Leo Sannen

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC

Institute for Transuranium Elements
Technical Physics

EUROPEAN WORKING GROUP
on
„HOT LABORATORIES AND REMOTE HANDLING"
Karlsruhe – Germany

October 13 – 15, 1999

FINAL AGENDA

Wednesday 13 October 1999

12:00 Registration

12:30 Lunch

13:45 Opening address by **Mr. Jean-Paul Glatz** (Institute for Transuranium Elements)

Session I: Safety & Quality Standards
Chairman: Jean-Pierre Levêque

14:00 *Rehabilitation of Nuclear Facilities in Operation. Cadarache Hot Laboratory (LECA)*
Jean-Philippe Girard, N. de Seroux

14:20 *Nuclear Installations in Operation: Control of the Containment and Methods for Improving the Associated Systems*
Alain Michel, Gilbert Bruhl

14:40 *ISO9000-Certification of a „Hotlab"*
F. Groeschel, G. Ledergerber, G. Bart

15:00 *Quality Assurance in Nuclear Fuel Research at the Laboratory of High- and Medium-level Activity at SCK-CEN*
L. Sannen, A. Gys, M. Verwerft

15:30 Coffee break

16:00 *How to apply „Quality" in Nuclear Analytical Chemistry: an Illustration*
S. Van Winckel, M. Gysemans, L. Vandevelde

16:20 *QA in the Hot Cells Laboratory at NRG-Petten*
Gin-Lay Tjoa, K.A. Duijves

16:40 *Application of the ALARA Principle to the Design of New Nuclear Laboratories, and to the Definition of Safety Options for Dismantling Operations, with Regard to the Radiation Protection Objectives*
Gilbert Bruhl

19:00 Dinner at Hotel Renaissance

Thursday 14 October 1999

Session II: Waste Management - Decommissioning – Refurbishment
Chairman: Martyn Stucke

8:30 *Agreement between AEA-Technology and BNFL: New Joint Services Company*
Martyn Stucke

8:50 *Waste, Contamination Assessment, and Drainage Issues*
Fernand Benchikhoune, Christophe Lacroix

9:10 *The Hot Cell Radioactive Waste Concept of FZ-Jülich*
G. Pott, St. Halaszovich

9:30	*Epoxy Mounted Ceramographic Samples as a Waste Form* Max Lundström, **Leif Kjellberg**, Bengt Sundström and **S.Hammar**
9:50	*Maintenance of Three Cells in the Hot Cell Laboratory at Studsvik* Arne Holmér, **S. Hammar**, Rose-Marie Carlson and B.Sundström
10:10	*Dismantling and Decontamination of Nuclear and Radioactivity Facilities in Research Centres* J.L. Díaz, **Joaquin Serrano**
10:30	**Coffee break**

Session III: Topical PIE Techniques
Chairman: Günther Pott

11:00	*Review of Some Advanced Methods of Post-Irradiation Investigations Developed at SSC RIAR* V.A. Tzykanov, V.N. Golovanov, **Yu.M. Golovchenko**
11:20	*The use of Local Cooling Method for Investigation of Irradiated Fuel Pins and Fuel Assemblies of BN-and VVER-type Reactors* **J.M. Golovtchenko**, A.V. Suchich
11:40	*PIE – a Need for Future Developments* **W. Goll**, R. Manzel
12:00	*Neutron Radiography using the SINQ – Experimental Set-up and Operational Experience* **R. Bühner**, P. Schleuniger, L. Wiezel, E. Lehmann, F. Groeschel
12:30	**Lunch**

13:30	Departure for Institute for Transuranium Elements (ITU)
14:00	Visit to the Hot Cells of ITU

SOCIAL PROGRAMME

16:30	Departure for ZKM (Centre for Art and Media)
17:00	Visit to ZKM
18:30	Departure for restaurant "Kühler Krug"
19:00	Dinner hosted by the ITU
22:00	Departure for Hotel

Friday 15 October 1999:

Session III (cont.)

8:30 *Local Hydrogen Concentration Determination in Zircaloy Cladding Material*
R. Brütsch, D. Gavillet

8:50 *A Modified Hot Extraction Method to Determine the Hydrogen Content of Corroded Cladding Metal and Oxide*
H. Wiese (FH-Jülich), M. Steinemann, R. Bühner, A. Hermann

9:10 *Hot Cell Facility for Hydrogen Analysis*
J.G. Gravenor, J. Coole, P. Ramsay

9:30 *The „Fabrice" Process in LECA Laboratory at Cadarache*
Jacky Furlan, Michel Burger, Guy-Marc Decroix

9:50 *An Instrumental Method to investigate the Diffusion of Trace Elements in Zirconium Oxide Layers and Zircaloy Cladding Materials*
M. Betti, L. Aldave de las Heras, O. Actis-Dato, T. Gouder, E.H. Toscano

10:10 Coffee break

10:40 *Electron Microscopy for PIE: New Developments*
T. Wiss, I. Ray, H. Thiele, W. Huber and Hj. Matzke

11:00 *New Facilities for High-Temperature Physical Property Measurements in α–γ Active Materials*
C. Ronchi and **M. Sheindlin**

11:20 *New Machining Equipment of the Laboratory for Irradiated Material Studies*
Guy-Marc Decroix, Patrick Bottin, **Jean-Yves Blanc**, Patrick Duigou, Olivier Howland, Luc Moitrelle, Alain Rigou

11:40 *Experiences with Small Size Specimen Testing*
Gin-Lay Tjoa, M.G. Horsten

12:00 Lunch

14:00 Final Discussion of Sessions I, II and III

15:00 End of meeting and departure

October 18, 1999

EUROPEAN WORKING GROUP

on

« HOT LABORATORIES AND REMOTE HANDLING »

Chairman: J.-P. Leveque
1st session : Safety and Quality Standards

This session was devoted to the following items : Standards, Calibration, Validation, Regulations & Safety Authorities. The chosen subject was initiated by a letter from M. G. L. TJOA, from NRG (Petten) to the President of the Programme Committee, highlighting a common concern in these items to all the European hot laboratories.

Seven presentations were made during this first session.

1. **Rehabilitation of nuclear facilities in operation - Embodiment to the Cadarache Hot Laboratory (LECA) - Goals, processes and implementation** - J. Ph. GIRARD, N. de SEROUX (CEA Cadarache - DRN/DEC/PLCC - France).

This presentation, made by the head of the Hot Laboratory in Cadarache Project, described the method used for the reconditioning of the LECA. It included a description of the purpose of the operation, of the rehabilitation process and of the study and performance, currently under way. One of the main drawback of this project is that it must be performed taking into account a level of scientific work which remains very high. From this point of view, building a fully new facility seems rather less difficult than refurbishing an old one in operation.

2. **Containment control and improvement elements** - A. MICHEL, T. DELAFORGE, G. PEIDRO (CEA Cadarache - DRN/DEC/SEHA - France).

As an example and illustration of the first presentation, A. MICHEL described the refurbishment and the ventilation improvement of one of the concrete cells of the LECA.

3. **ISO 9000 - Certification of a Hot lab** - F. GROESCHEL, G. LEDERGERBER, G. BART (PSI - Switzerland).

F. GROESCHEL described the experience in elaborating, with the help of an external consultant, the PSI quality system and its final structure. He mentioned that the quality system is not absolutely necessary but it may help. All the documents are included in a computer file that can be easily reached by each member of the Institute. Such a system must « live » through a continuous improvement process.

4. **Quality Assurance in Nuclear Fuel Research at the Laboratory of High- and Medium-level Activity at SCK-CEN** - L. SANNEN, A. GYS and M. VERWERFT (SCK-CEN - Belgium).

The standards and validation methods developed and applied to the main nuclear fuel research experiments in the LHMA in SCK-CEN were outlined by L. SANNEN. Some applications to the non destructive (length, diameter, zirconia thickness, integrity, B.U.) and destructive (F.G. pressure and content, fuel density and microstructure) measurements using either calibrated or internal standards or disconnected various methods or scientific approach were described. The author highlighted the necessity to build a programme of measurements comparison through the European laboratories which participate to the working group.

5. **How to apply « Quality » in nuclear analytical chemistry : an illustration** - S. VAN WINCKEL, M. GYSEMANS, L. VANDEVELDE (SCK-CEN - Belgium).

After he outlined the difference between « Accreditation » (assessment and periodic audits of the QS by a third party) and « Certification » (guarantee that the calibration will be carried out conform to a QS and well documented), S. VAN WINCKEL illustrated the previous presentation with the example of the BU measurement by the isotopic analysis of plutonium.

6. **QA in the hot cells laboratory at NRG-Petten** - Gin-Lay TJOA, K. A. DUIJVES (NRG-Petten - Netherlands).

The continuous innovations of nuclear applications in the hot cells laboratory (energy issues and medical science) drove NRG to anticipate on all safety and environmental aspects. The management system of the lab has been laid down in a Technical Information Package (small but impressive « bible » booklet distributed to each employee), procedures (32, each in one A4 page) and supporting documents. Internal audits of each of the three groups of NRG occur twice a year leading to a living QS which next implementation will be an integrated management system for the two previous companies (ECN and KEMA) which became NRG last year.

7. **Application of the ALARA principle to the design of new nuclear laboratories and to the definition of safety options for dismantling operations, with regard to the radiation protection objectives** - G. BRUHL (CEA Saclay - DSNQ - France).

G. BRUHL described the general guidance for the application of the ALARA principle (« As Low As Reasonably Achievable ») to the design of new nuclear facilities and the recommended methodology for the improvement of the ALARA process for dismantling operations. The ALARA level can be defined as the boundary line between the acceptable and tolerable residual risk zones in term of individual exposure. The implementation process is a circular progression through the following steps : preparation (individual and collective dose objectives), realisation (dose performance), feedback (analysis) and back to preparation. The key word of the implementation process could « optimization ».

JP LEVEQUE

AEA TECHNOLOGY
NUCLEAR SCIENCE

SESSION 2

Chairman: M. Stucke
Waste Management, Decommissioning and Refurbishment

The session covered three topics, which are becoming more important in the operation of hot cell facilities.

Continued refurbishment of facilities will be needed in the future to maintain a hot cell capability in an environment where the construction of new facilities is unlikely. This refurbishment is needed to re-equip facilities for new activities, to meet the changing needs of the nuclear industry and of course, to maintain or improve safety standards.

Ultimately decommissioning is the fate of all facilities; learning from those doing it now will ultimately reduce future decommissioning costs.

Waste management is essential to the operation of all hot cell facilities both doing operations and decommissioning. It currently represents one of the major costs of facility operations and is tightly regulated in all European countries.

The papers in the session provided four excellent insights into:

- Waste management at Jülich in Germany
- A specific waste issue at Studsvik in Sweden
- Refurbishment of hot cells at Studsvik in Sweden
- Decommissioning of hot cells and a reactor at CIEMAT in Madrid, Spain

"The Hot Cell Radioactive Waste Concept of FZ-Jülich" G Pott and St Halaszovich

The first paper in the session described the hot cell radioactive waste concept at Jülich. This was a comprehensive description of the waste management from its categorisation, collection conditioning and interim storage – to its volume reduction by compaction, incineration and melting of metal waste to find longer-term storage on-site. The paper provided an excellent insight into a system for waste management, which is representative of best practise, and much can be learnt from it. The concept of incineration of burnable wastes and melting of steel for re-use was particularly interesting. These are not carried out to any extent in the UK, but clearly should be investigated in the light of these developments in Germany.

"Epoxy Mounted Ceramographic Samples as a Waste Form" M Lundström, L Kjellberg, B Lundström and S Hammar

The second paper covered a topic, which has caused all PIE hot cell operators difficulties; the disposal of epoxy impregnated fuel. In Sweden, with a policy of deep disposal of fuel, long-term radiolysis of any epoxy left in the fuel is the important issue. This paper from Studsvik described the experimental programme they carried out to evaluate the amount of gas produced and to qualify the containers used to store the fuel.

"Maintenance of Three Cells in the Hot Cell Laboratory at Studsvik, 1998" A Holmér, S Hammar, R-M Carlson and B Sundström

The third paper covered the refurbishment of three cells at Studsvik. This was a most interesting paper with lessons for all. Clearly the main lesson was planning, the time spent effectively planning the whole refurbishment process, from cell decontamination, dismantling, renovation and installation and finally testing would lead to a successful refurbishment project.

Success is measured in not only completion of the work, but also completion below dose budget (ALARP), within cost budget and within planned time-scales is vitally important in today's environment with both regulatory and commercial pressures upon facility operators.

"Decontamination and Dismantling of Nuclear and Radioactivity Facilities in Research Centres" J L Diaz and J Serrano

The final paper described the decontamination and dismantling of the JEN-2 reactor and a hot cell at the CIEMAT facilities in Madrid. The paper described the complex processes required to decommission such facilities in terms of the three stages used by IAEA:

Stage 1: Safe enclosure with surveillance.
Stage 2: External decontamination and partial dismantling
Stage 3: Complete dismantling to full free release of the site for non-nuclear use

The paper described the radiological state of the hot cell facilities after decontamination and proposed plans for the decommissioning of the JEN-2 reactor.

The last two papers made important points about the need to use trained operators for both refurbishment work and decommissioning. Contractors can clearly be used effectively and safely but they need to be guided by, and to work alongside, the in-house operations teams. Extended periods of surveillance in Stage 1 decommissioning would lead to a weakening of the in-house experienced operations team possibly with both cost and safety consequences for Stage 2 and 3 decommissioning.

Martyn Stucke

Session III

Chairman: G. Pott

P.I.E. Techniques

Since more than 40 years the behaviour of reactor fuel elements have been monitored by extensive P.I.E. of fuel, cladding and structural components. Non- destructive pool examinations in Nuclear Power Plants were supplemented by hot cell examinations. Also for the future, examinations in hot cells are necessary for the development of fuel elements and components. Besides the existing P.I.E. methods, the development of new examination techniques are necessary. [P.I.E., Goll; Manzel]

Advanced P.I.E. methods established at RIAR (Dimitrovgrad) were presented by Mr. Golovtchenko. Methods of testing irradiated zirconium claddings, analysing the Xe-release and the radial distribution of burnable poison of irradiated fuel pellets was discussed. Also the use of local cooling methods for fuel pins in order to detect more accurate the fission gas release had been taken into consideration.
[J.M. Golovtchenko]

To improve the understanding of the PCI and to choose better cladding materials, power ramps are simulated in the experimental reactor Osiris at Saclay in order to determine the cladding deformation or the Ramp Terminal Level without rupture.
[CEA]

These experiments need representative experimental rods adapted to the experimental needs. The new process allows to make short test rods using a part of a 4 meters long irradiated PWR rod. The procedure will be done at CEA Saclay.

With respect to higher burn up of LWR fuel elements, the lifetime of fuel cladding has to be increased. Therefore the hydrogen content of irradiated zircaloy cladding and the associated formation of brittle hydride particles is an important consideration with respect for achieving improved fuel performance. Preparing and measuring methods were discussed.

A technique has been developed to locally determine the hydrogen content in zircaloy cladding. This allows to study the influence of the local variation of the H distribution on the mechanical behaviour. After appropriate preparation, the surface of the sample is observed in a Scanning Electron Microscope (SEM) in the Back Scattered Electron mode. The image is then analysed with an image analysis program and the area fraction of the hydrides is quantitatively determined. A correlation between the hydride area fraction and the hydrogen content is established using standard specimens.

Of the methods available for hydrogen analysis, the hot vacuum extraction (HVE) technique was chosen by AEA Technology as being most suitable for hot cell use. Hydrogen analysis using HVE depends on the virtually complete evacuation of hydrogen from zircaloy at temperatures of 1100°C and low pressures of the order of 10^{-4} Pa or better. The hydrogen is collected and its mass determined by volume and pressure measurements. Since fundamental physical quantities are measured, there is no need for calibration against standards of known hydrogen content, although standards are used to check correct operation of the equipment.

Measurement of hydrogen levels and comparison with standard samples obtained from international standards organisations indicates that the accuracy achievable is better than ±1 µg/g (1 standard deviation). During the operation of nuclear power reactors, a layer of zirconium oxide is routinely formed on the cladding of the fuel rods. For the examination of these layers, different methods can be used. For thin films with thickness in the angstroms to nanometer range, techniques such as Auger electron spectroscopy, secondary-ion mass spectrometry (SIMS) and sputtered neutral mass spectrometry (SNMS) can be applied. For thicker coating of up to tens and hundreds of micrometers, glow discharge mass spectrometry (GDMS). At ITU Karlsruhe a GDMS has been installed in a glove box for almost ten years and continues to be the only such installation in the world.

New developments using Electron Microscopy for P.I.E. had been discussed with representatives of ITU Karlsruhe. As a powerful device for microstructural examination combined with chemical analysis, a Philips XL40 Scanning Electron Microscope (SEM) is being installed in a glove box for investigations of radioactive and contaminated samples. The combination of the SEM with a Back-Scattered Electron detector (BSE), an Energy Dispersive X-ray analysis system (EDX) together with a set of micromanipulators mounted in the specimen chamber and a Gunshot Residue Software (GRS) makes it compatible with a large type of applications.
The SEM is complemented by a Hitachi H 700 Scanning Transmission Electron Microscope (STEM) allowing the examination of radioactive specimens. The combination of SEM and TEM techniques provides a powerful combination for radioactive sample microstructure characterisation.
The measurement of high temperature physical properties in □ – □ active material is done with new equipment. The thermal diffusivity is obtained from laser-flash experiments, especially designed to enable also the heat capacity of the sample to be simultaneously deduced. The measurements can be performed on samples of arbitrary shape, under continuous monitoring of integrity and position with respect to the laser probe beam and to the pyrometer optical axis. The samples, with a maximum allowed activity is of the order of 100 Rem/h, are treated in an □ glove-box, surrounded by a 5 cam lead shielding. Selected experimental results of thermophysical measurements on irradiated fuel are presented.

One of the most interesting non destructive P.I.E. method is the Neutron Radiography. At PSI Würenlingen the neutron spallation source SINQ is used for the examination of irradiated nuclear fuel segments and highly activated samples. The specimens are prepared in the PSI hot lab., and then transferred to the SINQ facility. The corresponding installation, the transfer cask, which houses the samples, and the loading and handling procedures had been described. Results of the first experiments were reported.

The tendency to use smaller specimens in nuclear materials research has started many years ago. The driving force for the use of small specimens originates from the reduction of the waste and the increasing costs involved in using irradiation space in materials test reactors. Certain materials properties do not allow an unlimited decrease in size,. Issues like lack of constraint or specimen sizes that approach the grainsize of the material do not allow an unlimited reduction in specimen size. NRG Petten has designed and used over the years a series of specimens in nuclear materials research. The experimental facilities at Petten for testing small specimens had been described. The applicability of the small specimens is shown by the comparison of results obtained from large and small specimens.

For machining unirradiated and irradiated small and big samples at CEA Saclay new facilities had been installed in a hot cell. These are:

- large metallic Kasto saw,
- large fast diamond saw,
- universal numeric drive milling-machine,
- numeric drive turning lathe.

Two other apparatuses are designed for further hot cell commissioning:

- spark erosion machine,
- wire erosion machine.

Information on definition of needs, machines, modifications & adaptations, all technical aspect, safety issues and qualification programs are given.

G. Pott

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on

„HOT LABORATORIES AND REMOTE HANDLING“

KARLSRUHE – GERMANY
INSTITUTE FOR TRANSURANIUM ELEMENTS
OCTOBER 13 – 15, 1999

Compilation of Abstracts

Attendance List

EUROPEAN WORKING GROUP on
„HOT LABORATORIES AND REMOTE HANDLING"

Aldave de las Heras, Laura	ITU
Benchikhoune, Fernand	CEA S.T.M.I.
Bensch, Doris	FZJ
Betti, Maria	ITU
Blanc, Jean-Yves	CEA
Brütsch, Roland	PSI
Bruhl, Gilbert	CEA
Coad, Joseph P.	Jet Joint Undertaking
Cobos-Sabate, Joaquin	CIEMAT
De Haan, K.W.	NRG Petten
De Seroux, Nicolas	Framatome
Delaforge, Thierry	CEA Cadarache
Duijeves, Klaas A.	NRG Petten
Furlan, Jacky	CEA Cadarache
Girard, Jean-Ph.	CEA
Glatz, Jean-Paul	ITU
Goll, Wolfgang	KWU
Golovtchenko, Ioulian	Research Inst. Of Atomic Reactors
Groeschel, Friedrich	PSI
Hammar, Stefan	Studsvik Nuclear AB
Hoffmann, Rüdiger	Siemens KWU
Kjellberg. Leif	Studsvik Nuclear AB
Kleemann, Hans-Jörg	Inst. for Energiteknikk
Kytka, Miloš	Nuclear Research Institute Rez plc
Leveque, Jean-Pierre	CEA Cadarache

Manzel, Reiner	KWU
Michel, Alain	CEA Cadarache
Novosad, Petr	Nuclear Research Institute Rez plc
Oberländer, Barbara	Inst. for Energiteknikk
Pott, Günther	FZJ
Ramsay, Paul	AEA Technology
Sannen, Leo	SCK – CEN
Serrano, Joaquin	CIEMAT
Sheindlin, Michael	ITU
Stany, Klaus	Studsvik Nuclear AB
Stephen, William	BNFL
Stucke, Martyn	AEA Technology
Tjoa, Gin Lay	NRG
Toscano, Enrique	ITU
Van de Velde, José	SCK - CEN
Van Winckel, Stefaan	SCK - CEN
Wiss, Thierry	ITU

Abstracts

I. Safety & Quality Standards

Standards – Calibration – Validation

Regulations & safety authorities

Rehabilitation of nuclear facilities in operation
Embodiment to the Cadarache Hot Laboratory (LECA)
Goals, processes and implementation

J.-Ph. GIRARD* - N. de SEROUX**

**CEA COMMISSARIAT A L'ENERGIE ATOMIQUE, CEA/CADARACHE, F - 13108 ST-PAUL-LEZ-DURANCE, CEDEX FRANCE*

***FRAMATOME, DIRECTION NOVATOME, F - 30200 - BAGNOLS SUR CEZE, FRANCE*

Thirty months after the decision was made to implement a thorough reconditioning of the Cadarache Study Centre's Active Fuel Examination Laboratory (LECA), the Contracting Authority and the Main Contractor have drafted a methodological and technical report concerning the operation.

The purpose of this operation is to bring this laboratory back to standards, against the current safety requirements on the one hand, and to fit it with general equipment, to allow the examination of fuel highly loaded in actinides, on the other hand.

The rehabilitation **process** highlighted the fact that an accurate assessment of the site was required, followed by a detailed analysis of the existing facility against laws and regulations.

Finally, the **study and performance phase**, currently under way, raises the "configuration management" (knowledge of the facility's state at a given moment) issue, by taking into account the operation and maintenance, on the one hand, and the reconditioning operations, on the other hand.

The authors will provide a few items pertaining to the terms, costs, and main technical stakes.

Containment control and improvement elements

Alain MICHEL* - Thierry DELAFORGE* - Georges PEIDRO*

** CEA COMMISSARIAT A L'ENERGIE ATOMIQUE, CEA/CADARACHE, F - 13108 ST-PAUL-LEZ-DURANCE CEDEX FRANCE*

The purpose of this lecture is to present the method implemented to define the containment system improvements applied to the INB 55 LECA.

1. Survey and status of the existing facility.

2. Analysis and comparison against the design guidelines and recommendations,

3. Overview of the envisioned improvements and limits of the method.

4. An embodiment example.

ISO9000-Certification of a Hotlab

F. Groeschel, G. Ledergerber, G. Bart / LWV - PSI:

Paul Scherer Institut, 5232 Villingen, Switzerland

The Laboratory for Materials Behaviour is operating the PSI hotlab, which is used for its own research purposes but also serves as a user lab. In a long and intensive process guided by an external consultant, the operations have been structured to comply with the ISO9000 quality standards. Difficulties arose in the application of the production oriented system to research and the compliance of the system with the PSI organisation and the hotlab operation regulations. The experience in elaborating and implementing the system as well as its final structure are described.

Quality Assurance in Nuclear Fuel Research at the Laboratory of High- and Medium-level Activity at SCK•CEN.

L. Sannen*, A. Gys and M. Verwerft

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Quality assurance in nuclear fuel research demands specific calibration and validation methodologies. Indeed the analytical experiments in hot-cells on highly radioactive objects are non-standard and many times unique. The standards and validation methods developed for and applied to the main nuclear fuel research experiments in the SCK•CEN hot laboratory are outlined.

How to apply "Quality" in nuclear analytical chemistry: an illustration.

S. Van Winckel*, M. Gysemans and L. Vandevelde.

SCK•CEN, Boeretang 200, B-2400 Mol, Belgium.
Corresponding author - e-mail: svwincke@sckcen.be

In February 1995, the Ministry of Economy granted an accreditation certificate to the department "Nuclear Chemistry and Services" of the SCK•CEN for different routine analysis methods. This certificate proves that these analyses are performed in accordance with the requirements of the standard NBN EN 45001. Showing an example of an isotopic analysis - isotopic dilution (IA - ID) of Pu by Thermal Ionization Mass Spectrometry (TIMS), an overview will be given of what such an accredition entails, especially in terms of validation, traceability and quality control. The laboratory also applies the same "quality philosophy" to non-routine analyses. This will be illustrated by the methodology used for burn-up analyses.

QA IN THE HOT CELLS LABORATORY AT NRG-PETTEN

Gin-Lay Tjoa, K.A. Duijves

NRG, Petten, the Netherlands

The Hot Cells Laboratory, built in the early 1960's, was originally designed for research on radioactive materials. In the past 30 years extensive research programmes have been carried out in the frame of fission and structural materials originating from light water reactors, fast breeder reactors and fusion reactor technology. In 1995 the laboratory has been expanded with a facility for the production of Mo99. This isotope is used to produce Tc99m, which is the most used isotope in the world for medical diagnostics. On behalf of the research on transmutation of long lasting fission products an actinide laboratory was extended in 1997.

The continuing innovations of nuclear applications in the field of energy issues and nuclear medical science, and the attention on the nuclear discipline by society, make it for us inevitable to anticipate on all safety and environmental aspects.

To realise this a total management system was implemented based on the ISO 9001 and ISO 14001 standards.
The management system of the laboratory has been laid down in a Technical Information Package, procedures, and supporting documents. The system itself is part of the NRG Management System.

The realisation of activities is subject to National and International Nuclear Regulations, like the Dutch Nuclear Power Law and Licence. The quality, safety and environmental policy of the laboratory is to sustain efforts for a high degree of reliability and safety, verifiable improvements of the service and organisation for our clients, personnel and licensees.

Application of the ALARA principle to the design of new nuclear laboratories, and to the definition of safety options for dismantling operations, with regard to the radiation protection objectives

Gilbert BRUHL

CEA/DSNQ
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All activities concerned by the manipulation of radioactive substances shall respect the regulatory requirements in force, especially those regarding the nuclear safety and the radiation protection points of view.

Concerning these last objectives, the law impose namely the implementation of the ALARA[1] principle during all phases of « life » of the installation: design stage, normal use or special operations, modifications, maintenance, dismantling, as far as radiation protection aspects are concerned.

The present paper will describe in a first step, the general guidance for the application of the ALARA principle to the design of new nuclear facilities and in a second step, the specific methodology recommended for the improvement of the ALARA process and the definition of safety options for dismantling operations.

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(1) ALARA, which is an english acronym meaning « As Low as Reasonably Achievable », is a predictive and evolutionary procedure, applicable for the definition of the efficiency of the radiation protection, namely for quantifying protection actions, dose monitoring and dose management, in order to maintain the individual and collective exposure of the workers and the general public as low as reasonably possible, taking into account technical, economic, juridical, social, public and environmental policy considerations. This approach applies to fixed shieldings intended to reduce external exposures as well as to the means intended to reduce internal exposures and to the radioactive discharges to the environment.

Waste, contamination assessment, and drainage issues

Fernand BENCHIKHOUNE* - Christophe LACROIX**

** S.T.M.I., ZAC DE COURCELLE,
1, ROUTE DE LA NOUE, 91196 GIF-SUR-YVETTE CEDEX, FRANCE*

*** CEA DRN CADARACHE, F - 13108 ST-PAUL-LEZ-DURANCE CEDEX, FRANCE*

The drainage programme, the methods implemented for waste characterisation, as well as the contamination goal upon operation completion will be addressed. Throughout the project, contamination assessment is performed after fuel discharge by two complementary methods:

- gamma spectrometry measurement, with a recording of the flows emitted in the miscellaneous geometrical configurations,

- dose rate measurement with a variable collimation probe and surface scanning.

The creation of transfer functions combining the two measurements allows us to define the α, β and γ activity:

- in the cell, per sector and per equipment item

The Hot Cell Radioactive Waste Concept of Forschungszentrum Juelich

G. Pott and St. Halaszovich

Hot Cell Laboratory, Forschungszentrum Juelich, Germany

During the last 30 years extensive scientific examinations on radioactive metalls, ceramics and fuel elements have been carried out, so that a high volume of waste has resulted. Also from the dismantling of irradiated facilities metallice waste has to be handed. Prior for equipment repair the hot cell envolved has to be decontaminated and a large amount of lower active waste is produced. The waste is collected for conditioning and storing. There are different categories as: low active liquid waste, low active burnable waste, fuel waste, low and high active metallic waste. For each waste category special transport container are used. For the volume reduction our WASTE DEPARTEMENT is equipped with special facilities e.g.: furnace for burning, dryer, liquids evaporator, hydraulic press for pelletising, decontamination box for the dismantling ad cleaning of components. After conditioning the waste will be stored on site. Special documentation has to be done for the acceptance of this waste.

Epoxy mounted ceramographic samples as a waste form

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The Swedish national programme for the disposal of spent nuclear fuel entails interim storage in the central pool-storage facility (CLAB) for approximately forty years, followed by encapsulation of the fuel assemblies in copper-steel canisters. The welded canisters are then to be buried in vertical shafts in a deep geological repository which will be filled with bentonite and sealed.

All the irradiated oxide fuel at Studsvik is planned to be incorporated in the spent fuel programme, and a substantial amount of fuel residues (entire fuel rods as well as cut sections of fuel) have already been encapsulated in the Hot Cell Lab and taken to CLAB. These welded stainless steel capsules are designed to fit into PWR assembly positions.

A certain amount of the fuel residues at Studsvik contain epoxy. Epoxy is used for embedding and mounting ceramography specimens, and is therefore in intimate contact with the fuel and cladding. Radiolysis is expected to cause the gradual decomposition of the epoxy during long term storage, leading to the generation of gases. Tests have been performed to experimentally determine the rate of production of the gases formed by radiolysis, in order to assess the pressure increase during long term storage.

Maintenance of three cells in the Hot Cell Laboratory at Studsvik, 1998

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A major maintenance programme was carried out in the last quarter of 1998 on three of the concrete cells in the Studsvik Hot Cell Laboratory. Of these, the two largest, adjoining cells had not undergone a combined maintenance operation since 1981; since these two cells are usually used for storage of significant amounts of spent fuel, extensive preparations had to be made for alternative storage during the maintenance.

The maintenance included emptying of the cells, decontamination, servicing and renovation of installed equipment, installation of new equipment including a new hydraulic table and a sample transfer "train", and painting of cell surfaces.

The entire service was completed on schedule and well within the planned radiation budget.

Dismantling and decontamination of nuclear and Radioactivity facilities in Research Centres

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Currently, research projects on dismantling and decontamination of some of the CIEMAT nuclear and radioactivity facilities are being performed. The main goal of these projects is to actualise obsolete facilities to the new necessities of CIEMAT in R&D, which are focussed principally on industry requirements. In this presentation, also a brief description of the studies performed in order to minimise the radiolytic impact on human and environment due to these activities are discussed.

III. Topical PIE techniques

III.1. High BU fuel related PIE

FGR – Rim morphology –

microstructural features

Cladding corrosion

Review of Some Advanced Methods of Post-Irradiation Investigations Developed at SSC RIAR

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Methods of the post-irradiation investigations performed in the SSC RIAR hot cells are being continuously extended and improved.

A method of testing of irradiated zirconium claddings on long-term strength and corrosion cracking in the presence of iodine has been developed. The cladding is pressurized with internal gas pressure.

Simultaneously an axial tension of the cladding is possible.

A method of definition of damage parameters for irradiated zirconium claddings has been developed. The cladding is pressurized with internal hydraulic pressure. Simultaneously an axial tension of the cladding is possible.

The x-ray microanalysis method is used for investigation of xenon release from irradiated uranium dioxide.

SIMS method is used for investigation of golmium as well as gadolinium, dysprosium and boron isotopes distribution in the cross-sections of irradiated fuel and absorbing elements.

The mass-spectral method for gas analysis is used for measuring helium content in irradiated stainless sleels.

The use of local cooling method for investigation of irradiated fuel pins and fuel assemblies of BN-and VVER-type reactors

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The summary of the report at the meeting of Working Group "European Hot laboratories and Remote Handling", September 21-23, 1998, Windscale, United Kingdom.
Some devices and techniques for postirradiation investigation based on local cooling of irradiated fuel pins and fuel assemblies are developed and used in practice at State Scientific Center Research Institute of Atomic Reactors.
The features of these devices and techniques focused on study of various effects in fuel pins and fuel assemblies of BN- and VVER-type reactors are described and illustrated. Possible areas of use of fuel rods and fuel pins local cooling method are considered, including a search of untight pins in fuel assembly, a search of the sight of pins leakage, a search of "fuse" in a fuel column etc.

PIE - a need for future developments

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Since the late 60's, the operational behaviour of Siemens' FA in Nuclear Power Plants has been monitored by extensive examinations of fuel, cladding, and structural components. In the beginning, the examinations were geared to obtain and to confirm respectively basic inpile properties of UO_2, UO_2/PuO_2 (MOX), and UO_2/Gd_2O_3 fuel and of Zry-materials. Non-destructive testing in the pools of the Nuclear Power Plants were supplemented by hot cell examinations. In the course of time, the hot cell examinations were more and more used mainly for development and sometimes for clarification of unexpected findings. Today, they aim at further optimising the FA with regard to improved economical usage like reliability and discharge burnup.
In this presentation, some results are shown that can only be obtained from hot cell examinations and that are important for the understanding of the materials behaviour and thus are needed for its development. For example, the high burnup behaviour of UO_2- and MOX-fuel and the behaviour of cladding materials under different thermal load conditions are described.
Future developments and its demands on existing and new PIE techniques are addressed.

Neutron Radiography using the SINQ - Experimental Set-up and Operational Experience

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The neutron spallation source SINQ is used for the examination of irradiated nuclear fuel segments and highly activated samples. The specimens are prepared in the PSI hotlab and have to be transferred to the SINQ facility, which is operated by a different department and classified as a non-nuclear facility. The corresponding installation, the transfer cask, which houses the samples, and the loading and handling procedures are described. Special emphasis is placed on the requirements and procedures to comply with the various regulations. Results of the first experiments are reported.

Local Hydrogen Concentration Determination in Zircaloy Cladding Material

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A technique has been developed to locally determine the hydrogen content in Zircaloy cladding. This allows to study the influence of the local variation of the H distribution on the mechanical behaviour. After appropriate preparation, the surface of the sample is observed in a Scanning Electron Microscope (SEM) in the Back Scattered Electron mode. The image is then analysed with an image analysis software and the area fraction of the hydrides is quantitatively determined. A correlation between the hydride area fraction and the hydrogen content is established using standard specimens. Applying this correlation factor, the H concentration can be extracted from the local hydride surface measurement. The details of the specimen preparation, observation and analysis method are given and the precision of the method is discussed.

A Modified Hot Extraction Method to Determine the Hydrogen Content of Corroded Cladding Metal and Oxide

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Hydrogen uptake during the corrosion process is important for the integrity of cladding material. It is, however, difficult to discriminate between hydrogen from the metal and the oxide using the standard hot extraction method. For high burn-up fuel rods, the amount of hydrogen in the oxide can be considerable. A LECO RH402 hydrogen analyser was modified to allow to run controlled heating cycles. The effusion of hydrogen with the temperature was monitored. The different hydrogen fractions were correlated with their origin by running experiments with oxide and metal separately. A model on the effusion of hydrogen from an oxidised Zircaloy sample was developed.

HOT CELL FACILITY FOR HYDROGEN ANALYSIS

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The hydrogen content of irradiated zircaloy cladding and the associated formation of brittle hydride particles is an important consideration with respect to achieving improved fuel performance. Although zircaloy itself becomes only slightly activated during neutron irradiation, significant dose rates may be associated with cladding samples owing to the presence of fission products and bonding layers at the inner surface, particularly in high burnup fuel. A hot cell is necessary for analytical work on these samples and has been constructed and commissioned at the AEA Technology Hot Laboratory.

Of the methods available for hydrogen analysis, the hot vacuum extraction (HVE) technique was chosen as being most suitable for hot cell use. Hydrogen analysis using HVE depends on the virtually complete evolution of hydrogen from zircaloy at temperatures of 1100^0C and low pressures of the order of 10^{-4} Pa or better. The hydrogen is collected and its mass determined by volume and pressure measurements. Since fundamental physical quantities are measured, there is no need for calibration against standards of known hydrogen content, although standards are used to check correct operation of the equipment.

The HVE equipment incorporates a radio-frequency (RF) induction furnace and high vacuum system of compact design to facilitate installation and to occupy minimum floor space in the hot cell. RF induction was chosen for rapid heating while minimising heating, and therefore outgassing, of nearby components. The vacuum is maintained by a dual turbopump system having a compression ratio of 10^6 for hydrogen. The offgas is pumped into a collection volume and the hydrogen subsequently diffused out through a palladium membrane. The pressure change is then used to calculate the mass of hydrogen.

Measurement of blank hydrogen levels and comparison with standard samples obtained from international standards organisations indicates that the accuracy achievable is better than ± 1 $\mu g/g$ (1 standard deviation). A programme of hydrogen analyses on samples of irradiated zircaloy cladding has been sucessfully completed.

THE "FABRICE" PROCESS IN LECA LABORATORY AT CADARACHE

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In an industrial reactor, the fuel rods are exposed to thermal and mechanical conditions that may lead to strong contact between the fuel pellets and the cladding. An extensive experimental program is under progress in France, in collaboration between CEA, EDF and Framatome, to study the Pellet-Cladding Interaction (PCI).

To improve the understanding of the PCI and to choose the better cladding material, power ramps are simulated in the experimental reactor Osiris, in Saclay, in order to determine the cladding deformation or the Ramp Terminal Level without rupture.

Furthermore safety studies are performed on irradiated fuel in the experimental reactor CABRI in CADARACHE. It concerns the behaviour of the rods in case of Reactivity Injection Accident.

These experiments need to provide representative experimental rods (i.e. already irradiated in industrial reactor) adapted to the experimental needs.

The "Fabrice" process allows to make short test rods using a part of a 4 meters long irradiated PWR rod.

The process was developed by the Nuclear Reactor Directorate (DRN) in the CEA SACLAY Centre and around 20 rods were manufactured during the last four years. A new equipment was studied and installed in one of the hot cells of the LECA in CADARACHE and the activity has now been transferred in this laboratory.

In this paper, the main steps of the process are described, i.e.:

- description and specificity of the hot cell,
- characterisation of the part of the original irradiated rod,
- cutting and preparing of the short rod section,
- welding of the end plugs,
- pressurisation and seal welding,
- non-destructive examinations.

The development programme which is planned to carry out to fit out the short rods with instrumentation (thermocouple in the central part of the fuel pellets, pressure transducer) is presented.

An instrumental method to investigate the diffusion of trace elements in zirconium oxide layers and zircaloy cladding materials

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During the operation of nuclear-power reactors, a layer of zirconium oxide is routinely formed on the cladding of the nuclear-fuel rods. Such layers impact reactor performance in two negative ways: (1) these layers increase the thermal resistance of the cladding, impairing heat transfer; and (2) diminish the wall thickness of the cladding, making it mechanically weaker and more subject to fracture. The growth of these layers is intensified by the presence of boric acid (H_3BO_3) in the reactor cooling water. H_3BO_3 is added to the water at reactor start-up to control core reactivity. To counter act the formation of these layers, lithium is added to the water to raise its pH. In order to understand the effect of boron and lithium on the mechanisms and the kinetics of corrosion of zircaloy cladding, it is necessary to study the diffusion properties of these elements into the zirconium-oxide layer as well as into the metal. The complete elemental characterisation of complex thick films and interfaces requires a method with good sensitivity and accuracy for all pertinent elements, good depth resolution and reasonably rapid sampling through the entire structure. These requirements are met by glow discharge mass spectrometry (GDMS). GDMS is a recognised method for complete and accurate characterisation of high-purity solid materials, from matrix to trace level. For thin films with thickness in the angstroms to nanometer range, techniques such as Auger electron spectroscopy, secondary-ion mass spectrometry (SIMS) and sputtered neutral mass spectrometry (SNMS) can be applied [1]. For thicker coating of up to tens and hundreds of micrometers GDMS and glow discharge atomic emission spectrometry (GDAES) are appropriate [2]. Only SN and GD mass-spectrometer-based techniques have the capabilities to provide measurements over the entire Periodic table, from Li to U, at comparable sensitivity levels. Furthermore, in GDMS the calibration factors are essentially matrix independent, enabling accurate quantification in sequential layers of widely different composition [2]. In addition, GDMS provides isotopic-composition information [3]. At ITU a GDMS has been installed in a glove box for almost ten years and continues to the only such installation in the world [1].

In this paper the GDMS-based instrumental approach for the depth profiling of trace elements in Zirconium oxide layers is presented. Data relevant to fuel rods irradiated in commercial power stations are also included.

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Electron Microscopy for PIE: New Developments

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Abstract: As a powerful device for microstructural examination combined with chemical analysis, a Philips XL40 Scanning Electron Microscope (SEM) is being installed in a glove box for investigations of radioactive and contaminated samples. The equipment of the SEM with a Back-Scattered Electron detector (BSE), an Energy Dispersive X-ray analysis system (EDX) together with a set of micromanipulators mounted in the specimen chamber and a Gunshot Residue Software (GRS) makes it compatible with a large type of applications.

The SEM is complemented in the laboratory by a Hitachi H 700 Scanning Transmission Electron Microscope (STEM) allowing the examination of radioactive specimens. A non-exhaustive list of applications comprises cladding and fuel investigations and more recently microstructural analysis of weapon grade plutonium metal and PuO_2 powders in the frame of nuclear forensics investigations.

The combination of SEM and TEM techniques provides a powerful duet for radioactive sample microstructure characterisation.

New Facilities for High-Temperature Physical Property Measurements in α–γ Active Materials

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The paper presents new methods and equipment for the measurement of different thermophysical properties of fresh and irradiated nuclear fuel in the temperature range up to the melting point.

The thermal diffusivity is obtained from laser-flash experiments, especially designed to enable also the heat capacity of the sample to be simultaneously deduced. The measurements can be performed on samples of arbitrary shape, under continuous monitoring of integrity and position with respect to the laser probe beam and to the pyrometer optical axis.

The samples, with a maximum allowed activity is of the order of 100 Rem/h, are treated in an α glove-box, surrounded by a 5-cm lead shielding. The samples are handled through remote manipulators, while the maintenance of the equipment is performed with gloves. Since the experiments consist in different optical measurements, the various signals are channelled through glass fibres to the most delicate parts of the equipment (optical detectors and electronics), that are placed outside of the shielded box.

Up to 1700 K, the samples are heated in a HF induction furnace. At higher temperatures, sample thermal conditioning is produced with a powerful YAG laser beam. Thanks to this technique, the containment vessel could be significantly simplified in design and reduced to a small size (approximately ½ litre volume). This technique is presently used in a glove-box; implementation in a hot cell is, however, unproblematic, since the whole system of optical diagnostics (pyrometers, spectrometer, laser beam delivery systems with laser beam control device) can be placed at large distances from maintenance free vessels.

Selected experimental results of thermophysical measurements on irradiated fuel are presented.

III. Topical PIE techniques

III.2. Structural material corrosion related research

Miniaturisation – specimen conditioning & manufacturing

Autoclave environment in hot cell

NEW MACHINING EQUIPMENTS OF THE LABORATORY OF IRRADIATED MATERIAL STUDIES (LECI / CEA-SACLAY)

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A few years ago, the Nuclear Reactor Directorate of CEA decided to concentrate the post irradiation examinations of PWR fuel rods in the LECA-STAR facility at Cadarache Nuclear Centre, and examinations of irradiated materials, including claddings, in the LECI hot cells at Saclay.

This decision was followed by creating a project in order to refurbish existing hot cells and to build a new hot cell line in the LECI facility, devoted to mechanical testing (as described in the Studsvik '97 Working Group). Regarding the LECI equipment project, the machining equipment takes an important part. It is the vital starting point of the future laboratory.

The machining area has different objectives listed below:

- to form large pieces for roughing,
- to classify samples which have to be put in storage wells,
- to prepare samples for metallography, diffractography, microscopy or microprobe examinations,
- to form every kind of mechanical test pieces,
- to prepare corrosion test pieces,
- to prepare neutron absorber samples.

In order to attain these objectives, we introduced machining equipments in hot cells:

- large metallic Kasto saw,
- large fast diamond saw,
- universal numeric drive milling-machine,
- numeric drive turning lathe,

Two other apparatuses are designed for further hot cell commissioning:

- spark erosion machine (to be introduced this year),
- wire erosion machine (to be introduced later).

These equipments were transformed (« nuclearised ») in order to allow their running and their maintenance to be done by remote handling. Engines, driving rubber belt, sensors, tools, screws, cables, electronic cards, plastic pieces have been modified to withstand radiations. A qualification program has been realised after modification to validate the running of the machines, before entrance in hot cells.
Definition of needs, machines, modifications & adaptations, all technical aspect, safety issues and qualification programs are described in the paper.

EXPERIENCES WITH SMALL SIZE SPECIMEN TESTING

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The tendency to use smaller specimens in nuclear materials research has started many years ago. The driving force for the use of small specimens originates from the reduction of the waste and the increasing costs involved in using irradiation space in materials test reactors, which forces to use the irradiation space in the MTR as efficient as possible. The increasing amount of materials properties data obtained from large quantities of small specimens has to be justified however by the meaningfulness/applicability of the data. Certain materials properties do not allow an unlimited decrease in size. Issues like lack of constraint or specimen sizes that approach the grainsize of the material do not allow an unlimited reduction in specimen size. The nature of nuclear materials research, where the effects of radiation on materials properties is assessed, allows a certain reduction of specimen size because the properties will be measured on the same specimen geometry before and after irradiation. NRG has designed and used over the years a series of specimens in nuclear materials research. The specimens combine the efficient use of the existing HFR irradiation space with the production of useful and applicable materials properties data. The paper describes the experimental facilities for testing small specimens. The applicability of the small specimens is shown by the comparison of results obtained from large and small specimens.

WITHDRAWN

RADIOACTIVE WASTE MANAGEMENT – A WIDER PERSPECTIVE

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The availability of a repository for intermediate level radioactive waste in the UK continues to be delayed. This is resulting in increasing pressure on finding new, and sometimes novel, solutions to minimising the volume of radioactive waste requiring long-term storage and eventual disposal. This process started as a collection of separate initiatives but is progressively starting to resemble a cohesive strategy. This strategy has a single objective, namely to minimise waste volumes, together with minimising the associated environmental and financial costs, but the appropriate solution (or assemblage of solutions) is chosen to meet the local needs and resources.

This discussion paper briefly reviews the range of technological solutions under examination, development, or in use, in the UK and Europe, to minimise radioactive waste volume and their actual or potential application in UK hot cell facilities. These solutions range from: segregation, combustion and supercompaction; through processing and recycling; to the leading edge technology of partition and transmutation.

WITHDRAWN

FACILITY MANAGEMENT – AN ART OR A SCIENCE?

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Within AEA Technology, Nuclear Science, there has been a progressive drive towards a closer interaction between the management of the major radioactive handling facilities, the regulators, and the users. This has been brought about by the need to operate facilities in a fully commercial environment whilst maintaining the highest standards of safety required by the regulators in the UK. Simple tools have been employed to facilitate these improved interactions and these include:

- The production of facility guides, describing operational and financial arrangements
- Meetings between facility and safety managers with potential users, in order to develop an overall understanding of requirements on both parties
- The development of integrated project and facility schedules, to ensure appropriate resources are available as required
- Reviews of ongoing programmes
- Regular meetings between facility management and the regulators, and
- The wide dissemination of essential information within the business.

This paper provides an overview of the experience gained within AEA Technology, Nuclear Science, and is offered as a contribution towards the spread of best practice.