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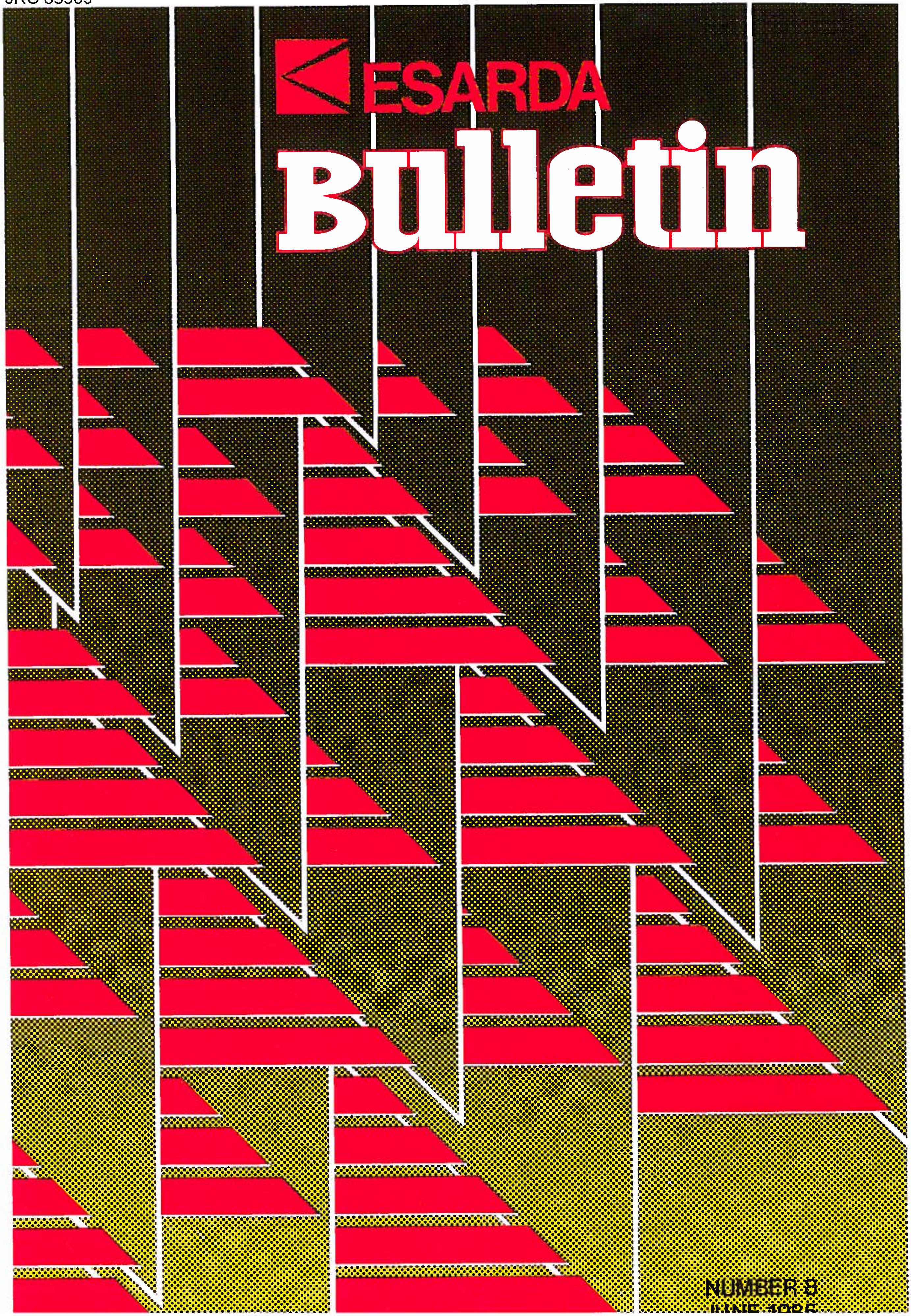

Foreword

The 8th issue of the ESARDA Bulletin sees the light of day a little late and in a reduced form. Some papers which had been promised did not arrive because the authors had other urgent commitments.

I now wish to point out that the Bulletin is an open publication which is not reserved to ESARDA partners only. It is, certainly, a means of circulating information on what the ESARDA partners and the seven ESARDA working groups are currently carrying out or on the organizational aspects and activities of the ESARDA association. But, on the other hand, it also aims to be a good vehicle to give technical information on any interesting work that is being done in the safeguards world. The ESARDA Bulletin has in effect a wide distribution to nuclear plant operators, safeguards inspectors, research specialists, commercial manufacturers and salesmen, etc. Please note that it also aimes to give information on nuclear material management and control, as evidenced by the title of each ESARDA Symposium on Safeguards and Nuclear Material Management.

For these purposes three other types of papers are welcomed :

1) original, purely technical papers
2) survey papers on some activity or some symposium or specialists' meeting, etc.
3) explanatory papers on some particular item or technique (in this case it can be a résumé of an already published paper).

All such papers are welcomed from people active in the nuclear safeguards and nuclear material management fields belonging to any institution of any part of the world.

The views of any signed paper do not automatically reflect the view of ESARDA.

L. Stanchi

French Support Programme for the Safeguards of the International Atomic Energy Agency (IAEA)

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Introduction

On 27 July 1978, the French Government signed a trilateral agreement with the IAEA and Euratom for the application of IAEA safeguards in France. This agreement entered into force on 12 September 1981. Subsidiary arrangements supplementing the agreement entered into force on 30 April 1983.

During the same year, the French Government decided to promote a support programme for IAEA safeguards. The Agency conducts its research and development activities chiefly within such programmes, set up jointly with a dozen countries, and it is beneficial for the IAEA to have French support too.

Until then, various activities had been pursued by French experts on behalf of the IAEA, including participation in working groups, research contracts, etc. After a number of discussions in the first half of 1983, a research, study and training programme was set up by mutual agreement in June, at the first meeting of the support programme coordinators in Vienna. This report, prepared eighteen months later, reviews the work done in the interim.

Technique of Correlating Isotopic Data

Measurements taken on feed solutions to spent fuel reprocessing plants play an important role in control of the fuel cycle, especially because the last precise measurements had been taken during fuel element fabrication. At this point of the cycle, it is therefore very useful to be able to make correlations to check the consistency of the spent fuel characteristics as announced by the nuclear reactor operators and by reprocessing plant operators. Irradiation in a reactor causes changes in fuel composition. Correlations can be made between certain isotopic ratios and characteristics such as burnup and plutonium/uranium ratio. Following a number of investigations on reactor physics, the CEA [1,2,3,4] developed a technique of isotopic correlation calculated for PWR and BWR reactors, which is also used by the La Hague reprocessing plant to monitor its feed balances. The calculated values were compared with experimental results, and adjustments were made to the computation methods to obtain more accurate results. All these investigations led the Service d'Etudes Nucléaires (SEN) of the CEA/Cadarache Water Reactor Department to propose a library of calculated correlation coefficients to the IAEA, as well as its assistance for the use of this library for the purposes of independent verification of uranium and plutonium input measurements in reprocessing plants. After technical discussions, the SEN gave the IAEA a computer program for correlation coefficients concerning two types of fuel reprocessed in Tokai-Mura. This program was introduced in 1984 in the Agency's data processing system for implementation.

Analysis and Interpretation of Nondestructive Measurement Results Applied to Spent Fuels

Over a period of several years, the SEN has developed [5,6,7,8] two techniques of nondestructive measurement applied to spent fuels, gamma spectrometry and neutron counting. These two techniques currently help to determine the burnup reached by a spent fuel assembly, as well as the mass of plutonium present. Exchanges of information are proceeding between the SEN and the Agency on the validity of these methods, on the equipment built to take these measurements in actual operating conditions, and on the comparison of the results obtained by nondestructive and destructive measurements.

Measurement of the Uranium 235 Concentration of Uranium Hexafluoride in Containers

To check rapidly and with a good approximation the ^{235}U isotopic content of uranium hexafluoride in transport and storage containers, an instrument has been developed and built by the Pierrelatte installation of Compagnie Générale des Matières Nucléaires (COGEMA). This nondestructive testing instrument called N.I.C. (Nondestructive Isotopic Controller) is portable and requires no sampling or breakage of seals apposed to the receptable.

The principle of the instrument is based on fissions of ^{235}U nuclei caused by the action of neutrons emitted by an

Fig. 1 - Non destructive isotopic controller

americium/lithium source contained in a block of high density polyethylene, and on the measurement of the fast neutron flux induced by these fissions. This instrument is used by national safeguards inspectors and by operators to check the ^{235}U content of depleted, natural and low-enriched uranium, with an enrichment range from 1 to 5 %. The N.I.C. was the subject of a presentation and a demonstration with uranium hexafluoride containers stored at the Pierrelatte installation, before Agency representatives who expressed an interest in continuing the test. An instrument was loaned to the IAEA by COGEMA for the purpose.

Plutonium Measurements by Thermal Fluxmetry

Calorimetry is a simple, reliable method for the nondestructive measurements of the mass of a radioactive substance. The calorimeter directly converts the alpha radiation energy, emitted in this case by plutonium, into easily measurable electrical energy. Thermal fluxmetry is a method newly developed in France by the CEA and by the Science and Technology Faculty of Marseille Saint Jérôme [10,11]. It is based on the principle of the double-resistance calorimeter and, in comparison with conventional calorimetry, offers advantages of measurement speed (20 min), low cost and compact size. On the other hand, the results obtained are less accurate. This nondestructive testing method is applied routinely by the French Nuclear Materials Safeguards Inspectorate on plutonium in containers stored in bird-cages, in concrete cells, and in metal bins. In the latter two cases, a containment surveillance system can be built by including sensors (thermistors) in the storage shafts or bins, and by connecting them to a computer.

A demonstration of this new nondestructive technique is under way for Agency representatives.

Determination of the Isotopic Composition of Plutonium

Agency representatives have visited the Cadarache Nuclear Research Centre to make gamma spectrometry measurements on plutonium samples, in order to test one of their instruments designed to determine the isotopic composition of plutonium. The materials made available were samples as well as cans of plutonium oxide, for which the isotopic composition of each product was well known. The instrument includes a germanium detector, a data processing unit from Lawrence Livermore National Laboratory, and a Silena Cicero analyzer. This project was carried out as part of the Agency's equipment development activity.

Resin Bead Technique

The resin bead technique is a technique for taking samples from solutions of spent fuels, intended for assay by mass spectrometry. It is mainly applied in independent assays performed by the IAEA concerning input solutions of reprocessing plants. It helps to reduce to a few nanograms the quantity of fissile material to be sent to the IAEA Safeguards Laboratory at Seibersdorf. The tests performed were designed to evaluate the accuracy of the resin bead technique when it is combined with the internal calibration method [12].

This project required the equipment of the French laboratories at the Saclay Analytical Studies Service, as well as that of COGEMA's Laboratory Service at La Hague. The first task consisted of building a $^{233}U/^{236}U/^{242}Pu/^{244}Pu$ quadruple tracer, so as to reduce the relative errors in isotopic fractionation by a factor of 3 to 4. Resin bead preparation operations took place at La Hague in the presence of representatives of the Seibersdorf Laboratory and the Oak Ridge National Laboratory, who are associated in this study. The interpretation of assay results is currently under way.

Fibre Optic Seals

The CEA and Compagnie Lyonnaise de Transmissions Optiques (CLTO) have developed a fibre optic seal for application to safeguards [13]. Further development of this seal is planned : by cutting off certain fibres from view, data concerning the properties of the nuclear materials contained can be stored and retrieved at any time, for analysis by means of a computer system. Hence this seal also plays the role of a label. To provide further information on this type of seal, a demonstration was conducted at

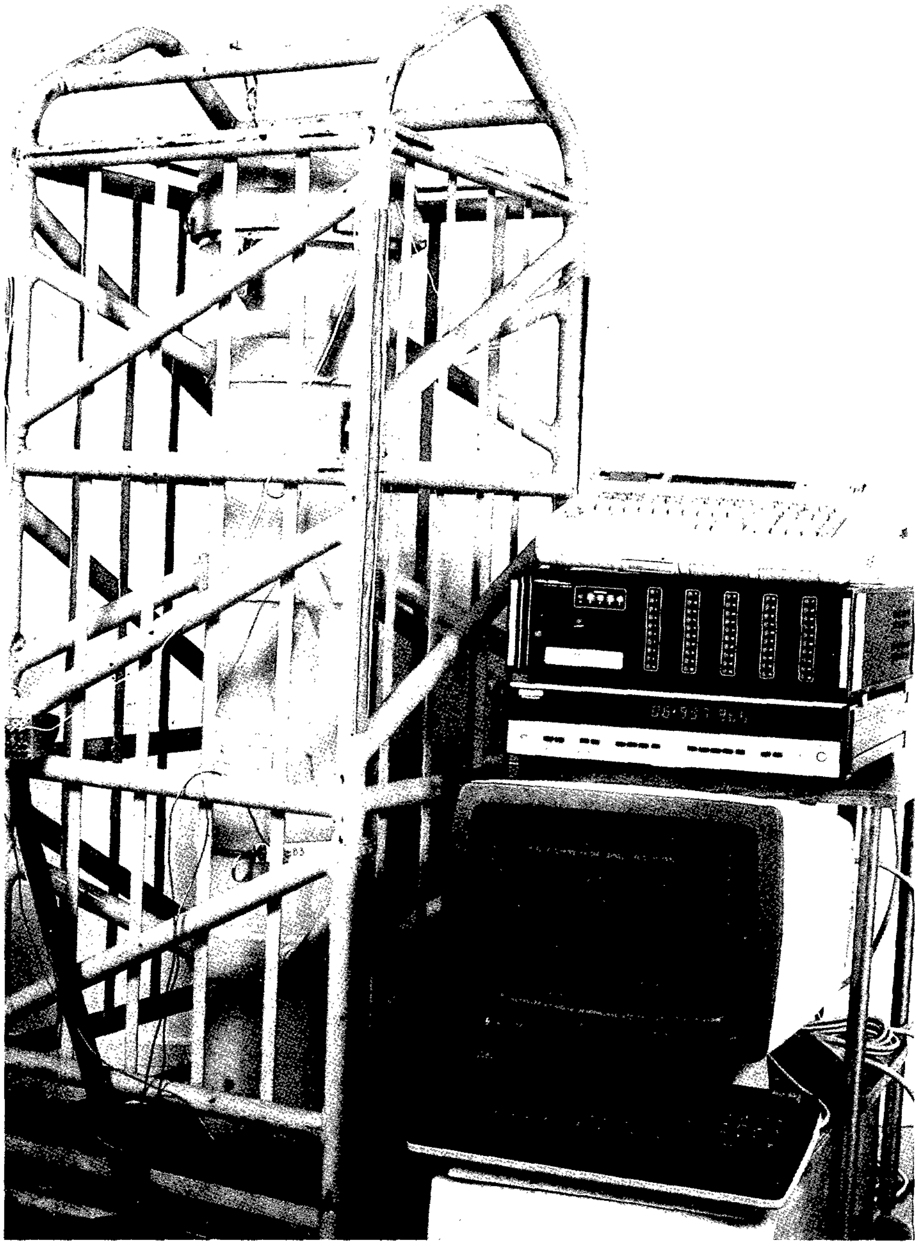

Fig. 2 - Thermal fluxmetry

Vienna by representatives of the CEA and CLTO. A number of seals have been made available to the Agency for tests.

Training of Inspectors

The French programme also features the training of Agency inspectors, in the area of spent fuel reprocessing. Two training courses have already been held, and in line with IAEA wishes this activity is now growing. The course includes a series of technical sessions given at the Institute of Nuclear Sciences and Techniques in Saclay, as well as a field trip to the facilities of COGEMA's La Hague installation.

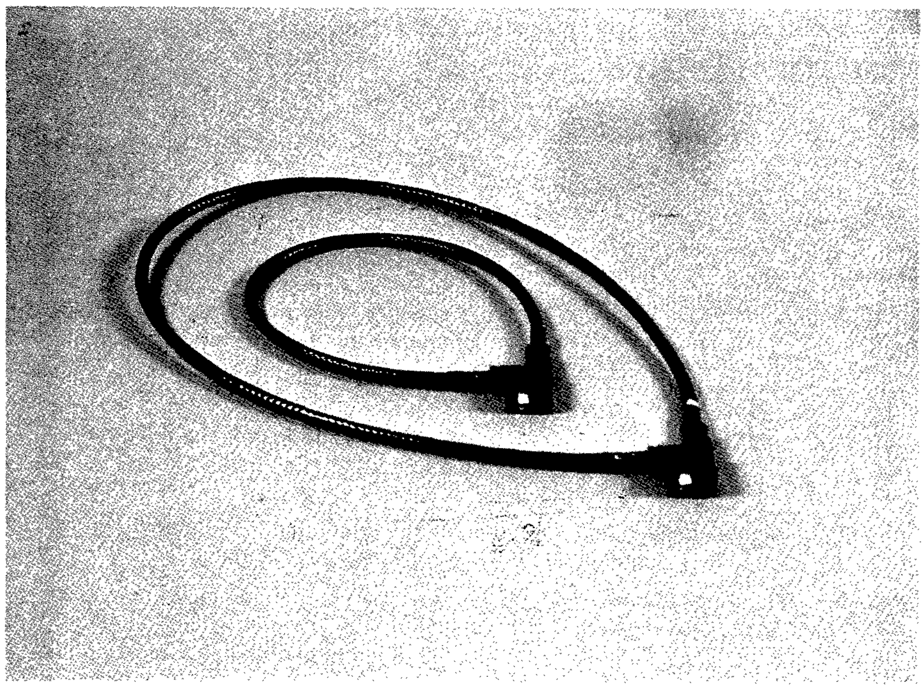

Fig. 3 - Fibre optic seals

References

[1] BOUCHARD J., GIACOMETTI A., ROBIN M. Reprocessing plant input balance controls based on reactor data. Proceedings of the First ESARDA Symposium, 25-27 April 1979, Bruxelles (Belgium)

[2] BOUCHARD J., GIACOMETTI A., GIRIEUD R., ARIES M., PATIGNY P. - Quatre ans d'expériences d'utilisation des corrélations isotopiques calculées dans l'établissement du bilan d'entrée à l'usine de La Hague - IAEA Nuclear Safeguards Technology, Vienna (Austria), November 1982, SM 260/24

[3] DARROUZET M., GIACOMETTI A., GIRIEUD R., ROBIN M. - Détermination expérimentale des sections efficaces des isotopes de Pu, Am et Cm dans un spectre de neutrons de réacteurs à eau - Nuclear Data for Science and Technology, 6-10 September 1983, Antwerpen (Belgium)

[4] GIACOMETTI A., GIRIEUD R., ARIES M. - Calculated ICT improvements: consequences of five years of industrial implementation. Proceedings of the Sixth ESARDA Symposium, 14-18 May 1984, Venice (Italy)

[5] MARIMBEAU P., PINEL J. - Non destructive testing of burn-up and cooling time on PWR spent fuels - NEACRP/L 254, September 1981

[6] DARROUZET M., FREJAVILLE G., PINEL J., MARIMBEAU P., REGNIER J. - Etablissement d'un bilan d'entrée de combustibles de réacteurs à eau par mesures non destructives gamma et neutron - IAEA Nuclear Safeguards Technology, Vienna (Austria) 1982

[7] PINEL J. - Détermination du taux de combustible et du bilan en isotopes fissiles des assemblages irradiés dans les réacteurs à eau légère par des méthodes non destructives - Note CEA N 2336 (March 1983)

[8] FREJAVILLE G., HEBERT D., PINEL J., DARROUZET M. - Non destructive measurements : hulls monitoring and burn-up determination - ANS/INMM/80, Head Island (Nov. 1983)

[9] PICARD R.A. - Mesure directe de la concentration en isotope ^{235}U sur les conteneurs d'hexafluorure d'uranium (UF_6) - Proceedings of the Fifth ESARDA Symposium on Safeguards and Nuclear Material Management, 19-21 April 1983, Versailles (France), p. 265

[10] SANSON C., MONIER, J., BOURRELLY P., PATIN H., SCHOEPP R. - Contrôle des quantités de plutonium par calorimétrie dans les magasins de stockage - Proceedings of the Fifth ESARDA Symposium on Safeguards and Nuclear Material Management, 19-21 April 1983, Versailles (France) p. 87

[11] SANSON C., MONIER J., BOURRELLY P., PATIN H., SCHOEPP R. - Fluxmétrie thermique : son application aux mesures de faible puissance dégagées et au confinement-surveillance du plutonium - Proceedings of the Sixth ESARDA Symposium on Safeguards and Nuclear Material Management, 14-18 May 1984, Venice (Italy) p. 151

[12] LUCAS M., GOUJARD T., RETALI G., HAGEMANN R. - Utilisation d'un étalon interne constitué d'un mélange d'isotopes 233 et 236 de l'uranium pour améliorer la justesse des analyses isotopiques et celle des dosages par dilution isotopique de l'uranium - IAEA-SM-260/26, Vienna (1982) p. 293

[13] MAUREL J.J., PECASTAINGS S. (CEA), CARRAT M., HAKOUN R., ROPAIN P. (CLTO) (in preparation)

The Adhesive Seal for Application in International Safeguards

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Introduction

The Verification Agreement between the European non-nuclear weapons states, the IAEA and the Commission of the European Communities among others refers to some aspects which deserve mentioning, before the issue of the adhesive seal is being dealt with. In Article 7(b)(i) of the Agreement it is mentioned that "Containment as a means of defining material balance areas for accounting purposes shall be made use of, in order to ensure cost-effectiveness". In connection with inspections surveillance and containment measures shall be applied and made use of (Art. 74(d)). "The Agency shall be enabled to apply its seals and other identifying and tamper-indicating devices to containments, if so agreed and specified in the Subsidiary Arrangements" (Art. 75(e)). Containment and surveillance measures are designed to ensure the continuous and complete knowledge of nuclear material flows and inventories, considering that the cost-effectiveness of inspections shall be optimized and the hampering of plant operation shall be minimized.

Containment measures make use of physical barriers such as walls, transport casks and storage containers, pressure vessels, fuel elements and piping. Safeguards measures of containment and surveillance are designed to support material accounting, which is the primary measure. In this sense, C & S help to ensure the identity and integrity verification of the contained nuclear material flows and inventories.

This article discusses the issue of the paper seal on a general basis.

Definition and Specifications

A seal, in general, is a tamper-indicating device used to join movable segments of a containment structure in a manner such that access to the sealed item becomes impossible without opening the seal (see IAEA/SG/INF/1, p. 51). The Glossary also mentions that besides general purpose metal cap seals, paper tape seals are most commonly used by the IAEA and that they are routinely applied to nuclear material stores and reactor vessels, shipping casks, sample containers, process or storage areas during inspections, and to other IAEA C/S devices.

It is possible to establish a list of performance criteria which need to be considered when establishing the capabilities and potential functions of C/S devices. In this article we examine the specification and possible applications of paper seals against the criteria, which we have identified as follows :

a) Ease of installations
b) Ease of interrogation (and identification)
c) Tamper resistance
d) Tamper indication
e) Equipment lifetime (robustness)
f) Functional lifetime
g) Level of assurance (a function of a) and f))
h) Cost to inspectorate and operator, compared to alternatives
i) Benefit to inspectorate and operator.

Before considering applications of the paper seal it is certainly helpful to specify such a type of safeguards seal more precisely. The basic concept is to have a means at hand, which enables in situ verifications of integrity and identity with respect to a nuclear material containment. An adhesive paper seal could be numbered for identification, dated, and signed by the inspector, just to give a few relevant features, and readily applied. In addition, it offers an inexpensive safeguards measure. Taking into account that such a seal would have to be specified by ease of handling, higher tamper resistance, and relatively low cost the issue should be dealt with on a broader basis, as far as the seal material is concerned. From that point of view it seems to be more reasonable to speak of an adhesive seal rather than a paper seal.

The adhesive seal is designed to join two parts of one containment. This requires the two parts to form roughly one plane. The seal has to have a certain adequate size which may vary with the application. It should not be possible to remove and reapply the seal without leaving unambiguous signs on the seal (i.e. the seal should be heavily damaged) or on the sealed item. Apart from the vulnerability of the seal, it would be advantageous to ensure that the seal cannot be purchased by any other body than the safeguards authority since it may be possible to replace the damaged seal with a forged replacement. This requirement could be fulfilled if the seal would incorporate identification marks which cannot be easily reproduced and which are the property of the authority. The production of the seal would be witnessed by the authority and all seal applications would have to be accounted for.

The seal should be specified as to its robustness regarding impact, temperature, humidity, chemicals, dust and dirt, radiation, and other environmental influences. It should be specified how long a seal can stay in place before it needs to be replaced because of ageing. A related issue would be the period of storage for the seal material before application and the minimum time for the applied seal to become effective. This latter feature depends on the solvent in the adhesive: the degree of adhesion initially increases with time after applications but may decrease again over longer periods due to other environmental factors. The manufacturer should specify the check list, which was applied to test the seal material.

It may be necessary to have auxiliary equipment for seal handling and/or verification; this has to be specified. Finally, the cost for the seal and the equipment as well as the means to remove a used seal should be defined. It should be pointed out that ease of handling and vulnerability of the seal are two incompatible requirements, i.e. a design that is easy to handle is likely to be more vulnerable.

From the point of view of safeguards objectives the key criterion of those listed above is the assurance provided by the seals that access to the sealed contents has not been achieved through the sealed routes. A seal can tell one no more, but the level of assurance it provides is degraded by deficiencies in its performance as measured against the appropriate criteria. The functional life of a seal should be determined in some way by the period beyond which its progressively degrading level of assurance reaches some unacceptable level. Determination of the functional life is a complex subject which we choose not to consider further here. Nevertheless it is clear that a robust, difficult-to-substitute-undetected seal should be expected to have a longer functional life than a fragile, easily-copied seal. Therefore it must be concluded that adhesive seals could not be expected to replace E-type seals except where the latter are being used for short term applications (i.e. measured in hours rather than days or weeks). The functional lifetime may also be extended if the location is covered by other C/S devices such as TV cameras, where the adhesive seal could provide a complementary level of safeguards assurance in the event of short term surveillance failure.

Possible Application and Status of Development

One can envisage several potential applications for adhesive seals. In some cases they may fulfill the function presently met by E-type seals but because of their shorter functional lifetime such applications may be limited. Nevertheless they should have a significant cost advantage for short term applications. One might envisage their use during inventory checks to seal flexible containers and to seal through loops where wire/cup seals have a longer term application. In the case of applying adhesive seals to rigid containers the containment surface should be polished metal to ensure a high tamper resistance. The adhesive seal would thus have a reliable basis. Any painted surface of containment would deteriorate the tamper resistance of the system seal/containment, because the containment could be cut open, welded and repainted without removing the seal. Adhesive seals may also have merit in certain cases where their less obtrusive geometry makes them less vulnerable to damage.

Adhesive seals are used for short term safeguarding of containments during physical inventory verification. In other words, the inspector is performing his activities in a plant when he decides to apply the adhesive seal. In general, one can say that this seal is predominantly used in bulk handling and storage facilities, in order to avoid the unnecessary remeasurement of nuclear material which is enclosed in a containment, and thus save inspection time and effort. In case of short term sealing the issue of tampering with the containment (painted surface) may not be so relevant. However, it may concern the plant operator if he does not want his plant to be spoilt by an adhesive seal, since the painted surface of the containment could be damaged.

The Agency and Euratom are currently using a paper label adhesive seal of limited tamper resistance. Therefore, in the FRG programme in support of the IAEA there is a task for development and testing of an improved adhesive seal. KFA Jülich is co-operating with the 3M Company. The status is that 3M has offered an acceptable material and is now asked for an adequate equipment for handling the seal (e.g. roll-off mechanism).

In Japan a pressure sensitive paper seal was under development (see proceedings of the 1981 ESARDA Symposium, p. 349).

BNL and UKAEA have both demonstrated the domestic safeguards benefits of using, in plutonium stores, tamper indicating adhesive seals incorporating a distinctive logo and overprinted with bar-codes. The bar-code system speeds up significantly the PIT with consequent reduction in operator/inspector exposure and a large reduction in transcription errors (INMM Annual Meeting 1983, Vail, and IAEA-SM-260/124). It is not obvious to what extent such a system can be of benefit to the international inspectorate other than in a long term store where there are no personnel or material movements and where a high assurance can be achieved from the other surveillance devices that tampering with the adhesive seals has not occurred. In this case the adhesive seals function solely as bar code labels and not as seals.

Discussion

The demand of the Agency with respect to the adhesive seal development has to some extent been directed towards longer term application. If the FRG developments with the 3M company are successful it is expected that a product will become available which compared to the presently used adhesive seals will have a superior performance against the criterion of tamper indication. If also the robustness could be improved both these criteria may support the case for accepting a longer functional life provided the source materials are adequately controlled. Two further criteria will have to be investigated as the material becomes available, ease of interrogation and cost to inspectorate.

If adhesive seals can be shown in some applications to substitute adequately for E-type seals in technical performance they should also show a benefit/cost advantage. However, we think that the advantages of an adhesive seal are almost entirely to be found in short or medium term application, i.e. during PIV and PIT. There may additionally be a limited number of other applications in operational areas where near continuous inspector presence occurs and the opportunity exists for frequent verification of seals in place or where they provide a complementary level of assurance to surveillance cameras and early seal reverification can be achieved in the event of camera failure.

ESARDA People

Meeting of the DA working group at Jülich on 2-3 October 1984

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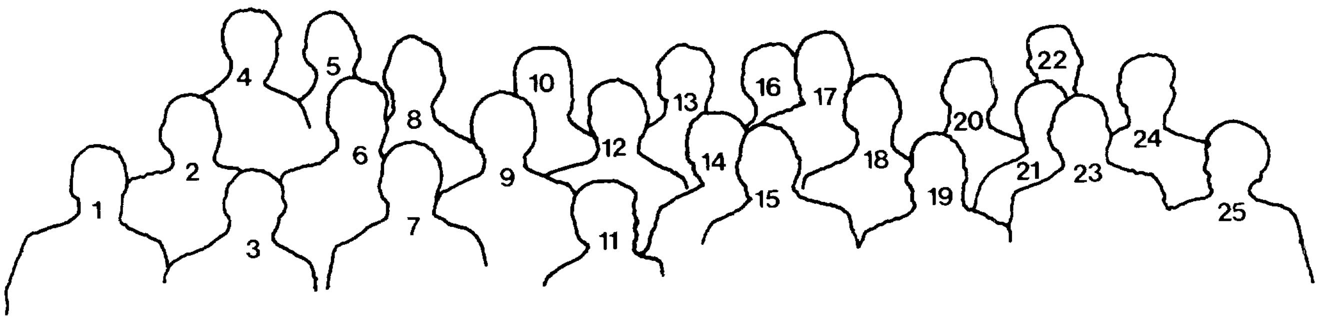

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