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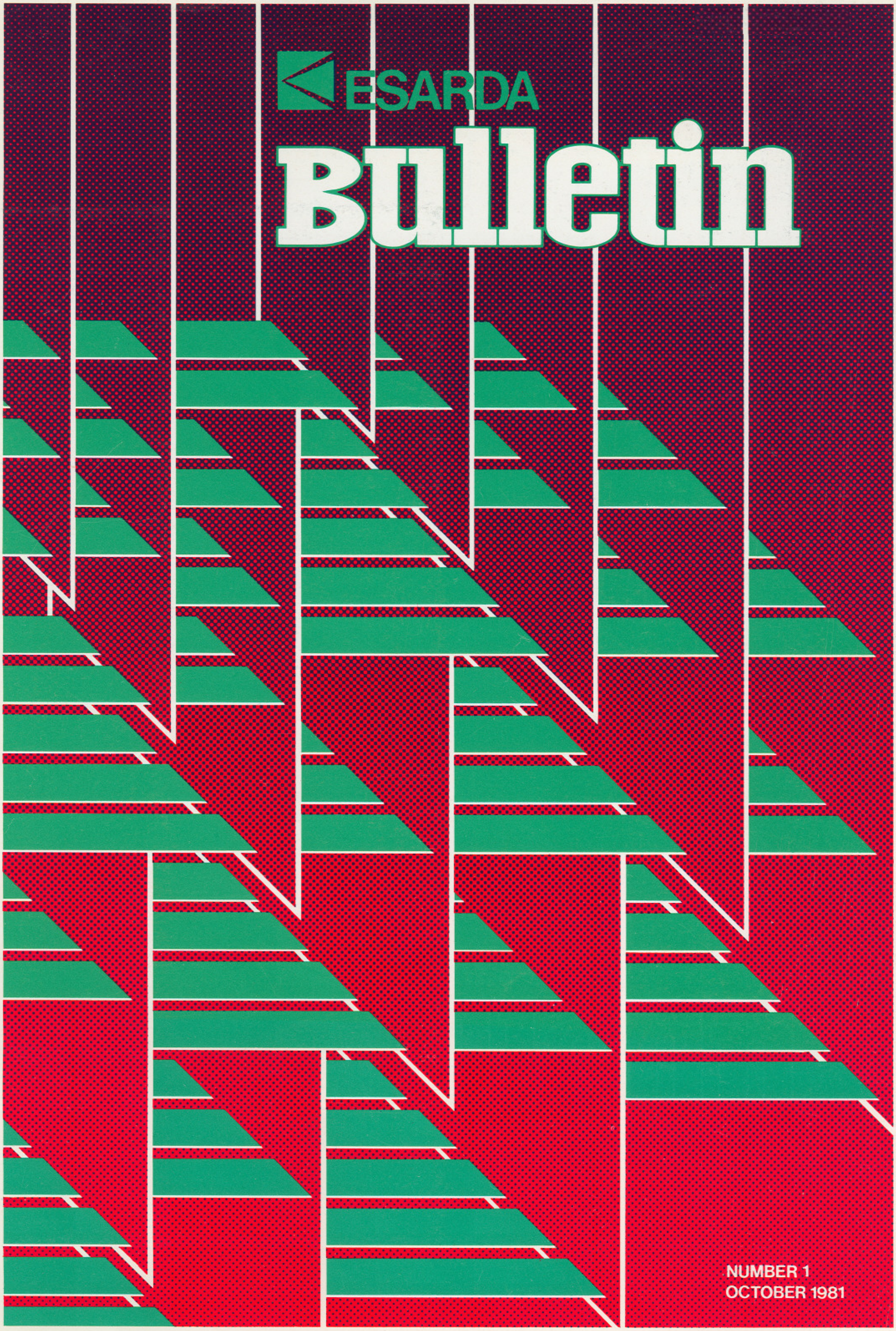

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ESARDA is an association of European organizations formed to advance and harmonize research and development for safeguards. It also provides a forum for the exchange of information and ideas between nuclear facility operators and safeguarding authorities.

Editorial Policy

Manuscripts should be sent to the Editor or to one of the members of the Editorial Board. They should be typed, double spaced, on one side of the page with wide margins and indented paragraphs. Technical papers from R & D people or operators are welcomed. Items for news sections should be addressed directly to the Editor, so that they appear promptly. Once a manuscript is accepted it will be published quickly and free of charge. Black and white photos or diagrams should be of very high quality so that they give a good result.

Publishers

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Joint Research Centre, Ispra

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ESARDA Bulletin

EUROPEAN SAFEGUARDS RESEARCH AND DEVELOPMENT ASSOCIATION

Contents

A New Bulletin for a New Policy

The European Safeguards Research and Development Association grew out of a series of research contracts (starting in 1969) between the European Atomic Energy Community, EURATOM, and research organizations, in certain of its member states, working in research and development for safeguards purposes. These provided means of exchanging information on their work and technical assistance, and of preventing unnecessary duplication.

The acronym ESARDA and the full title of the Association came into use in 1973 to cover the whole group of research organizations associated by the contract structure at that time. There was only one participating organization from each relevant member-state; the Commission of the European Communities participated primarily through its Joint Research Centre and the Directorate of Euratom Safeguards.

Over the past few years, it has become apparent that the efficient application of safeguards is a matter of crucial economic and operational importance to the whole of the nuclear industry of Europe, and that ESARDA could play a more effective role in meeting this challenge by also involving organizations operating on the industrial scale.

This policy has been reflected in the Working Groups in which the functions of ESARDA are mainly carried out, and which have attracted the participation of an increasing number of representatives from development and from production organizations. In addition, the Working Groups themselves have become increasingly directed towards the problems of practical application of safeguards.

The Steering Committee of ESARDA has examined ways in which the constitution of ESARDA could be amended to make the Association more representative of all safeguards interests within the European Community and to make it an effective forum for the discussion of European problems in this area. As a result, a new contract has been adopted by the members of ESARDA from the beginning of this year, which allows any organization, either R & D or operational, capable of contributing usefully to the purposes of the Association, to become a member.

The new contract is a culmination of a broadening outlook of ESARDA which has been manifested most prominently by the three successful annual Symposia on Safeguards and Nuclear Materials Management held in 1979, 1980 and 1981.

These grew out of earlier meetings held on more specialized topics and in the same way the new Bulletin has grown out of earlier intermittent publications in conjunction with the European Safeguards Bulletin.

The decision to initiate a regular and separate bulletin reflects the Steering Committee's concern to promote interest in the work that ESARDA is doing in the application of safeguards. It is hoped that it will make news about the progress of the Association as a whole and of the specialized Working Groups in particular available to all those who encounter safeguards in their daily work, and encourage them to comment and to provide inputs to the Working Groups or the Steering Committee, which will ensure that the really practical problems of safeguards are recognized, and, it may be hoped, solved.

Correspondence to the Editorial Committee either for publication in the Bulletin or as comment on the content or form of the Bulletin will be welcome.

The Steering Committee wishes to acknowledge the substantial help provided by the Commission through the Joint Research Centre, which has enabled them to embark on the publication of the new Bulletin.

The first issue of the Bulletin aims to inform people about ESARDA and its activities. Future issues will deal with topics of more specialized interest and we will welcome contributions of a technical, scientific or organizational nature about safeguards for consideration for publication.

The Editorial Committee

News about ESARDA

Two major events have dominated the last two years of our Association :
1) Establishment and signature of the new contract providing the legal instrument for the existence of the Association have been successfully completed; 2) acquisition of a major new partner, the French Commissariat à l'Energie Atomique (CEA). We would like to add our welcome to that already expressed by the Parties. It is worthwhile noting that the enlargement gives ESARDA an undeniable importance as a "European" voice in the area of safeguards.

The basic objectives of the Association, as expressed in the contract, remain unchanged, the framework has been expanded to provide a greater integration of the operators of industrial nuclear installations. They are now formally recognized as major colleagues, whose contribution to research will be of decisive importance.

In order to increase the efficiency of the Association and to assure the continuity which is indispensable for the development of long-term action the period of the contract has been lengthened to five years. The members have thus made a relatively long-term commitment showing their determination to ensure the success of the work undertaken.

The question of the enlargement of ESARDA had been frequently discussed. The spirit of the new contract clearly responds to the needs represented, even if not at worldwide level, by the importance of the problems being treated. In particular, mechanisms of association or participation, by organizations in countries which are not members of the European Communities, are foreseen. These will allow ESARDA a natural evolution in response to future needs. Finally, the contract provides for advance financial support from the Commission for certain ESARDA activities with subsequent reimbursement by the members.

Furthermore, there has been an agreement by the members on measures intended to increase the efficiency of the Association through a fairly fundamental modification of its previous structure. Even though the Steering Committee remains the controlling body of the Association, the contract foresees the creation of an Executive Board. This will have a limited membership in order to be more efficient, and will be responsible not only for day-to-day matters but will develop the general policy of the Association. In this respect the role of the Board is to undertake detailed study of policies with a view to the preparation of firm proposals for consideration by the Steering Committee.

The newly created Coordinators Committee, remains essentially equivalent to the Committee of Project Leaders. However, certain of its responsibilities have been more explicitely defined.

In the new structure the Secretariat, while keeping its traditional function, in certain cases has been also assigned a more important role, for example through the Secretary's permanent membership of the Board.

Finally, it should be noted with great satisfaction that during all this change, the activities of the Association, whether at decision making or operational levels, did not slow down. This is a clear sign of the Association's vitality and is particularly encouraging for the future.

J. Ley, JRC Ispra
Secretary of ESARDA

Outline Structure of ESARDA

Examining the schematic structure of ESARDA (see figure) leads to the following remarks: there are at least two levels of activity. The first one is of a managerial type and the second is of an operational type.

At the managerial level there are three main bodies:
the Steering Committee, which is the highest decisional level, composed of representatives of the Parties coming from R & D and industry fields.
the Board, which is a reduced executive body of the Steering Committee, the tasks of which are the management of the day-to-day life of the Association and the preparation of proposals such as policies on which the Steering Committee will have to take decisions.
the Coordinators Committee, which has a more scientific function, because it is charged with the formulation, on the basis of existing national programmes, of collaboration and harmonization proposals, as well as the screening and evaluation of the results from the Working Groups activities.

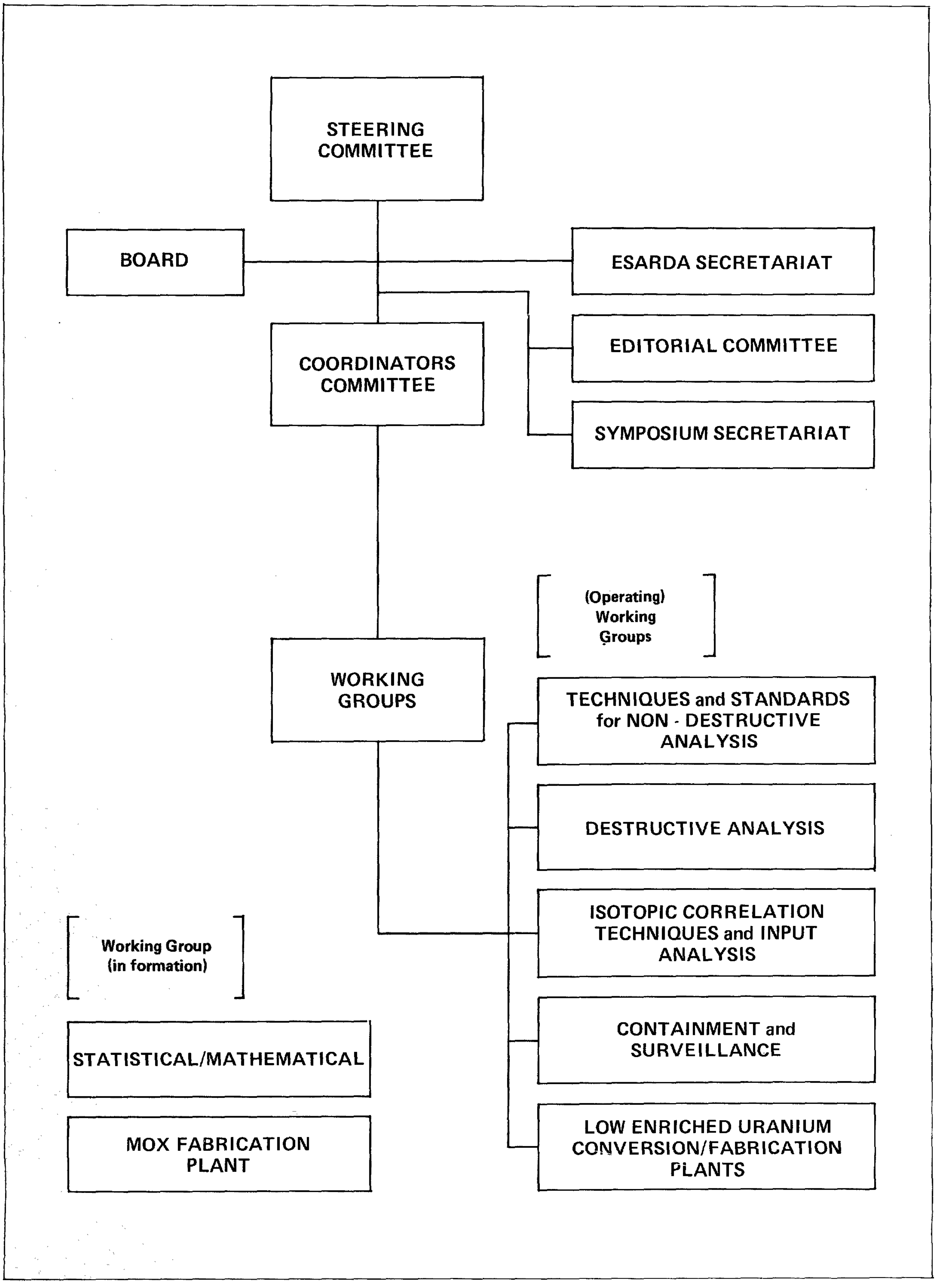
Two sub-committees, namely the ***Editorial Committee*** and the ***Secretariat for the Symposia*** are given specific responsibility. These concern respectively the publication of any ESARDA documents and the overall organization of symposia.

The operational level is formed by a series of ***working groups***. The presently operating working groups cover most of the fields of relevance to international safeguards and are either activity- (4) or plant-oriented (1). Of the two Working Groups which are under formation, one will be activity-oriented and the other plant-oriented.

Finally, the ***ESARDA Secretariat*** is a key point of the system in the sense that it should ensure the smooth and harmonious flow of all relevant information and decisions between the various levels and committees of the Association.

A list of current Parties of the Association is given below:

The European Atomic Energy Community (EURATOM)
The Kernforschungszentrum Karlsruhe GmbH (KfK)
The Centre d'Etude de l'Energie Nucléaire (CEN)
The Comitato Nazionale per l'Energia Nucleare (CNEN)
The Stichting Energieonderzoek Centrum Nederland (ECN)
The United Kingdom Atomic Energy Authority (UKAEA)
The Energistyrelsen (ENS)
The Commissariat à l'Energie Atomique (CEA)


STEERING COMMITTEE
BOARD
ESARDA SECRETARIAT
EDITORIAL COMMITTEE
COORDINATORS COMMITTEE
SYMPOSIUM SECRETARIAT
(Operating) Working Groups
WORKING GROUPS
TECHNIQUES and STANDARDS for NON - DESTRUCTIVE ANALYSIS
DESTRUCTIVE ANALYSIS
ISOTOPIC CORRELATION TECHNIQUES and INPUT ANALYSIS
Working Group (in formation)
CONTAINMENT and SURVEILLANCE
STATISTICAL/MATHEMATICAL
MOX FABRICATION PLANT
LOW ENRICHED URANIUM CONVERSION/FABRICATION PLANTS

Activities of the ESARDA Working Groups

1. Techniques and Standards for Non Destructive Analysis

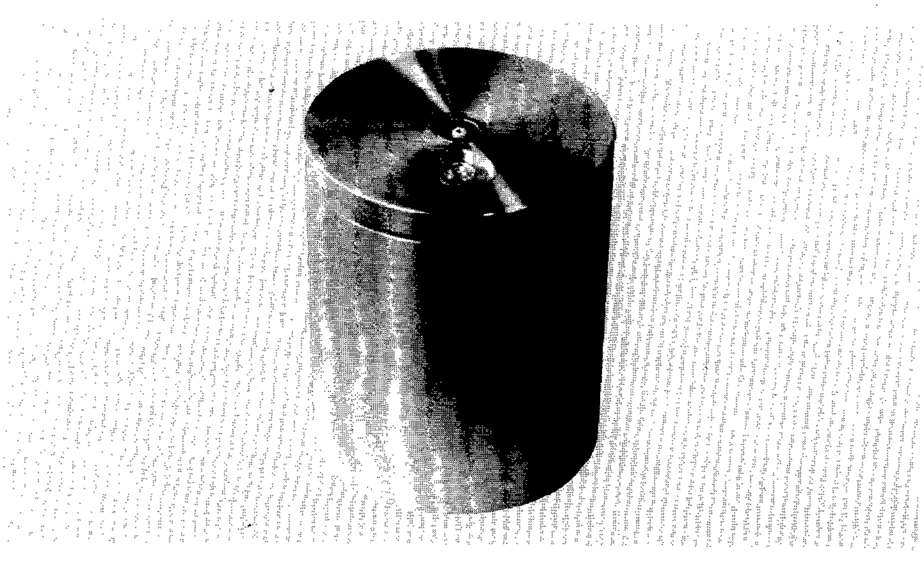
Jörn Harry, ECN, Petten
Convener of the ESARDA Working Group on Techniques and Standards for Non-Destructive Analysis

The ESARDA Working Group on Techniques and Standards for Non-Destructive Analysis organized an intercomparison on the determination of plutonium isotopic ratios by gamma spectrometry. The results of this exercise, in which nine laboratories of different countries and international organizations contributed with analyses of the measurements on the plutonium isotopic reference materials NBS-SRM-946, -947, and -948, are now published in the report KFK 3149, ESARDA/1/81, "Results from an Interlaboratory Exercise on the Determination of Plutonium Isotopic Ratios by Gamma Spectrometry", by H. Ottmar. On basis of the results it was possible to reevaluate some gamma branching intensity ratios required for plutonium isotopic ratio measurements.

On the invitation of Dr. C. Beets of the CEN/SCK, Mol, Belgium, an intercomparison was made of gamma and neutron measurements on cans of plutonium oxide containing either 0.5 or 3 kg Pu. The measurements were performed at the plant of Belgonucléaire in Dessel, Belgium. The results will be published around the end of 1981.

Upon the request of the Working Group new sets of plutonium isotopic intercomparison materials with an extended range of 7 isotopic compositions are currently under preparation at AERE Harwell. Those intercomparison materials will be available from Dr. A. Adamson to the invited parties by the end of 1981 for further intercomparison measurements under the name of PIDIE, i.e. **P**lutonium **I**sotopic **D**etermination **I**ntercomparison **E**xercise. The samples containing about 0.5 g Pu in a defined geometry will offer some possibilities for improvement of the measurement technique, because also it is foreseen that the material will be subjected to careful mass spectrometry analysis by the participating laboratories in parallel. The results of the limited PIDIE will guide us in the decisions which are needed for the definition of Pu certified reference materials for gamma spectrometry. For mass spectrometry NBS and CBNM are co-operating on standards of Pu with different isotopic compositions. In parallel the characterization work on the different batches of material can also serve for the NDA standards if the batches are sufficiently large.

Low Enriched Uranium Oxide Certified Reference Material Containing 200 grams of U_3O_8 Powder



The thoughts on the NDA project part are guided by the international project initiated by ESARDA on the uranium oxide reference materials for gamma-ray measurements of the enrichment. This project is described in full detail in the Proceedings of the 20th Annual Meeting of the Institute of Nuclear Materials Management, Albuquerque, N.M., U.S.A., July 16-18, 1979, at which meeting a special session was devoted to ESARDA. The fabrication of the Certified Reference Materials is going on at the Central Bureau for Nuclear Measurements, of the Joint Research Centre of the Commission of the European Communities. The CBNM and the United States National Bureau of Standards will co-operatively certify these materials which will become available in 1982. The acceptability of these standards for the safeguards authorities of Euratom, IAEA, and U.S. Nuclear Regulatory Commission have been considered carefully.

On the request of the ESARDA Steering Committee and for further use by the ESARDA Working Group on Low Enriched Uranium Conversion and Fuel Fabrication Plants Safeguards, the NDA Working Group made an assessment on the different techniques which are available to measure the nuclear material content of finished fuel bundles, which will be reported also in this issue of the ESARDA-Bulletin, and the NDA Working Group made with the collaboration of the plant operators a detailed study on the usefulness for safeguards and material accountancy of the so-called "rod scanners".

In some respects the application of NDA measurement technology encounters similar problems as occur in the application of chemical analysis. For instance in the fields of standards and interlaboratory experiments and also where some measurement techniques on the border line are developing, like e.g. the K-edge absorptiometry. A good co-operation with the ESARDA Working Group on Destructive Analysis is therefore established through the organization of combined meetings.

We hope to report in future issues of the ESARDA bulletins on the progress made.

2. Containment and Surveillance

S. Crutzen, JRC Ispra
Convener of the ESARDA Working Group on Containment and Surveillance

1. Introduction Terms of reference

The terms of reference given to the new Working Group on Containment and Surveillance in May 1979 could be roughly outlined by the following items:

a. Inventory of C/S techniques
b. Appraisal of theories/models for quantification of the assurance obtainable from C/S devices
c. C/S assurance + NMA assurance
d. Design specifications for C/S devices (known techniques)
e. R/D work required for the applications of devices to safeguards
f. Correlations between b, c and d, e
g. Costs of C/S solutions
h. Field testing / Reliability / Vulnerability
i. New devices (techniques not yet applied)

Since its first meeting, the group representing about 21 institutions from 9 countries (see Table 1), has worked within these terms of reference with emphasis on the inventory of techniques and on the aspect of quantification of the assurance from devices and systems.

A seminar was organized at Ispra in September 1980 which was a good conclusion to the first year of work and a reorientation of some terms of reference.

2. Inventory of C/S techniques

The actions regarding an exhaustive inventory of C/S techniques are illustrated by the joint U.S.A./ESARDA Compendium of C/S techniques which was started by the SANDIA Laboratories, continued by the JRC-Ispra and has now been taken over by subgroups on "devices", "field testing", "reliability and sensitivity data".

3. Models for the quantification of the assurance given by C/S systems and NMA

A subgroup on "quantification" mainly composed of representatives of KfK, BNFL, DWK, CEC-DCS, has analysed the problem and concluded on what was necessary to effectively use models as developed by U.K., U.S.A., Japan. It is essential for the Reliability-Sensitivity function of devices to be known prior to any correct evaluation of the assurance which can be given by C/S devices.

Engineering work has thus been recommended by the subgroup. The evaluation of U.S.A. and U.K. models brought them to a unique formulation.

4. Design specifications for C/S devices

Rapporteurs or leaders have been identified (to be informed of and to disseminate information on existing devices as well as in order to be able to specify design criteria for devices) for the following items :

- general purpose seals
- doorway-monitors
- cap-seals
- electronic seals.

Particular questions of the ESARDA Working Group on LEU were answered :

- interest is expressed concerning the possible use of seals for LWR fuel bundles
- virtual walls could introduce containment in plants
- containers of raw material could be uniquely identified but a cost/benefit study has to be performed.

5. Applications of devices - Assessment of the assurance obtainable - Costs

Prior to any consideration on application, effective assurance to be given by devices, or cost evaluation, basic knowledge of devices is necessary :

- all devices have to be considered
- the sensitivity function of devices has to be available or estimated
- reliability data have to be generated
- the aspect of tamper-resistance of the devices has to be considered.

The subgroup on devices will thus condition the rest of the work of the working group. Examples are put forward for consideration by the working group :

- VAK seals (cap seal for LWR fuel bundles)
- General purpose seals
- electronic seals.

6. Major conclusions of the working group activity on June 1981

Time has been spent on definitions : it was essential to get all members speaking the same language. The difference between conventional and extended containment/surveillance initiated important discussions which will be concluded only by the subgroup on Systems.

The concept of the assurance to be given by

- C/S devices
- C/S systems
- NMA systems

as well as the one of the combined assurance obtainable from both C/S and NMA systems, have been a major concern of the whole working group.

The final conclusion was a need for :

- complete descriptions of existing devices
- measurement of the sensitivity function of those devices

TABLE 1

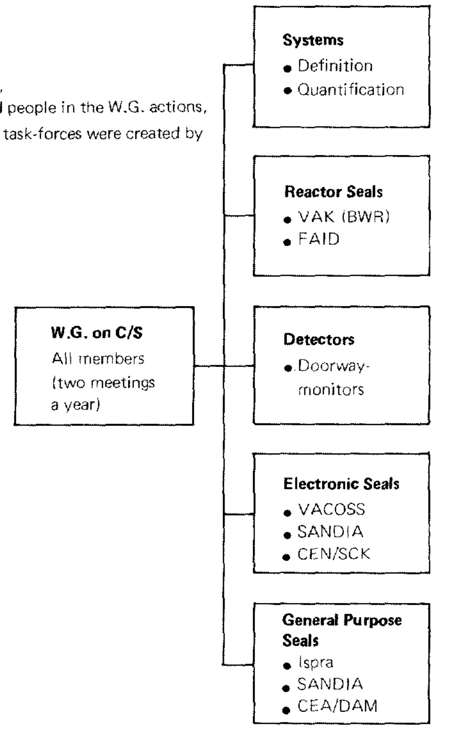
Participating institutions

Belgium	CEN/SCK (VDEW)
France	CEA, DSMN
	CEA,DAM
FRG	DWK
	KFA
	KfK
	RWE
	VDEW
Italy	CNEN
	ENEL/DCO
	FABBR. NUCL.
NL	ECN
U.K.	BNFL
	Dept.of Energy
	UKAEA, AERE
	URENCO
U.S.A.	SANDIA Labs.
Canada	AECL
C.E.C.	JRC
	Safeguards Directorate

TABLE 2

Subgroups of the ESARDA W.G. on C/S

To avoid losses of time,
To get more specialized people in the W.G. actions,
Short-life subgroups or task-forces were created by the W.G.



- assessment of the reliability of devices
- consideration of tamper-resistance features of devices.

Few proposals (only DWK) came up for the integration of real devices data into evaluation models of the assurance obtainable from C/S systems.

To tackle the identified actions efficiently short-life subgroups have been created (see Table 2).

3. Isotopic Correlation Techniques and Reprocessing Input Analysis

C. Foggi, JRC Ispra
Convener of the ESARDA Working Group on Isotopic Correlation Techniques

The activity of the group slowed down during the past year, due to the unavailability of the reprocessing plant WAK, where the experiment ICE-II should have been carried out.

The group dedicated its efforts to the completion of the previous projects, that is: the Isotopic Correlation Experiment (ICE) and the Data Bank of Isotopic Compositions in Irradiated Fuels.

The Isotopic Correlation Experiment (ICE)

This experiment aimed at demonstrating the applicability of the Isotope Correlation Techniques to the safeguarding of materials at the reprocessing plant input. The demonstration comprised several logical steps: i) determination of the accuracy of ICTs under normal operating conditions, ii) evaluation of the additional efforts required by the use of ICTs, iii) proving of the benefits obtained for safeguards and other fuel management purposes, iv) identification of additional information required in applying this technique, v) checking of the applicability of proposed ICT procedures.

The experiment was carried out at the reprocessing plant WAK in 1978, during the dissolution of 5 irradiated fuel assemblies of the Obrigheim reactor. Each assembly was processed in two halves, so that a total of 10 dissolutions was available for the experiment.

Ten samples were taken, one per each dissolution. They were subsequently diluted and subdivided into four subsamples, which were separately analysed by the laboratories of:

- the WAK operator
- the Euratom Safeguards Authority
- the IAEA Safeguards Authority
- the KfK (acting as reference).

Each of them measured the concentration of U and Pu in the sample, as well as the isotopic composition of U and Pu. In addition, the Institute for Transuranium Elements of the JRC measured: i) ratios of selected isotopes of Kr and Xe, at the off-gas system of the plant; ii) ratios of selected isotopes of Nd and Cs, the burn-up and the Cm-244 content, in the Euratom samples. A description of the fuel history was provided by KWO and KWU. Theoretical calculations of fuel burn-up were performed by CEA-Cadarache.

The data obtained from the experiment were evaluated both with purely statistical methods and with ICTs.

The main objectives of the statistical data evaluation were: i) the detection of suspicious data, and ii) the estimation of the random and systematic errors of the measurements performed by different laboratories on the same sample. The methods used for the analysis comprised: i) outliers detection by Dixon, Grubbs and Student criteria, ii) analysis of variances, iii) Grubbs' constant bias model (including paired comparison), iv) Jaech's non constant bias model.

ICTs were applied to: i) the detection of suspicious data within a single set of measured data, ii) consistency check with horizontal data, and iii) evaluation of the Pu and U mass balances.

The results of the data evaluation (to be published soon in the final report) can be summarized as follows: should be emphasized that the *experiment was conducted under routine* conditions. This includes the safeguards inspection and the input analyses as well. No additional effort was needed.

Information required by this technique is readily available. Outliers can be detected by ICT as well as by other statistical techniques.

Correlations beased on the isotope ratio of Xe-132/131 and Cs-134/137 and of the Cm-244 concentration seem to be as good as heavy isotope correlations. Considering the potential of measuring these nuclides in-situ by the inspector when compared to the time consuming transport of samples to central laboratories in order to measure heavy isotope ratios, this new type of correlation opens up the possibility of timely detecting a diversion.

It was surprising for the group to find that no established procedure existed to compare verification measurements of three or four labs. Several approaches were tested and finally a common procedure was agreed upon.

The follow-up experiment could be enlarged in order to compare with other techniques under development (NDT neutron interrogation etc.) or to test new concepts (mass balance of Pu on the basis of Pu-240 etc.) in a well characterized campaign.

The Data Bank of Isotopic Compositions in Irradiated Fuels

The Bank contains data on the isotopic composition of nuclear fuel, generated

		U - 235	Pu - 239	Pu - 240	Pu - 241	Pu/U
Isotope correlations with	Depletion U-235	0.4	1.1	1.0	1.3	1.0
	Pu - 242/240	1.9	1.2	1.5	1.9	1.6
	Cm - 244 IMA	0.9	1.2	1.1	1.6	1.1
	Xe - 132/131	3.1	1.1	2.7	2.9	2.0
	Cs - 134/137	3.7	1.3	2.4	2.6	1.7
	100 - Pu - 239 (a/o)	1.2	1.0	0.9	1.8	1.7
	Pu - (242 . 239) / (240 . 240)	2.8	1.6	1.8	2.2	1.6
Direct measurement	Average of 4 labs.	0.4	1.4	1.3	1.3	1.3
	Grubbs analysis RCH	0.4		2.8	3.0	2.8
	Grubbs analysis SAL	0.5	1.2	0.7	1.0	0.7
	Grubbs analysis TU	0.3	0.5	0.6	1.0	1.9
	Grubbs analysis WAK	1.0	1.5	1.8	0.7	5.4
Calculation	Theor. calc. CEA					0.75

Table 3 Mean variation coefficients, V(%), of nuclide concentrations as obtained with different methods.

As shown in Table 3, the accuracy of ICT is comparable to the direct analyses based on mass-spectrometric isotope dilution. However, it must be noted that the quality of the analytical work could be improved when compared with the potential accuracy of this type of analysis.

The application of the heavy isotope correlation technique procedures at reprocessing plants is feasible and does not put extra burden on plant operators. It

during a number of reprocessing campaigns of post-irradiation fuel analyses. These data are generally available for research purposes and for application. Various ESARDA members have collaborated to the setting up of the Bank, providing either data or software facilities.

The Bank is now fully operational. It contains 853 documents which are stored on magnetic disks at the AMDAHL computer of the JRC in Ispra. Access to the disks, for updating the bank or retrieving the data, is performed by means of the Data Management System ADABAS. Direct access to the disks is also possible from a video terminal, with the assistance of the TSO System (**T**ime **S**haring **O**ption).

Several scientific routines, written either in PL-1 or in Fortran language are available for the treatment of the data contained in the Bank.

Various plotting systems (CALCOMP or GOULD or BENSON) can be used in connection with the Bank, for the automatic plotting of the data and their regression line.

The Bank is also linked to a group of computer codes designed for computing isotopic correlations (this system is known under the name ISOCORR). The links between the Data Bank and the various programmes, storage areas and terminals are shown in Fig. 1.

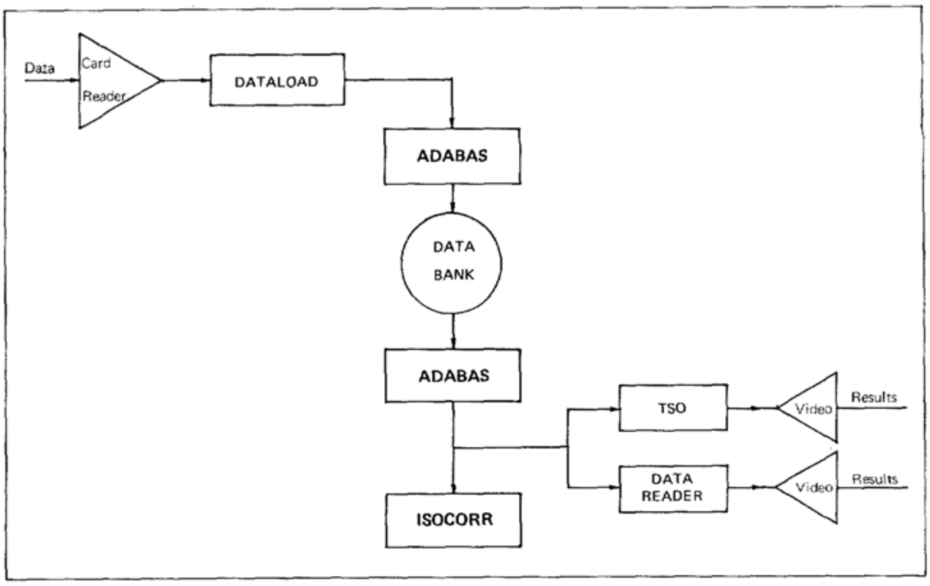


Figure 1 : The Data Bank and the ISOCORR System can also be remotely operated via the European Network or a normal telephone line.

3rd ESARDA Symposium, KfK Karlsruhe, 6th/8th May 1981
Closing Remarks

Reprinted with minor modifications from the Proceedings of the 3rd ESARDA Symposium

G. Stiennon
CEN/SCK, Mol. Belgium

Arriving at the end of this successful ESARDA Symposium, I would like to make a few concluding remarks on three levels: the controlling organizations, the plant implementation, the research and development. These remarks are not supposed to cover the subjects completely.

From Mr. Eklund's paper (1.1), we heard that following the I.A.E.A. estimates, the high rate of increase of the nuclear power - reaching 13 percent of the world total electrical capacity, 3,500 GW in 1990 - will imply important constraints on future safeguards implementation with the corresponding need to keep a large development effort, to maintain the present excellent record.

The budgetary limitations of the I.A.E.A. tends to induce a certain rationalization of the controls and Mr. Shea (paper 4.1) described the analysis done to fix the importance for safeguards of the different types of plant, permitting a systematic inspection allocation. The principle of "equal treatment for equal plant" remains the basic one.

In the equilibrium to reach between investments in manpower or investments in equipment, Professor Gillon deliberately proposed to reduce the mandays of inspectors and to largely substitute equipment for the automatic transmission of data: such topics are already being considered by the I.A.E.A. and Mr. Von Baeckmann (paper 7.1) presented a clear list of working groups on subjects affecting the future of the Agency. Several member states (U.S., Canada, U.K., FRG, ...) have offered and provided the I.A.E.A. with their assistance in the R & D area. The R & D support initiated so far covers nearly all aspects of safeguards R & D, with emphasis on training of inspectors, development of safeguards concepts, instruments, methods and techniques, treatment and

Dr. S. Eklund, Director General of IAEA

evaluation of safeguards information, including inspection results. I.A.E.A. has significantly profited from this support in its R & D programme necessary to establish and maintain acceptable and credible safeguards.

Mr. Schleicher (paper 7.2) presented the satisfactory situation of safeguards control on the Community level; he made an analysis of the main European actions relevant to the application of safeguards in view of reaching achievable goals. Future trends in safeguards development will depend on the goal objectives that could be reconsidered in relation to the larger size of the future plants and also on an extended use of informatics. Incorporation of design features in the construction of the new plants is also necessary to facilitate safeguards implementation, which imply a good cooperation with industry.

In the field of plant specific experience, an increasing number of papers mentioned the success of safeguards implementation. Plant results were presented in detail, mainly for mixed oxide fuel fabrication lines.

Mr. Marsden (paper 4.2) presented the results of campaign studies made at Harwell on laboratory scale to establish the random errors associated with inventory differences and procedures; he showed that the global error (±0.5%) is mainly due to human origin and not to the techniques used.

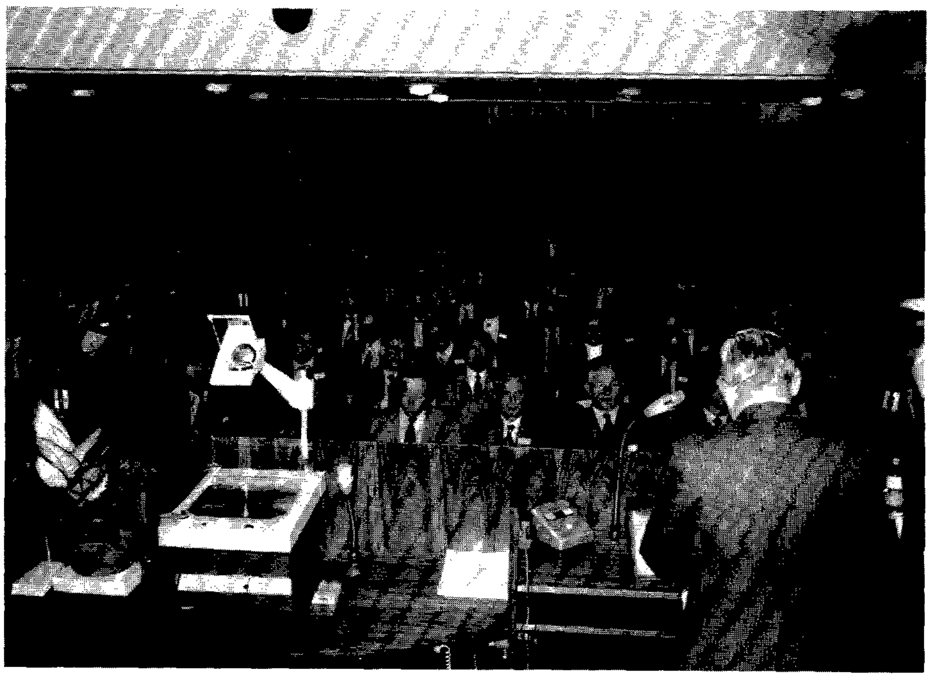
Mr. De Canck (paper 4.3) showed that at the Belgonucléaire plutonium plant it was possible to reach the same error limit (±0.5%); moreover, by adequate subdivision of the plant and by adopting a near real-time accounting system it was possible to make the verification possible every fortnight with only short interruptions in the production activities.

Mr. Bemelmans (paper 4.4) demonstrated for the same Belgonucléaire plutonium plant and by only using the plant measurements that a single yearly physical inventory was more than sufficient to comply with the present inspection targets. This confirmation is of great economic incidence and should influence the opinion of the controlling authorities in order to alleviate their requirements by making full use of the national data and by so doing could decrease the burden on the plant operator.

Mr. Beedgen (paper 6.6) used the NUKEM plant measurements to determine the optimal falsification and verification strategies for a given goal quantity and for a given total verification effort.

Mr. Nilson told the results of the first I.A.E.A. controls of three plants in the U.S.; he showed that by dialogs between inspectors and operators, it has been possible to largely reduce the inspection work in the benefit of both parties. Nobody is refusing to be controlled, but the plant operator must be recognized as a valuable negotiator.

In the field of research and development, a large amount of work was presented, both orally and on posters. Compared to "single component" developments, the number of "systems" studies has relatively increased. It is to be noted that practical considerations related to cost and implementation play an increased role in the works presented, still the diversity remains important both on the material side and on the analytical side. This confirms the importance of the coordinating role that ESARDA will continue to have in the future adopting programmes of common interest to promote the confrontation of the technicians with the controlling authorities and the plant operators in view of attaining agreed techniques as soon as possible.



Right: View of the KfK Congress Hall

Below: Prof. Gillon as luncheon speaker

R and D Cooperation Agreement between the Commission of the European Communities and the IAEA

M. Cuypers
JRC Ispra

An exchange of letters took place in May 1981 between Messrs. S. Eklund, Director General of the IAEA, and W. Haferkamp, Vice President of the Commission of the European Communities, to establish a formal agreement in the field of safeguards R and D. This agreement is put in the frame of a more general cooperation agreement between the IAEA and the European Atomic Energy Community signed in 1975.

The objective of this safeguards R and D cooperation agreement is to provide technical assistance in fields where expertise is required, in the harmonization of techniques and procedures of potential use in safeguards implementation and in the evaluation of R and D priorities as a function of the requirements of the European fuel cycle. The technical annex of this agreement comprises 27 tasks in the following areas: surveillance and containment, measurement technology, training courses and information data treatment and evaluation.

The defined tasks include the application of ultrasonic techniques for identity and integrity verifications of seals on a variety of materials such as CANDU fuel storage casks, light water reactor assemblies and of general purpose seals.

In the area of measurement technology, the main subjects are related to development of specific methodologies for destructive and nondestructive assay, to an approach of automation of measurement equipment for data transmission, evaluation and retrieval, to the characterization of reference materials and to the development of procedures for the use of isotopic correlation techniques.

For the time being, training courses are limited to the use of instruments developed by the Joint Research Centre, by IAEA-Euratom Joint Inspection Teams.

Concerning information data treatment and evaluation, the cooperation will be concentrated on the application and evaluation of nuclear material statistical accountancy systems developed at the JRC for typical plants of the nuclear fuel cycle, including the verification aspects of near-real-time accountancy systems. Finally, a comparative study is foreseen on the application of different computer codes for the establishment of statistical sampling techniques.

In several of the above mentioned areas, the cooperative effort has already been actively engaged.

This activity represents a considerable European support to the safeguards activities of the IAEA, particularly when seen in conjunction with the established Federal German support programme and the recently agreed U.K. programme.

Conclusions of the ESARDA Seminar on Containment/Surveillance

(Ispra, September 1980)

S. Crutzen

JRC Ispra

In September 1980 the ESARDA Working Group on Containment/Surveillance organized a Seminar at the Joint Research Centre of the CEC, Ispra Establishment.

About 80 specialists or people involved in International Safeguards attended the seminar. Besides European countries, U.S.A., Canada and IAEA were well represented.

The seminar was held under the auspieces of ESARDA. Its scope was first of all to bring together those involved in the subject of containment and surveillance, secondly the scope included also to complement the ESARDA Annual Symposia and the IAEA meetings on the same topic.

The object of the seminar was to present and discuss freely Containment/Surveillance (C/S) measures and techniques to be used for International Safeguards.

An examination of the state of the art of C/S techniques and devices was carried out and a compendium of C/S devices presented jointly by U.S.A. (SANDIA Labs) and ESARDA (KfK). The possible use of these techniques in conjunction or in place of other safeguards techniques, the reliability of the devices, their sensitivity function and the safeguards assurance they could give to the Safeguards Authority were discussed.

During the seminar it appeared implicitly that the C/S measures could be divided into two categories:

a. Conventional C/S, which is used to assure the validity of NMA measurements of flows and inventories.
b. Extended C/S, which is used to assure that nuclear material entering or leaving an area does so only at Key Measurement Points.

The traditional approach of the IAEA has been concerned* principally with (a), although the need for (b) has always been recognized.

The aspect of tamper resistance of devices was touched upon. For the first time, a session was dedicated to this difficult but nevertheless very important aspect of instrumented safeguards. Very little work has been done on this topic and many available measurement or surveillance devices have this weakness from a safeguards point of view.

Besides those aspects with a definitional or conceptual character, general conclusions can be drawn from the seminar:

- The participants recognized the general interest of the problems treated by the ESARDA Working Group on C/S.
- Useful information has been exchanged and closer contacts have been made to the benefit of future R and D work.
- Concepts and technical aspects are now much clearer with respect to: C/S devices generally, their reliability problems, the possible schemes for use of C/S measures, the value of

quantification of the assurance of detection of diversion given by C/S.

From a pure technical point of view it can also be concluded that many C/S devices are not fully suitable for safeguards use:

- In many cases, doorway-monitors were designed for Physical Protection and not for International Safeguards (e.g. such systems are not designed to be used unattended).

  Fibre optic seals are not yet available which could satisfy the IAEA**.
- Ultrasonic seals still present problems for large-scale application***.
- All electronic seals are (or were a little time ago) undergoing re-design.
- Film cameras often present reliability problems (film jamming) as well as errors of operation.
- Closed TV circuits have important reliability problems, as is generally the case for all complex devices which have to work unattended for a long period of time.

No data are available on much equipment which could be used for International Safeguards in the near future:

- Reliability data are missing and few field tests have been organized to acquire them.
- Sensitivity functions are only roughly evaluated which could help to establish a control scheme.
- The tamper safing aspect is not often dealt with: even when seals are concerned. Containers are not checked by means other than visual inspection.

The aspect of reliability is an important subject of concern.

* For example, see INFCIRC/153, paragraph 46(b) (ii).

** A new prototype fibre optics seal will be available in early 1982.

***The major problem: need to replace of ultrasonic transducer should soon be overcome. Note the acceptation by the IAEA of the CANDU Cap Seal in November 1980.

NDA Measurements on Finished Fuel Assemblies

R.J.S. Harry, ECN, Petten
Convener of the ESARDA Working Group on Techniques and Standards for Non-Destructive Analysis

Introduction

The ESARDA Steering Committee recommended at its meeting in Brussels on 17 November 1980 that the ESARDA Working Group on Techniques and Standards for Non-Destructive Analysis should perform a review and assessment of all NDA techniques available or in development for the measurement of the fissile material content of finished fuel bundles. This article is the short report on this action, written on the basis of individual reports by the members and observers of the NDA Working Group, by the convener.

Gamma Techniques

The 185 keV radiation of ^{235}U, which is completely absorbed within a uranium layer of 5 g/cm^2, is used in the autoradiography and the semiconductor measurements of fuel bundles. Both techniques have the disadvantage that the inspector has to insert his detectors into the fuel bundle.

The autoradiography technique enables the detection of dummy rods or rods of a clearly deviating enrichment, by the introduction of large slabs of photographic material in between the fuel rods of an assembly. After exposure times of 3-5 hours a qualitative statement can be based on the examination of the developed autoradiographs.

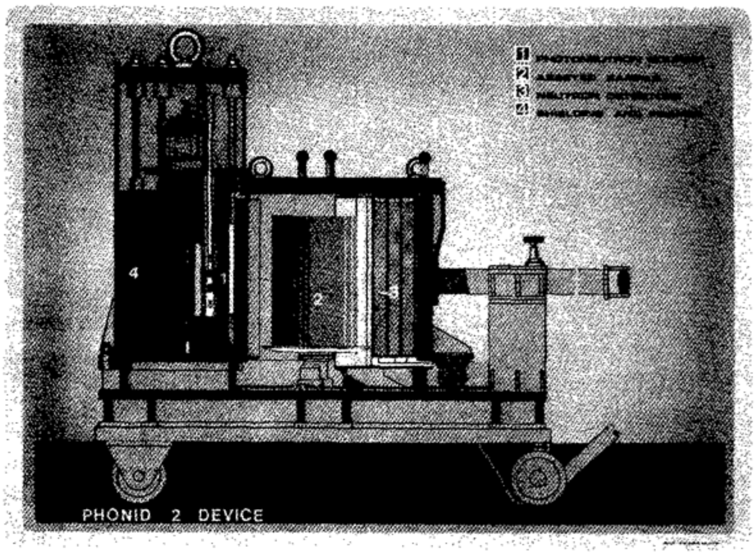
The development of CdTe and HgI_2 detectors, which can be used at room temperature, has led to investigations whether these types of detectors would possibly allow also enrichment measurements by insertion of these detectors between the fuel rods of an assembly. Two important disadvantages hamper at this moment the further application of this method, namely first there are yet no CdTe or HgI_2 detectors (commercially) available with the desired operational stability, and secondly this type of measurement is only representative for a small fraction of the observed fuel. Therefore measurements with neutrons, which are more "penetrating", are generally preferred.

Another possibility is of course to measure the fuel content of the assemblies in the "assembling" phase. As elements are loaded into the assembly layer by layer, it is in some plants possible to measure at that stage the gamma radiation of each layer on the moment when it is transferred into the assembly. Technically this is a feasible solution for the measurement problem, however, the practical realization in a real plant production campaign is not yet proven.

Also at the points where finished fuel rods are measured for quality control purposes, the application of so called "rod scanners" offers an opportunity for safeguards and accountancy measurements. On this subject the NDA working group made a separate study.

Neutron Techniques Investigated

Back in 1976 some experiments with a 10 Ci Sb-Be neutron source for interrogation



of the fuel bundles were reported by K. Baumung and K. Böhnel, Kernforschungszentrum Karlsruhe, who determined a uniformity of detection sensitivity for different fuel pin positions better than 10%. The precision for the total ^{235}U content was 0.5% when measuring a fuel element with 2.5% enrichment for 1 hour. For LWR fuel bundles, research is nowadays more concentrating on the "Neutron Collar" system, developed by the Los Alamos National Laboratory in the U.S.A. Over a length of 30 cm a collar of moderating material surrounds the fuel bundle. This instrument measures ^{235}U by measuring the coincident neutrons from fissions which are induced by the neutrons from an AmLi source, while in the passive mode the ^{238}U is measured due to its spontaneous fission. For the coincidence counting a set of 18 ^{3}He tubes is used.

Some field tests with a mock-up PWR fuel assembly are reported, which give an indication of the sensitivity of this type of instrument for detection of removal of rods in various positions. With 1000 s counting time and a random error of 2σ (95% confidence interval) it was possible to detect a minimum removal of ^{235}U of 1.90% (a later reported improvement to 1.36% is obtained) and the ^{238}U detection limit was 1.25% which figures correspond with the removal of 3 to 4 rods out of the PWR mock-up of 4% enriched uranium oxide fuel, containing an array of 16x16 rods. Improvements were obtained by application of a neutron source with greater source strength (from 5×10^4 neutrons/s changed into 6×10^5 neutrons/s). The electronics used for the registration of the counting results is standardized and similar to that used by the IAEA for measurements with the high level neutron coincidence counter.

Special attention has been paid to the possibility of presence of "neutron poisoning" in the fuel. In that case the interrogation can be repeated with the use of a Cd liner inside the collar, but this will reduce the counting efficiency also by a factor 10, so that less accurate results are obtained, or unacceptably long counting times are needed.

Proposed Neutron Techniques

There is good experience obtained with the PHONID (PHOto Neutron Interrogation Device), which has been installed in the NUKEM plant for several years. It measures smaller items containing high enriched uranium by interrogation with 25 keV neutrons from about 10 Ci of SbBe gamma-neutron sources. The Commission of the European Communities, Joint Research Centre, Ispra Establishment, who developed this instrument, reviews it at this moment thoroughly. It is suggested that also such in-plant installed devices could be adapted to the measurement of fuel assemblies in the fabrication plant.

Also there is a suggestion that, if in future one should "preirradiate" before dispatch the fuel assemblies, the measurement of the reactivity in the irradiation facility could serve as a measurement of the fissile content.

Conclusion

Concluding this assessment, it can be stated that this moment for full size fuel assemblies only the demonstration of the neutron collar equipment allows an evaluation of the more realistic near future application of this equipment in plant situations. Also the safeguards utilization of a PHONID can be considered, if one is ready to accept the in-plant installation of such (due to the needed shielding) very heavy equipment.

It is in the hands of the ESARDA Working Group on Low Enriched Uranium Conversion and Fuel Fabrication Safeguards to evaluate in more detail how the measurement techniques may be applied most effectively and also to consider the possibilities of the measurements at other points in the fabrication process, like e.g. at the stage of the fuel rods, which can be measured by the so called "fuel rod scanners" on which the NDA working group also made an assessment, or to measure ^{235}U gamma-rays at the loading stage.

The autoradiography technique offers a verification technique which gives only qualitative results. The other techniques mentioned seem to be too futuristic to be taken into real consideration at this moment.

ESARDA Main Publications

ESARDA Proceedings of a Symposium on Practical Applications of R & D in the field of Safeguards (Rome 1974).
ESARDA-2 W.L. Zijp: Guidelines for the Treatment of Errors in Nuclear Material Accounting and Safeguards (1974).
ESARDA-3 W.L. Zijp: Some Statistical Tests Relevant to Nuclear Material Accountancy and Safeguards (1974).
ESARDA-4 W.L. Zijp: Sample Sizes for Statistical Estimation and Discrepancy Detection (1977).
ESARDA-5 C. Bigliocca, M. Cuypers, J. Ley: List of Reference Materials for Non-Destructive Assay of U, Th and Pu Isotopes (EUR 6089.EN - 1978).
ESARDA-6 A.S. Adamson: Established Applications of Non-Destructive Techniques for Nuclear Materials Measurements Control or Verification; reported to ESARDA (AERE-R9167, August 1978).
ESARDA-10 Proceedings of 1st Annual Symposium on Safeguards and Nuclear Material Management (Bruxelles 1979).
ESARDA-11 Proceedings of 2nd Annual Symposium on Safeguards and Nuclear Material Management (Edinburgh 1980).
ESARDA-12 Proceedings of the 1st Seminar on Containment and Surveillance Techniques for International Safeguards (Ispra 1980).
ESARDA-13 Proceedings of 3rd Annual Symposium on Safeguards and Nuclear Material Management (Karlsruhe 1981).
ESARDA 1/81 H. Ottmar: Results from an Interlaboratory Exercise on the Determination of Plutonium Isotopic Ratios by Gamma Spectrometry.

In addition the two following publications were made in collaboration with ESARDA:

European Safeguards Bulletin, Issue No. 1 (Autumn 1976)
European Safeguards Bulletin, Issue No. 2 (Spring 1978)

It is worthwhile to mention that there also are several ESARDA papers published in the frame of national or international series and containing information on important ESARDA activities.

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