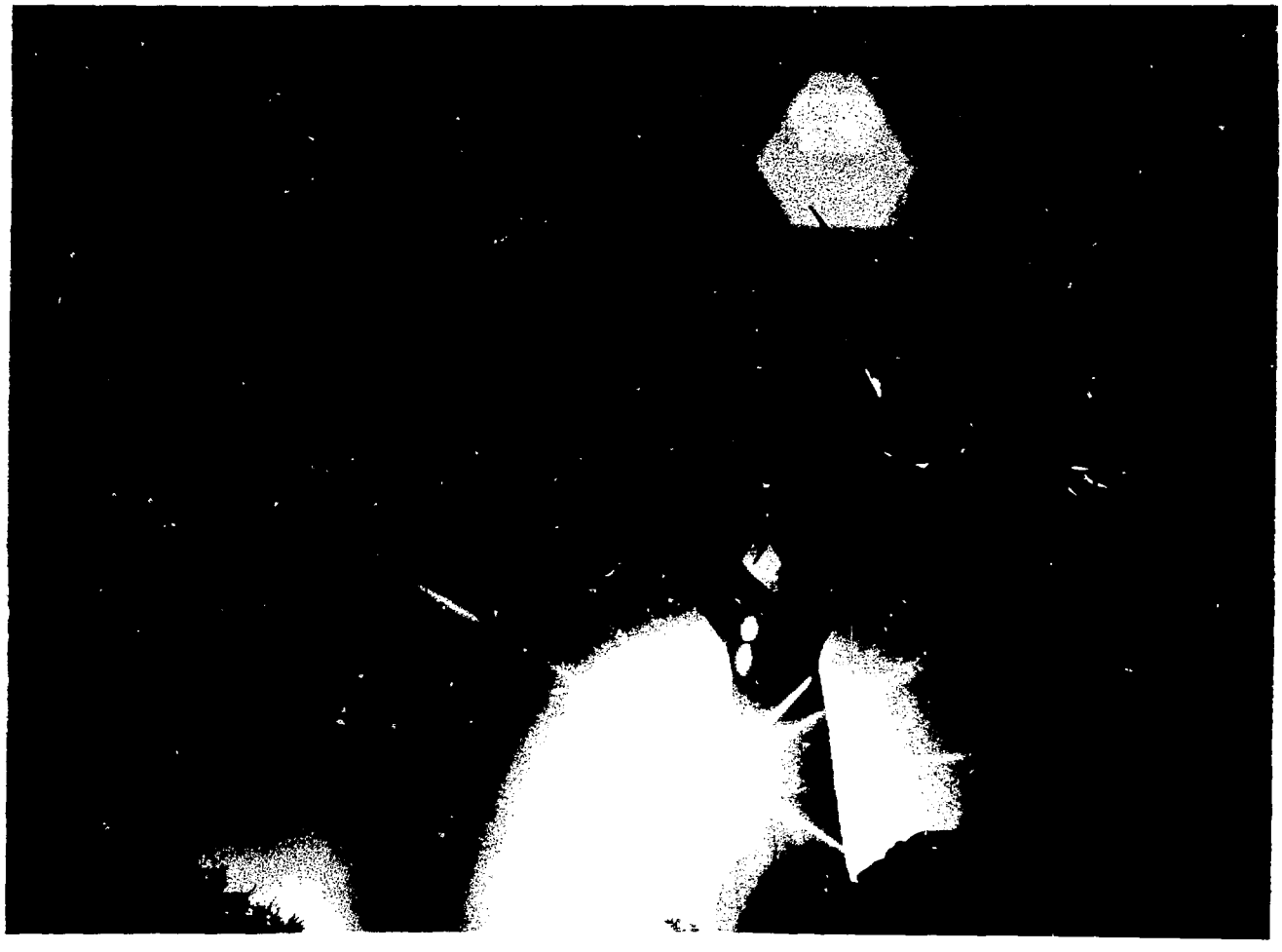
INIS-mf--10514

RADWASTE '86

7 - 12 SEPTEMBER 1986



ABSTRACTS VOLUME

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

CAPE TOWN SOUTH AFRICA

RADWASTE '86

ABSTRACTS VOLUME

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE, AND ITS DISPOSAL IN ARID REGIONS

7 - 12 SEPTEMBER 1986
CAPE TOWN, REPUBLIC OF SOUTH AFRICA

SPONSORS

THE ATOMIC ENERGY CORPORATION OF SOUTH AFRICA LIMITED

ESCOM

Compiled and Edited by L.C. Ainslie
Department of Geotechnology

AUGUST 1986

ISBN 0-86960-827-4

Published by the Atomic Energy Corporation of South Africa Ltd.
P.O. Box 582, Pretoria, 0001 Republic of South Africa

CONTENTS

Cesium extraction from reactor pool water using supported liquid membranes
W.M. Craig, D.L. Hofman, E.M. Buchalter, R.S. Birkill and J.J. Smit

An evaluation of the production of solid radioactive waste in the Tricastin nuclear power station and, more generally, in the other French nuclear power plants
R.G. Cuisenier

Dry storage of light water reactor fuel
J. Cumiskey, J. Cardito, G. Bushnell and S. Popper

Characterization of products arising from the incorporation of low- and medium-level waste in cement or polymer matrix
G. de Angelis and G. Caropreso

Resistivity studies on the Vaalputs Radioactive Waste Disposal Facility
J.H. de Beer and J. Blume

Impact assessment of buried low-level wastes under unsaturated flow conditions
G.C. Eichholz

Methodology for performing safety assessments for potential radioactive waste disposal facilities
J. Fitzpatrick, Z.A. Gralewski, D. vande Putte and G. Waplington

Site selection issues for radioactive waste disposal in arid regions of the United States
R.K. Gaynor

Incineration of burnable low-level waste
K.M. Gräbener, A. Kirchenmayer and K.L.V. Wasinger

Development of a metallic high integrity container
R.T. Haelsig

Transportation and storage experience
R.T. Haelsig

Botanical aspects of the ecological integrity of the Vaalputs Radioactive Waste Disposal Facility
A.V. Hall

Design criteria for experimental radioactive waste disposal trenches at the Vaalputs Radioactive Waste Disposal Facility
B.B. Hambleton-Jones and P.E. Moore

Safety assessment of a projected waste repository for HLW during its operational phase
A. Jacobi Jr.

Treatment of solid radioactive waste by Electricité de France (EdF)
P. Jeanson

Operating considerations of shallow land disposal
D.F. Jones

Long-term interim storage of spent fuel - approved technology for economical concepts
A. Kirchenmayer, J. Bank and K.L.V. Wasinger

Swedish studies of high-level waste disposal in crystalline rocks
K.B. Krauskopf

Geohydrology of the Vaalputs Radioactive Waste Disposal Facility
M. Levin, B.B. Hambleton-Jones, E. Raubenheimer and N. Niemand

The improvement program of radwaste treatment at Chinshan nuclear power station
M.H. Lin and C.Y. Huang

Operational experiences in the treatment of low- and medium-level radwaste in the Federal Republic of Germany
W. Lindow, D. Herbrechter and W. Stegmaier

Metamict minerals as model substances for radwaste
H. Müller

Radioactive fall-out from the Chernobyl disaster, and its aftermath in Central Europe
A. Müller-Broich

Radioactive waste management at Rocky Flats
J.D. Navratil

Zoological aspects of the ecological integrity of the Vaalputs Radioactive Waste Disposal Facility
J.A.J. Nel, M.D. Picker and T.S. Robinson

The design and performance of low-cost, soil cement cap for LLNW disposal trenches
E.A. Nowatzki

Considerations in the development of a site characterization field manual for near-surface geological disposal of LLNW
E.A. Nowatzki and J.G. Mc Cray

Communications: Roots of our problems
F.C. Olds and N.S. Olds

Dry storage of spent fuel : current practice, experience, and development trends
C.J. Ospina-Esperon

Cask-system for conditioning, transport, and storage of radioactive waste
D. Rittscher, G. Gestermann, K. Kroth and H. Lammertz

KEYNOTE ADDRESS

Radioactive waste, the Earth's crust and human society
R. Rometsch

Potential exposures and health effects from spent fuel transportation
G.M. Sandquist and V.C. Rogers

Probability of intrusion events at radioactive waste disposal facilities
G.M. Sandquist and V.C. Rogers

Safety and licensing requirements in the Republic of South Africa
D.M. Simpson and E.L. Langford

Modelling and prediction of radionuclide migration from shallow, subgrade nuclear waste facilities in arid environments
A. Smith, A. Ward and S. Geldenhuis

Earth science considerations on the storage and disposal of radioactive waste and used nuclear fuel in Taiwan, Republic of China
K.L. Soong

Radioactive waste disposal: solutions pursued in South Africa by ESCOM
P.H. Spencer, H.F. Röhm and M.I.J. Harris

Geotechnical aspects of trench capping for the Vaalputs Radioactive Waste Disposal Facility
D. Stephenson, P.E. Moore and B.B. Hambleton-Jones

Safety assessment for radwaste disposal in Korea: Part 1. Development of a code for simplified safety analysis
I.S. Suh, H.H. Park, K.W. Han and P.S. Hahn

Selection criteria for a radioactive waste disposal site in the Republic of South Africa
P.D. Toens and B.B. Hambleton-Jones

An improvement program of LAN-YU radwaste receiving and storage facility in Taiwan, Republic of China
C.M. Tsai and R.T. Lee

The Vaalputs environmental monitoring program
D. van As, C.A.R. Bain and S. Posnik

Radioactive waste disposal in South Africa
H.J. van der Westhuizen and P.E. Moore

Environmental isotopes assist in the site assessment of the Vaalputs Radioactive Waste Disposal Facility
B.T. Verhagen and M. Levin

Speciation aspects of predictive modelling in radioactive waste disposal
D.R. Williams

Engineering input parameters for the seismic design of nuclear facilities in Southern Africa
D.J.W. Wium and G.H.P. Opperman

CURRICULA VITAE OF THE PRESENTING AUTHORS

The papers will be presented by the author whose name has been underlined.

Further copies of this volume can be obtained on request from The Librarian, Department of Geotechnology, Atomic Energy Corporation of South Africa Ltd., Private Bag X256, Pretoria, 0001 South Africa.

A volume containing all the papers presented at the Conference will be posted, free of charge, to each delegate by the end of 1986. Additional copies of this volume will be available from the Atomic Energy Corporation at the above address.

TRN ZA8600407

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

COMPLIANCE OF THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY TO A FREQUENCY-MAGNITUDE RELEASE CRITERION AS REQUIRED FOR LICENSING

H.W.W. ADRIAN, H.H. GERBER, J. KRUGER and J. WEYGAND
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

Accidental releases of radioactivity from the Vaalputs Radioactive Waste Disposal Facility have been quantified, and release frequencies have been attached to a number of accident scenarios of human or natural origin. These have then been compared to a frequency - magnitude release criterion according to South African licensing requirements. It was shown that the criterion was applicable in three release bands. In two of these the criterion was met by some orders of magnitude. In the third band the permitted release frequency was a factor of 55 below the limit in spite of pessimistic release assumptions.

TRN ZA8600408

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

GEOPHYSICAL INVESTIGATIONS ON THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY IN THE REPUBLIC OF SOUTH AFRICA

N.J.B. ANDERSEN, and J.N. FAURIE
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

As the rocks of the Namaqualand Metamorphic Complex are sand covered in the area of interest, extensive airborne and ground geophysical surveys were undertaken to assist with the evaluation of the regional and local geology, as well as to locate and avoid possible mineralization.

A medium sensitivity aeromagnetic survey, as well as an airborne INPUT survey were used to locate potentially mineralized kimberlite and noritoid intrusions. After airborne detection, these targets were followed up on the ground using electromagnetic and resistivity techniques. Subsequent drilling proved them to be un-mineralized.

A thermal infrared line scan survey was used in conjunction with the aeromagnetics to evaluate the structural geology and assist with the location of groundwater.

Continuous seismic refraction profiling was used to locate an area of rippable overburden (i.e. having a seismic velocity of less than 1 500 m/s) and depth greater than 10 m for the excavation of the low level waste trenches.

The area was extensively drilled, and all boreholes have been radiometrically logged.

Since the Vaalputs area is entirely sand covered it was essential to use geophysical techniques to evaluate the subsurface geology, and to avoid placing the facility in an area of economic mineralization.

TRN ZA8600401

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

GEOLOGY OF THE VAALPUTS RADIOACTIVE WASTE DISPOSAL SITE IN THE REPUBLIC OF SOUTH AFRICA

M.A.G. ANDREOLI, N.J.B. ANDERSEN, M. LEVIN and N. NIEMAND
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

The Vaalputs site is underlain by an extensive veneer of Tertiary and Quaternary deposits covering a crystalline basement of Precambrian age. The geological history of the area, from the oldest to the youngest event may be summarised as follows:

1. Polyphasic ductile/ductile-brittle deformation and 1100 m.y. old granulite facies metamorphism of a (volcano-) sedimentary sequence, and of associated syn- to late-tectonic granitic and basic intrusions. This basement has been compared to the Grenvillian belt of North America because the age of the metamorphism (ca. 1100 m.y.) and the lithological associations (K-rich rapakivi granites, anorthosite, charnockite, etc.) are very similar.

2 Deposition of glacial tillite after a long erosional hiatus in Karoo (Permian) times, but preservation is limited to down-faulted structural blocks within the area investigated. Sills and dykes of basalt were sporadically injected in the Jurassic (?) along some of the many N-NNW and NW trending fractures and faults related to the opening of the Atlantic ocean.

3 Lower Tertiary rejuvenation of older faults and shear zones, accompanied by kimberlitic volcanism resulted in the uplift of the Kamiesberge (mountain) range west of the site. Intense erosion of these mountains shed abundant detritus, which accumulated in tectonically controlled troughs and fans. These fluvial sediments consist of white kaolinitic clay and sandy to gritty clay belonging to the Dasdap (older) and Vaalputs (younger) formations respectively.

4 From ca. 30 m.y. ago to the Present, tectonic stability and (semi)arid conditions have generally prevailed leading to an extensive thin cover of calcrete and Kalahari sands.

The unfaulted, highly impermeable nature of the Vaalputs formation optimizes the safe disposal of low- to medium-level radioactive waste in the area selected. However, the numerous faults and shear zones of the granitic and gneissic basement will need in-depth investigations should a high-level radwaste depository be required.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 3

BROAD SURVEY OF RADIOACTIVE WASTE TRANSPORT AND TRENDS

P.T. BLUM
Transnucléaire, Paris, France

ABSTRACT

This survey reviews radioactive waste (RW) transport in different countries, giving the origins, amounts, distances and modes of transport for the different RW categories currently moved. It appears that:

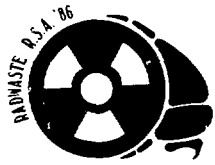
- Present transport experience concerns mainly low and medium level wastes (LMW) with short periods, and spent nuclear fuel (SF)
- RW transports are implemented in compliance with IAEA recommendations, which proved particularly helpfull to gain public acceptance; the bulk of LMW is transported as LSA materials (i.e. with packaging requirements just equivalent to those needed for their disposal) and SF as well as liquid RW are transported in type B packagings which can withstand severe accident conditions.
- Records indicate that transport worker irradiation is kept well below allowable limits and that accidents during RW transports did not cause significant release of activity to environment.
- The cost of RW transports including insurance, is small compared to that of RW disposal or processing.

Therefore, one may comment that RW movements are by no means slowed down by transport problems, and just follow the demand which may be delayed for reasons linked to the RW disposal strategy, or its public acceptance.

Then, the survey presents an assessment of RW transports until the end of this century and comments on related issues such as:

- Foreseeable changes of transport regulations, in particular, activity limitation of LSA materials transportable per vehicle
- Consequences of centralized facilities for LMW conditioning
- Interest in volume reduction of RW on production sites (LMW compaction/incineration, SF consolidation)
- Increasing part of RW generated by decommissioning operations
- Possible routes for disposal of RW with long periods, including burial in ocean sediments
- Control of transport equipment and operations by receiving facilities through standardization and planning
- Merits of different transport modes (legal and overweight trucking, rail with or without special trains, normal or special vessels)
- Evolution of SF transports (longer cooling time, transport/storage packagings)
- International transport of SF and RW resulting from SF reprocessing
- Physical protection applied to RW transports.

TRN ZA8600411



CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

MODELLING RADIOACTIVE TRANSPORT IN A POROUS MEDIUM

J.F. BOTHA
Institute of Groundwater Studies, University of Orange Free State, Bloemfontein, South Africa

ABSTRACT

The paper deals with the development of a numerical model to simulate the transport of radioactive material in a semi-arid region. The main interest is to determine to what extent can an unsaturated transport model be used in modelling a multi-layered non-homogeneous porous medium with special reference to an arid region.

Particular problems to be discussed include: The effect of depth to the water table on the moisture distribution in the unsaturated domain, interpretation of field data with special reference to the unsaturated hydraulic parameters, admissible boundary conditions, and the calibration of the model.

The suitability of such a model to yield quantitative information on the behaviour of radioactive isotopes leaking from a near surface depository will also be discussed.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

FEASIBILITY OF DISUSED UNDERGROUND MINES FOR LOW-LEVEL AND INTERMEDIATE-LEVEL RADIOACTIVE WASTE DISPOSAL

W. BREWITZ
Gesellschaft für Strahlen- und Umweltforschung mbH (GSF), Institut für Tieflagerung, Braunschweig, Federal Republic of Germany

ABSTRACT

Among the various concepts for geological disposal of radioactive waste, the use of underground mines and cavities is being widely accepted by the IAEA member countries, in particular for low- and intermediate-level waste (IAEA Safety Series, Nos. 59 and 62). The technical possibilities of existing or disused mines are manifold. and depend directly on quantities, nuclide inventories and condition of the waste types to be disposed of. Much data required for an overall safety assessment can be derived from site-specific geological and mining knowledge, which in other cases can only be made available by expensive and time consuming investigations. Taking socio-economic and ecological data also into consideration, existing or disused mines may be a potential alternative to the construction of new underground repositories, in particular in countries with well developed mining industries.

In the Federal Republic of Germany the disused salt mine Asse II near Braunschweig owned by GSF was chosen in 1964 to become the nations first and only pilot facility for radioactive waste disposal. From 1967 till 1978 about 125 000 200 1 and 400 1 drums of LLW were disposed of in existing mining chambers by using either stacking or dumping techniques. About 1 300 drums of ILW have been disposed of by using transport casks and remote handling techniques for radiation protection. Today the ASSE mine is a research and testing site for the development of disposal techniques for high-level waste.

The disused iron ore mine Konrad at Salzgitter was investigated by GSF for its feasibility for non-heat generating radioactive waste disposal. From 1975 till 1982 various geological, hydrogeological, seismic and rock mechanical investigations were performed, and specific technical concepts for waste disposal in underground galleries were developed. After the overall feasibility was proved the Physikalisch-Technische Bundesanstalt (PTB) took over and applied in accordance with the national atomic act for licensing with the appropriate authorities. It is expected that after licensing in 1987, and two years of construction, the disposal operation may start in 1989.

Although the German radioactive waste disposal concept is focused on the development of a new mine in the salt dome of Gorleben for high-level waste disposal, the first radioactive waste repository and the experimental facility were both designed in disused mines.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

RESIN DRYING IN HIGH INTEGRITY CONTAINERS - ADVANCED WASTE STABILIZATION METHODOLOGY

M.P. CARSON
Nupac Services, Inc., No. 1 Harbison Way, Suite 209, Columbia, South Carolina 29210, United States of America

ABSTRACT

Pre-disposal stabilization requirements for waste ion-exchange media have become more stringent over the past 10 years. As these requirements stiffened, the need for performance oriented, waste resin processing equipment and methodology has increased. Current U.S. requirements mandate no more than 1 % free standing water (FSW) by container volume for waste ion exchange media stabilized by high integrity container envelopment.

Nupac Services, Inc. provides waste resin processing services to several U.S. nuclear utilities, utilizing the Nuclear Packaging resin drying system and high integrity container.

The drying system is a modular, portable unit that contains all necessary equipment and controls for removing the free water from granular and powdered media, specifically ion exchange resin and filter media. The system has been tested extensively to certify it's drying capacity exceeds the requirements of 10 CFR 61 (1 % FSW).

Comprehensive full scale testing, utilizing fully instrumented containers was conducted during the design and engineering phase of system development. Concurrent with the full scale testing, extensive computer modeling was performed to allow subsequent predictive behaviour and demonstrate regulatory compliance. The resultant final system configuration is a technologically advanced drying system that follows theoretical water removal models for resin beds very closely.

Operationally, the Nuclear Packaging resin drying system allows rapid, remote, and demonstrable water removal from large volume containers ($19m^3$ containers can normally be dried in 8 hours or less). The system, therefore, reduces radiation exposure to the operators and utility personnel, conserves burial space through enhanced volumetric efficiency, and is economically superior in transportation and disposal through both volume and weight conservation.

TRN ZA8600414

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

THE HEALTH PHYSICS PROGRAMS IN LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT AT THE INSTITUTE OF NUCLEAR ENERGY RESEARCH, REPUBLIC OF CHINA

W-L. CHEN
Institute of Nuclear Energy Research, P.O. Box 3-10, Lung-Tan, Taiwan 32500, Republic of China

ABSTRACT

The primary mission of the health physics programs in low-level radioactive management is to ensure radiation safety for personnel and environment of the Institute of Nuclear Energy Research (INER), and also for the general public surrounding INER.

In view of the above, the Health Physics programs in low-level radioactive waste management are divided into three sub-programs: the radiation control program, the environmental survey and bioassay program, and the radiation dosimetry supporting program. The general guidelines, responsibilities, and performance of these programs will be discussed in this paper in the following order.

The responsibility of radiation control group is to conduct area monitoring and radiation surveillance for the radioactive waste treatment workers. It includes the control of radiation field level of the working area, servicing personnel dosimeters, instruction on radiation safety, and handling of radiation accidents.

The responsibility of the environmental survey and bioassay group is to perform environmental surveys and bioassays. Environmental gamma monitoring stations were installed both on-site and off-site at INER. For bioassays, urine samples are taken from radioactive waste treatment workers, and for internal contamination checks of workers, total body counting systems are being used.

The main responsibility of the radiation dosimetry group is to provide radiation dosimetrical support to the radiation control group and the environmental survey and bioassay group. Some typical work of the radiation dosimetry group is the qualitative assay and quantitative determination of radioactive samples, and calibration of dosimeters and survey meters.

In addition, the main facilities for low-level radioactive waste treatment at INER will be introduced briefly in this paper. The Health Physics Monitoring activities for these facilities will be described in detail, especially the ALARA principle for radiation control and environmental monitoring as applied in waste management.

TRN ZA8600415

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 1

TREATMENT OF WET SOLID LOW-LEVEL RADIOACTIVE WASTE

T-S. CHOU
Institute of Nuclear Energy Research, Atomic Energy Council, Taiwan, Republic of China

Y-D. LEE
Department of Chemical Engineering, National Tsing Hua University, Hsinchu, Taiwan, Republic of China

ABSTRACT

Recently low-level radioactive waste has caused much concern because of its long term impact on the environment. Most of the low-level radioactive waste is produced by nuclear power plants while a small fraction comes from medical applications, for example, radioactive isotopes. This waste exists in gas, liquid and solid forms. Research was carried out on wet solid low-level wastes, which were treated with polymeric materials. Their properties and applications were studied and evaluated.

Wet solid radioactive wastes come from evaporated condensates produced by light-water reactors. The main component of boiling-water reactor waste is Na_2SO_4 and that of pressure-water reactor waste is H_3BO_3. Furthermore the spent ion exchange resin also constitutes a major portion of the solid radioactive waste. In this research, unsaturated polyesters, such as ETERSET 2565P and 2144 HCM, were employed to solidify the wastes; i.e. Na_2SO_4, $Ca_3(BO_3)_2.2H_2O$, cationic ion exchange resin Duolite ARA 9366 and anionic ion exchange resin Duolite ARC 9351. It was found that the properties, such as density, compressive strength, water resistance and thermal stability of unsaturated polyester solidified wastes were excellent. The radiation resistance could be as high as 10^8 Rad and the leachability was low. The volume reduction ratios of all samples were better than those of cement solidified waste.

TRN. ZA8CC0416

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 1

CESIUM EXTRACTION FROM REACTOR POOL WATER USING SUPPORTED LIQUID MEMBRANES

W.M. CRAIG, D.L. HOFMAN, E.M. BUCHALTER and R.S. BIRKILL
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

J.J. SMIT
Potchefstroom University for C.H.E.

ABSTRACT

Cesium 137 is one of the fission products contaminating reactor pool water either by diffusion through the cladding or from leaks in fuel elements. In the conventional purification of the pool water, resins are used to remove the fission products. Recovery of these elements from the resin is, however, very difficult. Recovery of cesium 137, in particular, would be very advantageous.

In this paper it is proposed that the fission products be removed from the pool water, firstly by concentration of the solution using reverse osmosis, and then by selective removal of the elements from the concentrate using a supported liquid membrane.

Experimental results show that a PVDF membrane, impregnated with BAMBP and traces of crown ether, used between a feed solution at pH 10 and diluted nitric acid as strip solution, selectively recovers 6 g of cesium per square metre in a seven day period.

TRN ZA8600417

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

AN EVALUATION OF THE PRODUCTION OF SOLID RADIO-ACTIVE WASTE IN THE TRICASTIN NUCLEAR POWER STATION AND, MORE GENERALLY, IN THE OTHER FRENCH NUCLEAR POWER PLANTS

R. G. CUISENIER
Electricité De France, BP 9, 26130 Saint Paul-3-Chateaux, France

ABSTRACT

The importance of the effect of processing and packaging of solid radio-active wastes on the necessary staff, on the dosimetry acquired by this personnel and on the running costs will be presented, thus permitting a quantitative evaluation of the different types of waste produced, not only for the Tricastin plant but also for any typical French nuclear plant.

Experience in the Tricastin power plant has shown that the volume of solid wastes can vary considerable depending on the different problems which can arise during production (cooling system leaks or less regular incidents).

The different techniques used will be relooked at in order to facilitate the explanation of these fluctuations in the volume of waste produced and the measures which can be taken to limit them.

The different measures which have been taken to improve performance in this domain will be presented: Improvements in equipment, in methods, and in the increased awareness of the personnel concerning these problems.

TRN ZA8600418

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 3

DRY STORAGE OF LIGHT WATER REACTOR FUEL

J. CUMISKEY, J. CARDITO, G. BUSHNELL and S. POPPER
Stone & Webster Engineering Corporation, Boston, Massachusetts, United States of America

ABSTRACT

The definition of interim fuel storage life is argued to be up to 100 years. The storage of fuel at the generating power station or a central storage facility should be planned to eliminate the need to physically handle aged spent fuel assemblies. This paper identifies and describes a currently available alternative dry storage that meets this goal. This alternative is based on the British Advance Gas Cooled Reactor (AGR) dry fuel storage facility.

The total facility being presented is a combination of conceptual design work by Stone & Webster Engineering Corporation and detail design work of National Nuclear Corporation (United Kingdom). The facility has a number of unique features:

1. The vault and equipment design precludes oxidation of the fuel by keeping the fuel below 200°C and addresses and precludes corrosion of fuel containers and vault components. This corrosion protection does not depend on any coating system or mechanical equipment; it is a totally passive system.

2. The corrosion-free environment of the vault allows it to be built as a simple concrete block with built-in carbon steel forming material. In addition, the fuel containers are made of standard lengths of carbon steel pipe. This is in contrast to many other vault designs requiring expensive stainless steel racks. Although some of the other vault designs do not require containerizing the fuel, we believe the cost of containerizing is offset by the design differences which provide for a compact storage volume and cost effective heat transfer system.

3. Containerizing of the fuel allows storage of the fuel two-high in each vault channel in addition to other unquantified benefits for long-term storage such as fuel retrievability. As a result of the stacking of the fuel, we are able, with a small increase in construction cost, to double the capacity of each vault. The high

density storage allowed by the design effectively results in a lower dollar per kilogram cost.

The licensability of the facility is considered superior to other concepts, and a licensing schedule based on a comparison with the current ongoing British license process is estimated. The cost of the facility based on a construction program set to meet a utility or group of utilities need is presented showing a dollar per kilogram cost as low as 50$/kg.

The British AGR Dry Fuel Facility design work is directly applicable to South Africa. Only minor physical dimensional changes are required in the storage vault and this can be accomplished within the physical constraints of the vault design and do not invalidate any of the development or confirmation tests. A site specific evaluation would provide the data required to develop a safety analysis report.

TRN ZA8600419

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

CHARACTERIZATION OF PRODUCTS ARISING FROM THE INCORPORATION OF LOW- AND MEDIUM-LEVEL WASTE IN CEMENT OR POLYMER MATRIX

G. DE ANGELIS and G. CAROPRESO
ENEA, Department of Environmental Protection and Man Health, CRE Casaccia, Rome, Italy

ABSTRACT

The incorporation of LLW and MLW in an inert matrix gives rise to products which have to be characterized in order to evaluate their behaviour under accident conditions during interim storage, transport and final disposal, and to predict, as far as possible, the long-term durability of the solidified waste forms.

Due to the lack of a unique standard regulation several tests are currently employed, with the general aim to achieve a complete knowledge of the products under consideration. They include compressive strength, drop test, penetration test, hardness, impact resistance, dispersibility test, tensile test, flexural strength, high temperature resistance, fire test, freezing-and-thawing cycles, leachability, evaluation of porosity and permeability, thermogravimetric analysis, optical and electron microscopy.

Some process parameters, such as set time, viscosity, workability, heat evolution, which can influence the final properties of these materials, have also to be considered. Moreover studies concerning waste/matrix compatibility can help to predict the long-term behaviour. A general comprehension of the problems involved however can be achieved only by considering the system solidified waste/drum/final repository as a whole, and taking into account the possible interactions.

The present work is a presentation of the most important characterization methods, with the indication of the regulations followed. A brief review of the principal waste streams with notes concerning the problems which their incorporation poses is also given.

TRN: ZA8600420

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

RESISTIVITY STUDIES ON THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

J.H. DE BEER and J. BLUME
National Physical Research Laboratory, CSIR, Pretoria, South Africa

ABSTRACT

During 1983 a ground geoelectrical survey was done on the farms selected for the proposed radioactive waste disposal site. The primary aims were to outline basins of weathering, and to delineate faults, fracture zones and aquifers. The methods used were the Schlumberger electrical sounding technique and the rectangle profiling method. In total 167 Schlumberger soundings and 124 km of rectangle profiling were done. The investigation of linears detected by means of remote sensing methods showed that some of these features are related to faulting and fracturing, but also that these faults are not always continuous. The selected areas, chosen for more detailed investigation on the basis of the already available geophysical and geological data, proved to have no anomalies suggesting major basement fracturing or faulting.

During 1984 a 1 km x 1,6 km rectangle selected for the repository was studied in detail by 220 Schlumberger soundings positioned mostly on a 100 m x 100 m grid. The interpretation of the sounding data in conjunction with the borehole data showed that the upper surface of the solid basement is an uneven surface that varies in elevation between 982 m and 1005 m amsl within the 1,6 km^2 area. This corresponds to an overburden thickness that varies from 6,6 m to 36,5 m. A zone with large values of total longitudinal conductance, and thicker than normal overburden running roughly north-south through the rectangle was delineated geophysically and proven by drilling. Of the five boreholes drilled in this zone, four yielded water and the other intersected basic rock. The thickening in overburden along this zone seems to relate to a feature in the basement such as a linear zone of jointing or faulting.

TRN IA8600421

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

IMPACT ASSESSMENT OF BURIED LOW-LEVEL WASTES UNDER UNSATURATED FLOW CONDITIONS

G.G. EICHHOLZ
Georgia Institute of Technology, Atlanta, Georgia, United States of America

ABSTRACT

The environmental impact assessment of shallow land burial site for LLW depends on a realistic assessment of the actual and worst-case infiltration rate for water, the retention and drainage capacity of the trench backfill and underlying soil, the leach rate under unsaturated flow conditions, and the ion exchange properties of the soil. Additional factors of importance are the pH of the water after equilibration with the soil, the existence of suspended particulates, the presence of any chelating reagents in the waste, the residual moisture content of the soil, and any tendency to crack formation.

Extensive modeling has been done to simulate 1D and 3D dispersion effects in waste sites. The presence of interfaces and interstices can affect flow patterns and reduce the source term, or conversely increase it by causing ponding. The installation of trench floor drainage can significantly reduce the source term but only for soils with a low residual moisture value.

For areas of low or lightly intermittent rainfall, conventional models tend to overestimate impact by assuming flooding of the site and saturated flow conditions. To be meaningful a model must incorporate highly site-specific parameters, and the drainage conditions of the site must be planned carefully.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

METHODOLOGY FOR PERFORMING SAFETY ASSESSMENTS FOR POTENTIAL RADIOACTIVE WASTE DISPOSAL FACILITIES.

J. FITZPATRICK, Z.A. GRALEWSKI, D. VANDE PUTTE and G. WAPLINGTON
Electrowatt Engineering Services (UK) Ltd, Horsham, W. Sussex, United Kingdom

ABSTRACT

Current strategies for the management of all types of radioactive wastes have as their ultimate aim the disposal of these wastes safely isolated from man's environment. The primary concern in establishing the suitability of a site is the safety of disposal and therefore an essential requirement is a safety assessment. This paper outlines a methodology developed by Electrowatt Engineering Services (UK) Limited for performing safety assessments of radioactive waste disposal systems.

The methodology consists of a step by step approach from establishing the virgin site characteristics, to predicting the risk from releases in the future (up to millions of years). Both simple and more complex mathematical models are used. The simpler models are used to give a first indication of the safety of the system and to help identify data requirements for more complex models. The simpler models are also suitable for use in non-deterministic type computations using codes such as SYVAC.

The disposal system is divided into three regions namely near field, far field and biosphere. In the near field the effectiveness of the chosen engineered barriers are assessed in terms of their ability to provide both physical and chemical containment of the radionuclides. For the far field the ability of the chosen site is assessed in terms of inhibiting the transport of nuclides from the near field to the biosphere. Both a reference system and release enhancing scenarios are assessed. In the biosphere various exposure pathways can be analysed based on current human habits and projected future hypothetical practices.

The approach is described in the light of assessments performed for British Nuclear Fuels plc (UK), Department of the Environment (UK), Physikalisch Technische Bundesanstalt (D), Nationale Genossenschaft fuer die Lagerung Radioaktiver Abfälle (CH) and Nuclear Industry Radioactive Waste Executive (UK).

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

SITE SELECTION ISSUES FOR RADIOACTIVE WASTE DISPOSAL IN ARID REGIONS OF THE UNITED STATES

R.K. GAYNOR
US Ecology Consultants, 1600 Dove Street, Suite 408, Newport Beach, California, 92660, United States of America

ABSTRACT

In the United States, shallow land burial has been utilized for low-level radioactive waste disposal for the past 24 years. Experience has included disposal sites in both arid and humid environments. This paper provides a general overview of the experience to date at the arid sites with contrasts to the humid site experience. Current practices are reviewed with respect to surface water management, trench construction and disposal operations, environmental monitoring of air, water, ground water, soil and vegetation. Recent site specific impact assessments, and relevant physical and chemical site parameters are discussed and compared with those for humid disposal sites.

As a result of recent federal legislation, new disposal sites are soon to be developed in various regions of the country. Site selection, licensing and development of these new facilities will be governed by federal regulations which have developed on the basis of past experience and research. 10 Code of Federal Regulations Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste", sets forth certain site suitability requirements and performance objectives with respect to acceptable levels of impact to man and the environment. Guidelines for the site selection process and site characterization are also provided. In this paper, these requirements and their conceptual bases are discussed, particularly in relation to implementation at an arid location.

Another rule, 40 Code of Federal Regulations Part 193 is being developed to establish "Standards for Low-Level Radioactive Waste Disposal". This rule is being supported by a risk assessment computer model developed by the United States Environmental Protection Agency. The risk assessment computer model and related risk assessment models/techniques are discussed in this paper together with the relevant factors of concern for arid disposal sites. These factors include climatologic, ground water and vadose zone characteristics.

Arid locations present unique difficulties in characterization and environmental monitoring. New trends in investigation and modelling techniques, instrumentation and sampling are discussed.

TRN ZA8600424

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

INCINERATION OF BURNABLE LOW-LEVEL WASTE

K.H. GRÄBENER, A. KIRCHENMAYER and K.L.V. WASINGER
Kraftwerk Union AG, Offenbach, Federal Republic of Germany

ABSTRACT

At the German research centres in Karlsruhe and Juelich, incinerators for volume reduction of burnable radwaste have been developed and operated for many years.

The first commercial incinerator in Germany started its operation this year at the KWU service centre in Karlstein.

The principle of the incineration corresponds to the "Juelich Incineration Process". The capacity of the plant is 100 kg/h. Incineration takes place in two stages:

Stage 1: the waste is pyrolyzed
Stage 2: the pyrolyzed products are burnt.

The off-gas is filtered in three units so that the release of radionuclides is minimized. Operation experience will be reported in the paper.

The burnable waste is transported from the power plants by rail or by truck to the incinerator for volume reduction. The ash and the rest of non-burnable components are subsequently compacted and fixed in cement. The over-all volume reduction factor is about 45:1. The drums containing the fixed waste are qualified for final storage.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 2

DEVELOPMENT OF A METALLIC HIGH INTEGRITY CONTAINER

R.T. HAELSIG
Nuclear Packaging, Inc., 1010 South 336th Street, Suite 220, Federal Way, Washington 98003, United States of America

ABSTRACT

Nuclear Packaging, Inc., a Pacific Nuclear company, has developed a new metallic high integrity container (HIC) for the burial of low level radioactive waste. This class of container has received the most extensive review of any burial container licensed in the United States. It is also the first container that has been licensed to meet the requirements of Nuclear Regulatory Commission Regulations 10CFR61.

The design and subsequent review considered 300 years corrosion at a depth of 55 feet with no degradation of container structural integrity. The design also included a technical requirement that the container possess a positive vent that would exclude moisture.

The alloy that was selected allows for significant flexibility in container size and configuration which is essential to accommodating the various waste forms. This allowed the development of containers in various sizes and with a variety of closures, that accommodate the internal dimensions of various shipping shields and help minimize radiation exposure during packaging operations.

The material used in the metallic container is high-corrosion resistant which reduces the need for strict chemical controls at the waste generating facility. This acts to ease the operational requirements in the treatment of several waste streams.

The design result is a family of metallic High Integrity Containers (HIC)s that meet all the performance criteria imposed by the regulations, as well as provide a disposable waste container with good transportation efficiency and minimum operational constraints.

TRN ZA8600426

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

BOTANICAL ASPECTS OF THE ECOLOGICAL INTEGRITY OF THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

A.V. HALL
University of Cape Town, Rondebosch, South Africa

ABSTRACT

Botanical factors play a key role in maintaining the long-term integrity of ecosystems. The results of botanical research at the Vaalputs Radioactive Waste Disposal Facilty in Bushmanland, South Africa are outlined. Vaalputs is in an arid region and its vegetation is a patchy mosaic of low shrub and grass communities. Soil variation from site to site is the main determinant of community structure and erratic precipitation is a major stochastic forcing factor.

Management measures to conserve taxa, ecosystems and local genetic biogeography are discussed in relation to natural and artificial disturbances which may occur over long time-scales. Restoration of vegetation over the burial trenches should, as far as possible, be to the site's former ecotypes except that deep-rooted species should be excluded. Precautions should be taken against the accidental establishment of exotic plant invaders at Vaalputs especially if they are deep-rooted. More is now known about plant ecology at Vaalputs than any other part of Bushmanland. It would be valuable to develop such studies further and establish Vaalputs as a permanent reserve for arid-zone biological research.

TRN: ZA8600427

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

DESIGN CRITERIA FOR EXPERIMENTAL RADIOACTIVE WASTE DISPOSAL TRENCHES AT THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

B.B. HAMBLETON-JONES and P.E. MOORE
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

The development of the experimental trenches at Vaalputs was a multifaceted project designed to obtain site-specific data on different variables that ultimately would be used in the construction of the final disposal trenches. The following factors were addressed: evaluation of excavation machinery, detailed geology, engineering geology of the excavation, suitability of excavated material for backfilling and capping, characterisation of backfilling and capping methods, natural rehabilitation of ground/soil moisture, corrosion of the drums and the rehabilitation of the natural vegetation on denuded areas.

Backfilling procedures were designed to determine the strengths of the materials placed in the trenches. Three of the trenches were backfilled and capped whereas the fourth was left open such that the suitability of the sidewalls being exposed to the atmosphere could be monitored in the long term.

Trench 1 was backfilled with lumpy, dessicated clayey grit with the material varying in size from -10mm to lumps of about 0,5m in diameter.

Trench 2 was backfilled entirely with uncompacted screened dessicated -10mm clayey grit.

Trench 3 was backfilled with waste 200 metal oil drums with the spaces being filled with the -10mm screened clay.

The caps consisted of two varieties, both of which were designed to limit the infiltration of surface water, which in the long term may adversely affect the integrity of the radioactive waste. The simple cap consisted of 2m of clayey grit compacted to a bulk density of about 1 800kg/m^3. The complex cap contained in addition a 250mm thick gravel layer designed to create a wick effect.

Aluminium neutron tubes were installed in all the trenches in order to monitor the rate of moisture rehabilitation, and also the percolation rate of surface water through the cap.

Data collected from the experimental trenches has assisted with the design of the final disposal trenches at Vaalputs, in particular the design of the caps with respect to moisture infiltration and cracking phenomena, methods for determining moisture content, and the best techniques for rehabilitating the denuded areas of the trenches caps and environment.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

SAFETY ASSESSMENT OF A PROJECTED WASTE REPOSITORY FOR HLW DURING ITS OPERATIONAL PHASE

A. JACOBI, JR.
Nuclear Division, Electrowatt Engineering Services Ltd., P.O. Box 8022, Zurich, Switzerland

ABSTRACT

Design, construction and operation of a waste repository should take into account the safety requirements both during the operational and the post-closure phases of the facility. This goal is not easy to achieve, especially in the case of a high level waste (HLW) repository needing a long period of isolation from the biosphere.

Based on the Swiss repository concept for HLW[1], which is similar to a deep mine, a thorough safety assessment was performed for the repository's operational phase. The results are discussed in this paper.

One starting point of the assessment was the operational analysis of the facility. Once the sequence of normal operations was established and the frequency of the routine work determined, different failures/malfuntions were postulated. These operational incidents were then grouped together into typical categories:

- mechanical impact
- lack of heat removal from the waste packages
- fire incident
- combustible/explosive gas accumulation
- failure to remove water from the sump
- breakdown of ventilation system in the repository.

Among the different possible scenarios those having the greatest consequences at a given location of the repository were then analysed in detail.

Another starting point for this assessment was a review of initiating events with repository-external origin:

- airplane crash
- earthquake
- atmospheric impact
- landslides, avalanches and external flooding.

As only the region and not the exact location in which the HLW repository might be sited was known, it was only possible to evaluate the effects of such disturbances in a qualitative manner.

As a third starting point of the analyses, extreme accident scenarios, representing either hypothetical or unrealistic accident cases, were developed and studied[2]. The aim of these investigation was to gain an insight into the repository's capability to withstand and mitigate even the consequences of such events. Representative cases of the studied extreme accident scenarios were, e.g.:

- shaft liner collapse with subsequent flooding of underground works
- fall of a HLW package into the repository shaft
- cave-in of the roof of a disposal cavern.

The studies described briefly above have shown that the Swiss repository concept for HLW is basically sound, and, once constructed, will meet the safety requirements during its operational phase, if these requirements are not drastically increased in the future.

References

1 Nagra Projektbericht NGB 85-03, Projekt Gewähr 1985, Endlager für hochaktive Abfälle: Bautechnik und Betriebsphase, Jan. 1985.

2 The Fall of a HLW Package into a Repository Shaft, Jacobi A. Jr., Paper submitted for presentation at IAEA International Symposium PATRAM 86 in June 1986.

TRN. ZA8600423

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

TREATMENT OF SOLID RADIOACTIVE WASTE BY ELECTRICITE DE FRANCE (EdF)

P. JEANSON
Electricité de France, 6 Rue Ampere, B.P. N114 93203, Saint-Denis, Cedex 1, France

ABSTRACT

After a brief review of the French nuclear-electric generating program the paper discusses the production of radioactive waste, its containment, and levels of activity for a 900-MW PWR unit.

The criteria to be respected and the origin of containment methods are listed. These involve fundamental safety rules established by the Central Department of Safety for Nuclear Installations (Ministry of External Trade and Industrial Redeployment) and the additional instructions required by the National Agency for the Management of Radioactive Waste. The relationship between these organizations and the producers in achieving ANDRA approval are explained.

An economic evaluation is presented. It gives the cost of treating the waste for a 900-MW PWR unit. It also describes the work carried out by EdF on the use of reusable shells and bulk discharge.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

OPERATING CONSIDERATIONS OF SHALLOW LAND DISPOSAL

D.F. JONES
Pacific Nuclear Systems, Inc., 1010 South 336th Street, Suite 220, Federal Way, Washington 98003, United States of America

ABSTRACT

Shallow land burial (SLB) is a widely used and accepted technique for disposal of low level radioactive wastes. In the United States, such activities are governed by U.S. Nuclear Regulatory Commission Regulations (10CFR61).

Operating a shallow land burial facility is a complex process requiring concurrent and consistent management emphasis over a broad spectrum of interrelated activities. The degree of emphasis required by some of these activities is predetermined by rigid external influences. Prevailing natural conditions and characteristics of the site as well as state and federal regulations are basic, direct and inescapable influences on site operation.

Management of a Low Level Radioactive Waste (LLRW) disposal site involves developing accurate and detailed processes to cover all of the site's activities. These processes are almost always reduced to written procedures, and many become part of the operating license for the facility. Detailed procedures are developed for; excavating and preparing disposal trenches; installing and sampling the environment; scheduling, receiving and inspecting waste shipments; handling and disposing of the waste; and practices to ensure things are done properly (quality assurance and safety). Development of these procedures is pre-requisite to site licensing and operating.

Having a comprehensive set of outstanding operating procedures does not insure that things will be done correctly or even done at all. As in most operations, the overpowering consideration in operating the disposal site is the skills and qualifications of both management and operating personnel.

Consequently, the most critical factors in the administration of a safe and effective disposal operation is the viable recruitment, selection and training of personnel. Ultimately, the degree of success depends upon the training process.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 3

LONG-TERM INTERIM STORAGE OF SPENT FUEL - APPROVED TECHNOLOGY FOR ECONOMICAL CONCEPTS

A. KIRCHENMAYER, J. BANCK, and K. WASINGER
Kraftwork Union AG, Offenbach, Federal Republic of Germany

ABSTRACT

For several reasons long-term interim storage of spent fuel became more and more important.

As a first stage, most economical measures were taken, by a significant number of nuclear power plant owners, by use of compact or densified storage racks where neutron absorbing material ensures subcritically. This lead to a significant reduction in the spacing between the fuel assemblies stored. By use of compact storage racks, the storage capacity for spent fuel can be more than doubled allowing an operation period of 10 to 15 years without shipment of spent fuel off site.

Further extension of storage capacity can be achieved by rod consolidation, for which submerged equipment has been developed to be used in nuclear power plant pools, using successful experience in fuel repair services. Since fuel rods from two assemblies can be stored within the overall dimension of one while structural material such as spacers are wasted, existing storage capacity can be doubled.

Once nuclear power plant pool storage capacity has been fully utilized, storage facilities away from the reactor form the next step in long-term interim storage of spent fuel. For this purpose, wet storage facilities based on nuclear power plant pool design have been successfully operated for many years in several countries. Not being the most economical way - wet storage needs energy consuming active cooling systems and secondary waste treatment - R&D activities were started more than 10 years ago in order to reduce non-productive investment in spent fuel storage, resulting in various alternative retrievable storage concepts. Dry well, storage container and vault dry storage facility were developed from this research. A significant number of experimental tests showed that structural integrity is not affected by dry storage conditions.

The development last year of a single cycle aircooled vault-type dry storage facility, the so called "Bunker Storage Facility" led to a significant cost reduction, making it economic where minor storage capacities are required, while fulfilling all safety requirements.

The technology available today permits long-term interim storage of spent fuel at affordable cost, while maintaining the necessary flexibility to be able to adapt to further advances in the closure of the fuel cycle.

TRN ZA8600432

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

SWEDISH STUDIES OF HIGH-LEVEL WASTE DISPOSAL IN CRYSTALLINE ROCK

K.B. KRAUSKOPF
Geology Department, Stanford University, Stanford, California 94305, United States of America

ABSTRACT

Crystalline rock as a medium for the disposal of high-level nuclear waste is under consideration in many countries, and is being studied intensively in Sweden. Swedish scientists have explored in great detail several areas underlain by granite and schist, using surface mapping, many drillholes, and geophysical techniques. Prediction of subsurface conditions from the surface exploration has enabled them to eliminate some areas on the basis of too much fracturing, and to find a few areas where volumes of nearly unfractured rock exist that are adequate for repository construction. Studies of permeability and ground-water composition have made possible predictions about rates of escape of radionuclides from a breached repository. Especially notable is Swedish research on flow of ground water in fractured rock and on retardation of radionuclides by sorption and dispersion. In addition to field studies, Swedish scientists have established an underground laboratory in granite, where in-situ studies are under way on the effects of heating and radiation, and on techniques of backfilling and sealing of tunnels.

TRN ZA8600433

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

GEOHYDROLOGY OF THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

M. LEVIN, B.B. HAMBLETON-JONES, E. RAUBENHEIMER and N. NIEMAND
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

One of the most important factors in the characterization of a low-level waste disposal site is knowledge of the movement of water in both the unsaturated and saturated zones. These are aspects that received much attention at Vaalputs Radioactive Waste Disposal Facility.

A model was developed to predict long-term behaviour of ground water movement, and the consequent migration of radionuclides. Modelling of the ground water at Vaalputs was divided into calibration and verification phases, the latter being still in progress. During the calibration phase certain parameters such as the hydraulic conductivity, hydrodynamic dispersion coefficient, distribution coefficient and soil moisture were determined in the unsaturated zone below the proposed trenches.

In addition to the above, isotope analyses of tritium and ^{18}O in the soil moisture were undertaken to study the rate of soil moisture movement in the clay of the unsaturated zone. Chemical analyses of the clays indicate that percolation is inhibited as a result of the high inherent salinity.

Studies in the saturated zone included the regional geohydrological setting of the site, piezometric level monitoring, sampling for chemical analysis, dating of the ground water, and pump, packer and injection tests. Slow movement of the ground water is borne out by the hydrogeochemistry and ^{14}C isotope data while tritium results showed slow and localised recharge to the underground storage. Pump tests suggest fair yields but storage is limited in the fractured granite. Packer tests indicate transmissive zones above and below the piezometric surface implying that recharge to underground storage could take place once water penetrated the overlying clay beds.

The favourable site characteristics, backed by the geomorphological stability of the area make the Vaalputs Radioactive Waste Disposal Facility one of the most suitable sites available in the world.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

THE IMPROVEMENT PROGRAM OF RADWASTE TREATMENT AT CHINSHAN NUCLEAR POWER STATION

M.H. LIN and C.I. HUANG
Taiwan Power Company, Republic of China

ABSTRACT

Chinshan 1 and 2, the twin 636 megawatt boiling water reactors with independent radwaste treatment facilities, located in northern Taiwan, started power generation in 1977 and 1978, respectively. The initial years of operation of CSNPS indicated a need for improvement of the radwaste scheme originally provided.

The major betterment program for the radwaste system includes:

1. Addition of auxiliary demineralization system and resin storage tank/demineralizer.
2. Addition of dry laundry and miscellant drain system.
3. Addition of off-gas charcoal delay system.
4. Tie connection of the liquid waste system of units 1 and 2.
5. Solid waste system retrofit study.
6. Volume reduction study.

Besides these hardware improvements, the administration and water quality controls have also been much improved and, indeed, play a very important role in decreasing the release of radioactivity to the environment.

The discharge of radioactivity in liquid effluents, after the improvement was implemented, is 99 % lower than that during initial operating. The radioactivity of gaseous effluents is also expected to decrease after the charcoal delay system is operational. The incineration of combustible waste is currently underway and also contributes to lowering the production of solid waste.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 1

OPERATIONAL EXPERIENCES IN THE TREATMENT OF LOW- AND MEDIUM-LEVEL RADWASTE IN THE FEDERAL REPUBLIC OF GERMANY (FRG)

W. LINDOW, D. HERBRECHTER and W. STEGMAIER
Kraftanlagen AG Heidelberg, Im Breitspiel 7, 6900, Heidelberg 1, Federal Republic of Germany

ABSTRACT

Most of the activity in liquid waste in the FRG, as elsewhere arises from nuclear fuel reprocessing. Whereas high-level liquid waste has been collected and stored in special tanks since 1966, aqueous medium- and low-level liquid waste is segregated by evaporation, ion exchange and precipitation into an essentially inactive part discharged to the municipal sewage system, and a salt- and activity-wise, rather concentrated part, which is incorporated in either bitumen or concrete for final disposal.

Intermediate storage of the solidified waste is practised for the time being in huge storage buildings. All solidified waste is monitored, and pertinent data are stored in a data base, thus facilitating good inventory control at all times. Practical experience in liquid waste treatment has been compiled for more than two decades at yearly production rates of up to 40 000 m^3 low-level and 1 000 m^3 medium-level waste without major incident.

Some 30 000 m^3 per year of primary solid waste are, depending on their nature, either incinerated or compacted with subsequent fixation by cement, or treated individually. Individual treatment includes electro-chemical decontamination to back-ground activity, or plasma-arc cutting to pieces to reduce bulkiness.

TRN ZA8600436

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

METAMICT MINERALS AS MODEL SUBSTANCES FOR RADWASTE

H. MüLLER
Institute of Inorganic and Analytic Chemistry, Section Radio-Chemistry, Freiburg i.Br., Federal Republic of Germany

ABSTRACT

Metamict minerals are substances which have been separated during geological processes in crystalline form, but which have become amorphous with the course of time, due to decay of uranium and/or thorium which is part of the mineral. Metamictization occurs particularly in uranium/thorium bearing niobates-tantalates-titantates of rare earth elements and in some silicates. Recoil nuclei which emerge with high kinetic energy of the order of 100 keV from the decay are responsible for the amorphization. Quantitatively the mechanism of the lattice damage is still not well understood. It is expected that metamict minerals may be used as model substances for long-term storage of high-level radioactive waste from spent nuclear fuel.

Metamict minerals of known chemical composition have been investigated by thermogravimetric and X-ray diffraction methods. These investigations offer information about loss water, oxidation, heat release and recrystallization. The main objective was the identification of the crystalline phases produced during annealing.

TRN 86CC437

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

RADIOACTIVE FALL-OUT FROM THE CHERNOBYL DISASTER, AND ITS AFTERMATH IN CENTRAL EUROPE

A. MüLLER-BROICH
Institute for Biophysics and Physical Biochemistry, University of Regensburg, Regensburg, Federal Republic of Germany

ABSTRACT

Radioactive fall-out originating from the disaster of the nuclear power station at Chernobyl in the Soviet Union was measured in Bavaria and other parts of Central Europe.

Nuclide composition and spatial distribution of fall-out are presented and compared to radioactive debris from nuclear bomb tests. The uptake of radioactive material by plants and its passage into human food is discussed. The contribution of direct deposition,redistribution within plants and transfer from soil into plants is considered. Factors determining the paths of radioactive material into milk and meat are outlined.

Safety precautions against excessive incorporation of radioactivity issued by the authorities are given. Irradiation of humans from external and internal fall-out is assessed. Nuclides composition is shown to be of major importance only for internal radiation.

In view of the dominating abundance of radioiodine and radiocesium the differing physical and biochemical qualities of these nuclides are described in more detail. Finally, the resulting risk of cancer induction including leukemia is considered.

TKN ZA8600438

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 1

RADIOACTIVE WASTE MANAGEMENT AT ROCKY FLATS

J.D. NAVRATIL
Colorado School of Mines, Golden, Colorado 80401, United States of America

ABSTRACT

Radioactive waste management at Rocky Flats involves the treatment of process liquid wastes from the plutonium recovery areas and all other plant liquid-process wastes which do not meet the requirements of on-site impoundment. The treatment removes radioactive contaminants from aqueous process wastes and converts the resulting solids to a shippable form for storage off-site.

This paper gives a brief overview of the present production waste treatment process and provides details of a new ferrite waste treatment process presently undergoing production testing. Actinide removal and chemical properties of ferrites will be described as well as results to date of the testing of the ferrite waste treatment process.

TRN ZA8800431

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

ZOOLOGICAL ASPECTS OF THE ECOLOGICAL INTEGRITY OF THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

J.A.J.NEL
Department of Zoology, University of Stellenbosch, Stellenbosch, South Africa

M.D. PICKER
Department of Zoology, University of Cape Town, Rondebosch, South Africa

T.J. ROBINSON
Mammal Research Institute, University of Pretoria, Pretoria, South Africa

ABSTRACT

The possible effects of nuclear waste disposal at the Vaalputs terrain on the endemic fauna are being monitored by assessing changes in the occurrence of small mammal species, their density, food, reproduction, parasite load, gross abnormalities and longevity, as well as the occurrence of chromosome and chromatid lesions. Interactions between the radiation source and animals are studied by monitoring burrowing activity of arthropods, and the soil they transfer to the surface, as well as the burrowing activity of rodent species.

TRN ZA8CC440

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

THE DESIGN AND PERFORMANCE OF A LOW-COST, SOIL CEMENT CAP FOR LLNW DISPOSAL TRENCHES

E.A. NOWATZKI
University of Arizona, Department of Civil Engineering and Engineering Mechanics, Tucson, Arizona, 85721, Unites States of America

ABSTRACT

Over the past three years, the University of Arizona has conducted research for the U.S. Nuclear Regulatory Commission (USNRC) to assess various trench cap designs from the viewpoint of structural stability, water infiltration, and economy. As part of that project, four experimental trenches were built and monitored at each of two semi-arid sites in the vicinity of Tucson, Arizona.

In this paper, the design and construction of one of those trenches are described in detail. That trench included a cap-crown system that incorporated compacted soil backfill and a steel-reinforced, soil-cement cap with an overlying "wick" drain.

The results of structural monitoring over a period of approximately two years are presented, and compared to those of a more conventionally designed trench. The results are evaluated with respect to surface subsidence and movements of the cap-crown components as they affect moisture infiltration. Recommendations are made regarding standard design criteria for LLNW disposal trenches based on the results of this research.

TRN ZA8C0441

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

CONSIDERATIONS IN THE DEVELOPMENT OF A SITE CHARACTERIZATION FIELD MANUAL FOR NEAR-SURFACE GEOLOGIC DISPOSAL OF LLNW

E.A. NOWATZKI
University of Arizona, Department of Civil Engineering, and Engineering Mechanics, Tucson, Arizona, 85721, United States of America

J.G. MC CRAY
University of Arizona, Department of Nuclear Engineering, Tucson, Arizona, 85721, United States of America

ABSTRACT

The University of Arizona, under the sponsorship of the United States Department of Energy has recently (1985) developed a site characterization field manual for near-surface geologic disposal of low-level radioactive waste. The manual was developed to aid states and regions in formulating a program for the detailed characterization of a proposed near-surface LLNW disposal facility. Included in the program are procedures for site characterization management, identification of pertinent technical parameters and methods for their determination, and the development of general procedures for conducting a site characterization study.

The nine technical study areas identified as critical to LLNW disposal are discussed in this paper. A representative parameter, fluid conductivity, is chosen from the area of groundwater hydrology to illustrate the format used in the manual to describe why that parameter is important, and how it can be evaluated. An illustration is also given of the total characterization of a site with respect to geotechnical engineering parameters. Finally, a brief description is given of a general procedure for site characterization that can be used by planners, managers and staff personnel to implement the process of evaluating the suitability of a site for LLNW disposal.

TRN ZA8600442

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session - Media Session

COMMUNICATIONS: ROOTS OF OUR PROBLEMS

F.C. OLDS and N.S. OLDS
910 Wilwood Drive West, Prospect Heights, Illinois 60070, United States of America

ABSTRACT

Waste management programs are having great difficulty in gaining public and political acceptance in a number of countries, and communications have played a major role in this adverse development. Communications consist of many types of information exchange. On the one hand are scientific peer group discussions, which seek a consensus of technical truth. On the other are political communications designed to prevent closing the nuclear fuel cycle, nuclear truths notwithstanding.

Opponents of nuclear power have had much more success in their uses of political types of communications than the proponents have had in their use of scientific facts. An analysis of this difference in success, amply illustrated, shows why. In addition, the trend in some nations toward what is called "participatory democracy" adds another advantage to the nuclear opponents by putting the power of final decisions into the hands of masses of people who lack the knowledge upon which to base intelligent decisions. In the words of one influential U.S. Legal authority "it is more important for the decisions to be reached by democratic methods, meaning popular vote, than it is for the decisions to be right." The implications of this trend are explored.

These factors, however, do not leave the nuclear industry defenceless in its quest for public and political acceptance. There are some 50 ways of reaching the politicians and the general public that do not depend on such mass media vehicles as TV and newspapers. These 50 are underutilized by the nuclear community.

Further, there are messages of high impact that the industry could use to get itself out of the defensive mode. Sadly enough, however, the industry allows itself to be too preoccupied with responding to accusations to mount an effective public education campaign.

TRN IA8CC443

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 3

DRY STORAGE OF SPENT FUEL: CURRENT PRACTICE, EXPERIENCE AND DEVELOPMENT TRENDS

C.J. OSPINA-ESPERON
Swiss Federal Institute for Reactor Research, CH-5303, Würenlingern, Switzerland

ABSTRACT

The storage of spent fuel is a very important independent step of the nuclear fuel cycle, which has to be considered in the plans and policies of a nuclear power station and the electricity utilities, and must cope with the interim storage, handling and transportation of it before a final decision is taken. Therefore spent fuel is not a matter of waste management alone, but spent fuel management links the fuel cycle with the waste management together.

Under these circumstances, and given limitations in actual water pool storage at reactors, there is the necessity for alternative interim storage systems which allow for long-term passive operation, inherent safe transport readybility, easy decommissioning and flexible implementation. Appropriate dry storage systems comply with the mentioned technical necessities.

Dry storage systems have been rapidly developed as a complement to wet storage in pools, therefore opening various options while bringing back to nuclear power reactor operators the flexibility and time independence required in order to take decisions appropriately. Dry storage development is been pursued with more than six different technologies ranging from stationary systems (eg. vaults), modular fixed systems (eg. silos and concrete canister), up to modular transportable systems (eg. transport and storage casks).

More than 30 different projects have been committed worldwide to date, ranging from small demonstration units up to a number of national large commercial projects, and including seven different types of nuclear fuel and operational experience ranging from 8 to 25 years. The formulation of dry storage technology is well established, permitting clear specifications on heat transfer, shielding, safety, waste management and operational criteria. The licensing framework has been established and verified through very sophisticated quality assurance procedures. The economics of various dry storage systems have been also refined and proven, and therefore optimum systems can be used.

The operational experience accumulated to date confirms the formulated design targets of various dry storage systems. This experience allows the development and demonstration of similar dry storage systems for high-level waste, which facilitates greatly nuclear waste management under optimum technical and economical conditions.

TRN. ZA8600444

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 2

CASK-SYSTEM FOR CONDITIONING, TRANSPORT AND STORAGE OF RADIOACTIVE WASTE

D. RITTSCHER and G. GESTERMANN
Gesellschaft für Nuklear-Service mbH, Goethestr. 88, 4300, Essen 1, Federal Republic of Germany

K. KROTH and H. LAMMERTZ
Nuclear Research Centre Jülich GmbH, Postfach 1913, 5170 Jülich 1, Federal Republic of Germany

ABSTRACT

With the conditioning of radioactive waste from the operations of nuclear facilities in MOSAIK casks, a way was found to safely and economically put radioactive waste into a form fit for interim or final storage. Suitable for storage are those wastes which must be provided with shielding due to their activity, or which can be consolidated with appropriate waste conditioning to high specific activities. Specifically this includes: cut-up core components, evaporator remains, filter auxiliaries and ion exchange resins, among others. The conditioning of a waste mixture can be particularly economical, and in some cases improves the product.

The casks, which can be used in various types of construction, consist of a thick-walled cask body made of nodular cast iron, which is sealed leak-tight with a lid system. The wall thicknesses of the cask are designed according to the required shielding and, if necessary, can be reinforced with lead inserts. For use in conditioning processes, the casks are provided with the corresponding connections. MOSAIK casks are licensed as Type B (U) packaging.

Beside the actual loading with the most varied waste, even under water, the concentration of liquid waste is of particular importance, since aside from the economy of this process the radiation exposure is also minimized.

The suitability of the casks for transport as well as for interim and final storage has been proved in extensive testing, such as drop tests from a maximum of 800 meters height on to a concrete foundation, fire tests with a duration of 60 minutes in a petroleum fire, long-term corrosion tests, and a measurement program lasting several years.

The measurements, made independently by the KFA-Jülich, Inst. ICT, on casks loaded at nuclear power plants, included inventory analyses, release behaviour, pressure build-up, and leak-tightness, in part at final storage temperatures (50°), with various types of casks and wastes. On the 8 casks examined to date (measurements are still being made), no reasons have been found which would prevent the interim and final storage of radioactive waste with MOSAIK-casks.

In German nuclear facilities more than 2 000 MOSAIK casks are in use to date.

TRN ZA9600445

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session - Keynote Address

RADIOACTIVE WASTE, THE EARTH'S CRUST, AND THE HUMAN SOCIETY

R ROMETSCH
Nagra, Parkstrasse 23, CH-5401 Baden, Switzerland

ABSTRACT

Four billion human beings are living in a thin layer around the planet Earth. Life has always been at risk in several ways in the limited space defined by the interface between the earth and the atmosphere:

Cosmic changes could be so overwhelming that we do not even want to consider them. We have learned to live and die in natural catastrophes caused by the continuous movement of matter in the outer part of the earth's crust and the surrounding biosphere.

And there are those effects resulting from human activities. Although we do not like to admit it, perhaps the greatest danger lies in the human character itself; the root of killing and wars. The growing number of human beings gives rise to a greater impact on the environment.

The nuclear debate has sharpened our wits with regard to the special case of radioactive wastes, perceived by large parts of the population as a particular threat. Hence, their management and disposal has become a test case to prove that human society is capable of keeping the environment essentially free of these waste products. This explains the worldwide efforts in this field - and also this conference.

The results already achieved with regard to radioactive wastes justifies hopes the it will become possible, technically as well as politically, to control all kinds of toxic by-products of our technical civilization.

TRN ZAR8604446

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 3

POTENTIAL EXPOSURES AND HEALTH EFFECTS FROM SPENT FUEL TRANSPORTATION

G.M. SANDQUIST
University of Utah, Salt Lake City, Utah, United States of America

V.C. ROGERS
Rogers & Associates Engineering Corp., Salt Lake City, Utah, United States of America

ABSTRACT

The radiation exposures and consequent health effects associated with normal operations and accidents during transportation of spent fuel have been analyzed and evaluated. This study was performed for the U.S. Department of Energy (DOE) as contributory data for response to specific public inquires regarding the Draft Environmental Assessments issued in 1984.

Large quantities of spent fuel from power reactors must be shipped by truck and/or rail from the site of generation or temporary storage to a designated nuclear waste repository. This transportation activity has the potential for increasing radiation exposures and risks above normal background levels in the vicinity of the transportation route. For normal, accident-free transport of spent fuel, radiation exposures arise from both gamma and neutron sources within the spent fuel cask. The neutrons result from certain transuranic nuclides in the spent fuel (U, Pu, Cm, etc.) which undergo spontaneous fission.

U.S. regulations presently limit the radiation dose equivalent rate to 10 millirem per hour at any point 2 meters from the outer lateral surfaces of the transport vehicle, so precise cask composition and geometry data are not required to establish the maximum radiation field. The neutron dose flux component was modeled using DISNEL, a generalized, one-dimensional, multi-energy group neutronics code. Computer program PATHRAE-T was then developed and employed to determine the total, combined dose field, including both ground and sky scatter from neutrons and gamma photons for any position around a truck or rail spent fuel cask. Both near and far field radiation isodose fields were determined. Four activity classes, viz., caravan, traffic obstruction, resident and pedestrian proximity, and servicing of the cask transport vehicles were reviewed for maximum individual exposure assessments. Projected doses for typical activities under maximum exposure conditions were 6 mrem or less per event. Repetitive occurrence of similar doses to the same persons arising from subsequent shipments were found to be very unlikely in general.

A spent fuel rail cask containing up to 14 PWR spent fuel assemblies could conceivably be involved in a variety of rail related transportation accidents. Since there has never been a transportation accident involving radioactive material release from spent fuel, the most likely radiation consequence of such an accident would be the external dose field determined above. Actual release of radioactive materials from spent fuel to the environment and human exposure is a complex, improbable process with numerous physical mechanisms. For severe, but credible accidents, spent fuel casks could suffer impact rupture, or both impact and burst rupture, or a combined impact and burst rupture enhanced by oxidation.

PATHRAE-T was used to estimate the maximum individual doses from rail accidents. The maximum individual exposure, primarily due to inhalation, is about 10 rem and occurs about 70 meters downwind. Estimates of the 50-year dose commitment for general populations located downwind of the accident for no avoidance or cleanup were determined. Ground deposited nuclides account for 99 percent of the population dose. The maximum population dose could result in about 22 latent health effects for a heavy urban population. However, during the same period about 400 000 cancer fatalities would arise from all other causes.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

PROBABILITY OF INTRUSION EVENTS AT RADIOACTIVE WASTE DISPOSAL FACILITIES

G.M. SANDQUIST
University of Utah, Salt Lake City, Utah, United States of America

V.C. ROGERS
Rogers & Associates Engineering Corp., Salt Lake City, Utah, United States of America

ABSTRACT

A probabilistic model and data set are established to estimate radiation doses individuals might receive from radioactive low level waste (LLW) sites following cessation of surveillance and institutional control.

If p_1 is the probability that a given event e_1 with radiological consequences (viz., external exposure, inhalation or inhalation of radionuclides) will occur in the time interval T_1 then the probability distribution function for n sequential time periods is given by the multinomial distribution function.

$$M(e,p,n) = \prod_{i=1}^{n} (q_1 + p_1) = 1$$

where $q_i = 1-p_i$ and p_i is independent of all time periods except T_i. The expanded form of the distribution function may be interpreted as the probability of occurrence of a particular set of radiological events in a series of n time intervals. The probability of no occurrence of a radiological event during any of the n time periods is given by $q_1q_2..q_n = (1-p_1)(1-p_2)...(1-p_n)$. For radiological risk assessment the probability that at least one or more radiological events will occur is of particular interest.

The entire event space in which radiological events can transpire has dimensions in both space and time. The spatial distribution function is associated with the selection of land area sites for various uses (e.g., residencies, farms, grazing land, etc.). The temporal distribution function is associated with the time interval in which the event might occur. Although radioactive waste is stored in numerous locations throughout the U.S., focus is made upon the LLW sites at the Idaho National Engineering Laboratory (INEL) and the Savannah River Plant (SRP).

The major land use fractions for principal pathways by which persons might be exposed to radiation for the LLW sites at INEL and SRP aredetermined. Data are given for the U.S., the appropriate agricultural regions and the states hosting these two sites and projections of land use fractions for the INEL and SRP sites if no LLW sites or institutional control existed. Percent changes over the past 24 years (1959 to 1982) are determined to assess trends over time. Estimates for the annual probabilities for each land category with potential for exposures (food from croplands, diary products from pasture and cropland and residencies). are made. The mean turnover time intervals are assumed to be 100 years for cropland and pasture and 50 years for residencies.

The probable occurrence of at least one radiological exposure event is tabulated for cropland pasture and residency at the INEL and SRP sites following control. Cropland siting at the INEL and SRP sites approaches unity within 5 000 years after loss of site control. Pasture and grazing use approaches unity within 1 000 years at INEL and 10 000 years at SRP. Residency use at both sites approaches unity only after about 100 000 years or more.

TRN ZA8CC0448

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

SAFETY AND LICENSING REQUIREMENTS IN THE REPUBLIC OF SOUTH AFRICA

D.M. SIMPSON and E.L. LANGFORD
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

The principles for licensing of nuclear installations in South Africa are based on the control of mortality risk to the operators of an installation and the population resident in the vicinity of the site. This paper describes the development of this safety philosophy, and the nuclear licensing process used in this country.

The structure of the nuclear regulatory function is briefly described, including the respective roles of the Atomic Energy Corporation, Licencing Branch and the Council for Nuclear Safety.

The development of risk criteria and quantitative release magnitude-probability criteria for radioactive material is outlined. Tasks that have to be undertaken by a potential waste disposal site licensee before a site licence is issued are described. These tasks include projections of future population distributions, analyses of release mechanisms, calculation of event probabilities, consequence modelling, and culminate in risk estimation. All such analyses should be performed with no more effort than that required to show compliance with the risk criteria. Thus simple, but conservative, assumptions can be made. By comparison with the projected risks arising from a nuclear reactor, it is expected that the necessarily larger uncertainties associated with predicting the risk from storage of long-lived radionuclides will be offset by the smaller risks provided by the remote location and the absence of inherent features such as high temperatures, pressures etc.

It is assumed for the purposes of these analyses that the current societal needs, structure and capabilities will be maintained over the time period during which it is expected that the waste will pose a threat to mankind. Thus it is deemed that any radical change in population location, land usage or mineral and water resource utilization would result in further risk analyses and, where necessary, further engineered barriers or relocation of the waste.

Once the facility is commissioned periodic monitoring procedures will have to be adopted throughout the lifetime of the facility. The scope of typical monitoring activities is outlined and the ongoing analyses to be performed and the records to be kept are discussed.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

MODELLING AND PREDICTION OF RADIONUCLIDE MIGRATION FROM SHALLOW, SUBGRADE NUCLEAR WASTE FACILITIES IN ARID ENVIRONMENTS

A. SMITH
Steffen, Robertson and Kirsten (B.C.), Vancouver, B.C., Canada

A. WARD and S. GELDENHUIS
Steffen, Robertson and Kirsten (Mining) Inc., Johannesburg, South Africa

ABSTRACT

Over the past 15 years, prodigious efforts and significant advances have been made in methods of prediction of the migration rate of dissolved species in aqueous systems. Despite such work, there remain formidable obstacles in prediction of solute transport in the unsaturated zone over the long time periods necessarily related to radionuclide bearing wastes. The objective of this paper is to consider the methods, issues and problems with the use of predictive solute transport models for radionuclide migration from nuclear waste disposal facilities in arid environments, if and when engineering containment of the waste fails. Having considered the ability for long-term solute prediction for a number of geological environments, the advantages of a disposal environment in which the solute transport process is diffusion controlled will be described.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

EARTH SCIENCE CONSIDERATIONS ON THE STORAGE AND DISPOSAL OF RADIOACTIVE WASTE & SPENT NUCLEAR FUEL IN TAIWAN, REPUBLIC OF CHINA

K.L. SOONG
Institute of Nuclear Energy Research, Atomic Energy Council, Taiwan, Republic of China

ABSTRACT

Limited land area, precipitous topography and complex geological structure make the selection of a storage and disposal site for radioactive waste and spent nuclear fuel a challenging task in Taiwan, ROC.

Site selection in Taiwan requires that particular attention be paid to the following earth science considerations:

1 In some developed countries, crystalline rocks, tuffs, and salt deposits have been tested and demonstrated to be suitable for radioactive waste disposal. This is unlikely to be the case in Taiwan and less well tested rock types will have to be investigated.
2 Taiwan is situated on the circum-pacific seismic zone and experiences strong and frequent earthquakes. Tectonic mobility is high with upheaval and erosion rates being among the highest in the world.
3 The geothermal gradient is high, and hot springs are widespread throughout the islands. Rock consolidation and induration processes are comparatively rapid. Groundwater hydrology has not been well studied or understood, but marked wet and dry seasons cause large seasonal fluctuations of the water table in some parts of the island.
4 The island is structurally complex with a high density of folding and faulting.
5 There are no active volcanoes on Taiwan, but Pleistocene volcanoes have been identified and post-volcanic activities are present.
6 Neogene sediments contain oil and natural gas deposits. Many prospect and producing wells have been drilled.

The criteria above indicate the following lithologies on the island of Taiwan, and offshore islets, to be suitable candidates for further study:

a) Thick, plastic, and impermeable shale formations.
b) The more stable and shallow Mesozoic basement highs close to the west coast of the island.
c) The quartz porphyry islet in the Taiwan Strait
d) Highly silicified and impermeable Eocene quartzite formations.
e) The Mesozoic granite gneisses of Kirmen Island.

TRN ZA8600451

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 1

RADIOACTIVE WASTE DISPOSAL: SOLUTIONS PURSUED IN SOUTH AFRICA BY ESCOM

P.H. SPENCER, H.F. RÖHM and M.I.J. HARRIS
ESCOM, Sandton, South Africa

ABSTRACT

By producing nuclear power from the 1844 MWe Koeberg power station, the Electricity Supply Commission (ESCOM) became South Africa's largest producer of radioactive waste. In preparing for this eventuality, ESCOM and the Atomic Energy Corporation (AEC) studied the requirements, after which the AEC agreed to embark on establishing a national radioactive waste repository for the safe disposal of Koeberg's waste. This work culminated in the establishment of the National Radioactive Waste Disposal Site at Vaalputs situated in the Northern Cape.

At the same time ESCOM began the evaluation of the possible intermediate steps required to ensure the safe and cost-effective storage and disposal of high-level waste from Koeberg.

This paper describes and discusses achievements, work underway, and future plans for storage, transportation and disposal of low-level waste, intermediate-level waste, spent fuel and high-level waste from the Koeberg nuclear power station.

TRN. ZA8CC0452

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

GEOTECHNICAL ASPECTS OF TRENCH CAPPING FOR THE VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

D. STEPHENSON
University of the Witwatersrand, Johannesburg, South Africa

P. MOORE and B.B. HAMBLETON-JONES
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

Drums containing radwaste will be buried at Vaalputs, and capped with screened clay suitably compacted. The moisture capacity and mechanical characteristics of the proposed capping material were investigated in order to optimize the cap design.

Despite being in an arid area, the cap was to be designed to shed moisture, to remain intact, and to minimize the penetration of rain water or other surface moisture into the trenches as far as the drums. Soil compaction tests indicated optimum density and lowest permeability could be achieved for the cap at a moisture content of 14 % but maximum moisture retardation due to retention capacity of the soil was achieved at 10 % moisture. Laboratory tests indicated permeability of the cap system could be further reduced by putting a gravel layer beneath the clay cap, with a geotextile in between.

The configuration of the cap was optimized using a computer model to represent stresses and displacements of the fill material and cap. A finite difference grid model represented the fill between the drums and side of the trench and its settlement under load. The keying of the cap to the side of the trench and the edge of the stack of drums critically affected settlements and stresses in the cap. The configuration of the fill was adjusted and remodelled to minimize the possibility of cracking of the cap. The surface of the cap was also overfilled to counter possible settlement and to encourage the shedding of surface water.

TRN ZA8600453

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

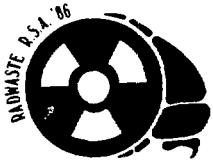
SAFETY ASSESSMENT FOR RADWASTE DISPOSAL IN KOREA: PART 1. DEVELOPMENT OF A CODE FOR A SIMPLIFIED SAFETY ANALYSIS

I.S. SUH, H.H. PARK, K.W. HAN and P.S. HAHN
Korea Advanced Energy Research Institute, P.O. Box 7, Daeduk-Danji, Choongnam, Republic of Korea

ABSTRACT

A simplified safety analysis code has been established in order to provide a basic methodology for the preliminary evaluation in deciding a disposal alternative which is prerequisite to meet the low- and intermediate-level radwaste management program in Korea. The code covers resaturation and leaching, rock-soil layer migration, and biosphere transport such that the rock cavern disposal option can be evaluated compared with that of shallow land burial.

TRN ZA8600454



CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

SELECTION CRITERIA FOR A RADIOACTIVE WASTE DISPOSAL SITE IN THE REPUBLIC OF SOUTH AFRICA

P.D. TOENS and B.B. HAMBLETON-JONES
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

A program commenced in 1978 to select a suitable site for the disposal of nuclear waste in South Africa. This entailed the examination of a variety of socio-economic and earth-science related parameters over large parts of South Africa.

The site-selection program, for which the Department of Geotechnology, Atomic Energy Corporation of SA Ltd (AEC) (previously the Nuclear Development Corporation (NUCOR)) accepted responsibility, commenced with an initial screening phase, and lead to the identification of potentially suitable areas by mid 1980. A site suitability phase involving regional, and subsequently detailed socio-economic, geological, geohydrological and geophysical studies in the areas identified by the screening phase was completed by December 1982.

As a result of very positive indications that the district of Namaqualand was the most suitable candidate area it was possible, after further detailed investigations, to identify and purchase a site judged to be suitable for the disposal of low and intermediate level waste by February 1983. The area acquired measures some 10 000 ha in extent and is situated 100 km south of Springbok in the northwestern Cape and 600 km north of the Koeberg nuclear power station near Cape Town.

Further detailed investigations identified an area overlain by a clay layer of up to 20 m thick, which detailed examination indicated as most suitable for the disposal of low- and intermediate-level radioactive waste in shallow trenches. An area measuring 0,9 by 1,1 km has been set aside for this purpose. The delivery of the first consignment of low- and intermediate-level waste is expected in November 1986.

TRN ZA8600455

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 3

AN IMPROVEMENT PROGRAM OF LAN-YU RADWASTE RECEIVING AND STORAGE FACILITY IN TAIWAN, ROC

C.M. TSAI and R.T. LEE
Radwaste Administration, Atomic Energy Council, Taiwan, Republic of China

ABSTRACT

Low level waste generated from three nuclear power plants in Taiwan is stored at Lan-Yu island. The storage facility comprises 23 near-surface concrete trenches, inspection centre, office building and various other buildings, and is operated by the Radwaste Administration, Atomic Energy Council, Republic of China. Construction of the facility was completed in January 1982, and it has been receiving waste since May, 1982. To date, about 30 500 drums of solidified waste are stored in this facility.

An improvement program for the existing receiving and storage operation at the Lan-Yu facility was begun in 1984 by the Radwaste Administration. The first step will be to install a semi-automatic inspection line in the inspection centre and remote-controlled unloading equipment for the storage operation. The new installations will enhance the efficiency of the operation, and reduce exposure to inspectors. Detailed engineering design was completed in January 1985, and installation will be completed in May 1986. The second step will be to develop an upgraded design for the second-phase construction of the facility. The intent of this design change, based on the ALARA concept, is to reduce the risk of exposure of workers to radiation, and at the same time preserve the landscape. Thus, the new design will incorporate remote handling to minimizing exposure to workers, and landscaping at the storage area. The concept design was completed in January 1986.

TRN ZA8CC456

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

THE VAALPUTS ENVIRONMENTAL MONITORING PROGRAMME

D. VAN AS, S. POSNIK, and C.A.R. BAIN
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

An environmental monitoring programme was initiated in November 1984, two years before radioactive waste was due to be disposed of at the Vaalputs Radioactive Waste Disposal Facility. During this time a database was established against which future changes in the radiation levels of the environment could be assessed. These data allowed the critical pathways to the local population to be determined and supplied input data for the assessment of the collective dose contribution to the population.

The monitoring programme which includes the establishment of the meteorological parameters such as wind, temperature, humidity, rainfall, soil temperature, quantifies the critical pathway be which radioactivity can be dispersed in the environment i.e. precipitation, percolation, leaching and ground water dispersion.

A survey of the habits of the surrounding population was conducted to identify the principal food chains. The pathways of drinking water, consumption of mutton, fruit and vegetables were quantified and derived concentrations in ground water for each of these was established.

A monitoring network to a 20 km radius around the site was established which included the measurement of radiation doses, radioactivity levels in soil, vegetation, ground water and agricultural produce. A natural radiation dose of 1,1 mGy per annum was established.

In addition to complying with the licensing requirements for the waste disposal site, the environmental monitoring programme is contributing valuable scientific information on evapotranspiration and percolation in semi-arid environments.

TRN ZA8600457

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 4

RADIOACTIVE WASTE DISPOSAL IN SOUTH AFRICA

H.J. VAN DER WESTHUIZEN and P.E. MOORE
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

The South African policy on radioactive waste management is outlined. The State is responsible for providing off-site storage and disposal facilities for radioactive waste and spent fuel. Such activities are controlled by the Licensing Branch of the Atomic Energy Corporation in accordance with the appropriate legislation.

The amounts of radwaste produced are given. The waste disposal practices at Pelindaba, and the proposed practices at the Vaalputs Radioactive Waste Disposal Facility are described. Details of the planning, design considerations (including activity inventory), and construction of Vaalputs are given.

Vaalputs is considered to be an ideal site for radioactive waste disposal and it admirably satisfies recognized site selection criteria.

The construction of the buildings at Vaalputs is almost complete and the Facility is scheduled to accept waste from Koeberg Nuclear Power Station in November 1986.

TRN ZA8600458

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

ENVIRONMENTAL ISOTOPES ASSIST IN THE SITE ASSESSMENT OF VAALPUTS RADIOACTIVE WASTE DISPOSAL FACILITY

B.T. VERHAGEN
Wits-CSIR Schonland Research Centre for Nuclear Sciences, University of the Witwatersrand, Johannesburg, South Africa

M. LEVIN
Atomic Energy Corporation of South Africa Limited, Private Bag X256, Pretoria, South Africa

ABSTRACT

The first South African nuclear waste disposal facility is to be sited in an arid environment with average annual rainfall of about 100 mm, resulting in scant and possibly only sporadic ground water circulation. The geohydrology of the area, crucial to the assessment of potential radionuclide dispersal, is therefore difficult to study with standard hydraulic methods. Environmental isotopes which label the water molecule and some dissolved constituents can give synoptic information about the history of the ground water from which some projections about future mobility can be made.

Tritium profiles in the unsaturated zone show the limited extent of rain water infiltration which generally extends down to 3-4 metres, with sporadic evidence of deeper penetration through cracks and rootholes in the thick clay cover. Soil moisture seems to occur in tightly bound and more mobile components. This is confirmed by occasionally measurable tritium observed in the saturated zone.

Radiocarbon in the ground water cannot be simply interpreted because of the nature of the granite aquifer. Although suggesting ages of several thousands of years, radiocarbon proves that the water is not "fossil" or derived from the last pluvial period, postulated to have occurred some 12 000 years ago. Recharge appears to occur periodically and locally as a result of outliers within the present climatological regime.

Regional movement of ground water is very limited however, as variations seen in the radiocarbon data of the ground water are non-systematic. These conclusions are supported by the distribution of the non-radioactive isotopes, such as oxygen-18.

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

SPECIATION ASPECTS OF PREDICTIVE MODELLING IN RADIOACTIVE WASTE DISPOSAL

D.R. WILLIAMS
Department of Applied Chemistry, UWIST, Cardiff CF1 3XF, United Kingdom

ABSTRACT

Our environment is precious and has to be protected by scientists choosing the very best disposal site which minimises the environmental impact of radioactive waste when eventually it leaks from a disposal vault and reaches man. Such disposal systems have to be acceptable to scientists, to the public who reside in the country concerned, and also to international bodies. A full appraisal of the risk assessment involves studying the detailed chemistry of the waste packaging, of the disposal vault, of the geosphere, and of the biosphere.

The amounts and speeds through which radioactive waste components travel from packaging through to the biosphere are critically dependent upon the specific speciation occurring. To chemists and geochemists, "speciation" refers to the different chemical forms in which an element exists as a solid, liquid, gas, or as a range of complexes in solution. Some of these forms will move rapidly whereas others will be precipitated; some species will be reasonably bio-available and others will present relatively little challenge to living organisms.

Countries which have had a nuclear power programme for many years use large computer models in order to assess the likely risks from a given waste disposal scenario. A detailed representation of the speciation chemistry is necessary as input into these models and for cross-verification and validation exercises. This requires two types of speciation program - those that calculate species present at equilibrium and those which can assess mass transfer phenomena.

TRN ZA8600460

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa 7-12 September 1986

Session 4

ENGINEERING SEISMIC DESIGN CRITERIA

D.J.W. WIUM and G.H.P. OPPERMAN
Van Wyk and Louw Inc., Pretoria, South Africa

ABSTRACT

A prime objective in design of a nuclear waste disposal facility, such as that at Vaalputs, is to ensure that the probability of the release of radioactive material be maintained at acceptably low levels. The integrity of all containers and structures has to be ensured even in the unlikely event of an earthquake. This paper summarizes a method for establishing engineering input parameters for the seismic design of critical structures. The probability-based approach incorporates the seismic and geological properties, and history of the tectonic regions in the vicinity, and provides response spectra for the design of the structures that correspond to appropriate recurrence periods. Seismologists provided data on the seismicity and seismic behaviour of Southern Africa and this was supplemented with applicable data from other sources. An attenuation law for earthquake intensities was derived from published isoseismal maps of the region. Seismic activities were obtained from the Seismological Data Bank. Finally, empirical models from foreign sources were used to represent the relationship between intensities and engineering earthquake phenomena, such as peak ground acceleration and the Fourier spectrum value at a range of frequencies. These sets of data were used to obtain a Fourier spectrum for the design earthquake and corresponding response spectra were generated for the particular recurrence period. Finally the use of this methodology in seismic risk analyses is discussed.

CURRICULA VITAE OF THE PRESENTING AUTHORS

Adrian, Dr. H.H.W.

Dr. H.W.W. Adrian is the head of the Subdivision: Risk Analysis at the Atomic Energy Corporation of South Africa Ltd.

He joined the AEC in 1968 as a solid state physicist. Over the years he has been involved in a number of projects including health physics, testing of nuclear ventilation systems, and the planning of a hot cell complex. In his current position as a risk analyst, he has gained experience relating to hazards of a nuclear, and chemical nature.

Dr Adrian graduated with an M.Sc. in Physics from the University of Cape Town in 1968. He was awarded a D.Sc. in physics by the University of Pretoria in 1978.

Andersen, N.J.B.

Mr Andersen is Head of the Geophysics Division in the Department of Geotechnology at the Atomic Energy Corporation of South Africa Ltd. (AEC).

Prior to joining the AEC in 1981 Mr Andersen worked for 10 years as a mining geologist and base metal explorationist in South Africa, Namibia and Zimbabwe. Since he joined the AEC he has been involved with the execution and interpretation of detailed airborne and ground geophysical surveys directed at the evaluation and selection of nuclear sites.

He is a graduate of the University of Zimbabwe with a Special Honours degree in Geology.

Blum, P.T.

Mr. Blum is Delegated Director of Transnucleaire, Paris, France.

He spent ten years with the Commissariat a L'Energie Atomique (C.E.A.) where he was in charge of fuel and waste problems related to various types of research reactors. These included visual and x-ray examination of fuel and core components, thermal and hydraulic experimentation, and the development and operation of fuel assembly dismantling and storage facilities. He subsequently became technical manager of Societé Lyonnaise de Plomberie Industrielle. He held this position for four years before joining Transnucleaire 17 years ago as a Technical Manager. The major areas of his activities have been the development of casks for the transport and storage of radwaste, and the development of

ancillary transport equipment. He has recently been promoted to his present position of Delegated Director. He is also a member of the group representing France for the revision of the IAEA transport regulations.

Mr. Blum is a graduate chemical engineer from the Ecole Centrale, Paris, France.

Botha, Prof. J.F.

Professor Botha is Professor in the Institute for Groundwater Studies at the University of the Orange Free State, Bloemfontein, South Africa.

Brewitz, Dr. W.

Dr. Brewitz heads the Project Department of the Institut für Tieflagerung of the Gesellschaft für Strahlen und Umweltforschung.

He joined Otavi Mining Company Pty Ltd in 1968 and worked on various copper exploration projects in South Africa and South West Africa/Namibia. In 1974 he was appointed General Manager of the company's refractory brick plant near Belfast in the Eastern Transvaal, South Africa. He returned to Germany in 1977 to take up a position with Gesellschaft für Strahlen und Umweltforschung in which he coordinated feasibility studies for the disposal of radioactive waste at the defunct Konrad iron ore mine. He was also in charge of the geological working group.

Dr. Brewitz graduated in geology from the Technical University of Clausthal in 1969. He received his Ph.D. in 1974 for a thesis on geophysical and geochemical exploration methods applied in the search for metamorphosed sedimentary copper/zinc deposits.

Carson, M.P.

Mr. Carson is President of Nupac Services, Inc., located in Columbia, South Carolina, U.S.A.

From 1976 to 1978 he was employed as an Inspector by the U.S. Nuclear Regulatory Commission. He then served with Chem-Nuclear Systems, Inc. in various areas, but latterly as Director, Domestic Nuclear Marketing. In 1981 he moved to Charles Moore Associates, Inc./Energy Cycle Associates, Inc. where he became the Managing Partner responsible for technical and marketing elements. He joined Nupac in 1983 as President and is responsible for the provision to clients of a complete range of radwaste management services, including treatment, containment and transport.

Mr. Carson is a graduate of the Colorado State University where he obtained a B.S. degree with high honors and an M.S. degree.

Chen, Dr. W.L.

Dr. Chen is the Director of the Health Physics Division at the Institute of Nuclear Energy Research, Republic of China.

Both his academic background and work experience are in the field of health physics. The research areas in which he specializes are radiation dosimetry, radiation biology and applied health physics.

Dr. Chen received a B.S. degree in physics from the Chung-Chen Institute of Technology. This was followed by an M.S. degree, also in Physics from the University of Tennessee. His Ph.D. degree in nuclear engineering was awarded by the Georgia Institute of Technology.

Chou, Dr. T.S.

Dr. Chou is Director of the Radwaste Management and Radiation Application Division at the Institute of Nuclear Energy Research (INER), Republic of China.

During his time with INER Dr. Chou has been engaged in the design of various radioactive waste disposal systems. These include the design of treatment plants for both low- and medium-level radioactive waste, an incineration plant for radioactive waste, and the national radioactive waste storage site of the Republic of China. He has also carried out a feasibility studies on oceanic dumping of radwaste. He has held a number of positions in INER prior to taking up his current post.

Dr. Chou is a graduate in chemical engineering from the Chung-Chen Institute of Technology. He subsequently obtained a doctorate, majoring in nuclear engineering, from the University of Leuven, Belgium.

Craig, W.M.

Mr. Craig is a Subdivisional Head in the Process Metallurgy Department of the Atomic Energy Corporation of South Africa Ltd. (AEC).

He began his career in the uranium industry at the Buffelsfontein Gold Mine, where he was involved in the development of the Bufflex and Purlex solvent extraction processes. He subsequently spent a period at Mintek before joining the Atomic Energy Board (now the AEC)

in 1972. There he worked on large-scale pilot-plant activities involving ferric leaching, solvent extraction, resin-in-pulp, and continuous ion-exchange. In 1981 he joined Sentrachem as a Technical Consultant - Ion Exchange. Two years later he rejoined the AEC, and is at present engaged in both ion exchange resin and solvent extraction research, particularly the extraction of metals with selective extractants using supported liquid membrane technology.

Cuisenier, R.G.

Mr. Cuisenier is Deputy Manager of the Nuclear Production Center of Tricastin, Electricité de France.

Cumiskey, J.

Mr. Cumiskey is a Senior Engineer with Stone and Webster Engineering Corporation in Boston, Massachusetts, U.S.A.

He has had 19 years experience in power related and power industry fields, and has been Project Engineer for a number of nuclear plant projects. These include the reanalysis of pool structures, the installation of high density storage racks, and modifications to pool cooling and purification systems. He has also been responsible for the integration of primary and secondary plant sizing, design, purchase and installation of gaseous, liquid and solid waste equipment. He participated in the design of a spent fuel storage vault suitable for both advanced gas-cooled reactor fuel and light water reactor fuel. He has presented a number of papers on these, and related topics.

De Angelis, Dr. G.

Dr. de Angelis is with the Department of Environmental Protection at the Casaccia Research Centre of the Ente Nazionale Per L'Energia Elettica (ENEA), Italy.

He joined the ENEA in 1979, where he collaborated in the optimization of an analytical method for determining traces of radionuclides in human urine. Since then he has been engaged in contract work involving the characterization of low- and medium-level radioactive wastes, particularly the interaction of solidified waste with its repository at shallow depths. Recently the containment of industrial and toxic waste has been included in his activities. He has presented papers on the management of

hazardous, toxic and radioactive waste at various international conferences.

Dr. de Angelis is a doctoral graduate of the University of Rome, where he received his degree for a thesis on the synthesis and characterization of biological polymers.

De Beer, Dr. J.H.

Dr. de Beer is the Head of the Geophysics Division at the National Physical Research Laboratory (NPRL) of the Council for Scientific and Industrial Research, Pretoria, South Africa.

He joined the NPRL in 1969 and has been engaged in research in the field of geoelectrical geophysical methods. This includes the direct current Schlumberger sounding method, geomagnetic deep sounding methods, and time-domain electromagnetic sounding. The research covered not only the methods themselves, but also their application to the understanding of the Earth, and their use in resource exploration. During 1972, 1975, and 1976 he studied and did research at the University of Alberta, Canada. He is the author or co-author of more than 30 research papers published in various international journals. He was promoted to his present position in 1980.

Dr. de Beer graduated from the University of Stellenbosch in 1967 with a B.Sc. degree in geology and physics. In 1971 the same University awarded him an M.Sc. for his thesis entitled "The theory and application of techniques for the interpretation of Schlumberger sounding curves". A thesis entitled "Magnetometer array studies and electrical conductivity in South Africa" earned him a Ph.D. degree from the University of Alberta in 1976.

De Villiers, Dr. J.W.L.

Dr. de Villiers is Executive Chairman of the Atomic Energy Corporation of South Africa Ltd.

From 1952 to 1958 he was employed at the Council for Scientific and Industrial Research where he advanced to head of the Mass Spectrometry Division. In 1958 he became a bursar for the Atomic Energy Board (AEB) and after a period of further training and research at such notable institutions as Argonne and Brookhaven National Laboratories in the U.S.A., he returned to the AEB in

1962. Here he advanced to Director of the Reactor Development Division in 1967. Early in 1970 he founded his own undertaking, but in March 1972 he returned to the field of research and joined the Uranium Enrichment Corporation as head of the Safety Division. In June 1973 he became Vice-President of the AEB, and Deputy President in 1976. In 1979 he was appointed President of the AEB in which capacity he also served as Chairman of the Board. With the establishment of the Atomic Energy Corporation of South Africa Ltd on 1 July 1982 he was appointed to his present position.

Approximately 25 scientific publications have appeared under his name, and he is a member of the SA Institute for Physics, the SA Institute for Mechanical Engineers, and a council member of the South African Academy for Arts and Science. He is also a registered Professional Engineer and a member of the SA Council for Natural Scientists. He served on the Commission of Inquiry into the Supply of Electricity in the RSA. He is also Chairman of the Scientific Advisory Council.

Dr. de Villiers received his university training at the University of Stellenbosch, where he obtained the degrees B.Sc. in 1949, and M.Sc.(Cum Laude) in 1951. In 1957 he obtained a D.Sc. degree, also from the University of Stellenbosch.

Eichholz, Prof. G.G.

Professor Eichholz is Regents' Professor of Nuclear Engineering at the Georgia Institute of Technology in Atlanta, Georgia, U.S.A.

During World War II he served with the British Admiralty on the development of radar. After the war he was appointed Assistant Professor of Physics at the University of British Columbia, a position he occupied until 1951. He then joined the Canadian Bureau of Mines where he was in charge of the analysis of uranium ore, radiotracer tests in the mining and metallurgical industries, and process control developments. He moved to the Georgia Institute of Technology in 1963, and since then has directed research on radiation detectors, radiation applications, environment assessment, and impact of radioactive waste management. He has authored a number of publications in these fields.

Professor Eichholz received both his B.Sc. and Ph.D. degrees in physics from the University of Leeds.

Gaynor, R.K.

Mr. Gaynor is currently Project Manager and Vice President of U.S. Ecology Inc, as well as being President of U.S. Ecology Consultants, a division of U.S. Ecology Inc. in California, U.S.A.

Prior to joining U.S. Ecology he worked as a consulting geotechnical engineer. Since joining the Company in 1980 he has been involved in technical and policy issues related to the disposal of hazardous and radioactive wastes in various parts of the United States. He is currently responsible for the establishment of a new low-level radioactive waste disposal site in California, which should be licensed and operating by 1990. He has authored several papers on waste disposal in arid environments.

Mr. Gaynor is a graduate of the University of Kentucky where he obtained an M.Sc. degree in civil engineering.

Gestermann, G.

Mr. Gestermann is employed by the Gesellschaft für Nuklear-Service (GNS) in Federal Republic of Germany, where he is involved in the development of techniques for nuclear waste management.

He was first employed in 1977 in an engineering office, working on studies of reactor safety for various reactor types, as well as the safety engineering planning for the construction of a German reprocessing plant. In 1981 he joined GNS, where he has been engaged in the development of casks for the transport and storage of spent fuel assemblies, and the conditioning of wastes from nuclear facilities.

Mr. Gestermann first underwent practical training in a machine factory. He then went to the Technical University at Aachen where he majored in nuclear engineering and health physics.

Haelsig, R.T.

Mr. Haelsig is President of Nuclear Packaging, Inc., a Pacific Nuclear Systems company in Washington, U.S.A.

He has served as the Engineering Industry Manager for Boeing Computer Services, and as the Engineering Analysis Manager for the Aerojet Surface Effects Division. He joined Nuclear Packaging as Director of Engineering, and was later promoted to Vice President for Business Development, before becoming President. He has had 15 years experience in the design and licensing of packages for the transport of radioactive materials.

Mr. Haelsig has a B.S. degree in engineering and an M.S. degree in civil engineering from the University of California.

Hahn, Dr. P.S.

Dr. Hahn is a Senior Researcher with the Korea Advanced Energy Research Institute.

Hall, Prof. A.V.

Professor Hall is an Associate Professor of Botany and Assistant Curator of the Bolus Herbarium at the University of Cape Town.

Over the years he has been engaged in a number of areas of research. These include plant systematics, ecology, computer methods, and conservation biology, and currently his interests lie in systematics, restoration ecology, and the conservation biology of endangered plants. He has written extensively on these topics, having published over 50 research papers. He is a Fellow of the Linnean Society of London and the Royal Society of South Africa.

Professor Hall took his first degree in Botany and Chemistry at the University of Cape Town in 1955. He received a doctorate in plant systematics from the same University in 1963.

Hambleton-Jones, Dr. B.B.

Dr. Hambleton-Jones is Division Head in the Department of Geotechnology of the Atomic Energy Corporation of South Africa Ltd.

After working for a short period in the refractories industry, he moved to the Atomic Energy Board (now Atomic Energy Corporation) in 1971 where he did research work on the geochemistry of uranium deposits. Subsequent research resulted in the development of the ROAC radon detection system used in uranium exploration. Since 1980 he has been responsible for the site selection and evaluation program of the South African radioactive waste disposal project. During

the past ten years he has published and lectured both locally and overseas on several aspects of uranium geology and geochemistry, and radioactive waste disposal.

Dr Hambleton-Jones received his initial university education at the University of Cape Town majoring in both geology and chemistry, which was followed by an honours degree in geochemistry in 1967. His research into the geochemistry of uranium deposits earned him a D.Sc. degree from the University of Pretoria in 1976.

Herbrechter, D.

Mr. Herbrechter is Assistant Head: Nuclear Engineering with Kraftanlagen Aktiengesellschaft, Heidelberg, Federal Republic of Germany.

He started his career in 1959 with Essener Apparatebau designing and constructing chemical process equipment. From 1963 to 1971 he occupied various positions within Eurochemic involved with the chemical processing of irradiated fuels. He joined Kraftanlagen in 1971 and has been engaged in the design, construction and start-up of various radiochemical facilities, as well as various conceptual and design studies for the German research centres.

Mr. Herbrechter obtained a bachelors degree in chemical engineering in 1958 from the engineering college in Essen.

Jacobi Jr., A.

Mr. Jacobi is Assistant Vice President of Electrowatt Engineering Services Ltd. in Zurich, Switzerland.

He started his career as the assistant to the Superintendent of the Beznau N.P.S. in Switzerland. He has been involved in thermo-hydraulic calculations, applied piping stress analysis, and dynamic structural mechanics. After joining Electrowatt he did support work for ESCOM in the early years of the Koeberg project. His current responsibilities are mainly safety studies, assistance in licensing, and general consulting activities relating to nuclear reactors and nuclear waste disposal facilities.

Mr. Jacobi has an M.Sc. degree in mechanical engineering from the Swiss Federal Institute of Technology in Zurich.

Jeanson, P.

Mr. Jeanson is with Electricité de France.

Jones, D.F.

Mr. Jones is President of Pacific Nuclear Systems, Inc. in Washington, U.S.A.

He joined the United States Navy in 1962, and served as a Lieutenant on nuclear submarines until 1969. From 1970 to 1975 he was employed as the Planning Manager for the Weyerhaeuser Real Estate Company. In 1975 he joined Chem-Nuclear Systems as a Vice-President, where he was involved in treatment, transport and disposal services to U.S. power plants. He assumed his present position in 1983, and is engaged in providing systems for the transportation and storage of radioactive waste and spent fuel, as well chemical cleaning and decontamination services for nuclear power plants.

Mr. Jones received his B.S. degree from the U.S. Naval academy in 1962. He later went to the University of Pennsylvania where he earned an MBA in finance in 1970.

Krauskopf, Prof. K.B.

Professor Krauskopf is Professor Emeritus in the Geology Department at Stanford University, U.S.A.

He started his career as an Instructor in Chemistry at Stanford University in 1934, and in 1935 took the post of Acting Instructor in Physical Science. In 1939 he was promoted to Assistant Professor of the Geology Department, followed three years later, in 1942, by promotion to Associate Professor. During this time he also worked for the G-2 Geographic Section of the U.S. Army in Tokyo, and the U.S. Geological Survey. He was appointed Professor in the Geology Department in 1950, and occupied this position until 1976, when he became Professor Emeritus. He is a member of a number of international academic societies, and is a past president of the American Geological Institute, the Geological Society of America, and the Geochemical Society, as well as having received medals from these societies. He is the author or co-author of five books, most of which have had several editions, and numerous articles for technical journals, abstracts and book reviews.

Professor Krauskopf received his first degree in chemistry from the University of Wisconsin in 1931. In 1934 he obtained a Ph.D. degree

in chemistry from the University of California, and in 1939 a further Ph.D. degree, but in geology, from Stanford University. He was awarded an honorary degree by the University of Wisconsin in 1971.

Levin, M.

Mr. Levin is a Control Scientist in the Department of Geotechnology of the Atomic Energy Corporation of South Africa Ltd.

After six years in the chemical industry he joined the Chemistry Department of the Atomic Energy Board in 1970, where he was engaged in research involving ion exchange methods. He moved to the Geology Department of the Board in 1974 and was involved in assessing the uranium potential of sand-covered areas in the northwestern Cape. He is currently investigating the geohydrology of various areas as part of a program for selecting and assessing potential sites for nuclear facilities.

Mr. Levin received his B.Sc. degree in chemistry and mathematics from the University of Pretoria. This was followed by a B.Sc.(Hons) in geology from the same University in 1973. He obtained an M.Sc. degree for geohydrological investigations in the northwestern Cape from the University of Pretoria. He is currently working on a Ph.D. thesis on the geohydrology of the Vaalputs Radioactive Waste Disposal Facility.

Lin, M.H.

Mr Lin is Head of the Nuclear Chemistry Division at the Taiwan Power Company.

He joined the Taiwan Power Company in 1956 and worked initially on fossil-fueled power plants. Before transferring to nuclear power stations he spent two years taking special training programs in nuclear engineering at Tsinghua University, BWR technology, reactor chemistry and health physics at General Electric, and nuclear engineering at Oregon State University. He has been involved in plant startups and improvements, radioactive waste management, nuclear chemistry, and water treatment. He achieved his present position in 1982, and, in addition to the above, he is responsible for plant chemistry, which includes prevention of materials corrosion.

Mr. Lin is a graduate of Tamkang University where he obtained a bachelor's degree in chemistry.

Müller, Prof. H.

Professor Müller is Professor in the Section Radiochemistry of the Institute for Inorganic and Analytic Chemistry at the University of Freiburg, Federal Republic of Germany.

He joined the University of Freiburg as Lecturer in 1965 and in 1971 was appointed Professor. His main research interests are radiation damage in solids, the chemical effects of nuclear transformations in solids, metallic hydrides, mixed halogeno-metallates, hydrolysis of halogeno-metallates and the philosophy of science.

Professor Müller studied chemistry at the Universities of Mainz, Hannover, and Freiburg, and received his first degree from the University of Freiburg in 1955. The same University awarded him a Ph.D. in 1958 for his work on Nb-O, Nb-H, Nb-S and Ta-O systems.

Müller-Broich, Prof. A.

Professor Müller-Broich is the Dean of the Faculty of Biophysics and Physical Biochemistry at the University of Regensburg, Federal Republic of Germany.

Navratil, Dr. J.D.

Professor Navratil holds the position of Research Professor in the Department of Chemistry and Geochemistry at the Colorado School of Mines, U.S.A.

He first joined Rockwell International in 1961. He has held a several positions in the Analytic Laboratories and Research and Development (last position, Manager of Chemical Research), and in 1978-81 was on leave of absence to the International Atomic Energy Agency. Dr. Navratil's research interests are mainly chemical separations, actinide processing chemistry, and waste management. He was authored or co-authored over 100 publications and co-authored twelve books, and is on the editorial board of six other journals. Honors bestowed upon him include the Dow Scholarship (1968), Rockwell International Engineer/Scientist of the Year (1977), two Industrial Research and Development IR-100 Awards (1983 and 1985), and Colorado ACS Section Award (1984).

Professor Navratil has a Ph.D. degree in chemistry from the University of Colorado.

Nel, Prof. J.A.J.

Professor Nel is Professor of Zoology and Chairman of the Department of Zoology at the University of Stellenbosch, South Africa.

He joined the staff of the Zoology Department at the University of Pretoria as a Lecturer in 1960. He left there in 1984 to take up his present position at the University of Stellenbosch. He has done research work overseas at the Universities of Kansas in the United States and Oxford in Great Britain, and has presented papers at numerous local and overseas conferences. He is a past-president of the Zoological Society of South Africa and the Joint Council for Scientific Societies, as well as being an alternate member of the South African Council for Natural Scientists, and a member of several scientific societies. He has published some 43 scientific papers and a number of popular articles. His current interests are the ecology of small mammals, especially rodents, and the behavioural ecology of foxes and jackals.

Professor Nel is a graduate of the University of Stellenbosch where he obtained an M.Sc. degree in zoology in 1959.

Nowatzki, Prof. E.A.

Professor Nowatzki is Acting Head and Associate Professor of the Department of Civil Engineering and Engineering Mechanics at the University of Arizona, U.S.A.

Olds, F.C.

Mr. Olds is an internationally-known consultant in the energy communication field based in Illinois, U.S.A.

He worked for 20 years in the power and heavy engineering fields before becoming an editor with Power Engineering. During his time with the magazine he has travelled widely in both the Eastern and Western Bloc countries to attend conferences and visit advanced technology installations. He has interviewed top energy authorities in many parts of the world, and has been consulted by representatives of both industry and governments. In addition to having some 80 published articles and papers to his credit, he has also written a widely-read monthly column on nuclear power developments for almost the last 20 years. He recently retired as Executive Editor from Power Engineering to become a consultant in the energy communication field.

Mr. Olds is a graduate from the University of Michigan with degree in mechanical engineering.

Ospina-Esperon, Dr. C.J.

Dr. Ospina-Esperon is a Scientific Assistant in the Fuel Division of the Eidg. Institut für Reaktorforschung (EIR), Switzerland.

He first joined Merz and McLellan in the United Kingdom as an electrical engineer. He subsequently took a position as a nuclear engineer with the United Kingdom Atomic Energy Authority. The next move took him to the Federal Republic of Germany where he joined HRB in Mannheim as a nuclear engineer. Later he accepted a post with the Commissariat a L'energie Atomique in France. In 1971 he moved to Switzerland where he took up an appointment at the EIR.

Dr. Ospina-Esperon obtained his first degree from the University of Bogota in mechanical engineering. Later he studied electrical engineering at Newcastle Upon Tyne and nuclear engineering at Imperial College. He is also a graduate in project planning and management from the ETH, Zurich.

Röhm, Dr. H.F.

Dr. Röhm is a Senior Physicist in the Nuclear Engineering Division of the Engineering Group of Escom, South Africa's major electricity utility.

After graduating he lectured at the University of Pretoria, and did research in nuclear chemistry and physics at both local and overseas research institutions. Whilst at the Geological Survey of South Africa he was involved in establishing the routine analysis of trace elements in geological samples. Since joining Escom he has been working in various fields associated with the Koeberg nuclear power station, ranging from safety and licensing, the back-end of the fuel cycle, and siting studies for new nuclear stations. Several publications have flowed from his work.

Dr. Röhm is a graduate of the Universities of Stellenbosch and Karlsruhe where he studied chemistry and radiochemistry.

Rometsch, Dr. R.

Dr. Rometsch is the President of the National Cooperative for Disposal of Radioactive Wastes in Switzerland.

After doing post-graduate work at the University of Basle he joined Ciba Chemical Industries in Basle in 1945. He worked there until 1959, and during that time he took part

in the studies of the Swiss Joint Interest Group for Nuclear Reactors, and participated in the Study Syndicate of the Organization for Economic Cooperation and Development on the European Joint Venture for the reprocessing of used nuclear fuel. In 1959 he was appointed head of the company's Research Department and five years later promoted to Managing Director. In this post he was responsible for the inauguration of the first series of reprocessing campaigns. He was called to the International Atomic Energy Agency(IAEA) in 1969, and appointed Deputy Director General in charge of safeguards. During the following nine years he was involved in the development, implementation and extension of international safeguards in connection with the treaty on the non-proliferation of nuclear weapons. After retirement from the IAEA, he was appointed to his present position where he devotes most of his time to the development of ultimate repositories for radioactive waste.

Dr. Rometsch studied physical chemistry at the University of Basle, and in 1943 was awarded a Ph.D. degree.

Sandquist, Prof. G.M.

Professor Sandquist is Professor of Mechanical and Industrial Engineering at the University of Utah, U.S.A. He is also the Director of Nuclear Engineering and an Associate Research Professor of Surgery.

His career has always been intimately involved with the University of Utah, where he has occupied various academic positions since 1961. In 1965 he was appointed as Assistant Professor of Mechanical Engineering, and in 1971 promoted to Associate Professor. He was appointed to his present position in 1975. During his career he has engaged in a wide variety of research activities, including nuclear reactor kinetics, energy research and development, controlled thermonuclear fusion, biomedial engineering, environmental impact assessment, radiation transport, and expert systems, and he has published extensively in these, and other fields. He is a member of a number of international academic societies, including the American Nuclear Society, the American Society of Mechanical Engineers, and the American Health Physics Society.

Professor Sandquist obtained a B.S. degree in mechanical engineering from the University of

Utah in 1960. The University of California awarded him an M.S. degree in engineering science in 1961, he received his Ph.D. degree in mechanical and nuclear engineering from the University of Utah in 1964. He was a Post-doctoral Fellow at the Massachusetts Institute of Technology in 1969 and 1970.

Simpson, D.M.

Mr. Simpson is a Chief Scientist in the Licencing Branch of the Atomic Energy Corporation of South Africa Ltd.

He joined the Central Electricity Generating Board in the United Kingdom in 1964, and was involved in various aspects of electricity power generation, particularly in the nuclear field. In 1970 he emigrated to South Africa in order to join the Licencing Branch, where he has been instrumental in the development of the risk philosophy and safety criteria now being used by the Corporation for the regulation of all nuclear facilities in South Africa.

Mr. Simpson was educated in the United Kingdom, where he obtained a B.Sc. degree in electrical engineering from Manchester University

Smith, Dr. A.C.S.

Dr. Smith is an Associate Consultant on hydrogeochemistry for the Steffen, Robertson and Kirsten group of companies.

He is based in Vancouver, Canada, and provides specialist input on waste disposal and water contaminant problems in mining and manufacturing industries throughout the world. He has published extensively in the fields of hydrogeochemistry and waste disposal.

Dr. Smith is a Ph.D. graduate in hydrogeochemistry, and is a Chartered Engineer.

Soong, Dr. K.L.

Dr. Soong is a Senior Geologist and Project Manager with the Institute of Nuclear Energy Research (INER), Republic of China. He is also Professor of Mineralogy and Petrology at the National Taiwan Normal University.

His early career was spent with the Chinese Air Force involved with various electronic and engineering projects. In 1966 he joined the INER and participated in various exploration programs for uranium and heavy mineral sands. Other fields of activity were engineering

geology and plutonium fuel fabrication. In 1977 he was promoted to Project Manager for mineral resources and engineering geology. In 1978 he was appointed Associate Professor at the National Taiwan Normal University, and in 1982 was promoted to Professor.

Dr Soong first graduated from the National Taiwan University with a B.S. in geology. Further study at the University lead to a M.S. degree in geology. He subsequently gained his doctorate at Heidelberg University.

Stephenson, Prof. D.

Professor Stephenson is Professor of Hydraulic Engineering in the Department of Civil Engineering, and Director of the Water Systems Research Programme at the University of the Witwatersrand, South Africa.

He initially worked for the Rand Water Board, and then with a consulting firm where he became a partner, after which he joined the University of the Witwatersrand. The research group which he heads is engaged in urban hydrology, rural water resources, mine water, and real-time computer systems. His main research interests at present are computer modelling of hydrological systems and micrographic interaction. He is the author of over 90 technical papers and 6 books, and serves on the editorial board of 5 journals.

Professor Stephenson is a graduate of the University of the Witwatersrand, and holds the degrees of B.Sc.(Eng.), M.Sc.(Eng.), Ph.D. and D.Sc.(Eng.)

Toens, Dr. P.D.

Dr. D Toens is the Manager of the Department of Geotechnology at the Atomic Energy Corporation of South Africa Ltd.

After spending some years in the South African mining industry occupying senior positions with the General Mining and Anglo Transvaal Corporations, he moved to the Atomic Energy Corporation of South Africa in 1971 and was appointed to his present position in 1978. His main responsibilities pertain to uranium resources, nuclear geology research and radioactive waste disposal. He has published widely on a number of topics and has on occasion acted as an adviser to foreign governments. He has represented South Africa on a number of international technical committees, and is a past President of the

Geological Society of South Africa and a Fellow of the South African Institute of Mining and Metallurgy.

Dr Toens received his university training at the Universities of Pretoria (South Africa) and Innsbruck (Austria).

Tsai, Dr. C.M.

Dr. Tsai currently holds the position of Director, Radwaste Administration in the Atomic Energy Council of the Republic of China.

From 1960 to 1971 he was an Environmental Surveyor with the Health Physics Department of the Institute of Nuclear Science at the National Tsing-Hua University. His studies involved fall-out analysis and nuclear reactor radiation surveys. In 1971 he joined the Health Physics Division of the Institute of Nuclear Energy Research where he successively held the positions of Research Assistant, Engineer, Deputy Director and Director. He moved to the Atomic Energy Council in 1983 to take up his present position.

Dr. Tsai graduated from Tohoku University, Japan with a D.Sc., majoring in radiochemistry and health physics.

Van As, Dr. D.

Dr. van As is the Manager of the Isotopes and Radiation Department at the Atomic Energy Corporation Of South Africa Ltd. (AEC).

He joined the then Atomic Energy Board in 1963, and was appointed to his present position in 1979. A research scholarship was awarded to him, and he spent two years at the University of Pennsylvania in the U.S.A. In addition he was a staff member of the Department of Nuclear Safety and Environmental Protection at the International Atomic Energy Agency in Vienna for two years.

Dr. van As is a graduate in physics and chemistry from the University of Stellenbosch, and did a Ph.D. degree on the radiation impact of the nuclear industry in South Africa.

Van der Westhuizen, H.J.

Mr. van der Westhuizen is Manager of the Nuclear Waste Technology Department of the Atomic Energy Corporation of South Africa Ltd. (AEC).

He joined the AEC in 1962 as a Scientist in the Chemical Operations Division, and became

Head of the Analytical Section in 1969. Later that year he was appointed Head of the Division. In 1982 he was promoted to his present position. Since 1968 he has been responsible for the management of all radioactive waste at Pelindaba and from isotope users. He is currently also responsible for all the supply services to the Pelindaba site, and the design, construction and operation of the Vaalputs Radioactive Waste Disposal Facility.

Mr. van der Westhuizen is a graduate of the University of Pretoria, where he received an M.Sc. degree in chemistry in 1963.

Waplington, G.

Mr. Waplington is the Managing Director of Electrowatt Engineering Services (UK) Ltd.

He joined the Central Electricity Generating Board as a Research Officer engaged in the design and development of nuclear fuel handling equipment. Subsequently he transferred to the General Electric Company of Great Britain to work on AGR core and PWR balance of plant mechanical design. He joined Electrowatt in 1974 and became involved in probabilistic risk analysis. More recently this has included the project management of a radiological safety assessment of a deep disposal facility for nuclear waste.

Mr. Waplington is a graduate with a B.Sc. (Hons) degree in mechanical engineering.

Wasinger, K.L.V.

Mr. Wasinger is a Senior Project Engineer with Kraftwerk Union AG in the Federal Republic of Germany.

He joined Kraftwerk Union as a Project Engineer in 1969, and was engaged in the design, procurement, and follow-up of components for fuel handling and storage. In 1976 he became involved with the sales and marketing of retrievable spent fuel storage facilities. From 1982 to 1985 he was part of the project management team at the Atucha 2 nuclear power plant in Argentina, for the most part as a Senior Assesor. He returned to Germany in mid-1985, when he assumed responsibility for sales and marketing of components, systems and plants for radioactive waste and spent fuel management.

Mr. Wasinger is a graduate in mechanical engineering from the HTL at Ferlach in Austria.

Williams, Prof. D.R.

Professor Williams is Head of Department and Professor of Applied Chemistry in the Institute of Science and Technology at the University of Wales.

He taught and did research work at the Universities of Lund in Sweden and St Andrews in Scotland. In 1977 he was appointed to his present position where he heads a large research group in trace element speciation. Over the last 20 years he has developed computerized approaches to assess speciation at extremely low concentrations. These permit predictions of trace element behaviour in a variety of situations such as during leaching of radioactive waste disposal vaults.

Professor Williams graduated B.Sc. and Ph.D. in chemistry from the University of Wales. Further research lead to the University of St Andrews awarding him a D.Sc. degree. The Royal Society of Chemistry awarded him a silver medal for his research in environmental chemistry.

Wium, Dr. D.J.W.

Dr. Wium is an Associate in Van Wyk & Louw Inc., a firm of consulting engineers located in Pretoria, South Africa.

He first joined a construction company, and worked on various construction sites for two years before joining Van Wyk & Louw. There he was involved in bridge design and computer applications in civil engineering. More recently he has been involved in the design and analysis of complex structures, with particular emphasis on dynamic and seismic effects. One aspect of this work has been to define engineering input for the seismic analysis of new and existing facilities in Southern Africa.

Dr. Wium obtained a B.Sc. in civil engineering from the University of Pretoria in 1977. Subsequently he also obtained Honours and Masters degrees in structural engineering from the same University. He completed his doctoral studies on segmental concrete bridges at the Massachusetts Institute of Technology in 1984.

TRN ZA8600461

CONFERENCE ON THE TREATMENT AND CONTAINMENT OF RADIOACTIVE WASTE AND ITS DISPOSAL IN ARID ENVIRONMENTS

Cape Town, South Africa. 7-12 September 1986

Session 3

TRANSPORTATION AND STORAGE EXPERIENCE

R.T. HAELSIG
Nuclear Packaging, Inc., 1010 South 336th Street, Suite 220, Federal Way, Washington 98003, United States of America

ABSTRACT

Nuclear Packaging, a Pacific Nuclear Company, is the leading U.S. designer of radioactive material transport packages (casks and overpacks). The company has recently completed the design, fabrication and licensing of a new spent fuel transport container. This rail car mounted cask is the first such container to be licensed in the United States during the last decade. The composite lead cask was contracted for and designed to transport the damaged nuclear fuel from Three Mile Island Unit 2.

A unique consideration in the design is the two seperate levels of containment that are provided at all times, allowing the shipment of failed fuel without additional "canning". Another first is associated with the fact that no other previous U.S. cask design has undergone testing in support of the traditional analytical design tools.

This experience is the latest in more than a decade of specialized design and licensing activities conducted by Nuclear Packaging, Inc., providing safe and efficient transport containers to the U.S. and world nuclear markets.