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ESARDA BULLETIN

News about ESARDA

ESARDA Partners

The ESARDA partners are now eleven. The two new organizations announced in Bulletin No. 13 are now full partners of ESARDA :

- Centro de Investigaciones Energéticas Medio Ambientales y Tecnológicas (CIEMAT) - Spain
- Kernforschungsanlage Jülich (KFA) - F.R. Germany.

Who's who in ESARDA

Mr. W.L. Zijp, Netherlands, changed his function in ECN. As a consequence a new Dutch representative in the ESARDA Steering Committee and in the ESARDA Board was nominated. This is

- **Mr. A.M. Versteegh**
  ECN Petten, Netherlands

The ESARDA Coordinator of Italy is now changed. Prof. F.V. Frazzoli has been replaced in this job by :

- **Mr. M. Aparo**
  ENEA Casaccia, Italy

In Memoriam

It is with deep regret that we report the death of Graham Rogers on 18 January 1988. Graham was a very prominent member of the Non-Destructive Analysis WG and he will be greatly missed by his many frieds in ESARDA and the USA.

Meetings

- *10th Annual ESARDA Meeting, 3-5 May 1988, Karlsruhe (FRG)*
  The 10th Annual Meeting will be held at the Kernforschungszentrum Karlsruhe (KfK), F.R. Germany. The attendance will be limited to the ESARDA Steering Committee members, coordinators, working group members and observers. The title of this internal meeting of ESARDA is :
  Medium and Long Term Trends in ESARDA Working Groups' Activities
- *11th Annual ESARDA Meeting*
  The 11th Meeting will be a general **Symposium on Safeguards and Nuclear Material Management** and will be held in Luxembourg on 30-31 May and 1st June 1988.

Progress in PERLA

S. Guardini
CEC, JRC-Ispra

1. Introduction

The last occasion on which we wrote about the **PER**formance **LA**boratory (PERLA) in the ESARDA Bulletin was in No. 9 of 1985 /1/. That article was a rather comprehensive view of one of the tasks of PERLA, i.e. performance assessment, showing the importance of studying Safeguards instrument performances in a field environment, where the error behaviour is not the same as in the laboratory.

It was from a practical point of view a proposal, the realization of the laboratory being still distant.

Now, after two years, we can say that we have an operational facility PRE PERLA where all the tasks of PERLA can be pursued, and have been already initiated.

The general aim of PERLA /2,3/ was identified from the beginning **as bridging the gap between the laboratory development and the application of Safeguards instruments and techniques in an industrial environment.**

The laboratory is oriented specifically to NDA and C/S techniques; this paper is mainly concerned with NDA aspects.

The main themes of concern are :

- assessment of the performances of instruments and methods in near field conditions;
- periodic calibrations under well defined conditions of instruments used routinely by inspectors and operators in industrial facilities;
- training of inspectors and operators;
- development of new methods according to needs.

The aim of this paper is to give a progress report of the status of PERLA. Four aspects are mainly treated here :

1. the set up of the laboratories and their structures in the ESSOR complex (section 2),
2. the procurement and characterization of PERLA Standards (PS) (section 3),
3. construction of user oriented instruments (section 4),
4. training (section 5).

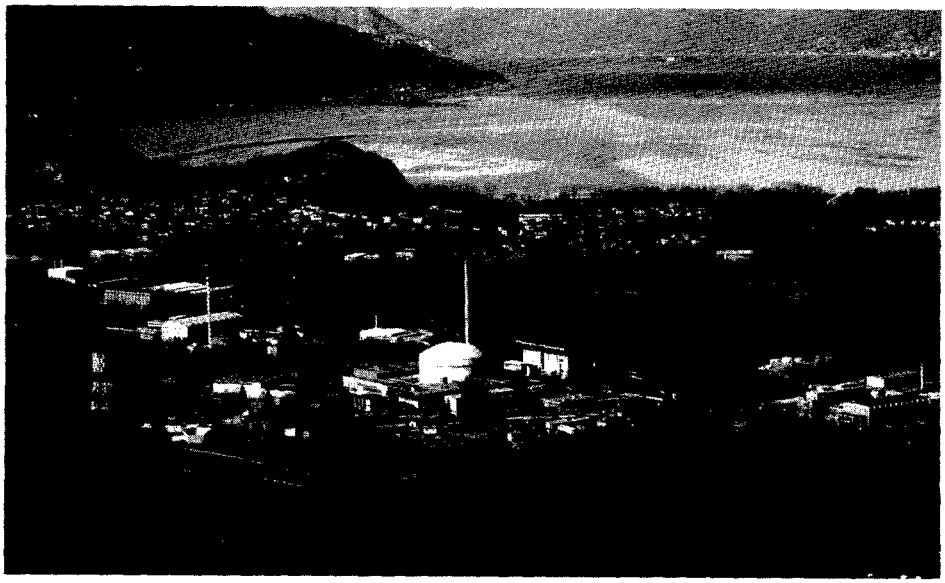

Fig. 1 - JRC-Ispra with a view of ESSOR complex

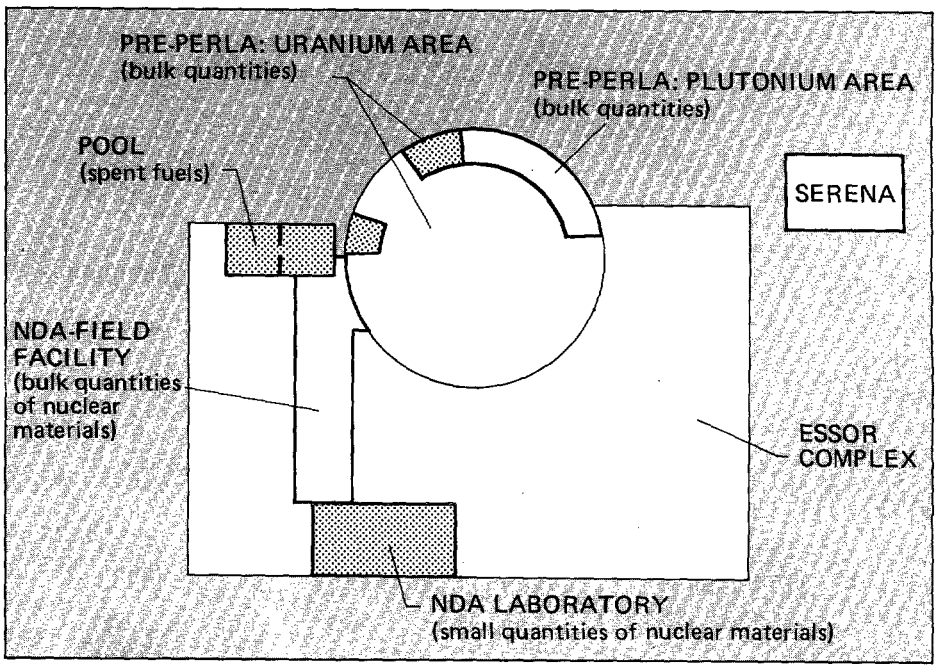

Fig. 2 - PERLA laboratory - general view

2. Set-up of Laboratories

PERLA is a laboratory which uses different facilities : PRE PERLA, the Non Destructive Assay (NDA) laboratory, the spent fuel pool, the NDA-field facility and SERENA (Figs. 1 and 2).

Some of the facilities are used only and specifically for Safeguards purposes (e.g. PRE PERLA), others (e.g. the pool) are shared with other programmes.

2.1 PRE PERLA facility

The PRE PERLA laboratory (Fig. 3) has been built inside the ESSOR reactor containment building. It has been equipped to measure bulk quantities of fissile materials (U and Pu). Its name comes from the fact that as the NDA-field facility has still to be constructed in another room, it was decided

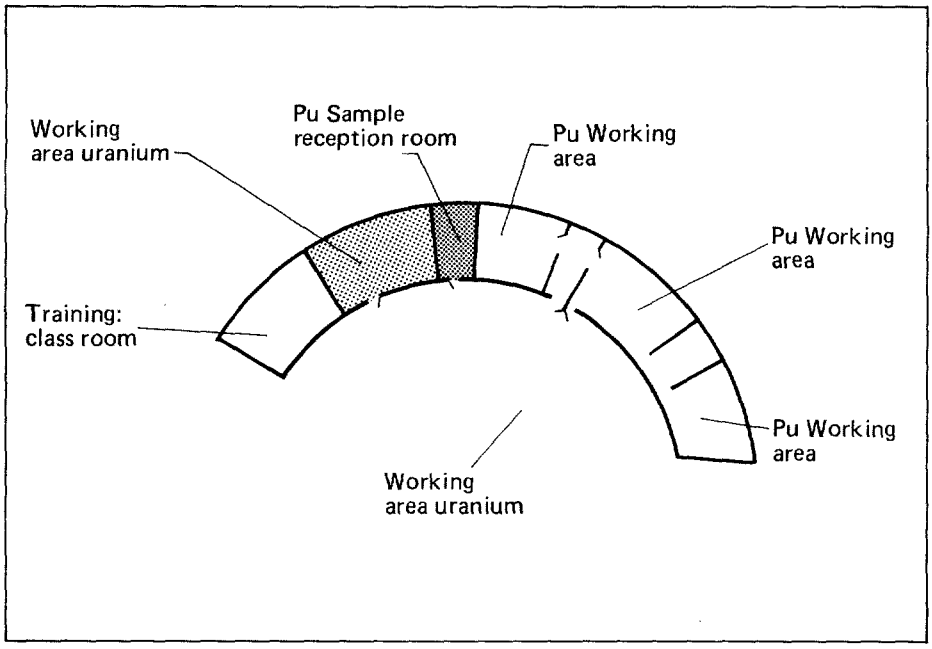

Fig. 3 - Schematic view of PRE PERLA

in 1985 to anticipate the beginning of PERLA type experiments. For this purpose four laboratories, storage rooms, handling rooms have been made available for the Safeguards programme in an already protected zone, where bulk quantities of fissile materials in sealed samples could be measured. PRE PERLA could then be set up and became operative at the beginning of 1987.

Calibration experiments with the ^{235}U inventory have already been carried out, as well as training (see section 5). In Fig. 4, PRE PERLA is shown during the simulated High Enriched Uranium (HEU) Physical Inventory Verification (PIV) training course / 4 / of July 1987.

2.2 NDA laboratory

It is a complex of 7 laboratory rooms where small quantities of fissile materials (~ 200 g) can be measured. Operative since 1986, it is dedicated to research and development of NDA techniques.

2.3 The spent fuel storage pool

Six spent MTR fuels from the ESSOR reactor were discharged in the pond. Four additional LWR spent fuels will also be procured and stored. Training and development of NDA techniques for spent fuels will take place in the pond. The ESSOR spent fuel pool is shown in Fig. 5.

2.4 NDA-field facility

The NDA-field facility will be realized modifying a large existing laboratory. It will have the same characteristics of PRE PERLA, i.e. measurement of bulk quantities of U and Pu.

The modification works will start in 1988 and will be finished in 1990 giving the facility the appearance shown in Fig. 6.

2.5 SERENA

SERENA is a Safeguards exhibition and training facility which will be fully equipped in 1988, joining other training facilities in the PERLA area, besides the nuclear laboratories where a large part of the practical training is carried on. SERENA is shown in Fig. 7.

3. Procurement and Characterization of PERLA Standards (PS)

3.1 Generalities

The first absolute necessity of a laboratory that aims to act as a calibration and training laboratory in the field of Safeguards is to have available a large inventory of well characterized and reference materials, representing to the largest possible extent samples that are most commonly encountered in the fuel cycle.

Identifying this inventory was actually the first task of the PERLA team. A further important task was to acquire fissile materials and to characterize them at a high level /5/.

Nevertheless, PERLA cannot and does not intend to substitute the field as far as instrument performance determination is concerned : as mentioned earlier it represents a bridge between the laboratory and the field. Neither can PERLA materials fully replace plant specific reference materials (PSRMs) like those standards that were obtained in a joint effort by Euratom Safeguards Directorate, IAEA and the JRC /6,7/.

That was an exercise which, as well as giving tools for really quantitative accountancy with NDA, gave us all much experience in preparing working standards. It was a positive experience which has been abandoned, maybe too early, if one thinks of the importance of having a frame of well characterized standards for authentication purposes, for the detection of biases, resolution of discrepancies, and, in general terms, for carrying out really quantitative NDA.

Nevertheless, that experience was very useful for acquiring the PERLA standards inventory, because the main rules followed were those suggested by that exercise /8/.

We now have a new task in front of us in the near future : to create close links

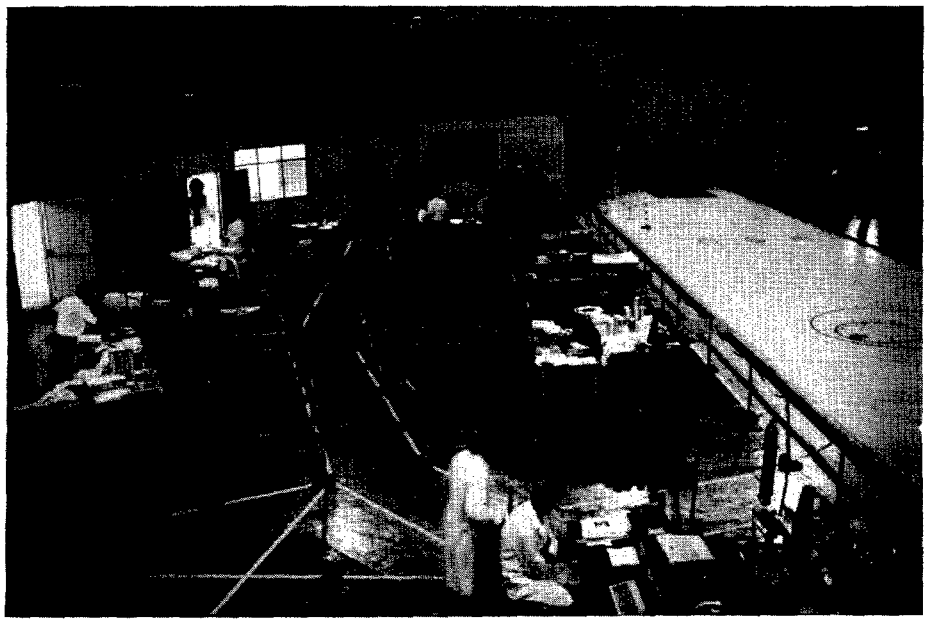

Fig. 4 - Picture of PRE PERLA during HEU Physical Inventory Training course of July 1987

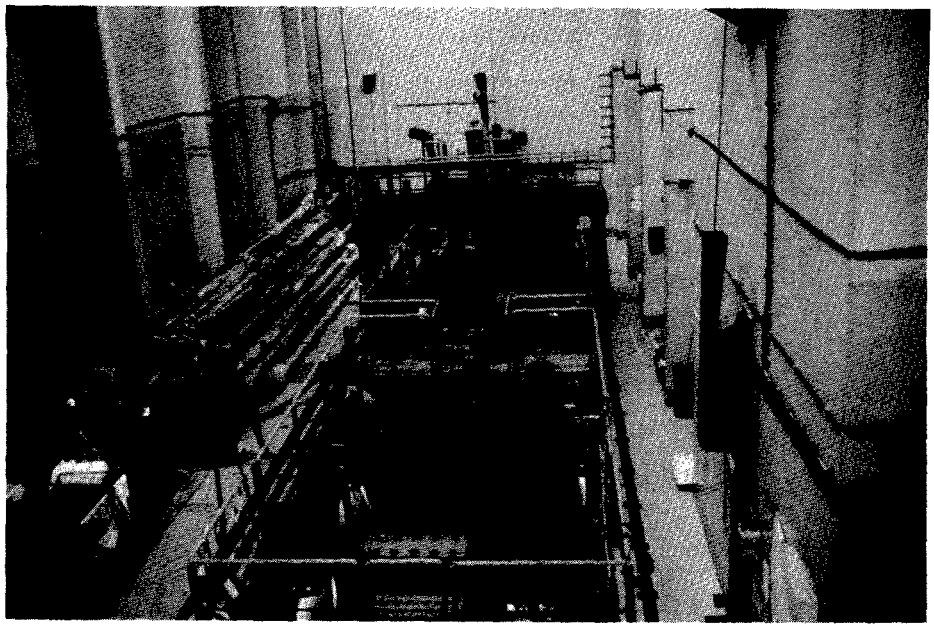

Fig. 5 - View of the ESSOR spent fuel pool

with the field, correlating the large inventory of samples of PERLA with standards already existing or to be prepared in European laboratories and plants.

3.2 Characterization of PERLA standards

Basic criteria for the characterization

As said before, in establishing procurement and characterization schemes for PERLA standards we followed very much the general criteria established when characterizing the PSRMs /8/. Detailed flow schemes were somehow different obviously, because of the different experimental situations encountered for PERLA and the different final use, but many procedures were the same.

The general requirements for PERLA standards we established were :

a. they must be representative of plant samples (e.g. PuO_2 cans, MOX industrial pins, MTR assemblies, etc.).
b. they should be prepared and characterized for specific NDA methods with defined "performance values" /9/ or "expected overall uncertainty values" /10/. Therefore overall random and systematic uncertainty must be a priori planned so that calibrations with these standards do not introduce an appreciable uncertainty component in the NDA measurements.
c. most of them must belong to the same family, i.e. come from the same original production batch so having the same chemical and isotopic characteristics. In this way, for instance, the gamma spectrometrist can measure the same sample in the form of powder and pellets and pins excluding any influence from the above chemical and physical parameters.
d. their characterization must be traceable back to primary standards.

General guidelines followed in the procurement schemes were :

- define the scopes of specific samples, i.e. the NDA measurement techniques for which the PS were prepared;
- define consequent uncertainty levels taking in mind the above "performance values";

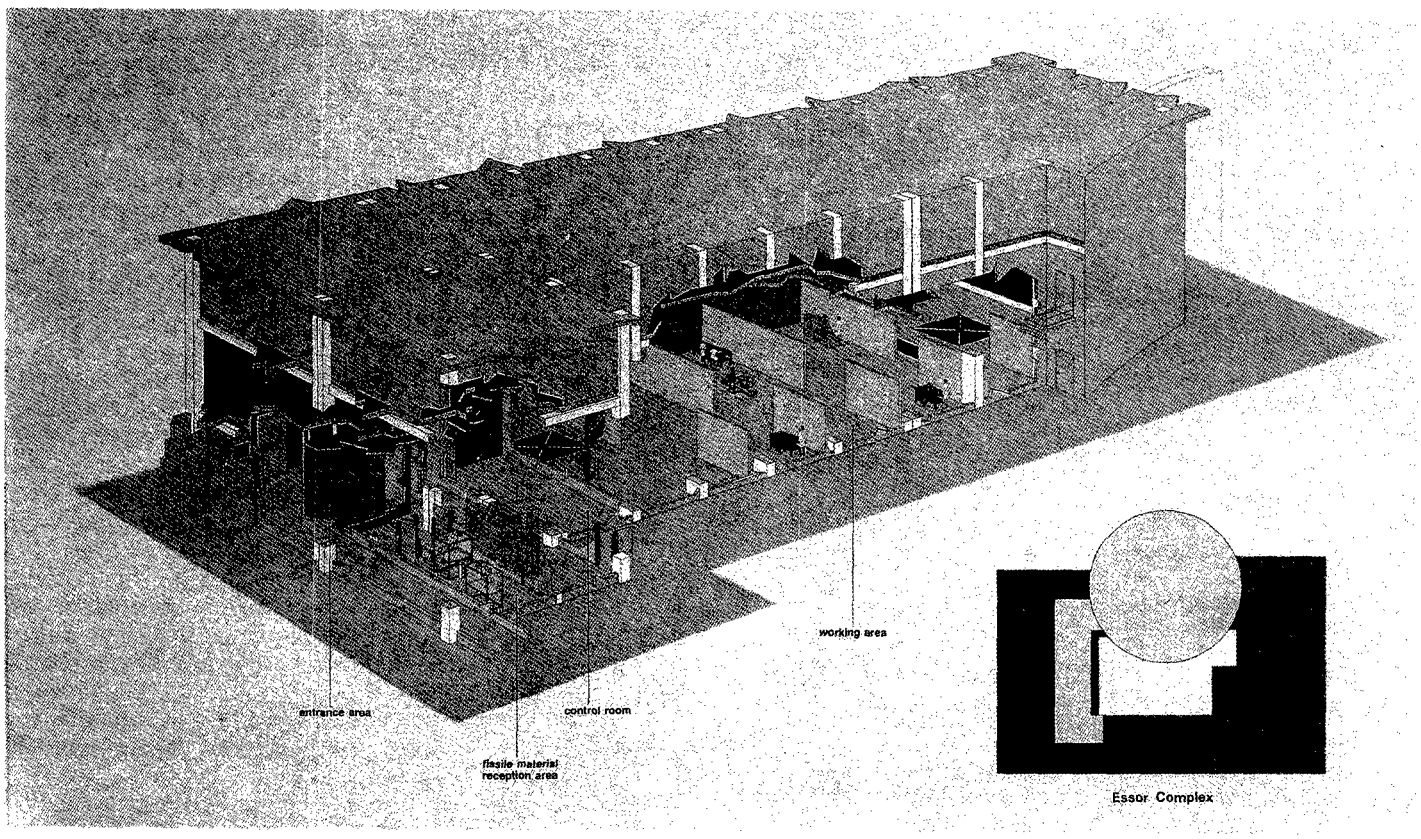

Fig. 6 - View of the future NDA-field facility

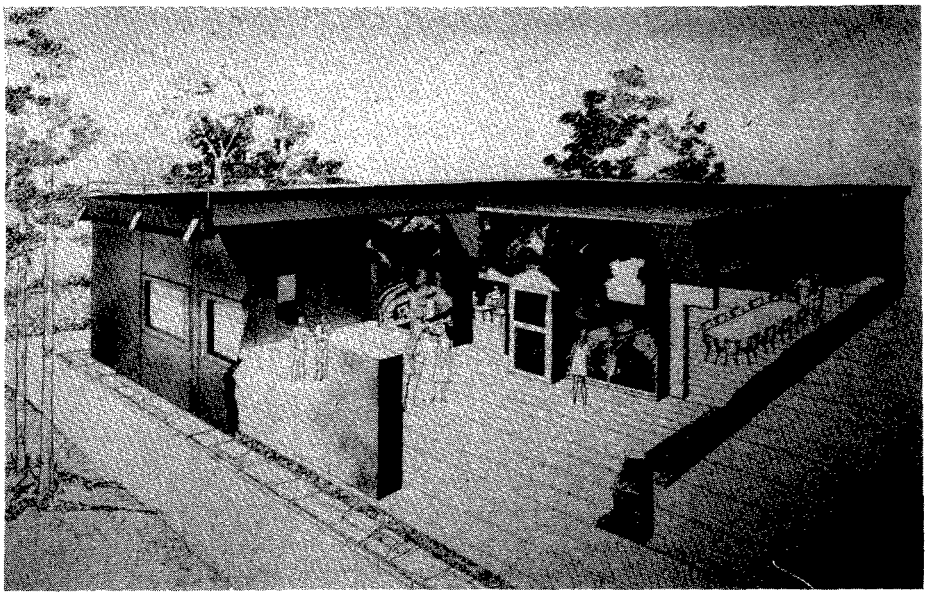

Fig. 7 - The Safeguards exhibition and training facility SERENA

- define preparation and characterization procedures to achieve such levels of accuracy;
- define error propagation schemes and statistical data evaluation schemes;
- define analytical instructions for the DA laboratories;
- prepare PERLA certificates and protocols to fully describe the PS and the procedures followed in their preparation and characterization and to record the traceability to primary standards.

The method followed in characterizing PERLA standards

1. The first important aspect to start with in the logical approach defined above to procure and characterize the standards was to a priori define the required level of accuracy in connection with the NDA technique applied to those standards and with the "expected overall uncertainty values" /10/ of that technique.
   In Table I a list of required accuracies for Pu standards is given together with the so-called "limiting factor", i.e. the technique and the parameter /11/ that imposes such a level.
2. The next step was to study the possibility of reaching such a degree of characterization, looking at the level of accuracy attainable by DA, which is the basis for any characterization. In Table II the typical expected accuracies for different techniques are shown, as defined by the three laboratories taking part in the characterization on the basis of attainable accuracies in DA /12,13/.

Table I - Required overall uncertainty for PuO_2

Parameter	Uncertainty (%)	Limiting factor
Pu content	0.2	calorimetry
^{238}Pu abundance	0.5	calorimetry, γ spectrometry
^{239}Pu abundance	0.2	calorimetry, γ spectrometry
^{240}Pu abundance	0.3	γ spectrometry
^{241}Pu abundance	0.3	γ spectrometry
^{241}Am	0.5	calorimetry, γ spectrometry

Table II - Typical Expected Accuracies of DA Methods

Measurement	Material	Method	σ
Pu-conc.	PuO_2	AgO or Mc. Don.	0.15
	MOX		0.15
U-conc.	MOX	Davies & Gray	0.1
Pu-238	PuO_2	Mass. spect.	0.5
	MOX	α-spec.	1.5
Pu-239	all	Mass. spect.	0.05
Pu-240			0.1
Pu-241			0.3
Pu-242			0.3
Am-241	all	γ-spec.	1.0
U-235	low	Mass. spectr.	0.1
	high		0.03
U-234	high	Mass. spect.	1.0
U-236	high		1.0
U-234	nat.		10
U-236	nat.		?

3. The third step was to define "accurate procedures" for the preparation of the standards and for their characterization with DA and NDA techniques suitable for attaining the required levels of accuracy. "Accurate procedures" means first of all identifying a priori on a preparation flow scheme the possible uncertainty sources; then one must reduce that error component and quantify it.

One example : Pu bearing samples

The preparation and characterization schemes were different for different families of standards; in Fig. 8 one of the five different scenarios is given showing the procurement of an LWR family of MOX powder-pellets-pins from the same batch.

An uncertainty build-up model was then developed which contained all the most important error sources predicted for that family. In Fig. 9, a generalized model for PuO_2 samples is presented showing, in a condensed fashion, the most important steps from where uncertainty could come. Each step was then developed in terms of: a) procedures to be followed to reduce uncertainty in preparation and b) quantitative definition of the error component. With reference to that PuO_2 family the most delicate points were identified as follows :

1. Homogeneity
   - a definition of homogeneity has been developed in /11/ again for different limiting factors or techniques applied; in other words, calorimetry, for instance, is not influenced by an inhomogeneity inside a PuO_2 box, while gamma spectrometry gives an answer on the internal homogeneity of a can.
   - preliminary DA/NDA measurements were done on the original PuO_2 production batches ensuring that internal/external homogeneity was acceptable /14,15,16/.
   - the sampling and DA scheme were worked out and implemented for homogeneity checks (Fig. 10), that gave the sampling component of the uncertainty.
2. Sampling and DA
   A sampling and analytical scheme was prepared taking into account the overall uncertainty required, the error propagation model and the statistical evaluation of the final overall uncertainty that takes into account errors : in the single determination, in the sampling homogeneity and in the interlaboratory difference (Fig. 10).
   Very detailed instructions were discussed with and then given to the DA laboratories, going from the number of repetitions, to the expected uncertainty from

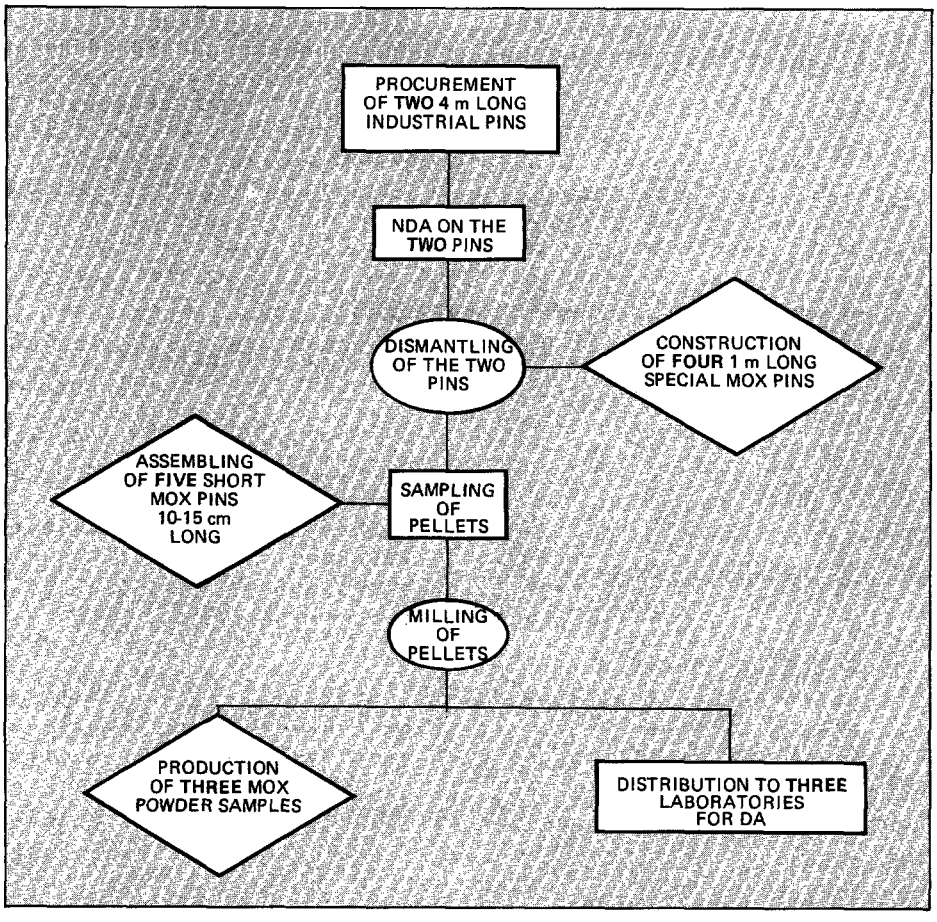

Fig. 8 - Procurement scenario for a reduced-size family concept (Light-water reactor DWR)

Table III - Nuclear Materials for PERLA

Material type			Certification level*
HEU	MTR platelets, plates	3 enrichments	4
	MTR assemblies (18)		4
	UO_2 powders, pellets (g-kg)	6 enrichments	3
	THTR particles, pebbles		3
	Metal buttons (kg)		4
LEU	UO_2 powders, pellets (g-kg)		
	UO_2 pins	not yet procured	
	Short assemblies		
	U_3O_8 CBNM/NBS	5 enrichments	1
PuO_2	Small cans (g)	3 burnup	2
	Large cans (kg)	3 burnup	2
	CBNM	5 samples	1
	PIDIE	7 samples	1
MOX	Pins	fast, thermal	2
	Pellets	recycle	2
	powders		4

*) The certification levels are as follows :
1: International reference material or many labs
2: PERLA certificate (3 labs)
3: PERLA certificate (2 labs)
4: PERLA certificate (1 lab)
5: others

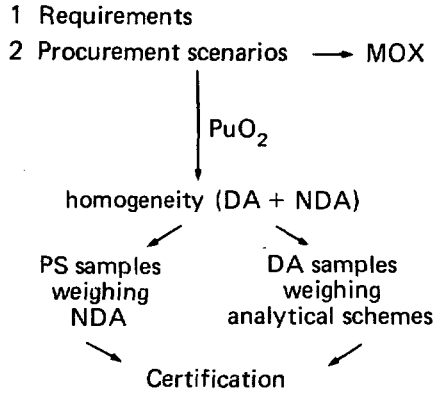

Fig. 9 - Characterization procedures for PuO_2 powder standards

DA (Table II), the nuclear data to be used, down to details such as the type of vial to be used in the analytical treatment (see a typical working protocol in Fig. 11).

3. Weighing
Careful sample weighing protocols have been established both for DA and NDA samples. The laboratories were also required to establish carefully documented balance control based upon standard weights.

4. Humidity
One of the most important parameters which could affect NDA neutron measurements is humidity content. General H_2O content limits were imposed as well as a strict check of the fabrication and sampling procedures, so as to ensure on the one hand a representative sampling and DA analysis, and on the other hand that no further H_2O pick-up could occur after sampling. Actually, the whole preparation and sampling process was carried out in inert atmosphere.

The PERLA inventory

In Table III, the total inventory envisaged for PERLA is summarized. At present, only HEU and Pu bearing samples are in the inventory; LEU and spent fuels are under study and their procurement schemes under preparation. They are expected to be procured for the end of 1989.

4. Construction of Safeguards Oriented Instruments

For some years it has been pointed out and it can increasingly be seen on the basis of the experience built-up over the years, that the main problem in transferring Safeguards instruments and methods from the developing laboratory to the field is that of producing reliable Safeguards instruments. It is, in fact, evident that most of the techniques when applied have a different (lower) accuracy in the field than they do when used in the laboratory.

It has only recently been realized that, generally speaking, this is due to objective reasons rather than to incorrect application of the instrument. The lack of extensive structured measurement **data bases** and appropriate **error models** delayed the process of understanding. The last point is particularly delicate : we must have in Safeguards a great concern for experimental error definition, particularly in NDA where the error behaviour is quite complex /17,18/.

The definition of target errors in DA for Safeguards was possible without detailed error models, because the samples are always measured in the same laboratory conditions : **DA always has the "same" sample.** These unmodelled parameters such as homogeneity, sampling errors, etc., from time to time lead anyhow to unexplicable discrepancies.

In NDA where the items to be measured are extremely variable an error model which assigns the same overall error to almost all different combinations of instrument and measured items cannot represent the complexity of the error phenomenology which generally exists when measuring a complex population.

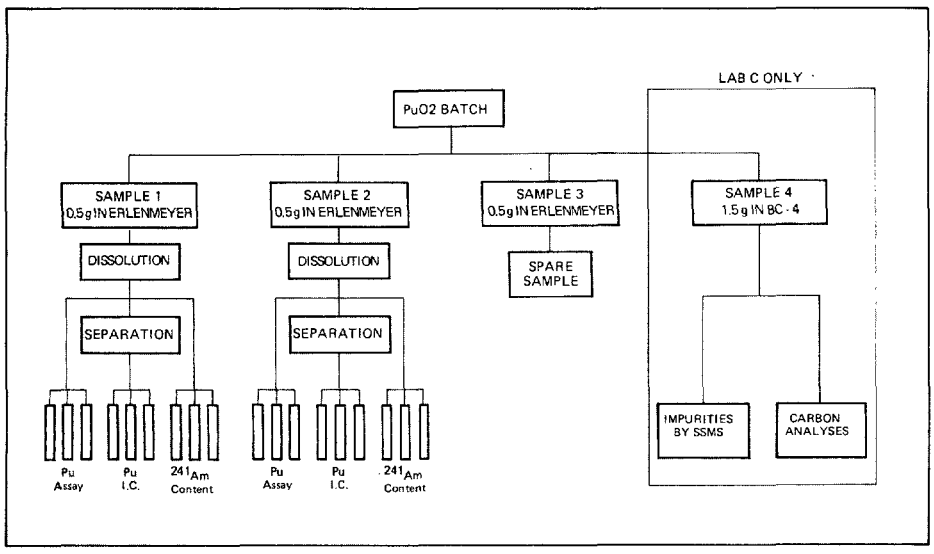

Fig. 10 - Analytical scheme for PuO_2. Same for labs A, B, C

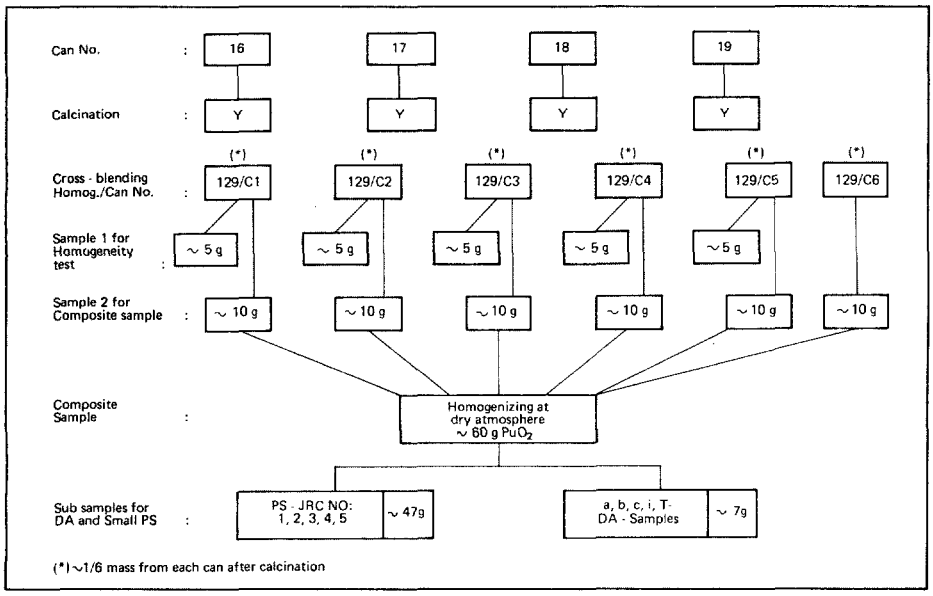

Fig. 11 - Preparation of small PERLA standards (PS) and DA-samples of PuO_2-lot 129/LB

Furthermore, the lack of time for performing measurements, forces sometimes the inspectors to reduce the counting time. In the absence of an analytical model quantifying the importance of the statistical counting variance on the overall uncertainty, subjective judgement could lead to contradictory results: sometimes the counting time reduction leads to an obvious degradation of the results, sometimes not.

But, finally, the fundamental reason for field-laboratory discrepancies resides in the fact that frequently the physical and statistical error models were lacking or were borrowed from applications different from those used in Safeguards, or again no model existed, therefore "intercomparison" experiments could not be extrapolated to experimental situations different from those actually checked.

Furthermore, traditionally a good experimentalist, when in doubt, overestimates his uncertainty without having negative effects /17/. But Safeguards control is based on 1) a sampling plan and 2) comparisons with declared values.

Overestimating the uncertainty in Safeguards means disturbing both the above procedures leading to a series of regrettable side effects, such as :

- artificially low false alarm rate
- unnecessarily high sample sizes
- waste of resources
- perturbed detection probabilities.

This means that, as well as besides specific statistics tools, we must also develop a new experimentalist mentality that could be resumed by saying that a good measurement may be useless without a good evaluation of uncertainty.

Or, to express the same concept in other words, a good laboratory physical instrument might be a poor Safeguards instrument, if it is not properly equipped with Safeguards procedures and ad hoc statistical error propagation, suitably tailored for use by inspectors and for HQ reanalysis. Being conscious of the above needs for field NDA instruments the JRC-Ispra has been constructing for some years integrated systems where together with a sound physical approach other Safeguards aspects are contained, namely :

- sampling parameters (to allow an error propagation to substrata, strata, whole inventory);
- tailored error models specifically developed for the instrument concerned and the way it is used;
- Safeguards verification procedures (calibration, recalibration, normalization) through which the error propagation is built accounting for random error, short and long term systematic errors, etc.;
- software protocols, data bases and data base managers, software supports, allowing acquisition-recording-transmission-field analysis and HQ reanalysis.

The various aspects of such multi-disciplinary instruments are regulated by the so-called FIDES rules /19,20,21/, FIDES being the **F**unctional **I**ntegrated **D**ata **E**valuation **S**cheme.

Examples of FIDES implementation are :

SIGMA (Fig. 12), a device in operation at HOBEG since 1974 for the monitoring of HTGR pebbles /22,23,24/, recently completely reviewed following FIDES criteria.

PU METER (Fig. 13) for the determination of Pu isotopic composition /25,26/.

PHONID (Fig. 14) for monitoring U and Pu bearing samples, from grams of waste up to kg samples. An exemplar of PHONID belonging to Luxembourg Safeguards Directorate has been performing measurements in the NUKEM plant since 1974. Another PHONID is operated by JRC-Ispra to support the Safeguards Directorate during physical inventories in European LEU fabrication plants /27,28/.

GAMMA SCANNER (Fig. 15) is a device for monitoring ^{235}U in MTR fuel elements. Two units have been working since 1972 in HEU plants. The instrument is now being thoroughly modified and improved to meet FIDES criteria /29/.

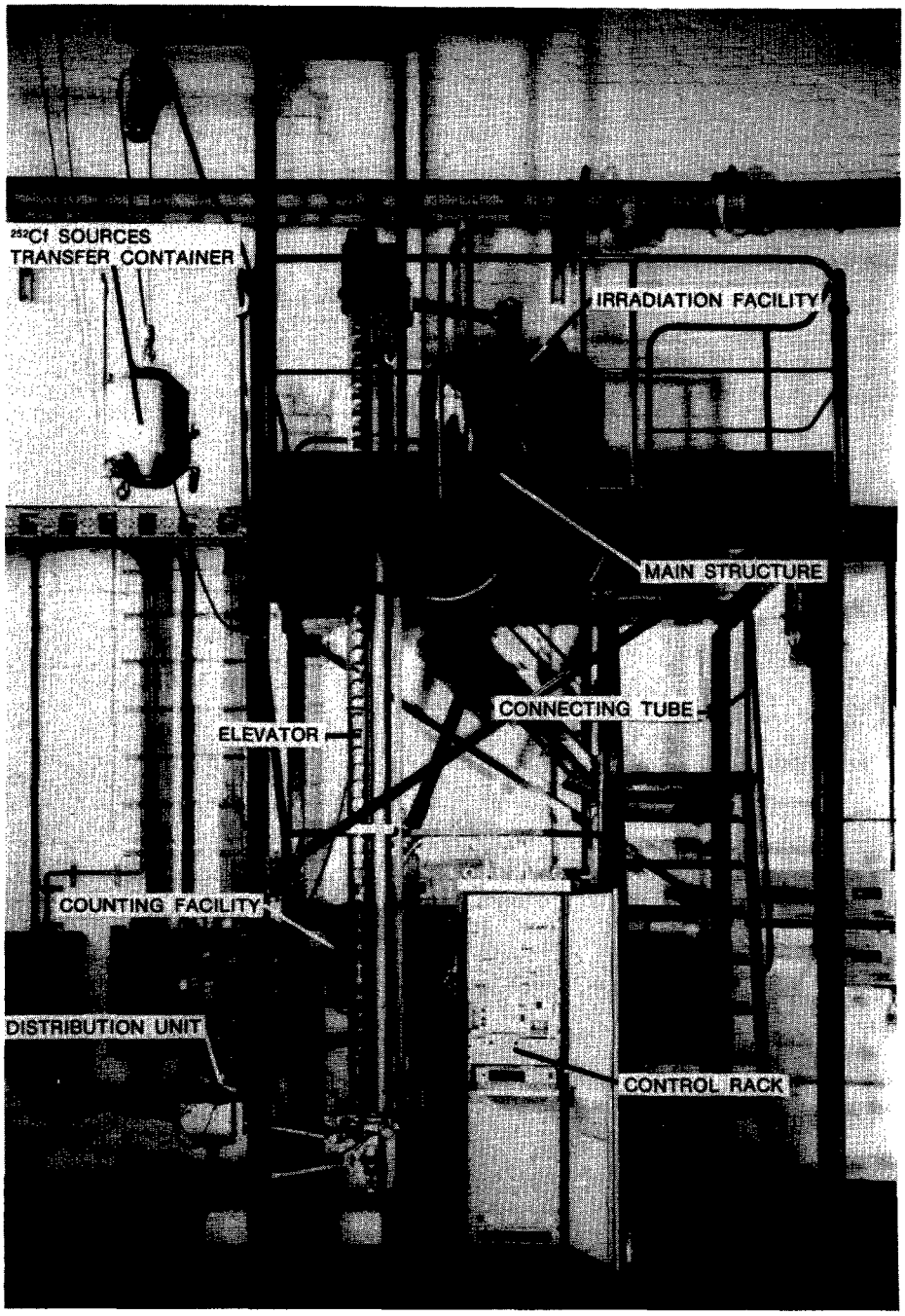

Fig. 12 - View of the delayed neutron counting device for monitoring THTR fuel pebbles SIGMA

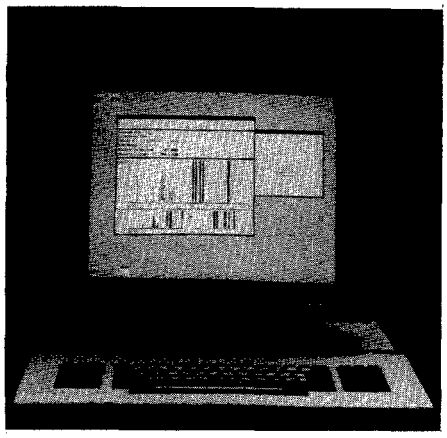

Fig. 13 - View of the Pu meter, an instrument for the determination of plutonium isotopic ratios

5. Training

The JRC-Ispra had in the past an intensive training activity. About 50 training courses have been given to Euratom (some to IAEA) inspectors, mostly oriented on NDA techniques and instruments such as :

- uranium enrichment determination
- plutonium isotopic composition determination,
- neutron coincidence counting (Variable Dead Time Counters and Shift Registers).
- uranium 235 content determination in THTR pbbles : (SIGMA and DUCA /30/)
- integrated training on HEU Physical Inventory Verification (PIV).

Much attention has been paid recently to training courses which, besides teaching the correct use of instruments, also provide a more integrated view of verification activities. Typically the PIV type courses on plutonium and uranium where inspectors are taught to plan an inspection, perform measurements and draw conclusions on a statistical basis, are being encouraged.

Following this trend, the training activity at Ispra is being restructured along the lines of PERLA, i.e. of a service and support provided by the Joint Research Centre of the Commission of the European Communities to other General Directions, particularly DG XVII, to European laboratories and installations and to IAEA.

A typical example of the new kind of training in PERLA was the course held at Ispra in July 1987 where eight IAEA and four Euratom inspectors were taught how to take a complete PIV on PERLA HEU Inventory /31/.

The training "menu" in PERLA will contain

- basic disciplinary courses on neutron detection, gamma spectrometry, calorimetry, statistics;
- instrument oriented courses at various levels of complexity;
- integrated courses, i.e. advanced courses on material type verification with combined techniques (e.g. Pu monitoring through combined calorimetry + gamma spectrometry) and complete PIVs.

The courses will be held by Commission officers when teaching JRC techniques and instruments, and/or by outside scientists in other cases.

6. Conclusions

The picture of the PERLA laboratory that we have tried to give with this presentation is that of an **open laboratory**, where calibration and training activities can be carried out by JRC staff together with officers from other institutions : inspectors, European and non-European scientists. They will find in PERLA well characterized fissile materials, specialized support and suitable laboratories.

References

/1/ M. CUYPERS, S. GUARDINI — Performance Assessment Method for NDA. A Challenge for PERLA. ESARDA Bulletin No. 9, October 1985

/2/ M. CUYPERS, T. DOYLE, S. GUARDINI, J. LEY — PERLA, a Laboratory for Training and Performance Assessment of Safeguards Technique. Proc. of INMM Intern. Symp., June 1986, New Orleans, La. (USA)

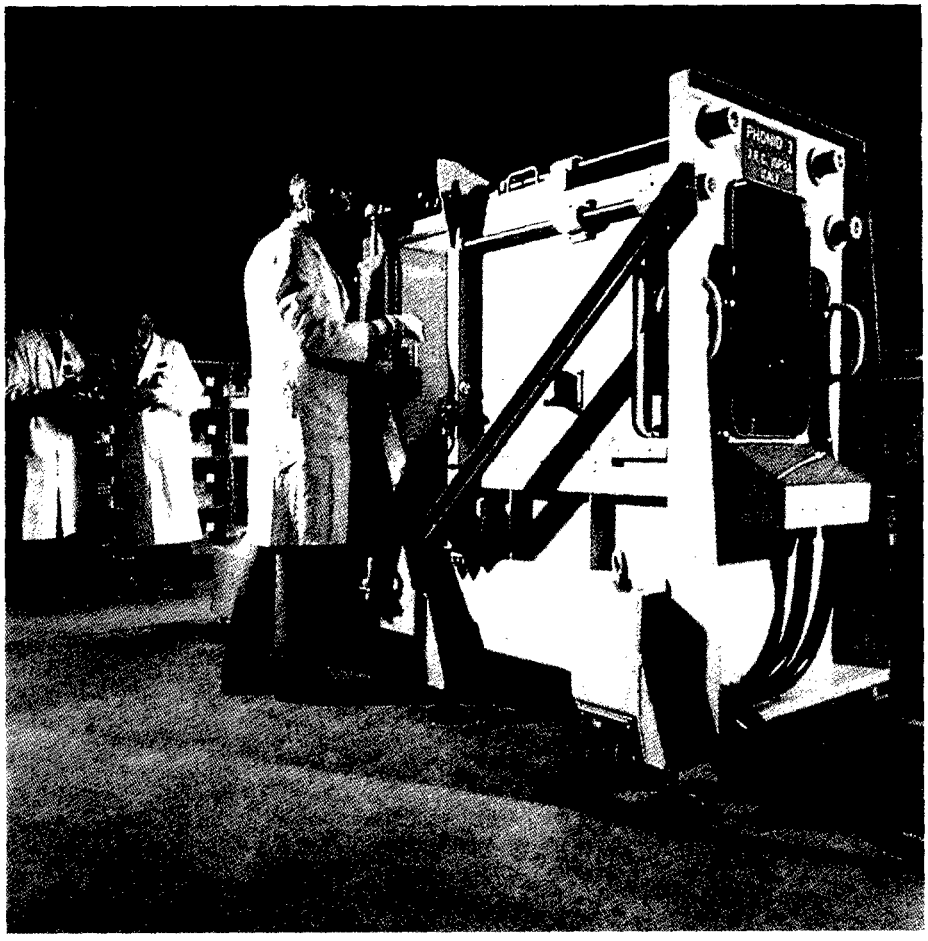

Fig. 14 - View of the PHONID 3 instrument, photoneutron interrogation device to monitor plutonium and uranium bulk samples

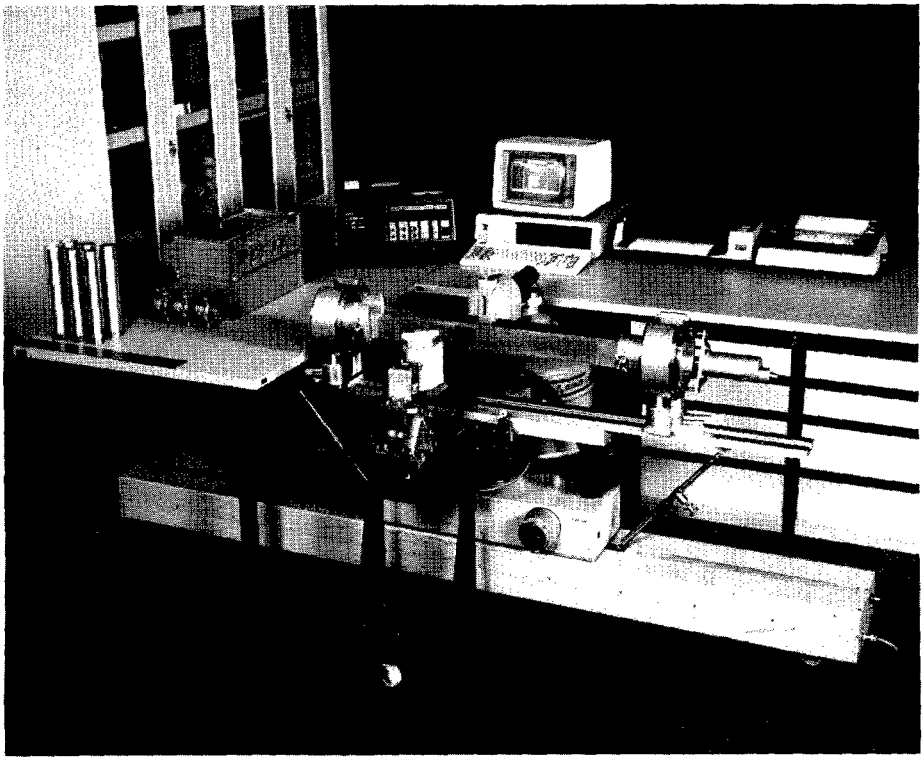

Fig. 15 - View of the MTR gamma scanner

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Monitoring of Field Data

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Abstract

Euratom is developing presently a modular monitoring system in order to enhance containment and surveillance measures in nuclear plants. Since this monitoring system includes the authenticable transfer of measurement data it will also be applicable for the monitoring of NRTA field data.

In the paper the functional design of the modular monitoring system is described together with an application to a tank store.

Introduction

With the scope of improving the efficiency of todays safeguards and to cope with the evolution of the fuel cycle in the European Communities, Euratom invests some effort to further develop containment and surveillance (C/S) methods /1/. These efforts also include the further development of the technical means. It had been proposed that the integration of monitoring, or data logging into C/S significantly improves the assurance which is obtained from the application of C/S measures.

We are in the process of completing the development of a monitoring system which we consider suited for a large range of applications. The collection of NRTA field data should be another useful application for this monitoring system.

Requirements for a Safeguards Monitoring System

Data from different measurement instruments, which will be called sensors, must be collected in a central station or in substations. The sensors may be distributed over large areas of the plant. The monitoring system which collects these data must fulfill the following requirements ;

- reliability (data must not get lost or modified),
- tamper resistance, data authentication,
- functional reliability,
- possibility for adaptation to field requirements and for extension,
- user-friendliness,
- cost efficiency (use of standard components).

Except for the authentication problem, commercial monitoring systems exist in industrial plants (so called Building Automation Systems), for instance, for the collection and evaluation of infrastructure related data. This experience had been incorporated into the design of the VACOSS fiber optic seal /2/ which started to enter safeguards use some five years ago.

Structure of the VACOSS Monitoring System

A design proposal for a Safeguards Monitoring was made in the early 1980s /3/ and a demonstration prototype was built for the continual verification of VACOSS seals, named Local Verification System (LOVER). Maintaining the basic structure, the system was redesigned and has been extended to accept as sensor also any ON/OFF sensor /5/. Presently also general measurements sensors are being included. Fig. 1 shows the layout of the basic system with its 4 levels. The combination of several systems in a fifth level, central station, is of course possible but not the scope of this presentation.

The system operates in a strictly hierarchical way, i.e. each level has direct access to the next lower level only. Each level operates autonomously after initialisation, surveils the lower level, retrieves and stores any new information and keeps it available for the next higher level. Since each level is equipped with suitable memory capacities the failure of a higher level does not cause a system failure.

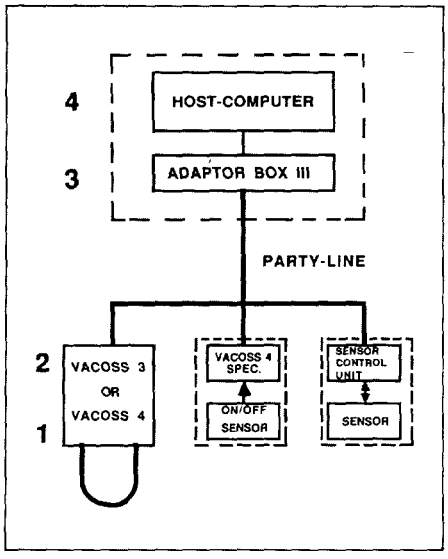

Fig. 1 - Modular Monitoring System

The sensor data is read by the level 2 sensor control unit (SUE); both are integrated into one, tamper resistant housing. Upon request by level 3 the SUE sends the requested information on the party-line to the adaptor box III (ADBIII) as clear text and encrypted text. By decryption and comparison the ADBIII authenticates the message, adds it to its own data set and in case the data set had been requested by the host computer the latter receives the message.

The VACOSS 3 and the improved VACOSS 4 seals are both fiber optic sensors combined with a SUE of limited capacity. The VACOSS 4 special is essentially the SUE which may surveil any ON/OFF sensor (motion detector, threshold detector, etc.). This presentation is concerned with the general SUE.

Description of the Monitor Components

Sensor

Any device which produces an information signal (electric current, voltage, frequency, or digital signal) may be used as sensor. There may be several signals, representing measurement information and dynamic or static states of the sensor. Dynamic states may change repeatedly between ON and OFF (fiber loop, sensor power supply, etc.); a static variable can only change once after initialisation and it is normally used to indicate tamper conditions or component failure.

Sensor Control Unit (SUE)

Figure 2 shows a symbolic diagram of the SUE. The main component is a single chip microcomputer (8 k Byte memory). The SUE continuously surveils the state of the sensor, it keeps the time and a record of the last status changes with the time when they occurred. Upon request of level 3 the SUE may give control information to the sensor and read measurement information.

The SUE number (the sensor address) and the identifier are fixed data; the encryption key and initialisation date and time are data which the SUE receives upon

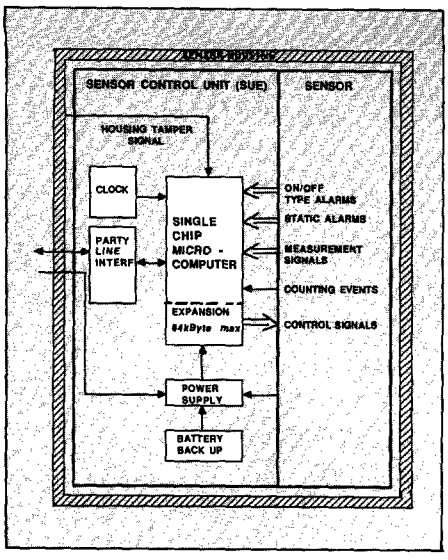

Fig. 2 - Schematic Diagram of Sensor Control Unit

initialisation.

The SUE may be extended (64 k Byte maximum) which allows it to perform quite complex data collection and evaluation functions.

Adaptorbox III (ADBIII)

The originally developed adaptor boxes I and II were designed for manual interrogation of the VACOSS seals; the ADBIII has been developed for automated interrogation of VACOSS seals and the VACOSS compatible SUEs. The ADBIII is an interface unit, a single board microcomputer (FALCON from Digital Equipment Corporation), which executes all the routine work required for the interrogation of the SUEs. Its basic functions are as follows :

- management of the party-line communication,
- encryption/decryption and authentication,
- maintaining of the data required for addressing and communication with the SUEs,
- date and time keeping,
- cyclic surveillance of the SUEs for changes of status and updating of the alarm table (table of status changes obtained from SUEs and detected by the ADBIII),
- communication with SUEs upon specific request from the host computer,
- communication with the host computer via an RS-232 port.

The frequency of SUE interrogation, the encryption key, the identifier (encryption key for the first initialisation), and the configuration of the SUE status change table can be defined individually for each of the SUEs.

Host Computer

With the routine work being executed by the adaptor box the host computer can be selected in view of the

- amount of data to be processed and the evaluation software,
- the required input/output facilities and periferals; one port (presently RS 232 C) is required for the communication with the ADBIII.
- the environmental conditions.

Multiple I/O ports, multitasking or parallel processors will normally not be required for the monitoring task.

The application software of the host computer must satisfy the following functions :

a) initialisation of all components (ADBIII and SUEs),
b) retrieval of status change information from the ADBIII, evaluation and storage,
c) retrieval of measurement information from the SUEs (through the ADBIII), evaluation and storage,
d) user-friendly inspector interface and preparation of output (hard copy, floppy disc, etc.).

We have used a HP41CX computer for a demonstration of the monitoring system with several VACOSS seals and a motion detector (VACOSS 4 special), satisfying functions a), b) and d) /4/. For laboratory test and development an IBM compatible PC is used presently.

Application of the Monitoring System

A first application of the monitoring system is presently developed for a Pu-nitrate store. The liquid arrives in small containers and is accumulated in 300 l tanks. Sealing of the tanks for Safeguards purposes ist not feasible technically.

In order to reduce the remeasurement effort the liquid volume will be monitored continuously using the operators level gauges (capacitance sensors). With the knowledge of

- the present volume and
- the volume changes since the last verification measurement,

the Pu content can be calculated if there were no volume additions in the mean time. Fig. 3 shows the system layout. The capacitance signal is converted to frequency and then converted into current to supply the operators control instrumentation. The output of the capacitance-frequency converter (sensor) is read by the SUE and transferred through the ADBIII to the host computer. The SUE will also monitor the status of the power supply of the converter. Since the frequency-current converter includes variable range adjustments it is better for safeguards purposes to pick-up the frequency signal. The electronic units and the positioning devices for the capacitive sensors will be protected by VACOSS seals.

The SUE in this application is equipped with an external memory expansion so that 2 types of measurement signals can be generated upon request of the host computer :

- single frequency readings,
- the average frequency and standard deviation of N readings at T/sec interval.

The host computer will obtain from the ADBIII the alarm information such as VACOSS seal events, power supply failures of converters, party-line continuity problems, etc. It will request through the ADBIII at regular intervals the results of the frequency measurement of the different SUEs.

The interpretation of the frequency values in volume is done by the host computer, using experimentally obtained calibration constants.

Calibration tests have shown that also temperature information is required for each tank in order to improve the volume calculation. This information is collected by different SUEs, which are not indicated in Fig. 3.

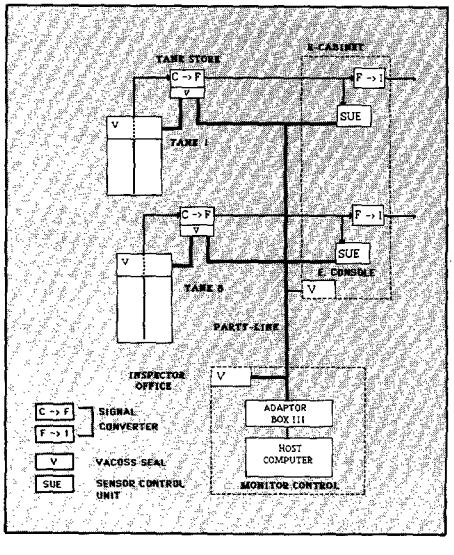

Fig. 3 - Liquid Level Monitor

With suitable algorithms the volumes, volume changes and the periods of stable volume are evaluated and stored.

Other software packages in support of the inspector are planned for the review, consolidation and documentation of the tank history. Together with inspection data from other sources the inspector will eventually be able to arrive at a complete safeguards analysis of the tank store. For this reason, a multitasking micro-computer has been chosen as host computer.

In the present project, 8 tanks will be read for level (frequency) and for temperature (current) and 5 VACOSS seals will be monitored, i.e. all together 21 sensors. In the long term the number of tanks will be increased.

No basic problems are expected in that respect. Since the data communication will always use the same party-line, no modification of the installations will be required.

Conclusion

The above described modular monitoring system will permit to collect field data in authenticable way making use of operators sensors (and measurement equipment) and of standard components for data communication. Addressable sensor control units which are connected by a single party-line and the encrypted data transfer simplify installation, operation and verification of the monitoring systems. This system will be suited also for the monitoring of NRTA field data.

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CBNM Information

Central Bureau for Nuclear Measurement
Commission of the European Communities
Joint Research Centre
Geel Establishment

Regular European Interlaboratory Measurement Evaluation Programme (REIMEP)

After the interruption of the US Safeguards Analytical Laboratory Evaluation (SALE) Programme, CBNM took the initiative to organize an enquiry among former SALE participants and the ESARDA-WGDA members (European Safeguards Research and Development Association - Working Group for Techniques and Standards in Destructive Analysis). Many laboratories announced their interest for such a programme and it was decided to launch a Regular European Interlaboratory Measurement Evaluation Programme (REIMEP) in 1986. Still the same year PuO_2 and UF_6 measurement rounds were organized and the results discussed with participants in June 1987. Both were very revealing, in view of comparing gas mass- and thermionic mass spectrometry with γ-ray spectrometry in the case of UF_6, or Pu element determinations on samples in different containers. Measurement rounds on UO_2 powder, UO_2 pellets, and Uranyl- and Pu-nitrate solutions are in an advanced state of preparation for 1988 (Fig. 1).

The objectives and characteristics of REIMEP can be summarized as follows :

a. Provide state-of-the-practice pictures for the assay of a given fissile isotope abundance or element content of a given nuclear material (Example, Fig. 2). It is not primarily intended to perform the evaluation of a particular method, nor is it intended to demonstrate state-of-the-art or ultimately achievable, optimum performance.
b. Officially guaranteed coded participation; individual results only to concerned participants.
c. Limited frequency; to be discussed with participants.
d. Participants to work under normal working conditions (their own choice).
e. Reporting of results in graphical display (again only to participants).
f. Conclusions to be drawn by participants for themselves; assistance is given if requested.
g. Provide characterization value with a provable total uncertainty which should be smaller than the interlaboratory spread.

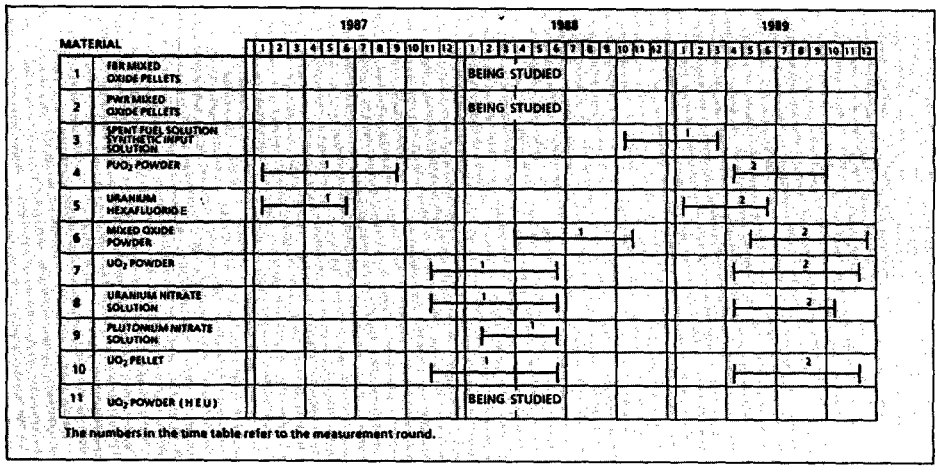


Fig. 1 - Approximate frequency of measurement rounds (status February 1988)

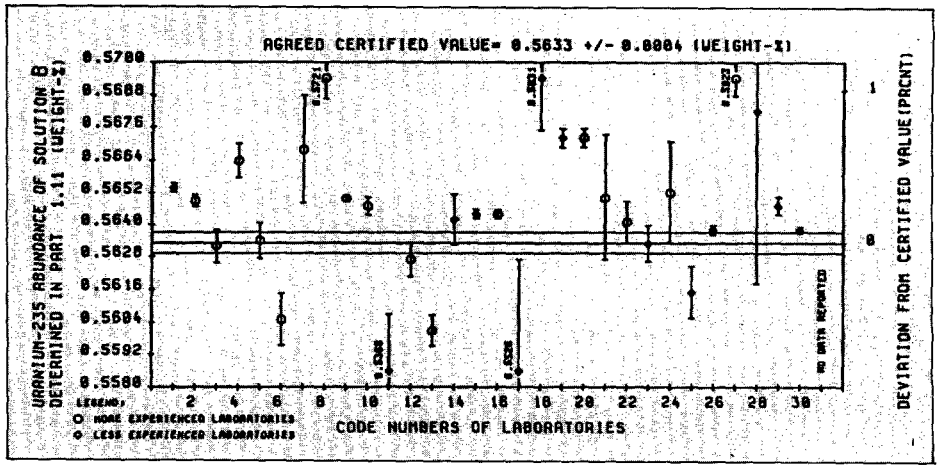


Fig. 2 - Typical example (taken from IDA-80) how a graph with REIMEP results will be presented

CBNM, supported by a few experienced European laboratories, is responsible for coordination, test sample preparation, dispatching and characterization of the material. Coding of participants, collection of results and evaluation is performed only by CBNM for reasons of its independence.

Participation is open to all laboratories within the European Community and - depending on the number of European participants - also open for some non-EC applicants. A participation fee is requested.

For further information, please address to : Central Bureau for Nuclear Measurements, Materials Division, Steenweg op Retie, B-2440 Geel (Belgium)
Tel.: (014)571271, Telefax : (014)584278, Telex : 33589 EURAT B

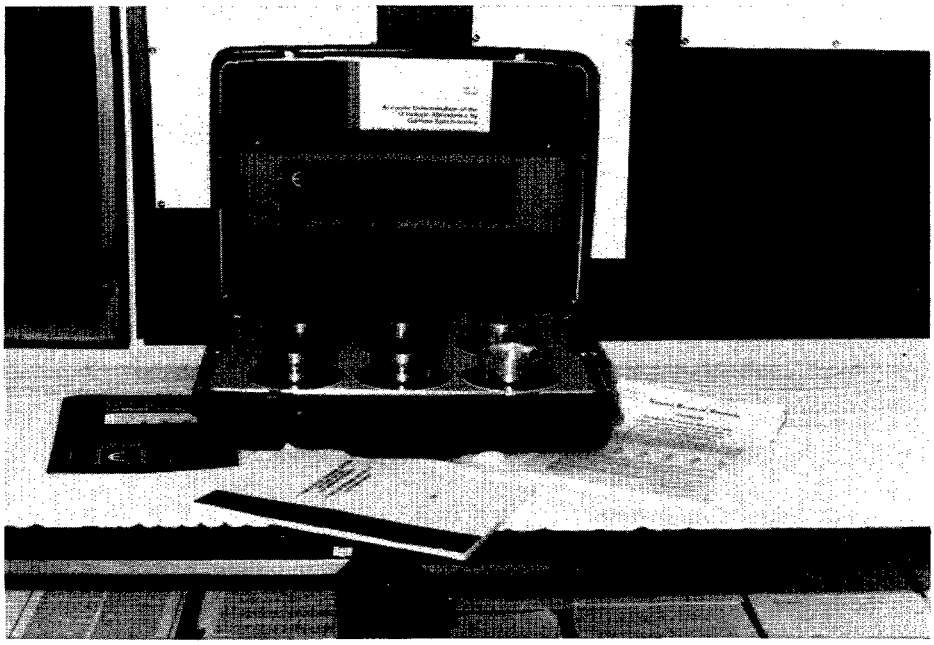
A Joint European-American Certified Reference Material for Uranium Isotopic Measurements by Gamma Ray Spectrometry

International collaboration co-ordinated by the Central Bureau for Nuclear Measurements of the Commission of the European Communities and the U.S. National Bureau of Standards has resulted in the preparation and joint certification of a Reference Material for gamma-ray spectrometric measurements of the U-235 isotope abundance in homogeneous bulk material.

The RM is designed both as EC-NRM 171 (European Community Certified Nuclear Reference Material No. 171) and NBS SRM 969 (National Bureau of Standards Standard Reference Material No. 969). It consists of a set of five sealed cans, each of which contains 200 g U_3O_8 with one of five different U-235/U isotope abundances. Their nominal values are 0.31, 0.71, 1.94, 2.95 and 4.46 mass percent. The set includes an empty can for measurements of material of unknown U-235/U abundance under similar geometric conditions. In addition, each reference sample prossesses an ultrasonic identification system which generates a unique ultrasonic spectrum. This system can be used to verify the identity and integrity of each can.

Detailed reports have been issued which describe the preparation and certification of the RM. The European report is published as report COM 4153; the corresponding U.S. report is NBS Special Publication 260-96. A User's Manual has been prepared by the Kernforschungszentrum Karlsruhe (KfK), Federal Republic of Germany, and is published as KfK 3752 (May 1985).

The Reference Materials set costs 4224 ECU. Additional information is obtainable from : Central Bureau for Nuclear Measurements, Steenweg op Retie, B-2440 Geel (Belgium).



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