonium in states and the tensions resulting from this presence. The IAEA statute (article XII.A.5) makes provision for the limitation of national stockpiles of plutonium even where safeguards are applied. In this context the US effort to limit the production of plutonium to a minimum has to be understood. This US effort was extended to highly enriched uranium as well.

Consequently, there is a need to ensure that the risks implied in national stockpiles of plutonium are reduced to a minimum, during interim storage and during further utilisation if so decided. International plutonium management could establish a control regime that contributes to an improvement of confidence among states that store the plutonium and those that do not.

Some of the CIS states agreed to the NPT, thus accepting full-scope safeguards. There are good reasons to suggest that plutonium becoming available after dismantling of nuclear weapons should be submitted voluntary to this same regime as well, when a decision is taken to transfer such material from the military into the civil domain.

Table 7: Evolution of world plutonium inventories (in tons)

Inventory	Up to 1990 (a)	From 1991 till 2000	From 2001 till 2010	Total to 2010 (cumulative)
Spent fuel arisings				
Minimum burn-up	114,740	+103,937	+115,907	334,584
Reference scenario	114,740	+93,043	+98,614	306,397
Maximum burn-up	114,740	+86,762	+82,728	284,230
Plutonium arisings in spent fuel				
Minimum burn-up	654	+797	+888	2,339
Reference scenario	654	+744	+805	2,202
Maxiumum burn-up	654	+719	+748	2,121
Plutonium separated				
Stretch-out reprocessing	122	+195	+129	446
Maximum reprocessing	122	+271	+398	791
Plutonium consumed				
Maximum MOX, maximum burn-up	50	+101	+357	508
Maximum MOX, reference burn-up	50	+88	+274	412
Moderate MOX, reference burn-up	50	+63	+170	283
Separated plutonium balance				
Maximum reprocessing, max recycle	72	+170	+41	283
Stretch-out reproc., moderate recycle	72	+132	-41	163
Stretch-out reproc., maximum recycle	72	+107	-145	34

[SOURCE: "World Inventory of Plutonium and Highly Enriched Uranium", Oxford University Press, 1992]

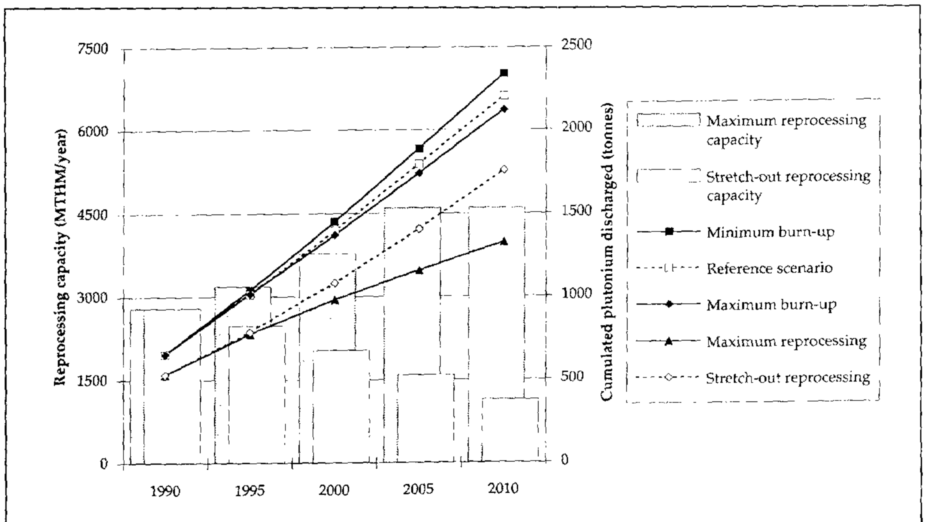

Figure 4: Estimated total world plutonium arisings in spent fuel

2.4 International plutonium storage

The dismantling of nuclear weapons in the United States and the former Soviet Union also creates a need for temporary storage of large quantities of separated plutonium.

The objectives of International Management are the promotion of international security, the fostering of public confidence, and the facilitating of a rational use of plutonium. Safeguarding problems may be reduced by concentrating and centralising interim storage of plutonium, separated or in spent fuel.

Decisions on the future destination of separated plutonium from the two stocks, civil as well as military, are still pending in most cases. Military plutonium may or may not become civil plutonium in part. Options under consideration for civil plutonium range from (i) plutonium use in fast breeder reactors (either for "breeding" more plutonium or for "burning" plutonium in a once-through mode) and (ii) use in mixed oxide (MOX) fuel elements for light-water reactors, or (iii) to be stored and treated as waste rather than used any further. Whatever option is chosen by the industrial and governmental parties involved, there is a need for interim storage.

International plutonium management does not have to lead to a great number of storage sites. Reprocessing plants might be involved and perhaps other centres could later be added in what could be an evolving process. Such discussions are however far beyond the context of this technical talk, and have to be held in international political organisations.

2.5 Political context - Public acceptance

It cannot be ignored that plutonium is a source of major public concern. Possible release of plutonium from existing stocks plays a large role in this public concern as well as the existence of the stocks themselves. The anxieties concerned could be weakened by the establishment of common agreements that are supported by the international community, and that contain clear and understandable criteria.

International management of plutonium stocks in this way would mean that countries jointly decide upon measures with a high level of transparency concerning plutonium strategy after release for further use or disposal. This could further the acceptance of a rational system of plutonium utilisation.

Arguments used by pressure groups against the use of MOX fuel, often combine misunderstandings and partial truth, neglect important judgement elements and are based on false technical and scientific data. A major effort is to be made in informing the public on the use of nuclear energy in general and plutonium in particular, in scientifically valid but for laymen understandable wordings.

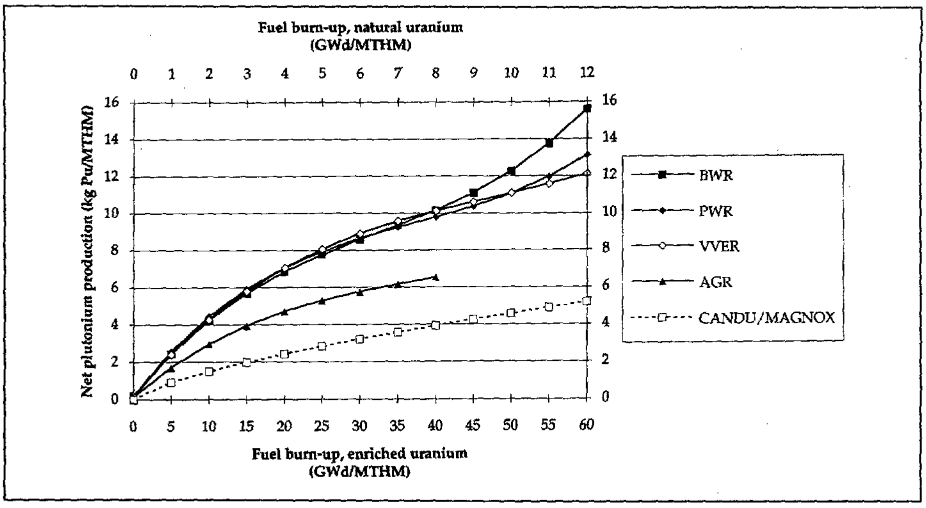

Figure 5: Specific plutonium production (by rector type)

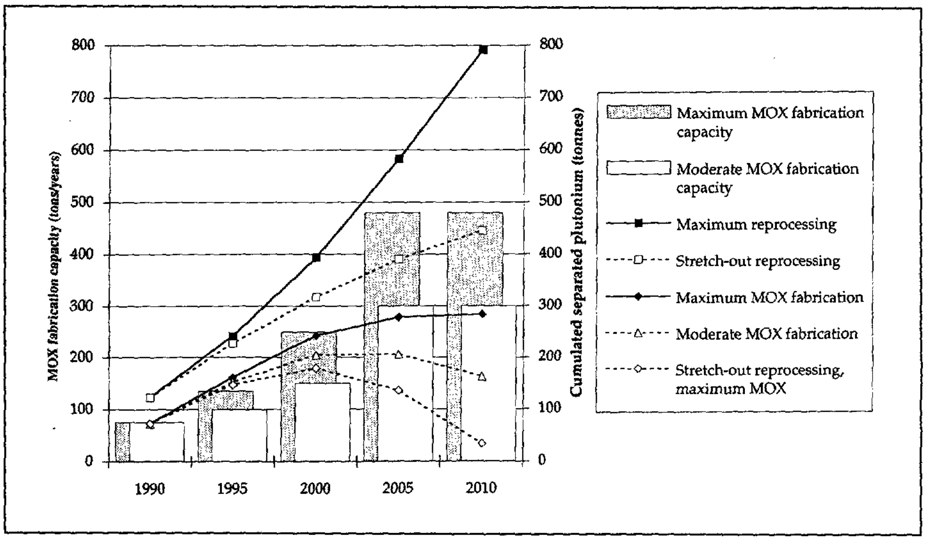

Figure 6: Estimated total world separated plutonium arisings

3. Conclusion

From the study of the evolution of the civil nuclear fuel cycle we have met two main problem areas:

- the excess of spent fuel in comparison with reprocessing capacity;
- the excess of separated Pu in comparison with MOX production capacity.

Possible solutions have been mentioned in a very generic way, but require further investigation. For these reasons, SCK•CEN intends to perform studies on the utilisation of existing Pu-stocks. The objectives are twofold: the application should be reasonable and it should be useful.

Vitrifying and treating as waste *existing* military plutonium stocks do not seem reasonable given the high quality and energy value of these materials. Creating *new* civilian plutonium stocks - through massive reprocessing without recycling - to be stored and eventually purified - or disposed of as waste does not seem useful.

Solutions have to be studied that consider the excess of spent fuel and separated plutonium compared to their treatment possibilities.

A possible solution that seems both reasonable and useful would be to increase fuel burn-up to a maximum extent possible in order to limit spent fuel arisings, to stretch-out or delay as much as possible reprocessing and to recycle to a maximum extent possible existing civilian stocks, followed by military plutonium stocks.

Recycling could be improved by increasing plutonium content and burn-up of MOX fuel. Safeguards could be facilitated and safety improved by limiting the number of LWR recycling MOX and using 100% MOX cores. Recycling of military plutonium could be accelerated by limiting the fuel burn-up (for instance only 20,000 MWd/tHM). This would require, however, additional MOX fabrication capacity. If remaining plutonium stocks have to be considered as waste and be vitrified, priority should be given to old civilian plutonium, given its contamination with americium-241 and non-fissile isotopes. Concentration and centralisation under international management of interim storage of excess plutonium stocks, both separated and in spent fuel, could facilitate safeguarding problems an public acceptance.

The use of plutonium as fuel in LWRs does not have to exclude the study of the final disposal aspects of spent fuel, provided interim storage is considered and integrated in an overall strategy. Efforts are already going on in the framework of the support programmes to IAEA safeguards.

After the MOX debate in Belgian parliament the Belgian political authorities gave the green light for the use of MOX fuel in Belgian reactors, but also requested the government to stop considering reprocessing as the only reference solution, and to pay attention to aspects of the once-through cycle, by stimulating R&D in the domain of final disposal of spent fuel. The studies mentioned should allow to make a new global evaluation within five years based on the following aspects: safeguards, safety, security and storage, radiation protection aspects towards workers and the public, economical and environmental aspects, and public acceptance. This has to be done in a spirit of objectivity and integrity, and with a sense of responsibility and openness towards society.

Finally, we would like to invite you to join us for further collaboration in the technical studies and in safeguards considerations in order to find an equilibrium between reasonable and useful applications for the plutonium stocks in the world, both civil and military, both separated and in spent fuel or warheads.

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ESARDA - The Forum to foster Nuclear Safeguards in Europe

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Introduction

1. The European Safeguards Research and Development Association (ESARDA) is celebrating its 25th anniversary. This is a good reason to reflect about the experience gained from the past, the impact it had on the development of safeguards in Europe and to give some thoughts on the further development and role of ESARDA in the safeguards field.
2. The purpose of the association, as stipulated in the ESARDA Agreement is manifold:
   the considerata of the Agreement, for example, stress the following points:
   > *"...it is thus important for all the the parties as well as for the nuclear industry as a whole to improve the quality, the efficiency and the cost effectiveness of international safeguards."*
   > *"...it is advantageous to seek the views of those concerned in the application of safeguards so that problems preventing their effective, efficient and economic application may be identified and solved"*
   > *"...it is advantageous for the Parties to harmonise their research and development programmes in the field of safeguards to mutual support in the performance of their research programmes to exchange the knowledge and experience thus required and to have a collaborative execution of parts of their programmes."*
3. Art 2 of the Agreement expresses the purpose "mission" of ESARDA as follows:
   "2.1 *The purpose of the Agreement is to facilitate collaboration on research and development in the field of safeguards and on the application of such research and development to the safeguarding of source and special fissile material. The research, development or application programmes of the Parties brought up to date annually shall be submitted to the Steering Committee, which will examine them in the light of identified safeguards topics which require investigation and recommend a basis for collaboration.*
   2.2 *Collaboration shall be effected as appropriate by coordination of the research, development or application work, by the exchange of information and assistance on the personnel and technical levels and by the joint execution of these programmes or parts there of.*
   Details of this collaboration, and particularly the liability for costs, shall be separately agreed in each individual case."
4. The Steering Committee was charged in Art. 3 to "identify those topics in safeguards requiring investigations, to suggest ways in which R&D programmes related to this Agreement could be adopted, to encourage joint execution of the programmes or parts thereof, to resolve individual problems arising from such joint activities and to organise technical and scientific meetings which should be open to the public.
5. The Euratom Safeguards Directorate is explicitely mentioned in this Agreement in Art 4, where it is stated that
   > *"one representative of the Euratom Safeguards Directorate will attend the meetings of the coordinators".*
6. The mission of nuclear safeguards, as outlined in the Euratom Treaty, comprises the set of measures performed **to enable the European Commission to satisfy itself**, that nuclear material is not diverted from its intended and declared uses (particularly to unlawful non-peaceful applications) in accordance with Art. 77a and that obligations arising from international agreements (Art. 77b) including those with the International Atomic Energy Agency (IAEA) concluded by the Community are complied with.
7. There is thus a link in the mission of ESARDA, as defined in the ESARDA Agreement, and the above-mentioned mission of nuclear safeguards in Europe.
8. This paper is intended as a contribution summarising the interaction between ESARDA and Euratom Safeguards, the impact which ESARDA had on the development of nuclear safeguards in Europe and to provide some thoughts on the further developments in the R&D area.

ESARDA - A forum for operator-laboratory interaction

9. One of the roles of ESARDA is to provide a forum, where plant operators, developers and "safeguarders" can exchange information and experience on a regular basis.
10. This exchange of information and experience takes place at essentially four levels:
    - at the level of the annual meetings, either in the form of an internal meeting or in the form of a safeguards symposium;
    - at the level of publications in the ESARDA bulletin, which informs regularly on all aspects of ESARDA;
    - at the level of discipline and plant oriented working groups and
    - at the level of coordinators/board and steering committee meetings.
11. The role of ESARDA as forum for scientific/technical exchange on all aspects of nuclear safeguards can only be underlined.
    The Euratom Safeguards Directorate has contributed to and thus used this forum with numerous contributions to the safeguards symposia/annual meetings organised by ESARDA in the following major areas:
    - new safeguards approaches
    - experience from safeguards implementation
    - safeguards verification technology and
    - nuclear material accountancy and material balance evaluations.
12. The reasons for these contributions to this activity of ESARDA are the following:
    - it is a unique and convenient forum to address, present and discuss current European - but also worldwide - nuclear safeguards issues;

- it reflects/emphasises the important political role which the European Union and its Member States attribute to non-proliferation and nuclear safeguards issues;
- it attracts active participation from the international safeguards community with numerous opportunities for discussion, exchange of information and initiation of common projects in the safeguards area;
- the field of nuclear safeguards attracts more and more the interest of the public. The safeguards symposia of ESARDA provide an excellent opportunity to cope with this increasing need of information and opportunities for discussion.

Experience gained and impact on nuclear safeguards developments

13. Apart from its participation at the annual meetings (symposia or internal meetings) as described above the Euratom Safeguards Directorate participated in the more managerial type of meetings (coordinators/board/steering committee) and in the technical working groups for destructive analysis, non destructive assay and containment and surveillance as well as in the plant oriented working groups like LEU fabrication, MOX and Reprocessing Input Verification (RIV).
14. The technical ESARDA working groups had a noticeable impact on the Euratom Safeguards, mainly in the following areas:
    - *New methods/techniques*
      The main benefit in this area was the provision of early information on the potential of new techniques, problem areas, ongoing R&D activities in different labs, etc;
    - *Existing methods/techniques*
      The main benefit was that discussions and exchange of information with users/developers often helped to give a better understanding of certain problems and pitfalls (example: undissolved particles);
    - *Contacts to developers/operators*
      Through contacts established in attending working group meetings, useful arrangements have been made for follow-up activities, like preparation of field tests, calibration exercises, specific discussion of technical problems, etc.;
    - *ESD safeguards requirements*
      Last but not least the Euratom Safeguards representatives have taken part in the discussions of the relevant working groups presenting their requirements/interests and convincing, for example, operator chemists of competence of ESD/ECSAM destructive analysis services.

    Concrete examples for the above-mentioned contributions to the work of the Euratom Safeguards Directorate are given below:
    - discussion and establishment of target values for uncertainty components in the quantitative determination of nuclear material and therefore detailed knowledge of real destructive analysis performance by method, material, laboratory and/or operator;
    - discussion, implementation and evaluation of nuclear material quality control programmes;
    - discussion and initiation of organisation of field tests for new types of NDA equipment (neutron coincidence counting methods, new codes for determination of plutonium isotopic composition, k-edge densitometry);
    - discussion and initiation of implementation of calibration exercises for NDA equipment;
    - organisation of passive neutron workshops and workshop on NDA on waste;
    - discussion and establishment of performance values values for NDA measurement equipment;
    - organisation of an intercomparison exercise on volume measurement techniques and an isotope correlation technique bench mark exercise
15. There is no doubt that the dialogue/interaction between the staff of the participating organisations has spread useful information and experience between the members of the different working groups and have made them more familiar with certain technical and sometimes political aspects of safeguards measurements, approaches and implementation.

Subjects for the Further Research and Development in Safeguards

16. The role of ESARDA in the years to come could be of considerable importance in the area of research and development of safeguards. The following areas may be included:
    - Contributions to and support in safeguards methodology to political questions in the field of non-proliferation;
    - Contribution to the research and development of instruments, methods and techniques;
    - Contributions to make the public and operators aware of the issues, role and importance of safeguards and non-proliferation

Contributions to the methodology of political issues in non-proliferation

17. Important developments in the field of non-proliferation relate, on the one hand, to the issue of enhancing IAEA safeguards in certain non nuclear weapon states were, for the time being, insufficient coverage of IAEA safeguards takes place. As this problematic relates mainly to legal issues and depends on the political will of those concerned, a direct contribution from the side of research and development in safeguards cannot readily be seen.
18. On the other hand, a further problem in non-proliferation relates to the detection of clandestine nuclear facilities in states subject to comprehensive IAEA safeguards. Here an important role of research and development could be identified, reference is made to the measures such as environmental monitoring, new, unconventional type of inspection regimes and others. While the political discussion on these measures advances it may be noted that the basic methodology has not been fully developed and discussed and a substantial role of ESARDA could be envisaged.
19. Furthermore, a most important problem in non-proliferation relates to disarmament of nuclear weapons and to the consequential transfer of weapons-grade nuclear materials to peaceful applications. While again the issues continue to be discussed in the political sphere of the countries concerned, the basic technical methodology on the transfer, the down-grading and the controlled use of such materials are still not fully available let alone fully discussed. An important contribution of ESARDA to these most important questions on the technical methodology of the disarmament and the putting of the resulting materials under international safeguards could be expected.

Research in instruments, methods and techniques

20. The contribution of ESARDA can readily be identified in the general field of research and development of instruments methods and techniques. In that respect the necessary terms of reference should be given to dedicated specialised technical

working groups to discuss, for example, a new generation of instruments while taking into account, amongst others, the interaction between human resources and investment. Keywords are safeguards efficiency, rationalisation and replacement of manpower by machinepower.

21. ESARDA should also contribute to the development, testing and evaluation of the environmental monitoring techniques. Euratom considers it essential that the scientific basis of these new methods be established and evaluated as well as the details of the necessary logistics, including cost, be discussed. To this end a dedicated working group should be established.

Public Relations

22. Public relations concerning safeguards and nonproliferation seems an area where insufficient attention has been devoted to so far. The Safeguards Directorate considers that making aware of both operators and of the general public on the importance and details of safeguards in Europe and of the wider issues of non-proliferation is essential. Moreover, in the absence of a concerted public information effort on these subjects, the thematic is left to anti-nuclear groups or to those who wish to use safeguards and non-proliferation for their own political interests.

23. ESARDA could and should play a prominent role in the information to operators and the general public to the benefit of all involved.

IAEA Safeguards Beyond the 25th Anniversary of the Nuclear Non-Proliferation Treaty

B. Pellaud, Deputy Director General
IAEA, Vienna

It is great pleasure and an honour to participate in this special session of the 16th Annual Meeting celebrating the 25th anniversary of the European Safeguards Research and Development Association, ESARDA. ESARDA and the IAEA have cooperated over these years, collegially and productively. A great deal has been accomplished in providing a sound technical basis for our safeguards activities. But the job is not done; the challenges of today are no less than they were 25 years ago.

It is a period of 25th anniversaries. The year 1995 will mark 25 years of IAEA safeguards under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Those safeguards are governed by the document entitled "The Structure and Contents of Agreements between the Agency and States Required in Connection with the NPT", INFORMATION CIRCULAR 153, for short INFCIRC/153, first issued in June 1972. In that document nuclear material accountancy is the safeguards measure of fundamental importance. Over these 25 years the IAEA has developed, standardized and codified its requirements and procedures for material accountancy. In this process the assistance of ESARDA has been of great help.

Nuclear material accountancy within the framework of IAEA safeguards begins with the nuclear material accounting activities which are undertaken by facility operators in response to obligations defined in safeguards agreements with the IAEA. Safeguards agreements conforming to INFCIRC/153 require the establishment and maintenance of a state system of accounting for and control of nuclear material subject to safeguards under the agreement, that is, an SSAC. In the case of the European Union, these functions are performed by EURATOM, in accordance with the safeguards agreement in document INFCIRC/193

The operator's nuclear material accounting activities and the corresponding accounting information generated and sent to the IAEA in reports are verified by the IAEA. IAEA safeguards procedures for independent verification of SSAC accounting information derive from "safeguards approaches". The assumption used in designing safeguard approaches is that the possible existence of undeclared activities cannot be excluded a priori by the IAEA. This has led to safeguards approaches which are based on independent verification by the IAEA of all safeguarded nuclear material at timeliness intervals. These verifications are, however, directed specifically to confirming that there has been no diversion of declared nuclear material.

There are a few, important, exceptions under INFCIRC/153 safeguards agreements where the IAEA has been performing activities which look for misuse of facilities to produce materials for a nuclear weapon programme. The two exceptions are, on the one hand, activities at enrichment plants to provide assurance that HEU has not been produced, and, on the other hand, activities at reactors to provide assurance that unreported plutonium has not been produced.

The IAEA was routinely applying safeguards in that manner, and then in 1991 the clandestine nuclear weapon programme of Iraq came to light, an event that exposed some apparent weaknesses of the conventional safeguards system. Here was the case of an NPT State that had handled its declared nuclear material, on the whole, properly. As it turned out, there was no diversion of declared material. Yet, Iraq had secretly embarked on a major undeclared programme to produce direct-use nuclear material, material which would have been suitable for use in a nuclear weapon.

This discovery sent tremors through the international safeguards community. The result has been that IAEA Member States are now looking to the IAEA to broaden its view beyond declared nuclear material, and to look for indications of undeclared facilities and undeclared activities which could be part of a nuclear weapons programme.

In general terms one can say that through the events in Iraq - and certainly also through the end of the Cold War - the co-operation and openness in many countries has further improved. However, since 1991 the case of Iraq has also given the IAEA a valuable hands-on, in-the-field experience that went well beyond normal safeguards practice: for the first time the IAEA learned to recognize the signs of a clandestine nuclear weapon programme, its components, its industrial infrastructure, its research and development requirements, its overt and covert procurement paths.

Already in 1991, the IAEA Director General stated that, in order for the IAEA to also focus on detection of undeclared activities in States with NPT-type safeguards agreements, the IAEA needs three types of access: access to more information, better access to sites, and access to the UN Security Council in case it finds indications that a State has violated its safeguards (and non-proliferation) obligations.

In 1992 these three principles led to first measures proposed to the IAEA Board of Governors and actions being taken, namely:

- reconfirmation of the right of the IAEA to carry out special inspections under the provisions of comprehensive safeguards agreements;
- endorsement of an expanded reporting scheme, under which States are beginning to provide the IAEA information on exports, imports and production of nuclear material and of specified equipment, beyond that required by their safeguards agreements; and
- acknowledgement that the IAEA can use all available sources of information, including information provided by States.

The IAEA Secretariat has, therefore, with the support of its Board of Governors, undertaken to investigate how a reasonable level of assurance of the absence of undeclared activities related to a nuclear weapon programme in States with comprehensive safeguards agreements could be achieved.

Meanwhile, events have continued at a rapid pace. More States have joined the NPT. One, South Africa, has given the IAEA new experience, first with initiating comprehensive safeguards in a State with a large prior nuclear programme, and second with confirming the dismantlement of a former nuclear weapon programme. When South Africa concluded its safeguards agreement with the IAEA in 1991, the IAEA was for the first time confronted with the task of inspecting comprehensively a suspected nuclear weapon State with major unsafeguarded facilities, including one plant for the production of highly enriched uranium. After several visits our inspectors concluded that they had found no evidence to suggest that the declared inventory of nuclear installations and material was incomplete. Then, came unexpectedly, in March 1993, South Africa's announcement about its former nuclear weapon programme. The Government of South Africa extended at that time an invitation to the IAEA to examine with full transparency the scope, the nature and the facilities of the nuclear weapon programme. From the findings of its subsequent inspections, the IAEA concluded that, firstly the nuclear weapon programme of South Africa was indeed terminated, secondly that all nuclear devices had been dismantled prior to South Africa's adherence to the NPT, and thirdly that all nuclear material involved in the nuclear weapon programme had been returned to peaceful uses prior to the conclusion of the safeguards agreement and placed under IAEA safeguards. The Government of South Africa has provided unhampered assistance to the IAEA in this unusual task. The South African case has certainly further expanded the experience of the IAEA, sharpened its inspection skills and heightened its capability to look into non-nuclear material-related activities of a clandestine nuclear weapon programme.

Elsewhere, Argentina and Brazil have established a comprehensive safeguards agreement with the IAEA under the Tlatelolco Treaty which entered into force on March 4, 1994. The former Soviet Union has evolved into a number of Newly Independent States which have or are expected to join the NPT and be subject to comprehensive safeguards. And a very difficult situation has developed from the IAEA's attempts to initiate safeguards under an NPT-type safeguards agreement with the Democratic People's Republic of Korea (DPRK). The DPRK adhered to the NPT on 12 December 1985 and brought the safeguards agreement with the IAEA into force only seven years later on 10 April 1992. Inspections conducted in 1992 revealed many inconsistencies between the information provided by the DPRK and the results obtained by the analysis of samples of material taken by IAEA inspectors. These inconsistencies suggested that the DPRK had not declared all of its nuclear material. The IAEA tried repeatedly until early 1993 - without success - to obtain additional and conclusive information about the DPRK's declaration. Then, the IAEA Secretariat and Board of Governors were shown photographic information on two undeclared sites thought to contain relevant nuclear waste. Because the DPRK would not allow the IAEA to carry out further activities to resolve the inconsistencies and denied the IAEA access to the two undeclared sites, the matter was reported to the IAEA Board of Governors which decided to refer the issue to the Security Council. The Security Council urged the DPRK to cooperate with the IAEA, but the DPRK initiated the process of withdrawal from the NPT, as a result of which the comprehensive safeguards agreement with the IAEA would have also expired. Shortly before the deadline, in June 1993, the DPRK suspended its withdrawal. The safeguards agreement is therefore - in our view and in line with international law - still in force. The DPRK claims otherwise. So far the issue has not been resolved, in spite of intense diplomatic efforts in the last few months and weeks. We have now been given the possibility to carry out additional inspections in the reprocessing plant, as requested by the Security Council in March 1994. But, we have not yet been allowed to fully monitor the refuelling of the 25 MW experimental reactor, including detailed scanning of the spent fuel to reconstruct the operational history of the reactor. These activities are needed to ascertain that there has been no diversion of nuclear material in the past. As this very moment, an IAEA team is in the DPRK for an important inspection, at the reactor and at the radiochemical laboratory.

In the light of these developments, the IAEA response to the changing situation could not stop with the initial steps approved by the Board of Governors in 1992. In the aftermath of Iraq, these steps were not sufficient. In 1993 the IAEA started a major development programme (Programme 93+2) to address in a more comprehensive and integrated manner the new desires of its Member States for assurance about the absence of undeclared activities, as well as for safeguards to be performed as cost effectively as possible. The main elements of the programme address how the IAEA could get, and use, more "information" and more "access". A substantial number of States, including members of ESARDA, are participating in and contributing to this programme, notably through hosting a number of field trials of possible new elements for IAEA safeguards. Major results from this programme should be available in early 1995.

More "information" would be used by the IAEA from all available sources. Those sources will in the future include:

- expanded information declared by States under their safeguards agreements;
- expanded reporting by States on exports, imports, etc.;
- information from open sources, e.g., the public media;
- information from States (including satellite and intelligence information);
- and new IAEA technical measures.

The most promising of the new technical measures is environmental monitoring. Environmental monitoring may provide useful information about undeclared activities at declared nuclear sites, or in their vicinity, and possibly at undeclared sites elsewhere in a State.

More "access" for inspectors will be needed at declared facilities under safeguards, in and around nuclear sites, and elsewhere in the State. Access might even include military sites (as has been the case in South Africa).

The development programme is addressing such major questions as:

- which measures directed to undeclared activities meet the tests of technical effectiveness and cost effectiveness?
- how can those measures be made acceptable to States, party to comprehensive safeguards agreements? and
- will measures directed to undeclared activities have an impact on safeguards as currently performed?

In addition, the programme is addressing the question of how the cost effectiveness of current safeguards could be improved, e.g., through increased cooperation with SSACs and through the use of new technologies in safeguards. Significant advances in this area are being made by EURATOM and the IAEA, under the New Partnership Agreement, and we are very pleased about that. We also look at new technologies to contribute to improving cost effectiveness, and in that area the work of ESARDA is of particular importance.

What would constitute "effective measures" for detecting undeclared activities? In this context, a critical question must first be raised: "Is it realistic to ask for comparable assurance about undeclared activities as current measures provide about the absence of diversion of declared nuclear material?" Well, the world may have to accept that practical, acceptable measures will only provide a qualified "No indication" of undeclared activities, and not a high degree of assurance.

As has frequently been pointed out, INFCIRC/153 provides significant flexibility for the IAEA to establish its safeguards procedures. INFCIRC/153 also states that, to ensure optimum cost effectiveness, verification procedures should be concentrated on "direct-use" material, and verification measures should be minimized in respect of other nuclear material.

Which verification measures could be minimized? The IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI) has suggested that with sufficient assurance about the absence of an undeclared reprocessing facility in a State, the timeliness goal for spent fuel at power reactors could be increased from three months to a year. Stating the question more broadly, under which conditions and to which extent could IAEA inspection effort on safeguarding reactor-grade plutonium at power reactors be redirected? What about the measures to provide assurance of the absence of unreported production of plutonium in power reactors?

Questions of a similar nature can be asked about minimizing verification measures at facilities handling indirect-use material, that is, at conversion and fabrication plants for natural and low enriched fuel, if there is assurance of the absence of an undeclared enrichment facility.

Now, remember the fundamental assumption, namely that the possible existence of undeclared facilities cannot be excluded a priori, an assumption which has led to the current intensive material accountancy safeguards regime. With effective measures providing assurance of the absence of undeclared activities, could that assumption be reinterpreted such that sufficient assurance about non-diversion of declared nuclear material could be obtained from a less intensive material accountancy regime, for example, based on greater transparency, openness and unpredictability as SAGSI has put forward? The IAEA and the international safeguards community will have to address these questions in the years to come.

At this point, let me mention some developments in the broader disarmament sphere. In Russia and the United States of America, tens of thousands of nuclear weapons are about to be dismantled. New confidence-building initiatives have been proposed by President Clinton in 1993. In September 1994, the American Government is expected to release substantial quantities of direct-weapon-usable material from the nuclear weapon programme. IAEA safeguards will be applied on that material and will provide assurances that the material would not be used in a nuclear weapon programme again. The IAEA may possibly be given a role in the verification of the comprehensive test ban treaty now under discussion at the Conference on Disarmament in Geneva and probably in the verification of a fissile material production cut-off convention, a proposal also taken up by the Conference on Disarmament. These would be new challenges and opportunities for the IAEA.

Certainly, the IAEA has reacted to the challenges of recent years and has tackled the opportunities by launching internal initiatives to give more "bite" to its verification activities. Incidently, I am convinced that IAEA safeguards have also contributed to the promotion of the peaceful use of nuclear energy throughout the world. The new challenges and opportunities may indeed permit the IAEA to contribute even more directly to world peace and prosperity.

Ladies and Gentlemen, let me conclude. A start has been made down the path towards IAEA safeguards beyond the 25th Anniversary of the NPT. The IAEA is making good progress in its comprehensive development programme, an effort which involves intensive interaction with Member States. The expectations from this work are high: that the IAEA will be able to provide an increasing level of assurance about the absence of undeclared facilities in States with comprehensive safeguards agreements, in addition to the assurance it provides about the absence of diversion of declared nuclear material from peaceful uses.

How far and how fast the IAEA can go will depend first on the results from the ongoing IAEA development programme on the technical and cost effectiveness of the new measures directed to undeclared activities. Second, it will depend on the determination of the IAEA and its Member States to expand and to revise the current safeguards regime. Third, it will depend on the States' acceptance of the new measures.

As ESARDA enters its second 25 years, and IAEA safeguards pass beyond the 25th anniversary of the Nuclear Non-Proliferation Treaty, I am sure we can look forward to continued close cooperation between ESARDA and the IAEA to meet the important challenges ahead of us.

INMM Present and Future Activities

C. Sonnier
Chair of the International Safeguards Division, INMM
Sandia National Laboratories, Albuquerque, NM, USA

The Institute of Nuclear Materials Management wishes to congratulate ESARDA on the celebration of its 25th year. Our two organizations have a long history of sharing common goals, and it is a history of which we are proud. Our teaming efforts are an example of how two professional societies can combine strengths to enhance each other's effectiveness. The INMM is proud of the past associations with ESARDA and hope that the future will result in even stronger ties. Some of our past teaming efforts include:

- 1978: International Target Values - ESARDA Destructive Analysis Working Group; later interaction with INMM Standards Working Group;
- 1979-80: Special session in INMM Annual Meetings dedicated to ESARDA activities

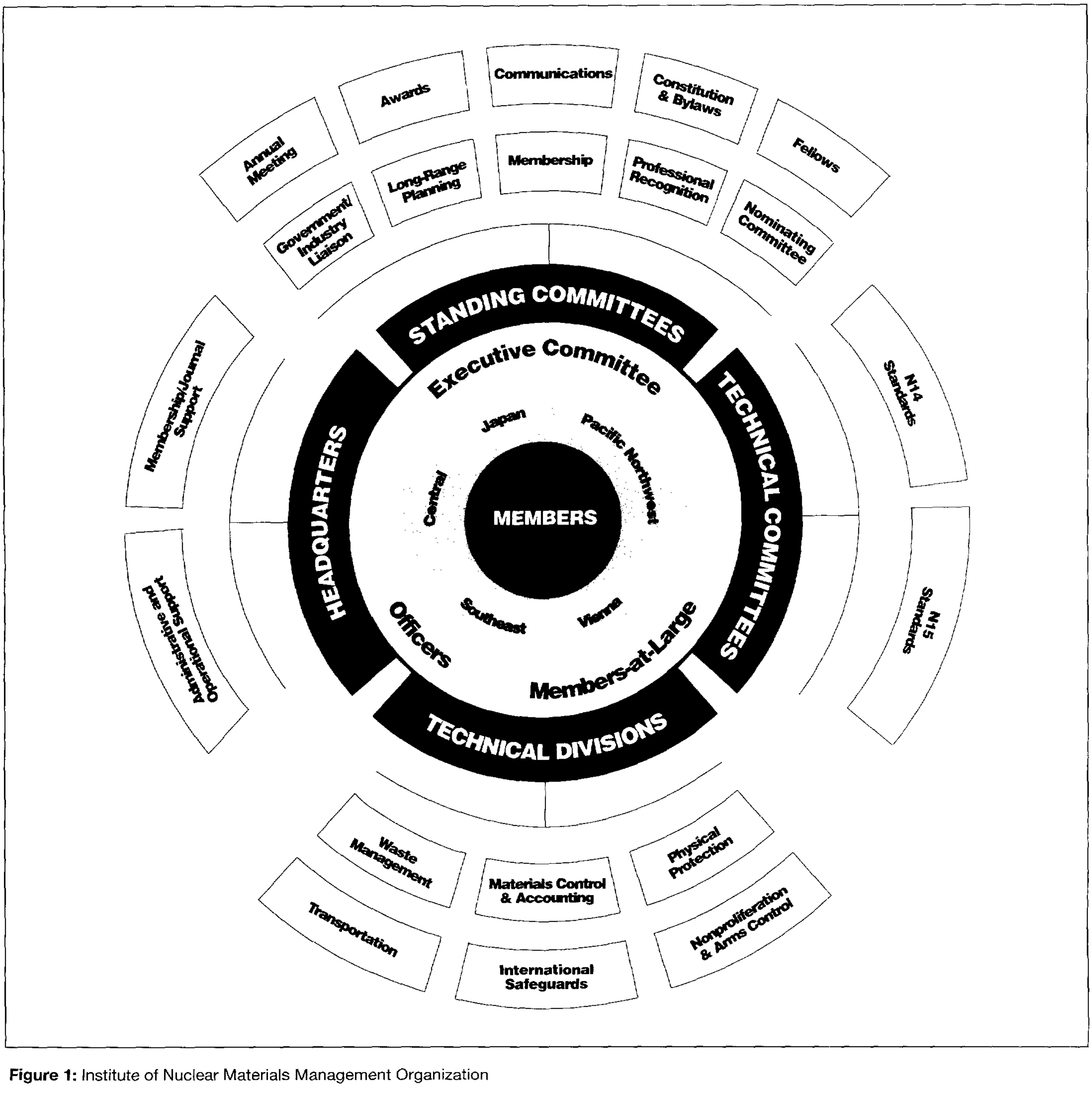

Figure 1: Institute of Nuclear Materials Management Organization

- 1983: ESARDA/INMM specialist meetings on NDA statistical problems
- 1993: Joint participation in international session of Japan INMM chapter meeting
- 1994: INMM/ESARDA/ANS-ENS/RNS joint sponsorship of IAEA Symposium
- 1994: Publication in INMM Journal and ESARDA Bulletin of 1993 ITV material
- Continuing: Papers by ESARDA and INMM officers in meetings of each organization.

INMM is a 34-year-old organization of 725 professionals. Its roots are deeply set in the recognition of the necessity to effectively control nuclear materials.

The INMM was formed to encourage in the broadest manner:

- the advancement of nuclear materials management in all its aspects;
- the promotion of research in the field of nuclear materials management;
- the establishment of standards, consistent with existing professional norms;
- the improvement of the qualifications and usefulness of those engaged in nuclear materials management and safeguards through high standards of professional ethics, education and attainments, and the recognition of those who meet such standards; and
- the increase and dissemination of information through meetings, professional contacts, reports, papers, discussions and publications.

Figure 1 depicts our organizational structure. Membership in the organization is open to qualified individuals who are active in nuclear materials management and related fields and who have an interest in advancing the objectives of the organization. Any reputable firm, association, institution or corporation may become a sustaining member of the INMM. There are also 23 corporate members so far:

AECL Technologies
Atomic Energy of South Africa
Australian Safeguards Office
Battelle Columbus Division
Battelle Pacific Northwest Laboratory
Brookhaven National Laboratory
European Commission
EG&G Idaho
EG&G Rocky Flats
E.R. Johnson Associates Inc.
Holtec International
International Atomic Energy Agency
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Martin Marietta Energy Systems Inc.
Meridian/Dyn Corp.
Nuclear Fuel Services
Pacific Sierra Research Corp.
Sandia National Laboratories
Stellar Security
U.S. Nuclear Regulatory Commission
Westinghouse Idaho Nuclear Co.
Westinghouse Savannah River Co.

The focal points for INMM's technical endeavors are the chairs of the six Technical Divisions. These people are asked to provide leadership and vision for their respective divisions, including the coordination of their division's contributions to the technical program of our Annual Meeting, and the responsibility for planning and conducting topical workshops.

INMM's Technical Divisions and chairs are:

- *Nonproliferation and Arms Control*, Ruth Kempf, Brookhaven National Laboratory, (516) 282-7226;
- *International Safeguards*, Cecil Sonnier, Sandia National Laboratories, (505) 844-2124;
- *Materials Control and Accounting*, Rich Strittmatter, Los Alamos National Laboratory, (505) 667-7777;
- *Physical Protection*, J.D. Williams, Sandia National Laboratories, (505) 845-8766;
- *Transportation*, Bill Teer, E.R. Johnson Associates, (703) 359-9355; and
- *Waste Management*, Ed Johnson, E.R. Johnson Associates, (703) 359-9355.

Nine standing committees serve the INMM as well, and are equally important. These are:

- *Annual Meeting Oversight*, Jim Tape, Los Alamos National Laboratory, (505) 667-8074;
  - *Local Arrangement Committee*, Deanna Osowski, Westinghouse Hanford, (509) 376-7822;
  - *Technical Program*, Charlie Pietri, Department of Energy, (708) 252-2449;
  - *Registration Committee* Bob Kellam, SAIC, (303) 966-3770;
  - *Exhibits*, Ken Ystesund, Sandia National Laboratories, (505) 667-0639.
- *Awards*, Yvonne Ferris, SAIC (301) 924-6185;
- *Communications*, Debbie Dickman, Pacific Northwest Laboratory, (509) 372-4432;
- *Constitution and Bylaws*, Roy Cardwell, Consultant, (615) 986-7347;
- *Government Liaison*, John Matter, Sandia National Laboratories, (505) 845-8103;
- *Professional Recognition*, Paul Ebel, BE Inc. (803) 259-2346; and
- *Membership*, Bruce Moran, Martin Marietta Energy Systems, (615) 576-8269, and Don Six, Westinghouse Hanford, (509) 376-7820.

There are two additional committees, the Fellows Committee and the Long-Range Planning Committee. Shelly Kops, consultant, (312) 761-0644, chairs the Long-Range Planning Committee and the Fellows provide assistance.

Through its technical committees, the INMM also serves as the secretariat for two ANSI standards. The chairs for these two committees are:

- *N. 14 Packaging and Transportation of Radioactive Materials*, John Arendt, Oak Ridge Associated Universities, (615) 483-6622; and
- *N. 15 Methods of Nuclear Material Control*, Bruce Moran, Martin Marietta Energy Systems, (615) 576-8269.

John Arendt also serves as the chair of the technical committees.

The INMM membership is served by five regional chapters:

- *Pacific Northwest*, Dean Scott, Battelle Northwest Laboratories, (509) 376-1584;
- *Central*, Dave Shisler, Martin Marietta Energy Systems, (614) 897-2331;
- *Southeast*, Paul Ebel, BE Inc., (803) 259-2346
- *Japan*, Tohru Haginoya, (81) 468-33-2395; and
- *Vienna*, James Larrimore, IAEA, 43-1-23600.

Two more chapters may be formed, one serving the southwest United States and one serving the Scandinavian section of Europe.

Our future looks bright. The world situation provides us exciting challenges for our professional society with our unique demonstrated technical competencies. It is up to all of us to meet these challenges.

The recent world events associated with, most notably, dismantlement activities, have heightened the need for sound nuclear materials management consistent with nonproliferation objectives worldwide. We believe our organization is well-postured to provide the professional society environment to allow discussions internationally on important issues facing us today.

Address at the 25th Anniversary of ESARDA

P. Frederiksen
Former ESARDA Chairman, Risø National Laboratory, Denmark

It is a great honour to participate in this celebration of the 25th anniversary of ESARDA, and I am very grateful to the Joint Research Centre Ispra for the kind invitation.

In 1969, 25 years ago, the establishment of ESARDA constituted an important initiative which resulted in a unique forum for technical research and development in the area of safeguards. During the years 1968-71, it was clear that major efforts had to be placed on technical, administrative, and political aspects in order to form the basis for comprehensive safeguards implementation in many countries. The risk of rapid proliferation of nuclear weapons was very high.

In 1969 Denmark was not a member of the European Community. Therefore I could not participate in ESARDA. However since 1965 I have been working on establishment of safeguards in Denmark. In 1968-70, I was consultant to the IAEA with respect to inspection principles.

In 1970-71, I participated in the IAEA Safeguards Committee concerning the text for the safeguards agreements in accordance with the Non-Proliferation Treaty.

In 1973, Denmark joined the European Community. Since then and until the end of 1992, I had the pleasure to participate in more than 40 meetings. I am very impressed by the quality of the experts and of the significant results of ESARDA. The direct contacts among research experts, operators, and persons from the Euratom Safeguards Directorate has led to a common understanding of the technical problems.

The world is changing rapidly. Therefore, safeguards should deal with the real situation. In 1992, when I was chairman of ESARDA, I proposed a group for investigation into the political and technical problems of the future and how ESARDA could contribute to the solution of the problems. The presentation at this meeting of the results achieved by the Reflection Group on the Future of ESARDA has been very interesting. I hope that the work can be continued.

The Nordic countries have also identified that it is necessary to study the link between politics and techniques in safeguards. In February this year I organized a Nordic safeguards seminar in Copenhagen. Here political, administrative, and general technical aspects related to safeguards were discussed. The future Nordic collaboration may concentrate on the various types of proliferation aspects including safeguards rather than on aspects strictly limited to safeguards techniques.

I will conclude by wishing ESARDA success during the coming years. I am sure that the expertise within ESARDA can be extremely useful for solving the many complicated problems of the future.

Possible Future Considerations for ESARDA

D. Gupta
Former ESARDA Chairman, from KfK, Germany

Friends:
it is wonderful being with you again. Your present Chairman Marc Cuypers suggested that I should share with you some thoughts on future possibilities of ESARDA. ESARDA has become 25 years old this year. It is quarter of a century. In six years from now, Mankind will enter the 3rd Millennium of the history of the western world. It will be a memorable occasion.

During the last decade of this century, unusual and powerful changes have started taking place, virtually all over the world. Age-old boundaries are tumbling down, new systems and structures are evolving, new stabilizing forces have started influencing age-old politically instable regions of the world. It appears that our society as a whole is purging itself of it past follies and unstable elements and preparing itself for a new start in the coming millenium. Some of these changes may also influence the future of ESARDA. For example, consider for a moment the development in the area of poliferation of nuclear weapons.

After the collapse of the USSR, the whole concept of vertical, horizontal and spatial poliferation is changing. Some of the weapon owning States, like the US, Russia, Ukraina, and Kazakhstan have started reducing their nuclear weapon potential and thereby systematically reducing the danger of vertical proliferation. Since vertical proliferation has always determined the potential for horizontal proliferation, this reduction is bound to reduce the incentives for horizontal proliferation. Coupled with this development, the growing financial and political interdependence among different nations will definitely decrease the probability for horizontal proliferation, particulary in Europe, the immediate operating sphere for ESARDA.

Consider also for a moment the development of nuclear energy in general and in the industrial countries in particular. There is a distinctly detectable pause, in its development for the foreseeable future. The fuel cycle activities are expected to be concentrated in a very limited number of regions of the world. On the other hand, large scale programmes for fusion technology will continue for several decades, well into the next century. They will definitely require attention regarding possibilities for safeguards.

Environmental protection will attract increasing international attention and will need, without doubt, large efforts for reducing and controlling pollutions caused mainly by specific human actions.

With such developments as possible influencing factors for the future functions of ESARDA, one might even ask the brutal question: who will miss ESARDA if it suddendly ceased to exist, in its present form, with its present sphere of activities? It is, therefore, worthwhile to pause for a while and take a hard look at ESARDA. One could start with its terms of reference and the boundary conditions for its operation. If necessary, change or modify them. For example, nuclear and non nuclear organisations from the expanded European Union as well as from other countries outside it, could be members of ESARDA. If necessary modify the objectives of ESARDA: they could include safeguarding and management activities in other areas, namely, areas in which human actions in an objective system result in a situation which needs external and explicit control. This could involve, for example, controlled dismantling and storage of nuclear material from nuclear devices, tritium technology, safeguarding of environmental pollution, etc.

The present safeguards and material management systems have acquired extraordinary capabilities and experience. They are adequate and sufficent in developing appropriate and functioning measures for other systems also. And, what is more important, these measures will be accepted and supported by all the involved parties since all of them need them.

Nuclear Safeguards in peaceful sectors of nuclear energy in the era of non proliferation have always had the problem of acceptance, because of the element of discrimination and distrust which is inherent in the system. International Safeguards in other areas could avoid such discrimination or distrust, and may have a more congenial atmosphere to work in.

A hard look at the present function and the necessary modifications can, I am sure, instill new vigour and life in ESARDA. And I am equally sure that it will continue to transcend national boundaries and continue to provide a forum for forces to join hands at the frontiers of knowledge and generate genuine confidence building measures for future generations.

You may try to check its progress after 788 million seconds. They are equal to the next 25 years from today.

Friends, it has been wonderful to be with you. Thank you.

Action of the European Commission

S. Finzi
Former ESARDA Chairman, from the European Commission

I am certainly, together with Dipak Gupta, the more ancient of the members of the Steering Committee of ESARDA present in this meeting.

As Mr. Cuypers mentioned, the first composition of the Association was including Germany and the European Commission. In the first meetings I represented the research arm of the Commission, when Mr. Mercereau, Director of Administration at the JRC, was the first Chairman of the Steering Committee (the second Chairman was Professor Haefele).

In fact the idea and the initiative of launching a Community Research Programme on Safeguards, as well as of establishing an Association on Safeguards Research were, I remember, from Mr. Kruys, at that date in charge of the Light Water Reactors R&D and of the corresponding Agreement with the U.S.A, under the authority of Jules Guéron.

In this period my activity was focused on building up the Laboratory of nuclear technology and devoted to implement the research projects which were assigned to the ISPRA Establishment and in particular to my Laboratory, and I was happy to be involved in a research which represented a certain diversification vis-a-vis the development of the ORGEL reactor, which absorbed all the efforts of my Laboratory.

I was nevertheless much more attracted by the technical challenge of this activity than by the undoubtedly important political significance of the venture.

I do not want to speak about the difficult period in which Europe was submitted to the pressures of the big States, and in the same time the interests of the individual European States were divergent: I am certainly not the more qualified person for reporting about that.

As a research man I was sometimes impressed by the subtle reasoning of the people more devoted to policy and astonished by the elaborate discussions involving istitutional and juridical matters.

My principal point of reference was in this field Dipak Gupta, who put his talent at the service of what was identified as the interest of the German Industry, under the leadership of professor Haefele, but I had also to appreciate some peculiar positions of the Safeguards Directorate, who had to be the guardian of the Commission's prerogatives. The discussion became more sprightly when André Pétit of the C.E.A. started his participation to ESARDA.

As far as Research is concerned, already in the first period the technical developments were remarkable, resulting in the production of measuring devices, adapted to the verification of the accounted nuclear material quantities, but I was particularly impressed by the committment of very capable scientists, who tried to optimise Safeguards systems, keeping always in mind the possible consequences of their implementation for their respective Country.

Altogether I feel that Research has brought a substantial contribution in order to offer workable solutions, through which the main needs could be satisfied.

In spite of the strong interest that I always put on ESARDA, my principal job was, especially in the last years, on nuclear safety: Nuclear Safety Research in the first period, operational aspects of Nuclear Safety in my last period at the Commission.

In this field the principal task was to contribute to reach a harmonisation of the safety principles and practices. The application in all the Community Member States of harmonised rules, accepted by everybody and adopted at Community level, would be the more valuable guarantee for ensuring that the protection against the risks of irradiation, in normal operating conditions of the plants or after an accident, would be not only efficient, but uniform for all the citizens of the Union. This is, in my opinion, the fundamental meaning of the Chapter 3 of the EURATOM Treaty.

The beginnings of the Commission's action in this direction were slow and difficult: the Member States were willing to develop their programmes of construction of power stations without the limitations possibly derived by a rigorous harmonisation at Community level.

The years 80's have seen the co-operation to take a more systematic and voluntary direction: the accident of T.M.I. provoked an important restart of research programmes on nuclear safety and the international co-operation at research level resulted in an improved concertation among the people responsible of safety in the Community Member States.

At the beginning of the 90's two important events had clear impact on the activities of the Commission in Nuclear Safety:

- the first, inside the Community, was represented by the start of the implementation of the single market, which imposed a serious reflection about the harmonisation of the safety requirements of the future generations of nuclear plants
- the second, at the Community borders, was represented by the consciousness by the different actors of nuclear safety in the Community - Manifacturers, Utilities, Safety Authorities - of the real problems raised by the East. In participating to the Community programmes PHARE and TACIS of assistance to the States of the central-eastern Europe and of the ex Soviet Union they reinforced their cohesion in developing a good co-operation with their homologous of the eastern Countries.

I find strong elements of parallelism between the driving interests in Safety and in Safeguards: also in the field of Safeguards the years 70th were characterised by a defensive attitude by the Member States and the years 80th by a progressive tendency to co-operate. In the years 90th the cohesion between the Commission and the Member States, as well as between the Member States themselves can be considered attained.

These reflections bring me to the following conclusions:

- it is essential for an action of the Community to have the fundaments on the Treaty: when this is not the case. a very strong political willingness must be explicitly expressed,
- common rules and common practices may be adopted in the Community only when a common understanding has been created through a work in common: concertation is an unavoidable process.

These two elements were present in Safeguards Research in the Community from the beginning, having regard to the obligations of chapter 7 of the EURATOM Treaty and to the context which was built via ESARDA. It is then not astonishing that this programme has passed through all the serious crises of the Community Research Programmes in Nuclear Energy with a real success.

At my age it is much more pertinent to look at the past, sometimes with satisfaction, sometimes regretting to have lost opportunities for doing better, than to launch new projects, but I think that if I had the opportunity now to say something on the orientation of Safeguards Research for the future I would insist on two points:

- the need of having a reasonable and perhaps new approach for handling the still standing problem of Pu management optimisation. It is of course not only a problem of safeguards and non proliferation, but it is my conviction that the development of Nuclear Energy cannot ignore the dimension of this problem.
- the need of homogenizing the implementation of international Safeguards.

We see at present in a large part of the nuclear world, i.e. in the State of the ex Soviet Union, a complete lack of experience on the implementation of international safeguards, due also to the approach that the soviet authorities followed, in a nuclear development where civil and military productions were under the same responsibility. We have at present the duty to assist our Russian colleagues, with all the respect and openness, in their obligation to reach a level of safeguards implementation compatible with the international commitments.

I see also in this case a similarity between the situation in Nuclear Safety and the one in Nuclear Safeguards. The problem of Pu management has the same weight as the problem of controlling severe accidents in Nuclear Power Plants. We need to reassure the public and ourselves and answer to the important challenges put by a sustainable development of nuclear energy: controlling severe accidents and avoiding the misuse of nuclear material. This is our present duty towards the mankind.

In the field of nuclear safety the expression SAFETY CULTURE was invented after the Chernobyl accident, in order to insist on the need of involving all the actors in the scene of the nuclear energy utilisation, with their clearly defined tasks and responsibilities: I think that we can define a SAFEGUARDS CULTURE as a goal to be reached, if we want to gain the confidence of the public and to satisfy the security of the States. A global approach to Safeguards, always maintaining, I repeat, a very clear distinction of the responsibilities of the different partners - the operators and the Authorities - will give its fruits in the optimisation of the nuclear fuel cycle management.

Accounting Nuclear Decay in MOX-Plants

MOX Working Group

1. Introduction

This paper gives a summary of the calculations and report procedures for Nuclear Transformation, as currently applied at:

BELGONUCLEAIRE, MELOX, SIEMENS

For detailed information we refer to the original papers from the respective companies.

2. Summary

The incoming PuO_2 is analysed after reprocessing at the reprocessing plant

ACTIVITY/PROCESS STEPS	BELGONUCLEAIRE	SIEMENS (former ALKEM)	MELOX
1. Receipt of the PuO_2 at the MOX plant	No NT is accounted for: – the material is registered with the shippers data NT reporting to EUR: none	NT is accounted for: – the shippers data are updated in the accounting system NT reporting to EUR: – per receipt referring to the original batch – period: from analysis date at reprocessing plant until the date of receipt	No NT is accounted for: – the material is registered with shippers data NT reporting to EUR: none
2. Master Blends (UO_2 + PuO_2 + Scrap) Introduction of items into the process	NT is accounted for: – PuO_2: from analysis date at reprocessing plant until blending date of the master blend. – Scrap: between blending date of scrap blend until blending date master blend NT reporting: per master blend	NT is accounted for: – PuO_2: from date of receipt (with Siemens analytical results) until analysis date of master blend. – Scrap: from date of analysis of recovered scrap until date of anal. of master blend NT reporting: NT quantities are recorded and accumulated over one balance period and declared prior to the PIV	NT is accounted for: – PuO_2: from date at reprocessing plant until date of entering of the item in the process (= blending date) – Scrap: between blending date of scrap blend until blending date of master blend NT reporting: NT quantities are recorded and accumulated over one month and declared at the end of the month
3. Secondary blends (Master blend + scrap + UO_2)	NT is accounted for: – master blends: from blending date master blend until date of secondary blend – scrap: from blending date of scrap blend until date of secondary blend NT reporting: per secondary blend	NT is accounted for: – master blends: from analysis date of master blend until analysis date on sintered pellets of secondary blend – scrap blend: from analysis date of recovered scrap until analysis date on sintered pellets of secondary blend NT reporting: idem as for master blends	NT is accounted for: – PuO_2: from date of introduction of the item into the process until analysis date on sintered pellets of secondary blend – scrap blend: from analysis date of recovered scrap until analysis date on sintered pellets of secondary blend NT reporting: NT quantities are recorded and accumulated over one balance period and reported prior to the PIV
4. Scrap blend (recovered/ recycled material)	NT is accounted for: – from various secondary blend dates until the new scrap blend date NT reporting: per scrab blend	No NT accounting although it is technically possible at present to do the same as for master and secondary blends.	No NT accounting
5. Shipments (Rods/assemblies)	NT is accounted for: – the calculation covers the period from the secondary blending date until the reference date imposed by the customer – the nominal values of the rods are updated as soon as the analytical results are available. The analyses are performed on sintered pellets combined with rodscanner values. NT reporting is done at the end of each campaign. The decay is calculated and reported per batch of ± 200 rods.	NT is not accounted for: the rods/assemblies are shipped with values of analyses date	NT is accounted for: – the analytical results obtained from the sintered pellets are used to determine the Pu quantities of the rods These values are updated until the reference date imposed by the customer when shipping the material Recording and reporting for each shipment

3. Nuclear transformation - conclusions

- The Working Group has considered all aspects of the application of nuclear transformations. It recognises that all plants are different in layout and to some extent in inspection regimes but the overriding essential principle is that continuity of knowledge should be preserved by always linking a Pu inventory figure to the corresponding isotopic composition and associated reference date.
- The specific procedures for shipments and especially for composite items as fuel assemblies may vary according to plant and customer requirements. There is no hand and fast rule. For example, decaying the total Pu figure to the date of pellet assay, the date of shipment or a foreseen date of reactor loading are all acceptable, provided that the date of inventory is stated clearly together with the isotopic composition at that reference date.

Integrated System BUD-CAVIS

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Introduction

The scope of this project is to combine the system BUD (Burn Up Device) with the system CAVIS (Computer Aided Video Surveillance) into one integrated safeguards system. The system BUD has been developed and installed by CEA/DAMRI in the reprocessing plant of La Hague /1/. It is used by EURATOM to verify the number and burn-up of the spent fuel assemblies transferred from a storage pond to a shearing cell in unattended mode. The system CAVIS-2S, developed by JRC, is a surveillance/monitoring system which performs the multiplexed recording of video signals from up to 16 cameras combined with simultaneous logging from 16 analogue and 48 digital input channels /2/. It is used by EURATOM in several plants in UK for optical surveillance and monitoring.

The inspector interfaces of both systems have been developed according to the specifications of EURATOM and therefore present similar data formats. Each system is controlled by a local computer. The transfer of data and commands between both computers will be achieved through serial interface and digital I/O lines. The CAVIS computer will act as master and data concentrator of the integrated system. A multitasking kernel is installed to allow switching between the various monitoring, control and communication tasks (fig. 1).

The development work of integration deals mainly with the following aspects:

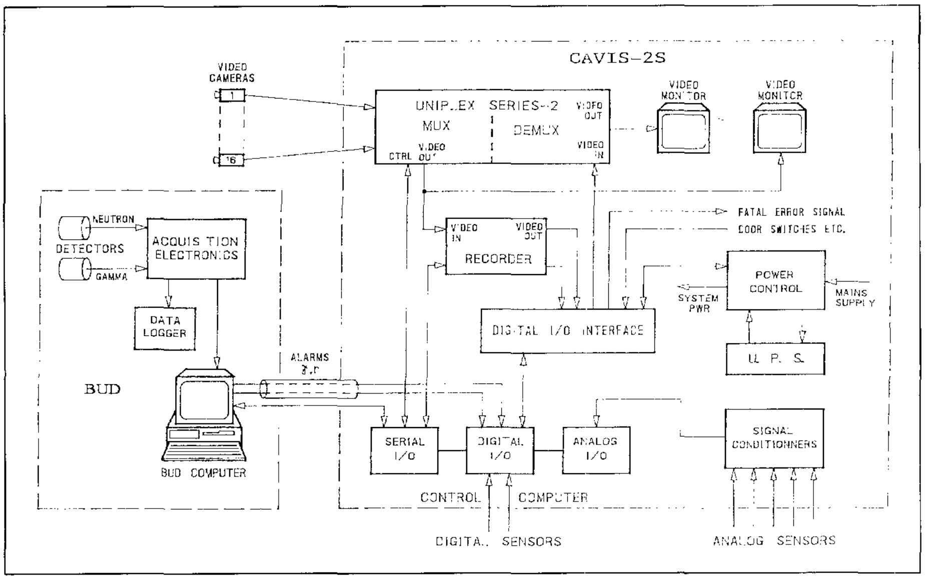

Figure 1: Bud-Cavis block diagram

Alarm History

05.07.93	11:04:12	Normal	System	Start of a new surveillance period
05.07.93	11:04:13	ALARM	Digital	Front doors of cabinets
05.07.93	11:04:20	ALARM	Digital	Read after Write signal from recorder
05.07.93	11:04:40	LOW	Analogue	Mains supply for arconditionar No 1
05.07.93	11:04:54	Normal	Digital	Read after Write from recorder
05.07.93	11:05:13	ALARM	Camera 1	Emergency exit
10.07.93	10:44:33	ALARM	System	Interruption for a system test
10.07.93	10:56:11	Normal	System	Restart after a system test
10.07.93	10:56:50	ALARM	Digital	Power failure
10.07.93	10:56:50	ALARM	Digital	Temperature limit exceeded
15.07.93	10:07:00	ALARM	Digital	Gamma detector No 2
16.07.93	15:10:93	ALARM	Digital	Motion detector
16.07.93	16:30:45	HIGH	Analogue	Container vibration

Dialogue

Use cursor keys or the mouse to scroll the alarm display
Press "ESC" to terminate

Figure 2: Example of integrated alarm history list of a CAVIS-2S System

1. Merging of alarm detections from both systems

The alarm conditions detected in all sensor signals from BUD and CAVIS are presented in an integrated alarm history table. This list includes date/time of each alarm or return to normal condition, the analogue or digital input line involved and the description of the sensor causing alarm (fig. 2). The system BUD filters continuously data from gamma and neutron detectors in order to detect activity periods and discard irrelevant information. The reduced data comprise date/time as well as the mean, maximal and minimal values of count rate on gamma and neutron chains. These data are transferred to the CAVIS computer which inserts them in the alarm table.

2. Control of the sampling rate of the acquisition process

It is useful to acquire more data from some sensors at an increased sampling rate the moment an alarm is generated by another sensor type. The additional information allows for a better time synchronisation during later review and eases the data interpretation by the inspector. If an alarm is detected on a gamma or neutron detector, the integrated system increases the image capture frequency of the video cameras pointing to that area. The same control feature will trigger a measurement cycle of the nuclear instrumentation if an activity is detected by the corresponding video cameras. The sampling rate of each video and I/O channel in CAVIS is computer controlled.

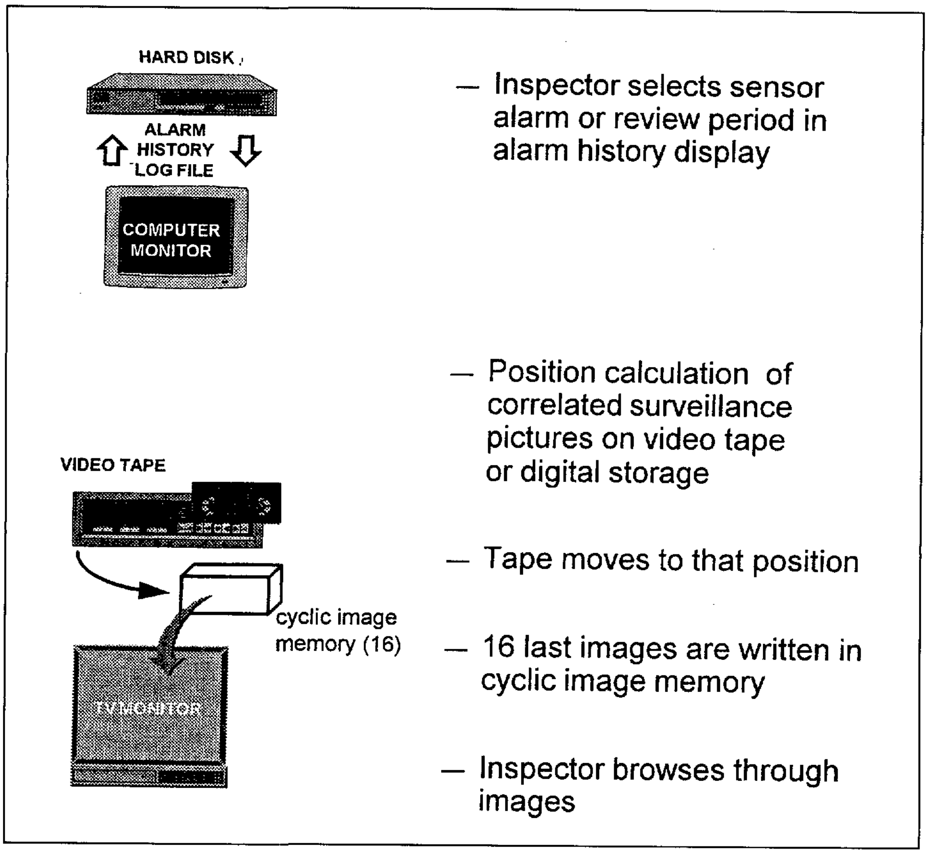

Figure 3: Review of video pictures from sensor alarm table

3. Synchronisation between systems

Independent time keeping based on both local computer clocks would lead to a significant timing error over long periods. The CAVIS computer will send the time information to the BUD computer in order to achieve synchronisation.

4. Correlated review of data

The developed software allows a correlated review of NDA, surveillance and monitoring data. It is based on the integrated alarm table and the setting of a time pointer. The inspector can select with the pointer an event in the table. The system calculates the position of the correlated surveillance pictures on the video tape or the digital storage medium. The last 16 pictures recorded at the selected event are transferred to a cyclic image memory. The inspector can browse through these images presented on a separate TV monitor using the computer keyboard or mouse (fig. 3). Another function displays the last 256 events up to the time pointer in a scrollable data window.

Further software development will be required for the graphical display of some BUD data on the CAVIS computer screen. This will help the inspector to analyse more in detail alarms of the gamma and neutron chains.

The functions of system tests and maintenance which are used by technical staff of EURATOM are executed on each local computer.

Conclusions

The integrated system BUD-CAVIS is based on two existing systems which are already in use by EURATOM inspectors. Their modular software architecture and common inspector interface allow an integration with a reasonable software development effort. The experience which will be gained by this system will significantly contribute to the preparation of guidelines for future systems.

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EURATOM Experience with Integrated Unattended Systems

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Abstract

Euratom has a wide experience of installed equipment in nuclear facilities in Europe. This paper describes the current status of installed measurement systems and outlines the factors which are important for the installation and use of such systems. Unattended operation is essential in modern facilities, whereas the extent of integration is variable and must be chosen appropriately. Operation of unattended systems has provided a number of lessons (cost of large software packages, difficulty of commissioning, standardisation of equipment etc.)

In the short term it is necessary to rationalise the resources available by replicating existing systems (if of adequate standard) and by making limited links between systems (e.g. video and NDA). At the same time the introduction of local computer networks allows all collected data to be integrated and reviewed in the most effective way.

1. Introduction

In general, portable equipment used by inspectors is cheaper and easier to authenticate than installed equipment. However in large modern facilities there are factors which force the use of permanently installed equipment. Firstly the material is often contained in areas where human intervention is not possible due to the need to limit the dose uptake. Secondly the material is often handled by automated equipment which makes it difficult or impossible to make special movements to bring the material to a manual detector. Thirdly the plants can operate continuously which means that inspectors would need to be available for 24h per day. These factors have led to a large increase in the amount of equipment installed by the Euratom Safeguards Directorate (ESD). This has been reflected in the fact that although the ESD budget for routine (attended) measurement equipment has been relatively constant since 1990, the budget for large plutonium plants has increased very significantly.

The types of different signals which are currently monitored in installed systems by ESD are:

- tank levels, densities, temperatures
- weights
- neutron total rates
- gamma total rates
- neutron coincidence rates
- gamma spectra
- crane positions
- cameras
- infra-red sensors
- microwave sensors
- item identities
- status alarm signals

Each signal is not limited to a single sensor type, so that the number of different combinations of sensors and protocols is extremely large. The emphasis in this paper is on Non-Destructive Assay (NDA) sensors.

2. Basic System Structure

A measurement system is a set of equipment which accepts an input from a sensor and presents an output in the form of relevant results to a user (inspector). The system consists of three parts: data collection, data transmission and data review:

- The data collection subsystem consists of local electronics and power supplies together with a certain amount of data processing and buffering.
- The data transfer system can range from a computer network to manual movement of floppy disks or other removable medium. In the case of ESD the typical configuration is the transfer of data from a number of local instruments in a facility to some central point (inspectors' office) in the same facility.
- The data analysis and review subsystem accepts data from the transfer subsystem and combines and processes them in order to present useful results to the user.

The equipment considered here is permanently located in a facility. The data collection occurs continuously and there is usually some associated containment and surveillance (C/S) measures. These C/S measures are provided both for the safeguards of the nuclear material and the authentication of the measurement system. The existence of logically associated sensors gives the potential for integrated systems. Integration can be applied to each of these three subsystems. Integration for data collection means that logically related data can be collected together; this can facilitate both subsequent review and authentication. Integration at the level of data transfer may also assist with authentication. Integration of the data review implies that information from linked sources is combined into a coherent presentation of associated results which should produce a review which is simultaneously both more effective and efficient. However it should be noted that integrated data collection does not automatically imply integrated review, and it is perfectly possible to carry out computer aided integrated review of data collected in a non-integrated way. The optimum amount of integration to be used in any particular application should be a balanced choice suited to the facility and the inspection regime.

Figure 1 shows the categories of integration which can be applied to data collection.

The first choice is between attended or unattended operation. The latter is split into "simple" (single source), parallel (in which for example neutron and C/S data are collected separately) and "integrated". The integrated systems can be divided into those linked by an exchange of triggering information (e.g. when a neutron counting rate threshold is exceeded the video sampling rate can be increased) or "fully integrated" in which all data is collected and packaged together.

The local equipment is normally supplied with power from an uninterruptible power supply (UPS) which has an autonomy of between one and a few hours. The central equipment may have

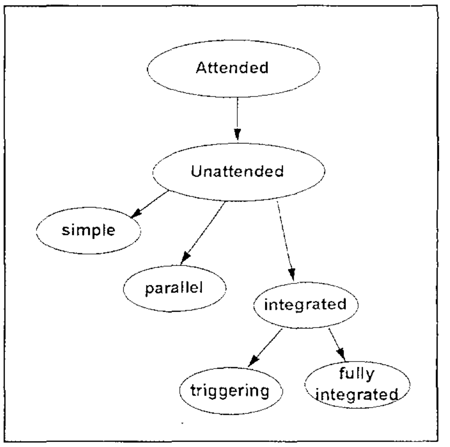

Figure 1: Data Collection Options

no UPS or one with a very short autonomy, just sufficient to allow "clean" shutdown of the computer systems. This has consequences on the system design in that the data accumulated in the local data processing electronics must be stored until the central machine acknowledges that a valid transfer has taken place. If the mains power interruption is sufficiently long, data can still be lost. The mechanism to cover this loss (when reverification requires significant effort) depends on the particular installation, but could include battery backup of essential (low power) equipment.

The system to be used for data transfer depends on the desired functionality and cost. The cabling can be point-to-point or a 'network', optic fibre or copper. The physical layout does not preclude a free choice for the logical interconnection (i.e. a point-to-point cabling can still be connected centrally to function as a network.)

3. Simple Data Collection

A widely used tool of ESD for recording levels, temperatures, densities, weights, neutron counting rates and barcode identities is the Ranger data logger. This has been described previously in safeguards meetings /1/. It is a good solution for unattended data collection in simple circumstances and also useful as a backup in more complex systems. The commercial review software package PRONTO provides useful facilities for basic data review.

4. Existing Custom-Built Systems

In this section, some of the existing ESD installed systems are considered. These systems have been described in other publications and so only a few comments relevant to integrated systems will be given.

4.1 Consulha

Consulha combines neutron, gamma and video information in a system used jointly by ESD and IAEA for monitoring the input of spent fuel assemblies into a reprocessing plant /2/. This was one of the first integrated systems deployed. Consideration is being given to an upgrade of the system using the BUD system described below.

4.2 BUD

BUD is a neutron/gamma system /3/ also used to monitor the input of spent fuel assemblies into a reprocessing plant. Work is currently in progress to combine the CAVIS video system with BUD. Details of this work are given at another presentation in this session ("Integrated System BUD-CAVIS" Daniel, Sannié, Tola, Mol and Sorel). The BUD system is our de facto standard for this type of application and ESD expects to have at least 4 such systems operating in about one year's time.

4.3 CEMO

CEMO (Continuous Enrichment MOnitor) is used at a centrifuge enrichment plant to give a 24h recording of the output enrichment /4/. A point of particular importance is that the system can be interrogated remotely in order to obtain its state of health.

4.4 FPFM, Hulls Monitor and Coques et Embouts

The Feed Pond Fuel monitor, Hulls Monitor and Coques et Embouts System are systems in which an independent ESD data collection system has been added to an instrument belonging to an operator. These are active neutron systems which require triggering links between the ESD data acquisition system and that of the operator. In this case there are additional constraints (e.g. exchange of trigger signals) which limit the available choice of ESD system types. These systems are therefore, by their nature, rather specialised and not amenable to standardisation.

4.5 Transfer Channel Monitor

The transfer channel monitor is a combination of gamma and movement sensors linked to a video surveillance system. /5/. It is used to record movements of spent fuel containers in between ponds in a reprocessing plant. The video system is triggered by signals from the other sensors.

4.6 NEGUS

NEGUS is a redundant data acquisition system designed to be used to record neutron coincidence data, high resolution gamma spectra and sensor data /6,7,8/. It can also acquire data from total neutron counting and multi-

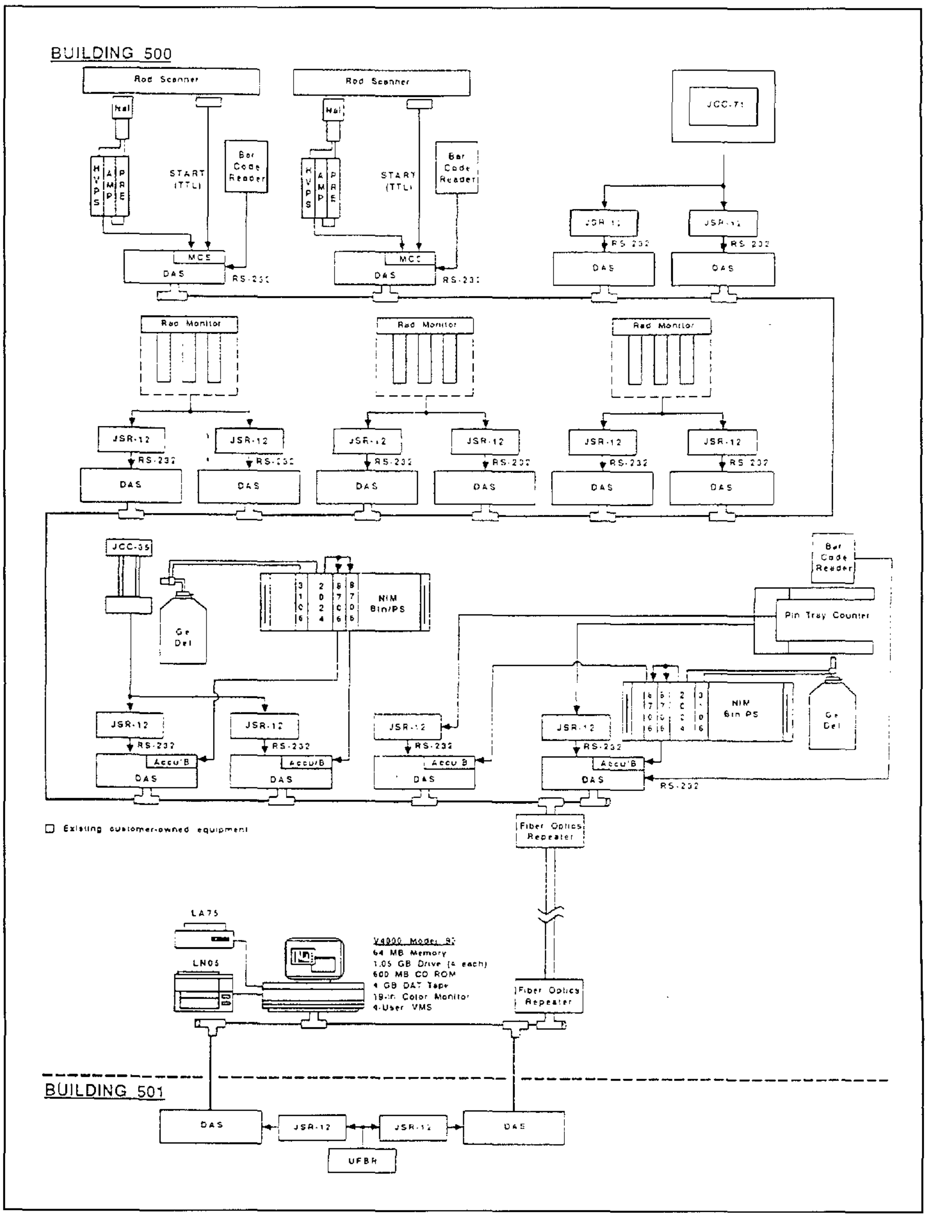

Figure 2: Schematic diagram of NEGUS neutron gamma unattended system

channel scaler data. The development began in 1990 and by the end of 1994 ESD expect to have three systems installed, designed to take data from a total of 16 neutron and neutron/gamma detectors. A schematic diagram of the largest system is shown in figure 2. This system is the ESD solution for data acquisition in all plants where large amounts of neutron/gamma data are expected.

5. Current Developments in Integration

There are several current projects which are designed to give the user the advantages of an integrated system. One of these has been designed at the early stages of equipment installation in a particular plant (figure 3).

It collects all of the non-surveillance data produced by safeguards equipment in a fuel fabrication plant. The data collection and transfer tasks are carried out by two software packages: NEGUS (discussed above) which collects NDA information and associated barcode identity information, and BRANCH which deals with weighing and associated identity information. These processes collect data from local electronics using an ethernet network and provide information to the main review program MIDAS using the same network.

A second example of current integration projects was described recently /9/. This consists of the provision of hardware and software capable of accepting both raw and processed information from a number of pieces of equipment which have been operating in a standalone way for some time. A schematic diagram is shown in figure 4. The design of this system is more difficult than that described above, because of the constraints of the existing equipment. This system should be operational in early 1995 and will give all the benefits of integrated review.

6. Factors Involved With System Choice

When a system has to be chosen for a new application, there are a number of factors which have to be considered which are common to all types of equipment installation:

- timescales and deadlines
- cost
- support effort required
- development effort required

For ESD applications, the timescales are often rather short and correspond to certain key phases during the construction of large nuclear facilities. Space envelopes and cabling schemes need to be defined well in advance of equipment installation. The price of the equipment is also very important, but the choice of system must take into account the overall cost associated with the equipment including the manpower needed to develop and support it.

Some importance factors need to be considered for each of the subsystems:

- Data Collection
  The definition of this system begins with the definition of the safeguards strategy for the plant, including the NDA and C/S measures which need to be applied. The constraints of the individual plant need to be considered. The large majority of ESD installed detectors have had to be made plant specific, although as far as possible standard components have been used. For example, all of our installed neutron coincidence systems currently use Amptek preamplifiers.
- Data Transfer
  The choice of data transfer system depends to a large extent on the wishes of the inspectors in a particular plant, and how they wish to organise the collection and review of data. Currently installed systems collect video information in parallel with the collection of other data, which means that the (non-video) data rates needed are rather low. It is also to be remembered that the usage of the data is never in real time and the authentication aspects of data transfer are much more important than the real time capability. As stated above the physical topology of the system is not usually important.
- Data Analysis and Review
  It is clear that fully specified software systems are expensive and inflexible. A more reasonable approach is to aim for open systems so that small additional requests of the user can be met internally, giving advantages in terms of both implementation time and cost. One way to achieve this is by storing the data in a commercial database for which standard access commands and macros are readily available. One important development in this area is that operator declarations often arrive in computer-readable form and the ability to include this data directly into the review system both reduces the time necessary and removes one possible source of error.

7. Lessons

This section describes a few lessons which have been learned from the implementation of unattended systems to date. They are a mixture of the general and the very specific.

Firstly big custom-built software packages are expensive, both in terms of the effort required to produce the user requirements and the purchase price of the final software. They are also very time consuming to commission. Most of the problems we have experienced have occurred with the user interface, which is the most difficult part to specify. Some problems have occurred with the automatic detection of 'events' from raw data. These problems would be made very much less by the use of open systems as described above. However when a system has been commissioned successfully it is prudent to replicate it in other suitable applications to profit from the investment made and to minimise the support effort needed.

Standardisation of components has been useful. In addition to the preamplifier electronics described above, the use of NIM modules is common to many of the installed systems as well as some of the portable systems. In this way the knowledge already gained with these modules could be applied to the mainte-

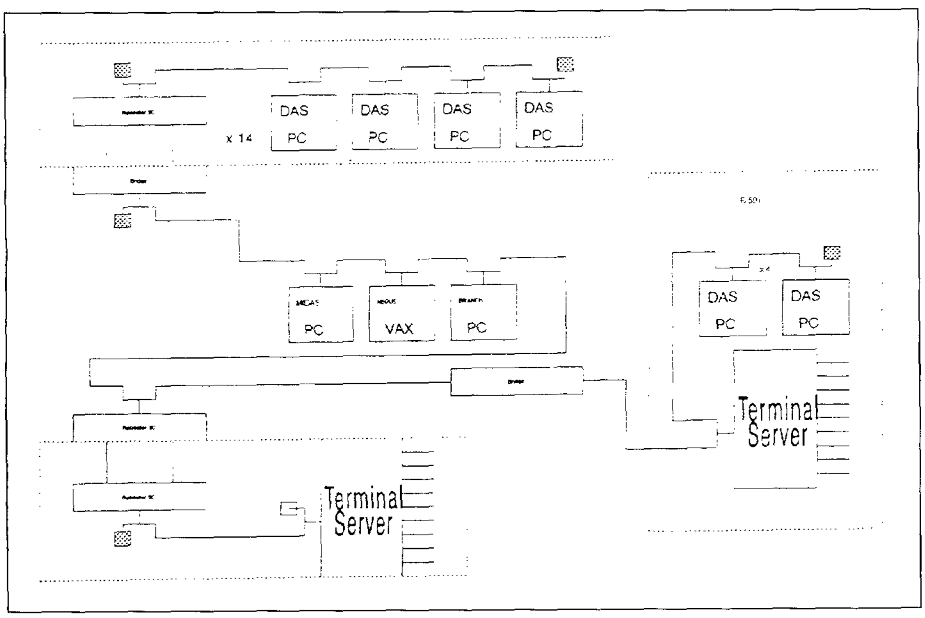

Figure 3: Example of networking of weighing, identity and NDA information

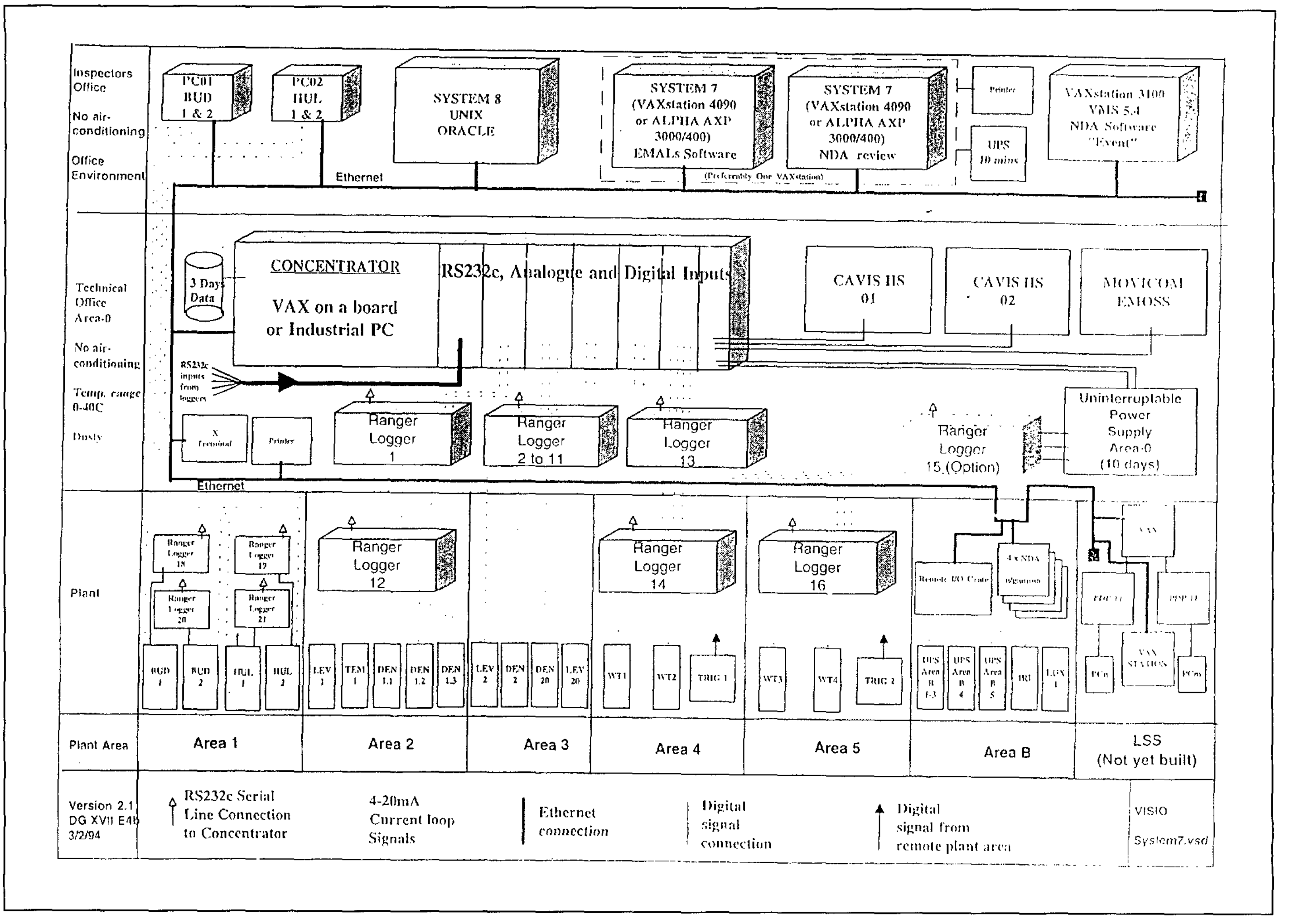

Figure 4: Overall Block Diagram of System 7 Euratom Safeguards Monitoring and Logging System

nance and support of the installed systems including common spares.

In the combined neutron/gamma detectors, automatic material movements have provided a good improvement in measurement precision resulting from reproducible positioning. The neutron detectors have shown the same good reliability of their portable counterparts, but the cooling system of existing compressor-cooled gamma detectors have necessitated a large maintenance effort. An important factor in the amount of effort needed has been the overall design of the mounting of the detector which makes the changing of the gamma detector and its cold-head a time-consuming operation. This is one manifestation of the consequence of installed systems which make inspection effort more efficient but at a cost of both capital investment and technical support effort. The maintenance of installed systems is an important factor which needs to be designed in to the system at an early stage.

Acknowledgements

The work described here has been managed by a number of current and former ESD staff and has been carried out by a number of state and commercial organisations.

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A Remote Monitoring System for Safeguards Applications

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Introduction

A Remote Monitoring System (RMS) was installed at the HIFAR spent fuel storage facility located at Lucas Heights, Australia. The HIFAR facility is operated by the Australian Nuclear Science and Technology Organization (ANSTO). The RMS installed in Australia was the first that was designed to test a number of different concepts that would be useful for unattended remote monitoring activities. The RMS was installed in Building 27 and sponsored under a joint Australian Safeguards Office (ASO) and the United States Department of Energy (DOE) bi-lateral agreement. ASO had already been working with a remote video transmission system in Building 23 at ANSTO under a support program project for the International Atomic Energy Agency (IAEA).

The function of any safeguards unattended system is to collect information to verify the operations at a nuclear facility. The safeguard information collected is grouped under two general headings which are Non-Destructive Analysis (NDA) and Containment and Surveillance (C/S). Limitations in the available technology has in the past kept these two types of information separated but now it is possible to create new combined approaches to safeguards information that formerly would been either impossible or too costly. Another part of the collection of safeguards information is the presence of an inspector. The presence of an inspector will always be necessary for some safeguards activities at certain facilities but at other facilities a RMS could provide the information to permit reduction in the frequency of visits or the time spent at a facility. The RMS tests are directed at demonstrating systems that can reduce the travel or time required to collect safeguards information by providing the capability of remote transmission of the safeguards data. ANSTO's spent fuel storage located in Building 27 is an ideal test site for an RMS. Fifty spent fuel storage pits are kept under IAEA seals. Inspectors must travel to verify that the spent fuel has not been removed. The RMS has been installed to demonstrate how the same information that is collected by an inspector on site could be collected remotely.

Technical Discussion

The RMS block diagram (See Figure 1) shows the interconnection of the equipment installed in Building 27. A network of nodes collect data from a number of different sensors and security devices. A four conductor network cable is used to interconnect all the nodes. Two conductors are used to supply power to all nodes. The other two conductors carry RS-485 network signals to all the nodes. A number of different sensors and detection devices have been installed to study how they can be used to complement each other for C/S applications. NDA information from radiation detectors for example could be collected by the network if such instrumentation were needed for a safeguards scenario.

Network Sensors

The Authenticated Item Monitoring System (AIMS) is used to monitor the storage tubes. AIMS Sensor Transmitters (ASTX) have been attached to the covers with Velcro. ASTX's contain motion sensors. Any motion of the ASTX or the storage tube cover to which it is attached will generate an alarm signal which is transmitted over a radio frequency (RF) carrier to receiver. A few of the ASTXs called Reusable In-situ Verifiable Authenticated (RIVA) seals are electronic seals which detect the status of a fiber optic loop. The RIVA seals send an alarm over a RF signal whenever the fiber optic loop is opened. Fifty AIMS transmitters are attached to the storage pits.

The data from the AIMS devices are collected in two different ways. A Receiver Processor Unit (RPU) operates independently to collect AIMS information. AIMS data can be collected from the RPU by connecting a computer to it and transferring the data from the RPU to the computer. A second AIMS recei-

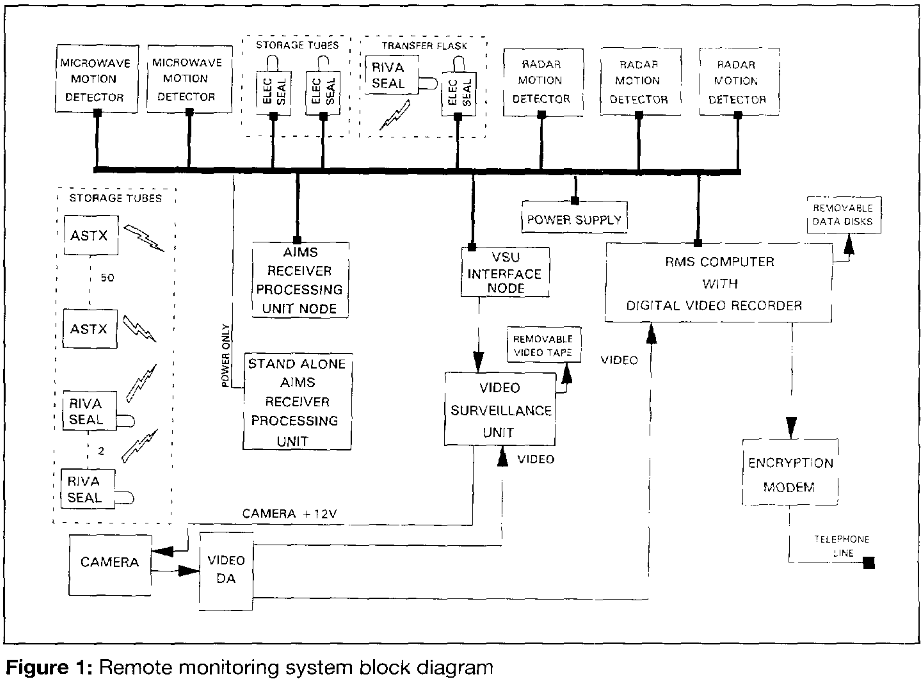

Figure 1: Remote monitoring system block diagram

ver attached to a network node also collects the same information for storage in the RMS computer and for remote interrogation.

Microwave motion detectors on the network are used to determine if any activity is occurring in the area. The microwave motion detectors send out RF pulses at approximately 10 GHz to detect motion in the area. Two microwave motion detectors are used to monitor the storage area.

Ultra-wideband Radar Motion Sensors have been installed to test their operation. The pulses emitted from these sensors are well below 1 microwatt and are spread over several GHz. Their coverage consists of a hemi-spherical shell around the sensor that has an adjustable radius out to 24 feet. They function as another type of motion detector. The data from these motion detectors will be compared to data from the microwave detectors.

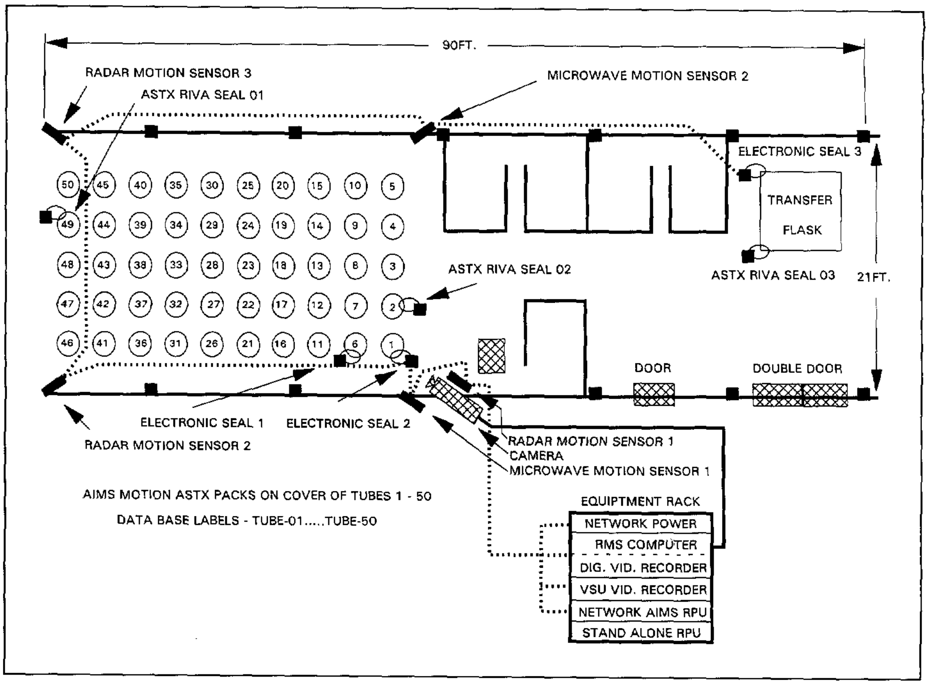

Figure 2: Sensor and equipment layout diagram

Video Systems

Detection of any alarm signals from the AIMS transmitters or the motion detectors will trigger video recordings to be made on the video recording systems. Dual video systems are utilized to collect video images. An analog recording system called the Video Surveillance Unit (VSU) has been connected to the network. It is programmed to make recordings when it receives alarms signals indicating that there is activity in the storage area. The VSU also makes time lapse recording in a manner similar to the Modular Integrated Video System (MIVS). The second video system uses a digital compression board in the RMS computer to collect digital images and store them on both a hard drive and an optical disk. The digital data and images can be accessed for remote transmission.

Remote Monitoring

Data and images from Building 27 are remotely monitored via telephone lines from Canberra, Australia and Albuquerque, NM, USA. Remote monitoring stations at these two locations can call and retrieve data and images from the RMS computer in Building 27 at ANSTO. The data and images are encrypted before transmission. Access to the RMS computer cannot be obtained without the correct encryption keys and passwords.

Periodically on-site personnel from ASO or ANSTO remove the optical disk from the RMS computer and video tapes from the video recording module for analysis and comparison with the remotely collected data. The "Write Once Read Many" (WORM) optical disk could be used to test the "Mail-In Concept". The data on the WORM disks can be protected against tampering by authenticating it and by being stored on a disk tagged with a reflective particle tag. Such a disk could be removed from RMS and mailed to the inspecting agency.

Equipment Installation

SNL and ANSTO personnel installed the equipment at the storage area during the first week of February, 1994. The ASTXs were attached to the covers on storage tubes. The Radar Motion Sensors, and Microwave Motion Detectors were attached to I-beams in the wall. The network cable was strung along the walls and attached to the existing building supports. An equipment rack was used to house the RPU, the RMS computer, modems, and the VSU. The rack contains the power supplies for the network as well as an Uninterruptible Power Supply (UPS) for the computer. A layout diagram (See Figure 2) shows the location of the sensors in the storage area of Building 27.

Summary

The installation of a RMS in the Building 27 spent fuel storage area has shown the technical feasibility of the remote monitoring concept. The hardware in the system has performed without any major problems during the first months of operation. Additional work must still be done to integrate the hardware into an easy-to-field configuration and to resolve software issues such as standard formats for data and images, users interfaces, and data base structures for handling a number of Remote Monitoring Systems.

Part of this work was supported by the United States Department of Energy under contract DE-AC04-94AL85000

The International Measurement Evaluation Programme IMEP

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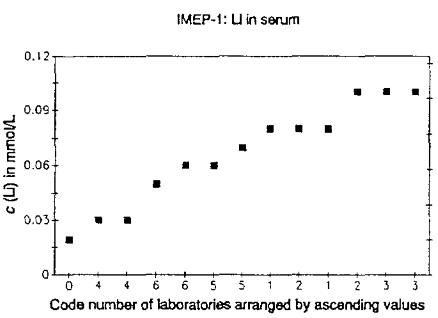
J. Moody
NIST, U.S.A.

A project of the EC Institute for Reference Materials and Measurements IRMM in cooperation with the National Institute of Standards and Technoloty NIST (USA) under the auspices of the International Union of Pure and Applied Chemistry (IUPAC), EURACHEM, a Focus for Analytical Chemistry in Europe, EUROMET, the association of European Institutes for Metrology, CITAC, the worldwide Cooperation for International Traceability in Analytical Chemistry, aiming at the improvement of the reliability of chemical measurements.

IMEP-6: Trace Elements in Water

We take pleasure in announcing IMEP-6, which aims again, as IMEP-3, at evaluating measurement capability of certain trace elements in water. The elements under examination in IMEP-6 can be found in App. 1.

IMEP-6 will be similar to IMEP-1 (Li in human serum), IMEP-2 (Cd in polyethylene) and especially IMEP-3 (Trace elements in simulated and natural water). Please find typical results in the figures. IMEP-1, IMEP-2 and IMEP-3 have been published. IMEP-4 is still running.



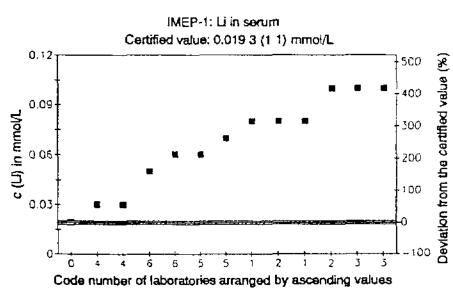
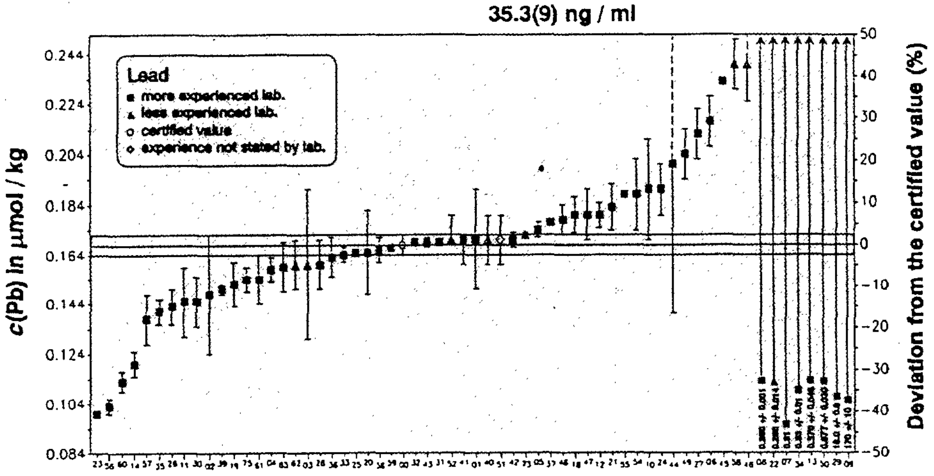


Table 1: Status March 1994

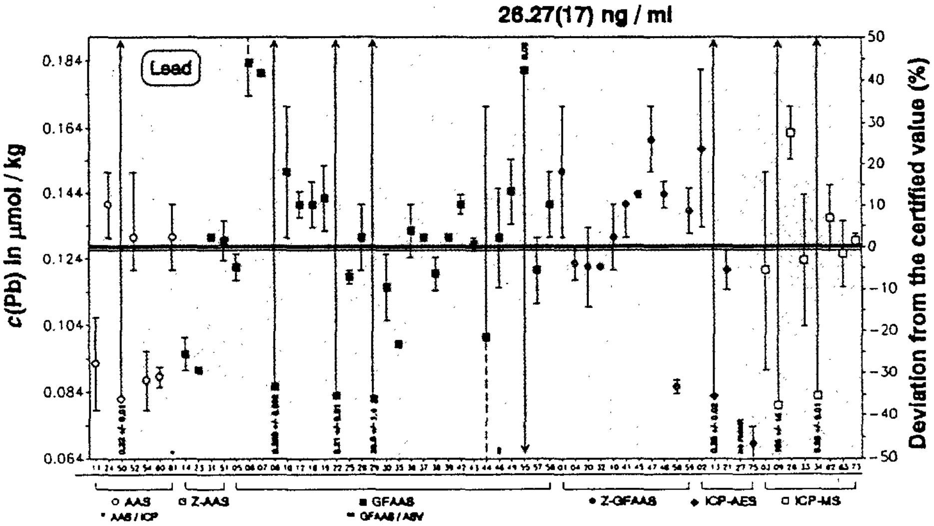
IMEP Number	Material (chemical matrix)	Element(s) to be assayed	Nominal Concentration (in mmol/kg)	Time Period
IMEP 1	Li in Human Serum	Li	0.02, 0.6, 1.2, 2.2	1989
IMEP 2	Cd in Polyethylene	Cd	0.35, 0.65, 1.8, 3.6	1990-91
IMEP 3	Trace Elements in Simulated and Natural Natural Water	Rb B Cu Zn Li Cd Pb Ca K Fe	0.0001 0.01 0.0003 0.001 0.003 0.0001 0.0001 1 0.05 0.002	1991-93
IMEP 4	Trace Elements in Bovine Serum	Li Cu Zn	<0.01, 1, 1.5 0.013, 0.015, 0.030 0.008, 0.012, 0.021	1991-94
IMEP 5	Fe in Human Serum	Fe	0.02	1991-93
IMEP 6	Trace Elements in Water	similar to IMEP-3		1994-95
		Tentative future rounds		
IMEP 7?	Plastics	Br, Cl, Pb		?
IMEP 8?	Agricultural related Matrices	B, Cd, Si		?
IMEP 9?	Cd in Rice	Cd		?
IMEP 10?	Car Catalyst	Pt, Pd, Pb, Rh, Zr, Ce		?
IMEP 11?	Pb, Cd in Whole Blood	Pb Cd	0.002-0.004 0.0001	? ?
IMEP 12?	Cd in Urine	Cd	0.0002	?
IMEP 13?	Hg in Urine	Hg	0.001	?
IMEP 14?	Al in Serum	Al	0.003	?
IMEP 15?	n(13C)/n(12C) in CO2			?
IMEP 16?	n(18O)/n(16O) in CO2			?

IMEP-3: Trace Elements in Synthetic Water A
Certified value: 0.168(4) µmol / kg
35.3(9) ng / ml



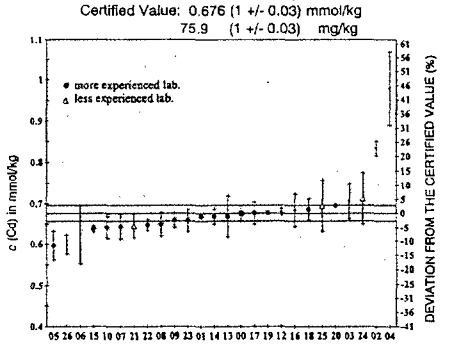
Code number of 61 laboratories arranged by ascending values

IMEP-3: Trace Elements in Natural Water B
Certified value: 0.127 0(8) µmol / kg
26.27(17) ng / ml

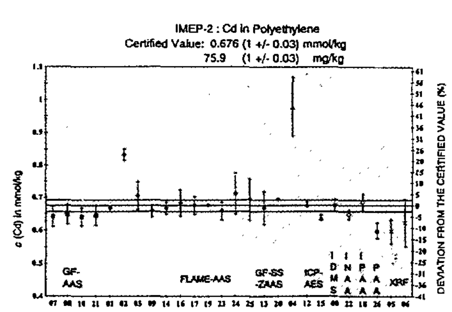


Code number of 60 laboratories arranged by methods

IMEP-2 : Cd in Polyethylene
Certified Value: 0.676 (1 +/- 0.03) mmol/kg
75.9 (1 +/- 0.03) mg/kg



CODENUMBER OF LABORATORIES ARRANGED BY ASCENDING VALUES



CODE NUMBER OF LABORATORY ARRANGED BY METHODS

IMEP-6 is *organized in cooperation* with NIST (Dr. John Moody), contributing in the preparation and the certification of the water samples.

The certification is done at IRMM, Geel, and at NIST, Gaithersburg.

From IMEP-3 onwards a participation fee was requested from the participants in order to cover a (very) small part of the cost of providing the material. In the case of IMEP-6, this fee is 300 ECU.

IMEP-6 is a further step into setting up an international external quality assurance programme for environmental monitoring measurements for Safeguards purposes.

Laboratories interested in participating in this programme, are kindly requested to complete the relative form and return it. It is not necessary to determine all elements mentioned. We have had requests for participation from official (-state) networks or from organisations having a network of water laboratories. These requests have been accepted.

Separate graphs will be produced for these networks. Also "national" graphs -per country- may result.

Participation to IMEP-6 is now expected to be worldwide and this is welcome. Under the international auspices quoted above, IMEP-6 will be a large international field test for establishing Traceability and Comparability for Chemical Measurements.

The **deadline** for notifying participation is September 30, 1994.

For any questions you may have on this programme, please contact

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Announcement

New REIMEP Rounds

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EC, JRC, IRMM Geel, Belgium

The Regular European Interlaboratory Measurement Evaluation Programme REIMEP is an external quality control programme for nuclear analytical laboratories. It is open for worldwide participation, however the agreement of the competent authorities for dispatch of nuclear materials is required for participants from non-EU countries. REIMEP's objectives and characteristics are:

- provide a state of the practice picture for the assay of a given fissile isotope abundance or element content of a given material
- opportunity for participating laboratories to perform an external check on their U and Pu measurements
- guaranteed coded participation
- participants work under normal measurement conditions
- results are provided in graphical form
- programme provides reference value with conservative uncertainty
- conclusions to be drawn by participants from themselves
- participants are asked to contribute to material costs of the programme
- certified values are released to the participant as soon as measurement results are reported.

Measurement rounds on uranium oxide powder and uranyl nitrate solution will be announced in early summer this year. However, participation is still possible. The materials will be dispatched to the participants in autumn. Uranium oxide samples consist of approx. 10 g of material in a screw cap vial. The uranyl nitrate sample consists of two solutions, a more concentrated one (ca. 170 gU/kg solution) requiring dilution prior to titration or IDMS, but directly applicable to NDA methods such as K-edge densitometry. The second solution is diluted (c.a. 15 gU/kg solution), hence directly applicable for titration.

REIMEP is being sponsored by the EURATOM Safeguards Directorate, DG XVII-E4.

LB-AB-94-024-EN-N