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THE SECOND US/FRG WORKSHOP ON NEAR-REAL-TIME ACCOUNTING FOR REPROCESSING PLANTS

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ABSTRACT

The second technical workshop on near-real-time accounting in an industrial scale reprocessing plant was held from December 7-9, 1987 in Los Alamos. The workshop was organized within the context of the US/DOE-FRG/BMFT agreement in the field of international safeguards. The workshop was initiated by the Los Alamos National Laboratory and the DWK, which has responsibility for construction and operation of a planned industrial scale reprocessing plant in the FRG.

The workshop objective was to review current state-of-the-art in near-real-time accounting and to develop a common understanding among experts from the participating countries to identify problems requiring additional work.

INTRODUCTION

The topic of near-real-time accounting (NRTA) for large-scale reprocessing plants has been under discussion within the international safeguards community for at least ten years. Within the last few years the studies have evolved from theoretical designs to actual testing of the concept under plant operating conditions. The first workshop held in Hannover in May 1986 resulted in descriptions of plant experiments conducted in the FRG at Karlsruhe, in the UK at Dounreay, and in Japan at Tokai. All of these experiments demonstrated the general applicability of NRTA and also identified areas requiring further technical development. The results indicated that implementation of NRTA would be highly facility specific.

The second workshop was held to review new work in the general area of NRTA that has been performed since the first workshop.

RESULTS OF THE WORKSHOP

The workshop was held from December 7-9, 1987, at the Los Alamos National Laboratory. Over fifty experts from five different countries and two safeguards inspectorates were in attendance. The workshop participants included plant designers, instrument designers, systems engineers, statisticians, and representatives from both IAEA and Euratom with expertise in both systems studies and inspections.

The workshop was organized to cover five topics. The first session reviewed the status of experiments demonstrating NRTA and process monitoring; the second session discussed work in calibration of equipment required for NRTA; the third session reviewed work in process simulation; the fourth session covered the general area of data treatment and statistics; and the fifth session reviewed work in the area of verification. The results of each session are briefly reviewed.

Experiments

Terry Jones of Dounreay reviewed recent experiments in NRTA that were performed during a campaign between September 1985 and February 1986.[1] The campaign involved the reprocessing of 32 fast reactor fuel subassemblies containing 350 kg of plutonium. The experiments demonstrated that NRTA provides an early warning of trends in material loss or gain that can be evaluated immediately. The technique is used routinely at Dounreay to monitor process operations as well as for safeguards purposes.

In the experiments at Dounreay the inventory of tanks is measured, whereas plutonium in solvent extraction contactors is not measured but rather is inferred from plant construction and plant operating parameters. Maurice Delange of COGEMA reviewed the cumulative flux technique that is used at La Hague to account for plutonium. No attempt is made to measure material within the process; rather values for process inventory are assigned based on process operating parameters.[2] Thresholds are arbitrarily set that are used to determine when process uncertainties are not acceptable, at which time a partial cleanout is effected to bring uncertainties back within acceptable limits. Future plans call for a statistical approach to establishing thresholds. For a typical campaign the in-process material may be between 150 and 200 kg with approximately 100 kg

within the reprocessing portion and the rest in the oxide conversion process. Although cumulative flux (also known as running book inventory) is used for accounting in the facility for the French National system, some questions were raised whether the technique is sufficiently timely or sensitive for international safeguards applications.

T. Nakai of PNC reviewed recent work on NRTA at Tokai for a campaign in 1986. The bias of CUMUF relative to throughput was approximately 1%. The conclusions of the study were (1) an abrupt loss of 3-1/2 kg of plutonium would be detected, (2) protracted losses cannot be distinguished from flow measurement bias, and (3) further study on measurement biases is needed.

Joachim Lausch of WAK summarized work at the Karlsruhe Reprocessing Plant. Only those measurements required for process operations are used for NRTA. Recent developments have concentrated on improving data bases. Three computers are available: a process control computer, laboratory automation computer, and an all-purpose computer that has information on in-process inventory and statistical analyses. A second area of development involves studies to improve plutonium inventory determination without disturbing the plant operator. A third area of study involves determination of in-process inventory through statistical techniques.

Frank Halford of the UKAEA expressed his thoughts on applications of NRTA. He noted that a lot of work has been done on statistics, and many statistical tests have been developed. He suggests that it is time to stop development of tests and concentrate on identifying one or two tests that can be applied universally. Outstanding issues include (1) determining the quantity of source data required, (2) determining the extent to which those data have to be independently verified, (3) establishing operational and political feasibility of acquiring and independently verifying the necessary data and only then (4) acquiring statistical tests and decision rules for drawing conclusions from the data. He believed that it should be possible at each facility to determine, on the basis of correlations, a minimum necessary and sufficient data set that would need to be verified. He also expressed the view that this data set need not be large because of the correlations and process constraints.

James Lovett of the IAEA reviewed work on process monitoring that they had funded. He has concluded that process monitoring has problems for verification and international safeguards and does not see any significant role for process monitoring within international safeguards. The IAEA will no longer support process monitoring as a possible safeguards technique. M. Ehinger reviewed process monitoring experiments that have been conducted recently at ORNL. In general discussion, the attendees expressed the opinion that process monitoring as such cannot be considered as an international safeguards tool, although it will be important for both plant operation and domestic safeguards.

Calibration of Equipment

The session on calibration of equipment indicated that much work has been done and is being done on calibration of the input accountability tank and calibration of tanks in general: however, not much work appears to be done on calibration of NDA methods. This is an area for possibly more emphasis in the future.

M. Aparo described collaborative work between Casaccia, the IAEA, and the U.S. in volume calibration. A RUSKA electromanometer is being compared to other volume measurement equipment and techniques. The effect of the shape of dip tube ends was reported.[3]

Accountancy tank calibration work also was reported by J. Lausch at WAK and T. Nakai at Tokai.

Process Simulation

The session on process simulation indicated that simulation will play an important part in understanding how a reprocessing facility operates as well as for designing processes and safeguards systems.

M. Canty reviewed the simulation of a triple tank system in the Wackersdorf reprocessing plant.[4] The use of triple tanks (receipt, sample, feed) for each purification cycle is unique to Wackersdorf. Because only the middle tank in each bank can be sampled, the simulation was designed to study possible errors that could be introduced into the process inventory contribution to MUF. The study showed that errors in holdup determinations introduced by concentration fluctuations during normal plant operations are small and probably negligible.

M. Aparo and coworkers in Italy are modeling the nuclear material flows and measurements through the EUREX pilot reprocessing plant.[5] Plant throughput and inventory are smaller than for other reprocessing plants that have been studied. The work reported was preliminary in nature. Additional work will determine the sensitivity of NRTA in detecting a diversion.

Three presentations addressed the relationship of solvent extraction contactor inventory to detection sensitivity. A. Beyerlein of Clemson has continued his excellent work in development of techniques for estimation of plutonium inventory. He has extended the work to include pulsed columns as well as mixer-settlers and has developed equations for non-steady-state operation.[6] Los Alamos workers are studying the contribution of uncertainties in solvent extraction contactor inventory relative to uncertainties in throughput

and other inventories to bound the IAEA independent verification problem.[7] J. W. Barnes of Los Alamos also reviewed methods for measuring or estimating contactor inventory.

Data Treatment, Statistics, and Other Tools

Rainer Beedgen (KfK) presented results of recent application of the computer program PROSA to data from reprocessing campaigns at WAK. The required input to the program includes the desired false alarm probability for the number of balance periods, the measurement model of the facility, and a sequence of materials balance results. PROSA now incorporates four statistical tests: CUMUF, Page's, Power One, and GeMUF.[8] He concluded that the NRTA test procedures are useful for detecting anomalies in currently available plant data.

Barry Jones described the progress at BNFL on applying Page's test to the SITMUF sequence. At present, he uses a joint test; that is, a computer program applies two tests, in turn, at each period.[9] For one test, the Page's test parameters are chosen to give the best chances of detecting abrupt loss. For the other test, the parameters are chosen for best performance against protracted loss. Of course, statistical tests can only detect an anomaly in sequential data. The problem remains to resolve that anomaly.

H. Nishimura (NMCC) showed plots and alarm charts from the statistical analysis of NRTA field test data acquired at the Tokai-mura reprocessing facility. He used a full covariance matrix and favors the Kalman filter test.

Group discussion focused on whether systematic errors should be included in the measurement model because their inclusion might lessen the sensitivity of the statistical tests. Sellinschegg (IAEA) pointed out that paired comparisons of data by the IAEA show that systematic errors are dominant. If they are not considered, the number of false alarms may increase unacceptably. Furthermore, systematic errors cannot be assumed to remain constant over a year, or even during a campaign. Erwin Leitner (DWK) described a statistical analysis of 2000 measurements, designed to elicit how long a given systematic error persists. The participants concluded that systematic errors should be found and corrected, or preferably eliminated by the adoption of unbiased measurement methods.

H. Kawamoto (JNFS) described the JNFS Reprocessing Plant, now under construction, and showed the basic process flow sheet. How NRTA will be applied in this facility is still under discussion. K. Ikawa (JAERI) presented detailed information on the computer system and operating procedures for the analysis of NRTA data at the Tokai Reprocessing Plant. The system features a common data base for the IAEA inspector, national inspector, and plant operator, as well as common utilization of software.

Verification

U. Wenzel of the IAEA reviewed some alternatives under consideration for verification of operators' declared safeguards data. These include

- on-site verification
  - using operator's equipment
  - using IAEA-installed instruments
  - in an IAEA on-site laboratory
- off-site analysis.

Consideration of the use of operator's equipment has been dropped for now. The IAEA on-site laboratory is considered too costly and is not now under consideration. The use of installed instruments on-site is preferred both for cost and timeliness, although precision may be sacrificed. The ultimate choice of techniques will be made on the basis of accuracy, authenticity of data, independence, and timeliness.

F. Franssen and U. Wenzel of the IAEA discussed on-site verification presently practiced at facilities. An IAEA-owned electromanometer is calibrated by the Agency and operated by the facility. A K-edge densitometer is owned and operated by the facility with some IAEA participation in calibration. Both systems are considered to provide acceptable verification of operator's data.

R. Haas of Euratom discussed a modular monitoring system applicable to NRTA field data. A first application is to monitor plutonium nitrate in product storage tanks. The technique is based on technology originally developed for monitoring VACOSS seals and is described in detail in Ref. 10.

R. Poulkes reviewed plans for verification of NRTA data at the THORP facility. The system implies use of operator's equipment and data with measurements sufficiently transparent to allow verification without compromising sensitive technology and without undue demands on operator's time. Data analysis and interpretation and anomaly resolution are important requirements.[11]

General conclusions from the session on verification were that although much work has been done since the Hannover workshop, this is the area probably requiring the most effort for implementation of NRTA in reprocessing plants for international safeguards.

REFERENCES

1. T. Jones and D. Gordon, "Near Real Time Materials Accountancy at Dounreay," in Nuclear Safeguards Technology 1986, Volume 1 (International Atomic Energy Agency, Vienna, 1987), pp. 97-105.

2. M. Delange, "Safeguarding a Reprocessing Plant with the Method of Cumulative Flux," 3rd International Conference on Facility Operations--Safeguards Interface, San Diego, California, November 29-December 4, 1987 (to be published in proceedings).

3. M. Aparo, M. Dionisi, and S. Suda, "Volume Calibration and Instrument Testing at ENEA Central Research Laboratory, Casaccia" J. Nucl. Mater. Manage. (to be published).

4. R. Avenhaus, M. J. Canty, E. Leitner, R. Weh, and H. J. Hein, "Material Accounting in the Triple Tank Systems of the Wackersdorf Reprocessing Plant," J. Nucl. Mater. Manage. (to be published).

5. M. Aparo, M. Dionisi, P. Zeppa, F. V. Frazzoli, R. Remetti, and C. Portale, "A Feasibility Study on NRTA Implementation at EUREX Pilot Reprocessing Plant: Process Flow Sheet and Measuring System Simulation," J. Nucl. Mater. Manage. (to be published).

6. A. L. Beyerlein and J. F. Geldard, "Nuclear Material Inventory Estimator in Solvent Extraction Contactors - II," Clemson University report (September 1987).

7. E. A. Hakkila, J. W. Barnes, and J. F. Hafer, "The Use of Process Information for Verification of Inventory in Solvent Extraction Contactors in Near-Real-Time Accounting for Reprocessing Plants," this meeting

8. R. Beedgen, "Present and Future Aspects of PROSA - A Computer Program for Near Real Time Accountancy," Nucl. Mater. Manage. 16 (Proceedings), 499-504 (1987).

9. B. J. Jones, "Comparison of Near Real Time Materials Accountancy Using SITMUF and Page's Test with Conventional Accountancy," in Proc. Ninth ESARDA Symposium on Safeguards and Nuclear Material Management, London, UK, May 12-14, 1987 (European Safeguards Research and Development Association, Joint Research Centre, Ispra, Italy, 1987), ESARDA 21, pp. 255-259.

10. R. Haas, Y. Haurie, H. J. Metzdorf, and H. Reuters, "Monitoring of Field Data," ~~to be published in the~~ ESARDA Bulletin, 14, 11-13 (May

11. R. W. Foulkes, "Production and Verification of Materials Measurement Data for NRTMA in THORP," J. Nucl. Mater. Manage. (to be published).