L. Sannen

AEA TECHNOLOGY
NUCLEAR SCIENCE

European Working Group "Hot Laboratories and Remote Handling" Plenary Meeting

21 - 23 September 1998

Low Wood Hotel, Windermere

Meeting Programme

Monday 21 September 1998

Arrive at Low Wood Hotel, Lake Windermere

1200 Registration

1230 Lunch

1330 Introduction to Meeting

Technical Session 1: Characterisation of Radioactive Waste
Chairman: Håkon Jenssen (Kjeller)

1400 Papers 1 to 5

1. Fuel Surface Measurement on Spent Fuel using BET-technique
   M Lundström and U-B Eklund - Studsvik Nuclear AB, Sweden

2. Methodologies and Facilities for Radioactive Waste Characterisation
   J Perfettini, G Brunel, N Langomazino - CEA Cadarache, France

3. Waste Package Characterisation
   L Sannen, M Bruggeman, A Daniels, R Harnie and J P Wannijn - SCK•CEN Mol, Belgium

4. Nuclear Waste Management at the PSI Hot Facilities
   J van Aarle - PSI, Switzerland

5 *PAPER WITHDRAWN*

1600 Coffee Break

Technical Session 2: PIE Techniques and Facilities
Chairman: Enrique Toscano

1615 Papers 6 to 8

6. Multiple Voltage Electron Probe Micro-analysis of Gas Bubbles in Solids
   M Verwerft - SCK•CEN Mol, Belgium

7. Neutron Radiography of Irradiation Fuel Rods - An Approach to Improve Spatial Resolution in Neutron Radiographs
   H K Jenssen, Bryhn-Ingebrigtsen, Arnesen and B C Oberländer - Ife Kjeller, Norway

8. The Nuclear Microprobe at the Pierre Süe Laboratory
   B Berthier, F Couvreur and C Gibert - CEA Saclay, France

1715 Close of Technical Sessions.

1730 Cruise on Lake Windermere, followed by dinner as guests of AEA Technology.

Tuesday 22 September 1998

Technical Session 2 (Continued): PIE Techniques and Facilities
Chairman: Enrique Toscano

0830 Papers 9 to 12

9 Partition of Grain Boundary and Matrix Gas Inventories in Nuclear Fuels: The ADAGIO Facility
S Ravel, G Ducros, T Petit, L Caillot and G Eminet - CEA Grenoble, France

10 The VERCORS HT Facility for Studies up to Molten PWR Fuel Conditions
P P Malgouyres, G Ducros, M P Ferroud-Plattet, M Prouve and D Boulaud - CEA Grenoble, France

11 High Heat Loading Tests and Temperature Measurements in Hot Cells
R Duwe, W Kühnlein and G Pott - Forschungszentrum Jülich, Germany

12 A Shielded SIMS ATOMIKA 4000: Concept, Construction and First Experience
T Aerne, D Gavillet, O Gebhardt - PSI, Switzerland
Matthias Martin

1000 Coffee Break

1030 Papers 13 to 16

13 Piercing Facility Optimised For Free Volume Determination
L Desgranges - CEA Cadarache, France

14 A Burst Test Facility For Irradiated Fuel Rod Segments
P Poerschke, M Martin, B Hirt, A Hermann and F Groeschel - PSI, Switzerland

15 ECN Welding Facility for Irradiated Material
G L Tjoa, D S d'Hulst and E V van Osch - ECN Petten, Holland

16 PAPER WITHDRAWN

27 A New Installation for Rod Puncturing and Fission Gas Release Measurement
P Schleuniger, A Hermann, F Groeschel - PSI, Switzerland

1200 Lunch

1300 Depart for Windscale Site

1430 Arrive Windscale Site

1500 Visit to Facilities

1730 Depart for Windermere

1900 Arrive Low Wood Hotel

2000 Dinner

Wednesday 23 September 1998

Technical Session 2 (Continued): PIE Techniques and Facilities
Chairman: Enrique Toscano

0830 Papers 17 to 22

17 Machining and Welding Technique in Hot Cell
P Novosad, M Falcník, J Málek and M Kytka - NRI Rez, Czech Republic

18 PAPER WITHDRAWN

20 Depth Profiling of Impurities in Zirconium Oxide Layers by DC Glow Discharge Mass Spectrometry
M Betti and E Toscano - TUI, Karlsruhe (No Paper - Limited sensitivity) No Reader

21 PAPER WITHDRAWN

22 The Activities of the RRC "KI" Reactor Materials Division in the Field of Post-irradiation Examination of Fuel Rods
V Bespalov - Kurchatov Institute, Russia → Lab Description : NDT / DT + Report / Test (No paper)

19 A Shielded Corrosion Testing Facility at Windscale
H G Morgan and J G Gravenor - AEA Technology plc, United Kingdom

1045 Coffee

Technical Session 3: Refurbishment Decontamination and Maintenance of Laboratory Infrastructure
Chairman: Klaas Duijves

1100 Papers 23 to 26

23 The New Fire Protection System in the Studsvik Hot Cells
S Hammar and A Holmér - Studsvik Nuclear AB, Sweden

24 Renewal of CEA Transport Packaging Inventory
J-E Noyes - CEA Cadarache, France

25 New Requirements for HEPA Filters for Ventilation Networks in Hot Laboratories, Especially Against Fire Hazard - Assessment of Their Efficiency by Specialised Test Houses
G Bruhl - CEA Saclay, France

26 A New Approach to Decontamination for the Nuclear Industry
M J Gilbert - AEA Technology plc, United Kingdom

1230 Resumé of Technical Sessions by José Van de Velde

1300 Lunch

1400 Depart for Manchester Airport

EWG "Hot Laboratories & Remote Handling"
Windscale, UK 21-22/9/'98

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Gérard Samsel	CEC-ITU-Karlsruhe, Germany
Enrique Toscano	CEC - ITU Karlsruhe, Germany
Reiner Duwe	FZ-Jülich, Germany
Günther Pott	FZ-Jülich, Germany
Marc Verwerft	SCK.CEN Mol, Belgium
José Van de Velde	SCK.CEN Mol, Belgium
Leo Sannen	SCK.CEN Mol, Belgium
Michal Falcnik	Nuclear Research Institute, Rez, Czech Rep
Milos Kytka	Nuclear Research Institute, Rez, Czech Rep
Petr Novosad	Nuclear Research Institute, Rez, Czech Rep
Bernard Berthier	CEA Saclay, France
Gilbert Bruhl	CEA Saclay, France
Guy-Marc Decroix	CEA Saclay, France
Lionel Desgranges	CEA Cadarache, France
Gérard Ducros	CEA Grenoble, France
Jean-Pierre Leveque	CEA Cadarache, France
Jean-Eric Noyes	CEA Cadarache, France
Serge Ravel	CEA Grenoble, France
Jacques Royer	CEA Saclay, France
Jean-Pierre Rozain	CEA Cadarache, France
Espen Eriksen	IFE, Kjeller, Norway
Håkon Jenssen	IFE, Kjeller, Norway

Svein Thorshaug	IFE, Kjeller, Norway
Stefan Hammar	Studsvik Nuclear AB, Sweden
Kaj Lilja	Studsvik Nuclear AB, Sweden
Max Lundström	Studsvik Nuclear AB, Sweden
Anders Mieski	Studsvik Nuclear AB, Sweden
Raimund Bühner	PSI, Switzerland
Matthias Martin	PSI, Switzerland
Peter Schleuniger	PSI, Switzerland
Klaas Duijves	ECN Petten, Holland
Klaas Willem de Haan	ECN Petten, Holland
Gin-Lay Tjoa	ECN Petten, Holland
Ferenc Oszvald	Paks Nuclear Power Plant Ltd, Hungary
Rüdiger Hoffmann	Siemens-KWU Erlangen, Germany
Giovanni Marangio	ENEA Rome, Italy
Gianfranco Caporossi	ENEA Rome, Italy
Valery Bespalov	Kurchatov Institute, Russia
Bill Stephen	BNFL Magnox Generation, Berkeley, UK
Paul Butler	BNFL, Sellafield, UK

Summaries from technical session 1: Characterisation of Radioactive Waste

"Fuel Surface Measurements on Spent Fuel using BET-technique" by M. Lundström and U.B. Eklund – Studsvik Nuclear AB, Sweden

Full Surface Measurements on Spent Fuel using BET-technique was the first paper given in the "characterisation of Radioactive Waste" session, and it was presented by Mr. Max Lundstrøm from the Hot Cell Laboratory at Studsvik Nuclear AB.

He said that due to the decision of not to reprocess but to store spent fuel in Sweden research has been going on for a long time in Studsvik evacuating the release of fission products and activities from spent fuel. This was performed as leaching tests in ground water and it was found that the leaching rate ought to be normalised against the fuel surface.

BET-method was used to measure the surface of fragmented fuel. The basic for this method is to measure the adsorption of a gas on the fuel surface. In-cell equipment was built and krypton was used instead of nitrogen to achieve better resolution.

Extensive tests were performed and measurements were done on unirradiated and irradiated fuel with burn-up in the range from 40-70 MWd/kgU. Measured specific area was between 50-300 cm^2/g and the reproducibility of the measurements was $\pm$ 20 %.

"Waste Package Characterisation" by L. Sannen, M. Bruggeman, A. Daniels, R. Harnie and J.P. Wannijn – SCK•CEN

The second paper "Waste Package Characterisation" was presented by Mr. Leo Sannan from SCK•CEN Mol, Belgium.

This paper described the methodologies which were developed and used to characterise the high- and intermediate level waste packages at the SCK•CEN Hot Laboratory. The main goal is to have a quantitative assessment of the relative contribution of the different fuel types in the waste packages at the laboratory.

The characterisation was based on "an estimation of the fuel inventory in a particular waste package", "a calculation of the relative fission product contribution", and "a comparison of the calculated and real or measured γ-dose rate on the waste packages".

An appropriate fuel inventory estimation route, a user friendly computer program for fission products and corresponding dose rate calculation and a simple dose rate measurement method was developed and introduced.

"Nuclear Waste Management at the PSI Hot Facilities" by J. Van Aarle – PSI, Switzerland

The third paper in this session "Nuclear Waste Management at the PSI Hot Facilities" was presented by Mr. Raimund Bühner.

He said that the PSI Hot Facilities are utilised for materials research and service work on a large variety of waste and other radioactive components and samples. Radioactive waste is produced due to PIE and fuel development.

Also, additional radioactive waste is shipped from other PSI facilities, medical uses, industrial and research facilities in Switzerland to the PSI Hot Facilities.

The paper describes the different type of waste characterisation and handling at the PSI Hot Laboratory.

Further Mr. Raimund Bühner said that a segment Gamma Scanner was installed at the Hot Laboratory for measurements of plutonium and uranium isotopic composition of the waste before any further conditioning or storage in the intermediate storage facility.

"Methodologies and Facilities for Radioactive Waste Characterisation" by J. Perfettini, G. Brunel, N. Langomazino – CEA Cadarache, France.

The last paper in the session "Methodologies and Facilities for Radioactive Waste Characterisation" was presented by Mr. Jean-Pierre Rozain form CEA Cadarache, France.

He said that characterisation of a waste package consists in determining its specific properties which must meet the specification established by the regulatory authorities and the waste manager. Characterisation is performed on the waste itself, of the material and the matrix and of the finished product.

Some of the properties examined are related to the basic knowledge of
a) the radioactivity of the waste
b) the chemical composition of the waste and of the coating matrix
c) the physical structure of the package other properties are related to the short or long term safety of storage

Further he said that research of characterisation has been going on for several years in France on raw or conditioned waste. The method, which can be used on actual packages, provides a characterisation system adapted to each type of waste.

SUMMARY OF THE TECHNICAL SESSION 2

PIE Techniques and Facilities

Chairman: E.H.Toscano

Paper 6

„Electron Probe Micro-Analysis of gas bubbles in solids: a novel approach"
M. Verwerft, Reactor Materials Research Department, SCK-CEN, Mol.

The paper discussed a novel application of the EPMA-measurements, based on the use of multiple voltage combined with the SEM-analysis of the bubble size distribution, to the determination of the amount of fission gas retained in irradiated fuels. The influence of sample preparation was evaluated and, on the basis of a theoretical model, the radial position at which the gas begins to be released was established. In the future, the application of the method to the RIM-zone could clarify the important question of the amount of gas retained in this low temperature region.

Paper 7

„Neutron radiography of irradiated fuel rods. An approach to improve spatial resolution in neutron radiography"
H.K.Jenssen, Institute for Energy Technology, Kjeller.

The use of dysprosium foils and cellulose nitrite films improved the spatial resolution of neutron radiography by digitising the image for further electronic image treatment. The results showed that high contrast and sharp images could be obtained even after 10 times magnification.

The technique was successfully applied to fuel degradation experiments and to the accurate measurement of the positioning of bellows introduced in fuel rods to measure the amount of gas released to the plenum during irradiation.

Paper 8

"The nuclear microprobe at the Pierre Süe Laboratory"
B.Berthier, F. Couvreur and C.Gibert, Commisariat à l'Energie Atomique Saclay.

A nuclear microprobe (NMP), operational since 1993, was described. It can perform highly sensitive analysis based on the use of atomic and nuclear reactions induced by light charged particles. Light elements (Li to Si) can be determined by nuclear reactions whereas heavier elements (Na to U) by measuring the X-ray emission.

The NMP can cope with irradiated samples and one of the first applications was the determination of the lithium profile in an oxide layer formed on irradiated Zircaloy. The future application of the technique to other coolant borne species will be very

interesting as well as the comparison with other techniques such as glow discharge mass spectrometry.

Paper 9

" Partitioning of grain boundary and matrix gas inventories in nuclear fuel: the ADAGIO facility"
S. Ravel, G. Ducros, T. Petit, L Caillot, G. Eminet, C.E.A. Grenoble.

The paper describes a very interesting method to quantify the amount of gas retained in the matrix as compared to the amount diffused to the grain boundaries. The method is based on the fact that, after several months cooling time, the only radioactive fission gas is ^{85}Kr, namely localised partially in the matrix and partially at the grain boundaries. A short re-irradiation of the samples at low temperature produced short life fission gas, mainly ^{133}Xe and mainly located in the matrix (since the time available to diffuse is very short). After that the samples were oxidise from UO2 to U3O8, opening the grain boundaries at about 450 °C. The following thermal treatments up to 1400°C quantified the release of the complete gas inventory. From difference between ^{85}Kr and gives ^{133}Xe the amount of intergranular gas was determined.

In the future, an improved sample preparation including a new core sampling device, could give valuable information concerning the radial distribution of the fission gas distribution with special emphasis on the RIM-effect and the retained (or not) gas in the periphery of the pellet.

Paper 10

"The VERCORS HT facility for studies up to molten PWR fuel conditions"
P.P. Malgouyres, *G. Ducros*, M.P. Ferroud-Plattet, M.Prouve, D. Boulaud, C.E.A. Grenoble and IPSN Saclay.

The VERCORS High Temperature (up to 3100 K) facility for the evaluation of the fission products release during a temperature excursion, when it is assumed that the integrity of the fuel elements has been lost, was described.

The primary objective of the programme for the facility is to improve the data base of fission products release and fuel behaviour, after the fuel integrity has been lost due to an increase of temperature similar to that occurring during a PWR severe accident. Measurements were performed concerning the release kinetics and total release of FP & structural materials, aerosol source and distribution size and the chemical forms of the FP.

The results will provide the data basis for the evaluation and interpretation of more extensive experiments like PHEBUS, validating models use in accident codes and creating a realistic data bank for computing FP-behaviour.

Paper 11

„High heat loading tests and temperature measurements in hot cells"
R. Duwe, W. Kühnlein and G. Pott, Forschungszentrum Jülich, Germany.

Thermal fatigue and thermal shock testing to select the best suitable materials for the first wall of fusion reactors, was performed under simulated plasma disruption conditions. Temperatures as high as 3500 °C were obtained by using an electron beam facility installed in a hot cell and measured by a special pyrometer and infrared camera system.

The most relevant information from these tests is related to the damage of the specimens due to erosion and cracking caused by high temperature loading.

Paper 12

„A shielded SIMS ATOMIKA 4000: concept, construccion and first experience"
M.Martin, D.Gavillet, O.Gebhardt, PSI, Switzerland.

A new SIMS-equipment with improved capabilities was installed in the hot cells. First application of device was the determination of radial distribution of Pu in irradiated fuel rods. In addition to that, the technique was applied to the depth profile determination of Li and B in the oxide layer of irradiated fuel rod cladding.

Paper 13

„A new puncturing apparatus optimised for free volume determination"
L. Desgranges, F. Dujet and A.Thouroude, CEA, Cadarache, France.

In the paper a new, faster method for the determination of the free volume of irradiated fuel rods was described. The method is based on the so-called double expansion which takes advantages of the high pressure present in the fuel rod before the puncturing to reduce the measuring time to measure the remained free volume. A relatively small puncturing chamber and high-pressure gages are necessary for the implementation of this method.

Paper 14

„A burst test facility for irradiated fuel rod segments"
P.Poerschke, *M.Martin*, B. Hirt, A.Hermann, F.Groeschel, PSI, Switzerland

A burst test device for irradiated fuel rod claddings was installed in a hot cell. The facility includes a measuring device to determine the diameter of the sample after burst and a special method for the retrieval of the internal fuel before the test was developed. The test can be performed by oil pressurisation from room temperature until at a maximum temperature of 350°C.

Paper 15

„ECN welding facility for irradiated material"
G.L. Tjoa, D.S.d'Hulst, E.V. van Osch, E.W. Schuring, ECN-Petten, Netherlands.

After introducing the new company, NRG, born from the merger of ECN and KEMA, Mr. Tjoa described a new welding facility using two techniques: TIG and Laser. Both methods yielded excellent results for joining irradiated stainless steel pieces.

This technique could be applied in the future for the replacement of damaged, neutron irradiated stainless steel components in a fusion reactor.

Paper 27

„Optimisation of the process for the determination of fission gas release from reactor fuel pins"
P. Schleuniger, A.Hermann, PSI-Switzerland.

A new optimised installation for the fission gas analysis was described. In the device a membrane-pump provides the possibility for the gas sampling. New electronic pressure gages ensure an accurate free volume determination.

In the installation already 20 irradiated fuel rods have been tested and more than 80 gas samples successfully analysed.

Paper17

„Machining and welding technique in hot cell"
P.Novosad, *M.Fracnik*, J.Málek and M.Kytka, NRI-Rez, Czech Republic

This paper presented machining and welding techniques, based on the use of an electron beam device installed in the hot cells. The facility was utilised for the reconstitution of irradiated samples for mechanical properties testing.

The electron beam technique was to the surveillance programme of containers for the VVER 440 reactors.

Paper 20

„Depth profiling of impurities in Zirconium oxide layers by DC Glow Discharge Mass Spectrometry"
O. Actis-Dato, M.Betti, *E.H.Toscano*, TUI-Karlsruhe, European Union.

A direct current Glow Discharge Mass Spectrometer was installed in a glove box. Among other applications, the device was used for the determination of the depth profiling of several elements borne in the primary coolant circuit of a nuclear reactor. The principles of the technique were discussed together with its applications to the determination of the Li-profile in the oxide layer of an irradiated fuel rod.

Paper 22

„The activities of the RRC „KI" reactor materials division in the field of post-irradiation examination of fuel rods"
V. Bespalow, Kurchatov Institut, Russia.

The hot cell facility at Kurchatov Institute was described. The installation includes NDT-facilities, microscopy, X-ray analysis, etc. Furthermore, the refabrication and instrumentation of short rods, including the possibility of drilling of holes on pellets in a cryogenic chamber, can be performed under remote handling conditions. Last but not least, a big van used for the transfer of fuel rods and the transport of equipment was described.

Paper 19

„A shielded corrosion testing facility at Winscale"
H.G. Morgan and J.G.Gravenor, AEA-Technology, UK. Paper presented by *Dr. Perks*.

The last paper of the session was presented by Dr. Perks describing the development of a testing facility at AEA Technology to test corrosion assisted mechanical properties on irradiated materials in the presence of an aqueous environment simulating the conditions of operating primary or secondary circuits. Furthermore, the tests will performed simulating actual loading conditions.

The materials to be tested will be pieces removed from operating plants or samples from surveillance programmes. Test temperatures as high as 360 °C will be achieved.

ECN

Technical Session 3: Refurbishment Decontamination and Maintenance of Laboratory Infrastructure

Mr. Hammar of the Studsvik Hot Cell Laboratory presented their new fire protection system based on environmental friendly gases like nitrogen, argon and carbon dioxide. According to Swedish legislation, halon was no longer permitted. A full scale test proved the good operation of the new system.

Mr. Noyes of CEA Cadarache told us of the problems of the transportation packagings which are more than 20 years old and do not comply with the existing regulations anymore. Extra costs for safety studies and modifications of casks have to be made. Unavailability of casks due to the fact that certificates are not renewed, with resulting delay in research programs, poses problems. CEA has therefore decided to initiate the renewal of the packaging inventory. Due to time constraints CEA has to set priorities to carry out this project successfully.

Mr. Bruhl of CEA/DSNQ/MSN presented a new type of HEPA filter used in ventilation systems of nuclear installations. The new type of filter has a better resistance to high temperature increases and other conditions which occur in case of fire.

A new decontamination approach for the nuclear industry was presented by Mr. Gilbert of AEA Technology. Advantages of this sponge blasting process are a reduced dose uptake for the personnel, lower waste volumes due to recycling and a reduction of the operation time.

K.A. Duijves