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December 16, 1986

J. O. Neff, Project Manager, SRPO

FOREIGN TRIP REPORT FOR TRAVEL TO FEDERAL REPUBLIC OF GERMANY AND BELGIUM, SEPTEMBER 26 THROUGH OCTOBER 11, 1986

Enclosed is a foreign trip report detailing the travel of D. Cattran of ONWI and K. Wu of SRPO to the Federal Republic of Germany (FRG) and Belgium on September 26 through October 11, 1986. The purposes of this trip were to:

1. Attend and participate in the U.S./FRG Bilateral Agreement Technical Coordinators and the Principal Coordinators meeting.

2. Visit and tour Asse Mine and the Gorleben salt repository site for discussion of past and possible joint studies and proposed information exchange.

3. Visit and tour relevant facilities at the Karlsruhe Nuclear Research Center and the Juelich Nuclear Research Center.

4. Visit and tour the underground research laboratory in a clay formation at Mol, Belgium.

In addition, D. Cattran researched possibilities for information exchange in the public information and institutional area, such as possible tours of Asse and Gorleben for key state officials and citizens.

This report has been arranged as follows:

- A brief summary of the various meetings, purposes of the trip, itinerary, and cost for SRPO travelers.

- A summary of the Bilateral Agreement Meetings and comments and recommendations on public information aspects. Note that the primary trip report for the Bilateral Meeting portion of the trip was prepared by J. Strahl of Weston for direct submittal to J. Fiore of OGR. Appropriate portions of this are included as Appendix C.

- A report for the visits to Karlsruhe and Juelich Nuclear Research Centers, which are not covered in the Weston report. The major report for the Mol, Belgium, portion was also prepared by J. Strahl and is included as Appendix H.

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1525

Visitors' Entrance: 1375 Perry Street, Columbus, Ohio
Telephone (614) 424-5674 — Telex 24-5454

Enc. to letter dated 12-16-8
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To: Neff, from: Carbiener



- A set of appendices covering the itinerary, names, and addresses of key contacts, meeting minutes, selected photographs, and pertinent technical papers.

This report has been reviewed by K. Wu of SRPO and has been prepared in accordance with Section 6.4.3 of DOE/RW-0064, OCRWM International Procedures. It will be issued according to the attached distribution list. If you have any questions or comments, please contact D. Cattran at Ext. 4-4303.

Wayne A. Carbiener

Wayne A. Carbiener
Program Manager

WAC/DEC:dmh

In triplicate

Encs.

cc: R. B. Lahoti, SRPO
K. K. Wu, SRPO
L. K. McClain, SRPO

WBS 1.3.5.4
ONWI-010-86-0169

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# TRIP REPORT

## U.S./FRG BILATERAL AGREEMENT MEETINGS AND FACILITY TOURS

## FEDERAL REPUBLIC OF GERMANY AND BELGIUM

by

Diane E. Cattran
Office of Nuclear Waste Isolation

Kan Kung (Roger) Wu
Salt Repository Project Office

September 28 - October 9, 1986

# TRIP REPORT

## U.S./FRG BILATERAL AGREEMENT MEETINGS AND FACILITY TOURS

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September 28 - October 9, 1986

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APPENDIX F: OVERVIEW OF THE FRG ACTIVITIES ON SPENT FUEL DISPOSAL

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APPENDIX I: U.S. DOE VISIT TO CEN/SCK MOL FACILITY

# SUMMARY

## U.S./FRG BILATERAL AGREEMENT MEETINGS AND FACILITY TOURS

## FEDERAL REPUBLIC OF GERMANY AND BELGIUM

September 28 - October 9, 1986

**Trip Report Date:** December 1986

**SRPO/ONWI Travelers:** K. K. (Roger) Wu, SRPO, Technical Coordinator for waste management portion of bilateral agreement; D. E. Cattran, ONWI International Coordinator

(Other key attendees for the first week's meetings were J. F. Strahl, Director of International Program Office at Weston; C. R. Cooley, OCRWM; and L. D. Tyler, Sandia.)

**Itinerary:**

| | |
|---|---|
| September 29-30: | GSF/IfT (Company for Radiation and Environmental Research, Institute for Underground Storage), K. Kuehn, Braunschweig |
| September 30: | BGR (Federal Institute for Geosciences and Natural Resources), M. Wallner, Hannover |
| October 1: | Asse Mine Visit, K. Kuehn |
| October 2-3: | BMFT (Federal Ministry for Research and Technology), Gorleben Facility Visit, R. Randl, (BMFT), G. Gruebler (DBE) |
| October 6: | KfK (Karlsruhe Nuclear Research Center), K. Closs, Karlsruhe |
| October 8: | KFA (Juelich Nuclear Research Center), R. Odoj, Juelich |
| October 9: | Underground Research Laboratory, CEN/SCK (Nuclear Energy Research Center); A. Bonne; Mol, Belgium |

A more detailed itinerary is included as Appendix A. Appendix B is a list of persons contacted, with addresses and telephone numbers.

**Purpose:** The purpose of the trip to the FRG was to participate in the U.S./FRG Bilateral Agreement Technical and Principal Coordinators' Meetings, tour the Asse Salt Mine and the Gorleben proposed repository site, and visit the Karlsruhe and Juelich Nuclear Research Centers for discussion of ongoing and planned studies relevant to the Salt Repository Project. The trip to Belgium was to visit the Underground Research Laboratory in a clay formation, discuss the Belgium disposal program plans, and evaluate potential cooperative activities with SRPO.

**Report Abstract:** On September 30, 1986, the GSF/IfT and DOE/SRPO agreed to extend the Asse Project Agreement for two years and defined specific activities to be performed under this agreement, including post-test evaluation of Asse irradiated salt samples. In addition, it was agreed that at least two joint workshops will be held in 1987, and personnel exchange to both the U.S. and FRG will continue. Additional work related to Asse experiments was discussed, including simulated spent fuel emplacement tests, backfill and sealing tests, and geomechanical modeling development. If implemented, parts of this work may require either a new project agreement or addendum to the existing agreement. Interest in information exchange in the area of public information and outreach programs was indicated, particularly the SRPO interest in arranging a tour of the FRG facilities for key state officials and citizens.

The SRPO representatives visited the Karlsruhe and Juelich Nuclear Information Centers to tour appropriate facilities and to further discuss relevant projects planned for the Asse Salt Mine. At Karlsruhe, the PUREX reprocessing plant and the POLLUX cask welding facility were toured, and possible SRPO participation in demonstration projects for spent fuel disposal was discussed. At Juelich, the discussions focused on medium activity waste and high temperature reactor fuel element borehole disposal tests and the waste container quality assurance work.

In Belgium, the overall status of the program was presented by A. Bonne of the Nuclear Energy Research Center (CEN/SCK), after which SRPO, CPO, ONWI, and Weston representatives toured the Mol Underground Research Laboratory in the Boom Clay formation. It was concluded that only CPO may have some interest in formal future interactions with the Belgium program.

| | | |
|---|---|---|
| <u>TRAVEL COST</u>: | K. K. Wu: | $4,500 (travel cost plus 80 staff hours) |
| | D. E. Cattran: | $9,500 (travel cost plus 200 staff hours) |
| | Briefing package and viewgraph preparation--time and materials: | $2,000 |
| | Total: | $16,000 |

## U.S./FRG BILATERAL PLANNING AND AGREEMENT MEETINGS AND TOURS

(September 29 - October 3, 1986)

On September 29-30, 1986, a delegation representing the U.S. DOE/OCRWM geologic disposal program, led by the Salt Repository Project Technical Coordinator, K. (Roger) Wu, met with the FRG geologic disposal delegation under the direction of K. Kuehn, Technical Coordinator from the Gesellschaft fuer Strahlen- und Umweltforschung mbH Muenchen, Institut fuer Tieflagerung (GSF/IfT, German Company for Radiation and Environmental Research, Institute for Underground Storage), to discuss progress under the existing agreement extension signed in August, 1984, in Park City, Utah, and to further define and reach an agreement on continued cooperative activities over the next two years.

On October 2-3, 1986, a delegation representing the U.S. DOE, led by the Principal Coordinator, C. Cooley, met with the FRG delegation led by R. Randl, Principal Coordinator from the Bundesministerium fuer Forschung und Technologie (BMFT, Federal Ministry for Research and Technology) to summarize agreements reached at the various Technical Coordinators' meetings and to sign an agreement on continued cooperative activities for the next two years.

A detailed report on both of these meetings plus tours of the Asse Mine and the Gorleben exploratory shaft facility was prepared by J. Strahl, Manager of International Affairs at Weston, and submitted to J. Fiore of OGR on November 14, 1986. SRPO/ONWI comments were incorporated in this report, and a copy of the appropriate portion is included as Appendix C. Minutes on both the bilateral planning and agreement meeting are included as Appendix D.

Please note that the attachments referenced in Appendix C have not been included in this report for the sake of brevity. Anyone wishing to see any of the attachments should contact Diane Cattran at FTS 976-4303, ONWI, or Jim Strahl at (202)646-6654, Weston.

### Comments and Recommendations on Public Information Aspects

Most of the general public information work on nuclear waste disposal has been conducted by the Physikalisch-Technische Bundesantalt (PTB, Federal Science/Engineering Laboratory). This is supplemented by work of the Deutsche Gesellschaft zum Bau und Betrieb von Endlagern fuer Abfallstoffe mbH (DBE, Company for Construction and Operation of Waste Disposal Facilities*), which is centered on the Gorleben site.

---

* DBE was formed by the PTB in 1979 specifically to manage construction and operation of waste repositories and is directly supervised by federal authorities. DBE, in turn, is made up of four government controlled corporations, including the Deutsche Gesellschaft fuer Wiederaufarbeitung von Kernbrennstoffen mbH (DWK, German Fuel Reprocessing Company).

The federal government has opened a site-specific disposal information center on nuclear disposal at Gartow, a small town near Gorleben. It is operated jointly by the federal government and the Land of Lower Saxony. The office is open four days per week and other times by appointment. The exhibits are extremely professional and well done. Upon entering the front door, the visitor is greeted by a large five-foot high chunk of pale pink rock salt. Particularly impressive are the three-dimensional model of the Gorleben salt dome and a model depicting shaft freezing and the various linings used to construct the shaft. Photos of various exhibits are attached as Appendix D. Upstairs are offices and a large conference room for viewing films and holding meetings. Dr. Wolfgang Schorr, who manages the information office for the State of Lower Saxony, showed a 30-minute, 16mm film "Abteufen eines Gefrierschachtes" ("Freezing Technique for Shaft Sinking"), in which the freezing method is demonstrated with animation and live footage of the underground construction operations. Dr. Schorr agreed to send a copy of the film for SRPO to translate.

The area surrounding Gorleben is primarily agricultural, although substantial local effort has been devoted to attracting tourists to visit resort cabins and participate in water sports at a small lake near Gartow. Since the area is very near the East German border, there is no longer any major east-west traffic, and the population is considerably smaller than it was twenty years ago. Lower Saxony has the lowest population density in the FRG. The federal government and contractors have worked closely with the officials of Lower Saxony and the local town officials resulting in quite good public acceptance among the local population. Most of the strong anti-nuclear sentiment in Germany seems to come from more or less "professional" nuclear opponents, and they are presently concentrating protest activities and demonstrations at the reprocessing plant construction site in Wackersdorff, Bavaria. Several meeting participants noted that the Chernobyl incident had been extremely detrimental to public opinion of the nuclear industry and they expressed concern that the incident could affect the outcome of the federal elections in January 1987.

The visit to the information office was followed by a tour of the actual Gorleben facility which was quite impressive, particularly the high metal fences topped with high-pressure water cannons and the guards circling the perimeter of the facility with dogs. The Gorleben administration buildings and shaft headframe are very solidly built, and do not look like a typical construction site. Many of the buildings are constructed of red brick, giving the impression of permanence. The exploratory shaft was completely frozen in August and construction started in September with progress down to the 70-meter level. The tour included observation of shaft 1 excavation, shaft 2 freezing operations, the freezing equipment facility, and the shaft elevator systems. Completion of the shafts is expected in 1989 and testing will take place from 1989 to 1992. After a five-to six-year licensing process, operation is expected around the year 2000. (See Appendices C and E for more details.)

The visit to the Asse Salt Mine on the previous day, October 1, 1986, provided a better understanding of the activities used by the FRG to

evaluate salt as a host rock for waste disposal and an update on future experiments planned in the mine. The tour highlights included the core storage facility at the 490-meter level where the samples from the brine migration tests are stored, the low-level waste storage room, and, of particular interest to SRPO, the brine migration test area at the 800-meter level. Three of the four heaters used in the brine migration test had been removed for testing, and the fourth was proving difficult to remove. The primary benefit of such a tour for the nontechnical person would be the general experience of being in a salt mine with its cavernous rooms and solid rock walls and ceilings. This atmosphere, combined with the specific nature and purpose of the R&D for high-level waste disposal in salt and the obviously knowledgeable staff, would contribute to the confidence that such an undertaking was feasible in theory and practice. (Again, see Appendices C and E for more details.)

In summary, a tour of these FRG sites for a group of Texas officials and/or citizens would be both feasible and desirable. The major benefit for the visitors would be a first-hand understanding of a country managing a credible and systematic program that actually has field tests and site characterization studies underway, using many of the same techniques (i.e., shaft freezing) that will be necessary in the SRP.

## KARLSRUHE NUCLEAR RESEARCH CENTER

(October 6, 1986)

On October 6, K. Wu and D. Cattran visited the Kernforschungszentrum Karlsruhe GmbH (KfK, Karlsruhe Nuclear Research Center) located near Karlsruhe in southern Germany. Dr. Klaus D. Closs, who visited SRPO/ONWI in September 1986, was the host and arranged for tours of the PUREX reprocessing pilot plant and the POLLUX cask welding laboratory, as well as further discussion on possible SRPO participation in the demonstration tests for spent fuel disposal.

### Spent Fuel Disposal

The R&D program on direct disposal of spent fuel is coordinated by KfK and funded by BMFT. Since the disposal concept involves emplacing large, heavy spent fuel packages, the licensing authorities have determined that the feasibility of direct disposal must be demonstrated before a license can be granted. Therefore, the main thrust of the program is to demonstrate the safe and reliable handling of large, heavy canisters in a repository on a one-to-one scale. Emphasis is also placed on investigating special thermal and rock mechanics aspects of the tunnel emplacement concept, as well as laying out a repository suitable for both reprocessed waste and spent fuel. One of the programs which Dr. Closs coordinates involves the R&D necessary for these demonstrations in three areas--shaft transport, underground handling and emplacement, and thermal and mechanical behavior of the back-filled tunnel. The third area is of most interest to the SRP and involves emplacing electrically heated canisters in the Asse Mine in two parallel drifts. The canisters will be surrounded by crushed salt and measuring instruments will be installed in the salt and surrounding strata to record and evaluate relevant parameters throughout the several-year test. Dr. Closs indicated that he will have further details on the test plan by the end of the year and will send them to SRPO for evaluation and possible cooperation. (See Appendix F, "Overview of the FRG Activities on Spent Fuel Disposal" for a more detailed description.)

### Reprocessing Plant

The reprocessing plant at Karlsruhe began operation in 1971. Since it was financed by the government, the plant is owned by KfK but operated by WAK, a 100 percent daughter company of the Deutsche Gesellschaft fuer Wiederaufarbeitung von Kernbrennstoffen mbH (DWK, the German Fuel Reprocessing Company). It is a small pilot plant which reprocesses approximately thirty tons of spent fuel per year, mainly from light water reactors. The PUREX technique for reprocessing involves bringing a fuel element from a pool in the processing plant to the hot cell by remote control, cutting off the head and foot portion, removing the fuel rods, and cutting them into pieces five centimeters long. These pieces are dissolved in nitric acid, and the leftover hulls and head/foot portion are put in drums which are filled with concrete. These drums are usually considered medium-activity waste. The final products

of this process are uranyl nitrate solution and plutonium nitrate solution which are eventually used for fuel element fabrication.

Although the FRG is developing techniques for direct disposal of spent fuel as an alternative, its philosophy for high-level commercial waste is that it should be reprocessed. Accordingly, the DWK is constructing a full-scale commercial plant designed to reprocess 350 tons per year. This facility near Wackersdorf in Bavaria is planned for startup in 1995. Meanwhile, FRG has reprocessing contracts with France and the United Kingdom.

Corrosion Studies, Institute for Materials Research

A brief visit was also arranged with Dr. Leistikow of the Institute for Materials Research (part of KfK), who was conducting electromechanical experiments to test and rank various alloys under consideration for canister materials. This involved using electrochemical methods to characterize their corrosion behavior in chloride-containing solutions at various temperatures and pH-values. Results had shown Hastelloy C4 to have the highest corrosion resistance of all tested alloys. (Details of this testing program are found in Appendix G, "Selection of Canister Materials: Electrochemical Corrosion Tests of Hastelloy C4 and other NI-CR-MO Alloys in Chloride Solutions.")

POLLUX Cask System and Welding

The last facility visited on October 6 was the Pfaudler Company near Karlsruhe to see the POLLUX cask system and a narrow-gap welding technique for sealing the outer lid. This system was designed by Dr. Franz Popp of DWK, and can be used for all kinds of fuel elements. The very flexible system allows for transport, long-term interim storage, and disposal, with the option of reopening the cask if reprocessing is later deemed desirable. The containment system uses a multiple barrier concept made up of the consolidated fuel assemblies, a "lost" disposal cask with a bolted primary lid and a welded secondary lid, an anticorrosive coating, and a shielding overpack and lid. (See Appendix F, "Overview of the FRG Activities on Spent Fuel Disposal" for diagrams and details.) Part of the laboratory program to qualify this concept was use of a special welding technique to coat the disposal cask with a Hastelloy surface and a narrow-gap welding technique to seal the outer lid.

## JUELICH NUCLEAR RESEARCH CENTER
(October 8, 1986)

The Kernforschungsanlage Juelich GmbH (KFA, Juelich Nuclear Research Center) is one of twelve major research facilities in the FRG, and was founded by the state of North Rhine-Westphalia in 1956 as a joint nuclear research center for the state's universities and colleges. The scientific work has centered on the development and testing of the high-temperature reactor (HTR) used for simultaneous production of electrical power and low-temperature heat, as well as the production of high temperatures for process applications such as coal gasification. Since 1972, ninety percent of the operating cost has been borne by the federal government and 10 percent by the state. According to Dr. Reinhart Odoj, our host, the great percentage of research was formerly on the nuclear fuel cycle, but now the emphasis is changing to toxic chemicals and the associated environmental effects (i.e., acid rain). He commented that the Chernobyl incident has changed the political scene which in turn has affected the FRG research objectives.

The focus of the visit was discussions on the medium activity waste (MAW) and HTR fuel element borehole disposal tests, the waste container quality assurance work, and the waste vitrification pilot plant process. We also had the opportunity to meet the Director of the Institute of Chemical Technology, Dr. Erich Merz, in whose area most of the nuclear work is centered.

### MAW AND HTR Fuel Element Borehole Disposal Tests

Dr. P. Brucher and his colleagues, Dr. E. Barnert, and Dr. D. Niephaus, described the FRG plans for testing for disposal of MAW and HTR fuel elements. The purpose of these tests is to develop techniques for final disposal of dissolver sludge, cladding hulls/structural components, and spent reactor fuel, and then to test the technique in the Asse Mine. The work is divided into two subprojects: (1) disposal/sealing technique test and (2) retrievable disposal test.

In the disposal/sealing test, they plan to develop prototype components for MAW disposal in boreholes and techniques for borehole sealing in a repository. The long-term plans for MAW disposal are to emplace it in 300-meter deep boreholes at approximately the 800-meter level. The test boreholes, however, will be between 10 and 30 meters deep and will be back-filled with crushed salt and sealed with salt and concrete. These test boreholes, currently being drilled at the Asse Mine, were seen during the Asse tour the previous week. The FRG had also developed a new technique and equipment for drilling deep holes in salt without using fluids. This test, headed by Dr. Barnert, is in the early planning stages, and he was extremely interested in making some contacts with SRP regarding borehole sealing and definition of boundary conditions. Dr. Wu gave him several report references and the names of K. Robinette of SRPO and R. Schornhorst and H. Kalia of ONWI. Dr. Wu indicated SRPO would be interested in reviewing the test plans as they were developed.

In the retrievable disposal test, the gas release from the MAW packages will be determined in a hot-cell experiment, and the safe underground handling of MAW and spent HTR fuel elements will be demonstrated by a retrievable test disposal with real waste packages in the Asse Mine.

The hot cell experiment is already underway at KFA and was observed later in the day. The waste packages, to be checked for at least one year, are six 200-liter drums put separately into gas-tight overpacks and checked for release of radioactive and nonradioactive gases. The overpacks are electrically heated to simulate the temperature in a borehole. After hot cell testing, the waste packages will be emplaced for up to five years in the Asse salt mine. This project, headed by Dr. Niephaus, is set and already underway, and Dr. Wu indicated that SRPO would like to receive reports and updates.

(For further details on both these tests, see Appendix H, "R&D Work on Geologic Disposal of Dissolver Sludges, Claddings, and Spent HTR Fuel Elements in the Federal Republic of Germany".)

Waste Canister Quality Control

Dr. Odoj provided an overview of the product control program for inspection and acceptance of waste disposed in a final repository. This inspection would ensure that waste received at an interim or permanent facility would meet requirements for disposal. He also described mobile and permanent stations being developed to test waste drums (LAW and MAW) for gas release or damage. We later saw a prototype of this equipment, the low-activity waste storage facility (storing 55-gallon drums), and a CASTOR cask containing four pressurized water reactor fuel elements undergoing gas release analysis.

FIPS Vitrification Process

The last tour for the day was to view the Fission Product Solidification (FIPS) vitrification process plant. This is a small-scale pilot process which has made approximately four cubic meters of liquid waste into glass per year. According to Dr. Odoj, this is the only FRG location where vitrification is currently done.

## NUCLEAR ENERGY RESEARCH CENTER AT MOL, BELGIUM

(October 9, 1986)

The last facility visit was to the Centre d'Etude de l'Energie Nucleaire/Studiecentrum voor Kernenergie (CEN/SCK, Nuclear Energy Research Center) at Mol, Belgium, to tour the Underground Research Laboratory in a clay formation and to evaluate whether the work is of interest to OCRWM. This portion of the trip included J. Strahl of Weston, R. Schassberger of CPO, and R. Robinson and M. Deyling of OWTD.

The Mol facility is an R&D laboratory to test the feasibility of the Boom clay formation to serve as a media for high-level waste disposal. The Belgians expect that the site, upon submission of a license application, could be recategorized as a repository within five years, and that the facility will be sufficiently complete to accept waste by the year 2020. SRPO indicated that work being performed at the Mol facility would not significantly benefit the SRP work; CPO concluded that the information may be of benefit to the reformatted Waste Technology Development work. (More details of this trip are provided in the report of J. Strahl to J. Fiore of OGR, attached as Appendix I.)

# APPENDIX A

# ITINERARY

FINAL REVISION

# ITINERARY (REVISED)

| DATE | DAY | LOCATION | CONTACT | SUBJECT OF DISCUSSION |
|---|---|---|---|---|
| September 26 | Friday | Flight to Frankfurt, Germany | | Travel |
| September 27 | Saturday | Frankfurt to Hanover | | Travel |
| September 28 | Sunday | Hanover to Braunschweig | | Rest |
| September 29 | Monday | Braunschweig (GSF/Ift*) | Klaus Kuhn | Pre-bilateral meeting to prepare for bilateral |
| September 30 | Tuesday | Braunschweig | | Finish pre-bilateral meeting |
| October 1 | Wednesday | Braunschweig | Tilman Rothfuchs | Asse Mine in a.m. |
| | | Gorleben repository site | Gernot Grubler | Tour Gorleben site and shaft freezing facilities in p.m. |
| October 2 | Thursday | Gorleben area | Rolf Randl | Bilateral meeting |
| October 3 | Friday | Gorleben area<br>To Hanover | | Finish bilateral meeting<br>Travel |
| October 4 | Saturday | To Karlsruhe | | Travel |
| October 5 | Sunday | Karlsruhe | | Rest |
| October 6 | Monday | Karlsruhe (Karlsruhe Nuclear Research Center) | K. Closs | Information exchange and visit facility |
| October 7 | Tuesday | To Juelich | | Travel |
| October 8 | Wednesday | Juelich Nuclear Research Center (a.m.)<br>To Brussels, Belgium (p.m.) | Erich Merz | Information exchange and visit facility<br>Travel |
| October 9 | Thursday | To Mol, Belgium | | Visit underground research laboratory |
| October 10 | Friday | To individual schedules | | |
| October 11 | Saturday | (Wu to London)<br>(Cattran to remain in Brussels) | | Travel |
| October 12 | Sunday | Flight to Columbus | | Travel |

*GSF/Ift - Institute for Underground Storage, Company for Radiation and Environmmental Research

SG2/DC-03 9/8/86
Revised 9/25/86

# APPENDIX B

# KEY CONTACTS

## KEY CONTACTS*

GSF/IfT (Company for Radiation and Environmental Research, Institute for Underground Storage)

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# APPENDIX C

## U.S. DOE/FRG BILATERAL PLANNING MEETING
## ASSE MINE VISIT, GORLEBEN BRIEFING/SITE VISIT,
## KARLSRUHE AND JUELICH NUCLEAR RESEARCH CENTERS

J. STRAHL

Please note that the attachments referenced in Appendix C have not been included in this report for the sake of brevity. Anyone wishing to see any of the attachments should contact Diane Cattran at FTS 976-4303, ONWI, or Jim Strahl at (202)646-6654, Weston.

## ENCLOSURE 1

## USDOE/FRG BILATERAL PLANNING MEETING: (September 29-30, 1986)

On September 29-30, 1986, a delegation representing the USDOE/OCRWM geologic disposal program, led by the Salt Repository Project Office (SRPO) technical coordinator, K.K. (Roger) Wu, met with the FRG geologic disposal delegation under the direction of K. Kuhn, technical coordinator from the Gesellschaft fuer Strahlen - und Umweltforschung mbH Muenchen, Institut fuer Tieflagerung (GSF/IfT), to discuss progress under the existing agreement signed in August, 1984 in Park City, Utah, and to further define, discuss and reach an agreement on continued cooperative activities over the next two years. Attendees of the Bilateral Agreement Planning Meeting are defined in Attachment E1-1. D. Cattran represented the Office of Nuclear Waste Isolation (ONWI), support contractor to SRPO, while the prime role of J. Strahl, Weston, was to review the proposed activities to ensure consistency with other OGR international activities and with the overall repository program. K. Kuhn further distributed an IfT organization chart to identify the organizational position of each FRG participant. This chart is presented in Attachment E1-2. The agenda prepared by the FRG and utilized for the Planning Meeting is presented in Attachment E1-3.

### Summary of Past Accomplishments

K. Kuhn opened the meeting by indicating that the work over the past two years has generally been productive and useful, including the planned workshops, technical studies, cooperative visits, and information exchanges. Action has been taken by the FRG to enhance the flow of documents to the DOE geologic repository program. M. Wallner generally

discussed the past Federal Institute for Geosciences and Natural Resources (BGR) work with the DOE, indicating that their activities have been mostly in cooperation with the USDOE Waste Isolation Pilot Project (WIPP) personnel and associated contractors. BGR is interested in cooperating with SRPO in the future.

K. Wu indicated that cooperative work over the past two years has been productive, including the following workshops:

1) Waste Package Materials Corrosion Workshop held in Karlsruhe on May 8-10, 1985.

2) Rock Mechanics Workshop held in San Francisco on February 26-28, 1986.

3) Sealing and Backfilling of a Salt Repository Workshop held in Albuquerque on September 23-25, 1986 (DP was involved in this workshop).

L. Tyler of the Sandia National Laboratory (SNL) stated that the WIPP personnel and associated contractors are interested in cooperating with the FRG in work focusing on salt consolidation, experience in the construction of seals and dams, and in-situ testing. A more extensive list of WIPP suggested topics is provided in Attachment E1-4.

Asse Brine Migration Test

T. Rothfuchs (GSF) subsequently provided an overview of the joint DOE/FRG Brine Migration Test at the Asse Mine. A summary project report dealing

with this test is provided in Attachment E1-5. He discussed the joint activities that occurred from October 1979 through November 1985, including the Asse licensing procedure schedule work performed with Westinghouse, the issues of the test, the test objectives, the radioactive source (CO-60) test configuration, instrumentation utilized, heater test chronology from May 25, 1983 through November 28, 1985, the mine-by work to obtain apparently affected salt in the vicinity of the test canisters, projected post-test activities, and conclusions of the test. Most of the information identified above is provided in Attachment E1-5. GSF explained that the validity of the initial test data is questionable, since salt dust collected in the vicinity of the instrumentation. However, there has been a noticeable darkening of the canister material (stainless steel with an Inconel clad) with radiation exposures in excess of 10E8 Rads (10E4 Rads/Hr). Laboratory testing will be performed over the next two years to define materials effects.

The USDOE proposal to extend the Project Agreement, identified in Attachment E1-6, was subsequently discussed by GSF and the DOE. T. Rothfuchs indicated that all brine migration testing will have been completed by Spring, 1987, and that an in-situ data report will be issued by the Summer of 1987. It was agreed that GSF (T. Rothfuchs) and SRPO (K. Wu) will meet in Columbus, Ohio in the Spring of 1987 to discuss the test results.

The GSF noted that the FRG funding for all brine migration testing, except the radiation effects laboratory testing, will expire at the end of 1986. (The GSF is willing to fund the radiation effects testing, since it is considered a normal transition to their next set of tests utilizing

simulated HLW). GSF will provide the post test plan to the SRPO. In addition, the post test activities will be published separately.

Salt Radiation Effects Investigations

The GSF noted a perceived problem with the current capability of the DOE to test irradiated samples in the forthcoming months. It was planned by the FRG to send samples to the Brookhaven National Laboratory (BNL). However, as a result of the communication by BNL indicating that the DOE would be required to approve the draft GSF/BNL plan, the GSF assumed that funding for the testing had not been obtained (See Attachment E1-7). SRPO assured GSF that BNL is funded to perform the tests, and described a letter from ONWI which defines their request for samples. As requested by SRPO, the GSF should forward the samples to the Office of Nuclear Waste Isolation in Columbus, Ohio (ONWI). The samples will subsequently be distributed for rock mechanics, geomechanics and radiation effects testing. SRPO will provide a test plan to GSF for review.

SRPO indicated that BNL is contracted to perform salt radiation effects testing through February, 1987. As a result of mutual interest, it was agreed to establish a plan to perform tests on irradiated salt samples comprised of Brine Migration Test samples, Asse samples and Gorleben samples in the frame of the existing Project Agreement. BNL will be requested to establish a proposal defining both cost and schedule to investigate the samples. The investigations will consider both the US and FRG repository conditions. It was further agreed that the Asse samples will be tested first.

The SRPO and GSF further discussed the proposal of including the Netherlands as a participant in the investigations. Since the DOE does not currently have a bilateral agreement with the Netherlands, it was recommended that the initial work proceed with only the FRG and DOE.

## Future Joint Testing Programs

T. Rothfuchs generally described the FRG plans to utilize the Asse Mine for high level radiation testing on salt. Using the PNL prepared simulated HLW glass logs, it is planned to irradiate the salt up to 10E11 Rads with a source radiation dose rate of 5x10E5 Rads/Hr. The Netherlands is contributing to the HLW test (canister guide system and data acquisition system). These investigations were to have been performed between 1982 and 1994, but the schedule has slipped.

H. Brucher of the Juelich Nuclear Research Center (KFA) described the FRG test plans in support of the disposal of Intermediate Activity Waste (MAW) and High Temperature Reactor fuel elements in boreholes at the Asse Mine. Attachment E1-8 provides detail on the technical plans. Summarizing, it is intended to dispose the wastes in 300 meter deep boreholes located >800 meters below grade level. The test boreholes will be 10 meters deep. The boreholes will be backfilled with crushed salt and sealed with a salt concrete. Each drum will maintain a heat output of approximately 100 watts. Tests will be performed to evaluate the integrity of the seal to radiolytic gas. Cladding hulls will be placed in 200 liter drums and fixed in cement. The heat output of each drum is expected to be 4.6 watts. The FRG also has a new technique and equipment for drilling deep holes in salt without the use of fluids.

Both the SRPO and WIPP (SNL) expressed interest in obtaining the results of both types of tests. (The SRPO has chosen, through previous discussions, not to participate in the HLW tests).

K. Closs of the Karlsruhe Nuclear Research Center (KfK) was to present the FRG plans associated with simulated spent fuel package emplacement and room backfill tests. However, SRPO and the KfK discussed the subject the evening prior to the DOE/FRG Bilateral Agreement Meeting (evening of October 1, 1986). The proposed test simulates the emplacement of spent fuel packages in tunnels. As explained by the KfK, the test will utilize simulated fuel assemblies and associated fuel handling equipment to emplace the fuel at depth in the Asse Mine. The tunnel into which the fuel is to be placed will be subsequently backfilled with crushed salt. SRPO expressed concern of participating in tests utilizing actual spent fuel, and was subsequently assured that the FRG intends to mock-up a fuel container to physically represent a fuel assembly (i.e., emplacement tests will not utilize actual spent fuel).

As a result of the discussions, the SRPO indicated that it expects to participate in the test plan design and development of the simulated spent fuel package emplacement and room backfill test at the Asse Mine. It is anticipated that a new project agreement or addendum covering these activities will be required.

H. Fischer of the German Company for Construction and Operation of Waste Disposal Facilities (DBE) presented the FRG plans associated with dam tests to be performed in the Asse Mine. In addition, W. Hansel of the GSF described the Pilot Dam Construction Program. The tests are to be performed in support of the licensing requirements of the Gorleben facility. Attachment E1-9 describes the FRG plans. Phase 1, which includes all conceptual design activities, is expected to be completed in 1986. Phase 2, which includes planning and construction of the test, is expected to be performed between July, 1986 and June, 1989. Phase 3, including development of test procedures and subsequent test evaluation, is expected to take place between June, 1989 and June 1992. BGR is responsible for the design of and subsequent test performance, and GSF is responsible for the scientific investigations. The tests will include the injection of water into the seal area during the operational phase.

Room sealing technology and testing is of interest to the SRPO. Even if seal designs differ substantially between the FRG and SRPO programs, the logistics and technology are of interest. As a result of the discussions, SRPO intends to participate in the test plan design and development of the dam tests to be performed at Asse. As in the case of the simulated spent fuel test, it is anticipated that a new project agreement or addendum will be required.

L. Tyler (SNL) described the work being performed at WIPP associated with backfill and sealing. WIPP is using crushed salt as a backfill material. The sealing material is composed of a 70/30 mixture of salt/bentonite. WIPP intends to use a multiple seal approach, including cementatious material, salt block, and bentonite. It is anticipated that full scale

tests will be initiated in 1988. SNL expressed interest in formulating a cooperative effort with the FRG. SRPO indicated interest in obtaining information from the FRG on their seal test program, including sufficient information in the form of reports to assist in the formulation of a position on participation in a cooperative effort with the FRG. The FRG indicated that a copy of the preliminary plan for the seal test program will be forwarded to SRPO in approximately four weeks.

## Site Characterization Programs

Short summaries of the SRPO and WIPP site characterization programs were presented by K. Wu and L. Tyler. The FRG indicated that a review of the Gorleben site characterization program would be given at the site on October 1.

## Flooded Hope Salt Mine-GSF Review

H. Herbert (GSF) briefly described the flooded mine experiment being performed at the Hope Salt Mine north of Hannover. The experiment, sponsored by the Federal Ministry for Science and Technology (BMFT), is expected to be completed in 1987. The program consists of four subprograms: the geochemical survey, the geomechanical survey, the geophysical survey, and the bulkhead development and installation activities. One of the most important aspects of the program is to test instruments (since several of the initial instruments failed, new instruments were required to complete the program).

Cooperative Laboratory Programs

K. Wu described past efforts of the SRPO with the FRG in the area of geomechanics, describing the formulation of plans for an intact salt creep program by M. Langer (BGR) and G. McNulty (ONWI) over the last six months. Per the discussions, it was concluded that two workshops should be recommended: one covering intact salt creep, and one covering salt consolidation. The intact salt creep work would include parallel verification and validation of codes for experiments. The work would be initiated utilizing information from the Asse Mine, and subsequently with the DOE Exploratory Shaft when it becomes available. The salt consolidation work would include parallel calculations of the FRG salt consolidation model along with parallel verification and validation of the codes ANSALT and SPECTRUM for field experiments in the Asse Mine and future DOE Exploratory Shaft. M. Wallner (BGR) prefers to initiate validation immediately and to fit the experimental data to that predicted by models. SRPO does not agree with this approach, indicating that long term creep is very important and therefore a general model is required first. K. Wu indicated that the previous work performed by RE/SPEC for WIPP is not representative of the type of models being prepared for the OCRWM geologic disposal program. SNL briefly described the geomechanical work being performed at WIPP. Attachment E1-10 provides additional detail of the presentation. Both SNL and BGR consider the past work very successful.

It was concluded that SRPO may participate in future activities associated with geomechanical model development, depending on the methodology recommended by the FRG to be utilized for programmatic implementation.

H. Herbert (GSF) briefly described the geochemical work (brine investigation program) being performed by IfT. Subsequently, SNL proposed that H. Herbert contact S. Lambert and K. Stein for further development of a cooperative effort. N. Jockwer (GSF) presented the geochemical and mineralogical investigation program on rock salt. SNL indicated that IfT should contact G. Nicks and M. Molecke for identification of the MITT test program results and applicability.

A cooperative program concerning the geochemical work will be developed by H. Herbert and N. Jockwer and forwarded to SNL and SRPO for review and comment.

Workshops

The FRG, SNL and SRPO discussed recent past workshop results and presented several proposals for workshops to be completed over the next two years. After much discussion, it was agreed that the following workshops should take place in 1987:

1) Geochemical Instrumentation and Measurement Techniques, to be held in the FRG. Contact persons are: H. Kalia (SRPO-leader), D. Munson (SNL), and T. Rothfuchs (IfT).

2) Repository Nearfield Geochemical Behavior, to be held in the U.S. Contact Persons are: J. Kircher (SRPO-leader), J. Nowak (WIPP), and N. Jockwer (IfT).

3) A bilateral workshop was proposed by H. Schneider (PTB) following the Seminar on Radionuclide Migration, sponsored by the University of Munchen, to be held in Munich on September 14-18, 1987.

Potential workshops for the year 1988 are:

1) Performance Assessment. Contact persons are: R. Strock (IfT) and R. Anderson (SNL). The SRPO contact person will be identified.

2) Salt Constitutive Models and Their Predictive Capabilities, to be held in the FRG in May, 1988. Contact persons are: M. Wallner (BGR-leader) and D. Munson (SNL). The SRPO contact person will be identified.

3) Waste Packaging. Contact persons are: K. Closs (KfK) and M. Molecke (SNL). The SRPO contact person will be identified.

4) Waste Acceptance Criteria. H. Schneider (PTB) offered this workshop based on experiences obtained from the acceptance criteria developed for the Konrad Mine. Contact persons are : H. Schneider (PTB) and J. Jackson (WIPP). The SRPO contact person will be identified.

## International Symposia/Meetings

Several international meetings were identified by the GSF for general information. These include, but are not limited to, the following:

1) Waste Management Meeting, Tucson, Arizona, March 1-5, 1987.

2) Zechstein Symposium on Salt Geology, Hannover, FRG, April 28-30, 1987.

3) IAEA International Symposium on the Back End of the Fuel Cycle, Vienna, Austria, May 11-15, 1987.

4) ISRM Symposium, Montreal, Canada, September, 1987.

## Personnel Exchange

Following a brief discussion on the past activities associated with personnel exchange between the DOE and FRG, the following agreements regarding future exchanges were recorded:

1) In January 1987, H. Herbert (GSF) will be placed on assignment to the U.S. for one year. He will work at the University of Arizona and the University of California at Riverside.

2) SRPO will send a U.S. representative to the FRG GSF/IFT office in Braunschweig for a minimum of one year.

3) Medium and short term visits are to be continued. The FRG will develop a procedure to ensure the U.S. visits are defined well in advance to enhance accomodations.

4) The public information exchange program agreement was discussed at the Bilateral Meeting on October 2. To maintain consistency of the proposed agenda, the summary statement is provided below: "There is an area of mutual benefit in the exchange of public information materials and outreach programs."

BGR VISIT AND TOUR: (September 30, 1986)

In the afternoon, after conclusion of the technical coordinators meeting. J. Strahl, K. Wu and D. Cattran toured various facilities at the Federal Institute for Geoscience and Natural Resources (BGR).

USDOE/FRG BILATERAL AGREEMENT MEETING: (October 2-3, 1986)

On October 2-3, 1986, a delegation representing the USDOE, led by the principal coordinator, C. R. Cooley, met with the FRG delegation under the direction of R. P. Randl, Principal Coordinator from the Federal Ministry for Science and Technology (BMFT), to discuss progress under the existing agreement signed in August, 1984, in Park City, Utah, and to further define, discuss and reach an agreement on continued cooperative activities over the next two years. Attendees of the Bilateral Agreement Meeting are identified in Attachment E1-11.

Summary of Past Accomplishments

R. P. Randl opened the meeting by generally discussing the current status of the FRG nuclear energy program. He mentioned that the nuclear opposition within the FRG is not negligible. The Socialist Democratic Party is opposed to nuclear power, as are several other groups such as the "Greens". The BMFT does not expect much to happen in the promotion of reprocessing prior to the upcoming elections in Bavaria. The Konrad Mine licensing application (for deposition of low heat generating alpha waste) is progressing smoothly, although it is approximately one month behind schedule. The rest of the industry is operating as expected.

An announcement of the DOE/FRG Bilateral Agreement Meeting was distributed to the meeting attendees (See Attachment E1-12). In addition, a summary of activities defining cooperative work over the past two years was distributed to the attendees (See Attachment E1-13).

C. R. Cooley subsequently summarized the current status of the DOE waste management programs, focusing on the OCRWM program. He mentioned the current location of the salt site recommended for characterization, current status of the second repository program, and issues associated with transportation, the MRS, dry cask storage activities and liability.

L. Tyler (SNL) discussed the status of WIPP mentioning that, although the NRC regulations utilized for the civilian program do not apply to the defense program, the EPA standards are enforced by WIPP. J. White (DOE/RL) summarized the current status of the DWPF, indicating that it should be in service at the SRL and RL in 1990. T. McIntosh (DOE/DP) presented the

current status and schedule of the West Valley activities. K. Wu (SRPO) briefly presented the current status of the SCP, the QA plans, and the ONWI contract, which expires in September, 1987. SRPO expects to utilize two contractors to promulgate the salt program. The deadline for the proposals for the contracts is October 3, 1986.

K. Kuhn (GSF) summarized the activities and agreements formulated by the geologic disposal group on September 29-30, 1986 (See the Bilateral Planning Meeting Summary presented above). K. Closs (KfK) discussed the FRG program on spent fuel research which is expected to be performed between 1986 and 1993. The program is comprised of three tasks: Task 1- to identify the requirements for the transport of heavy loads through the shaft; Task 2- to define the horizon engineering requirements (high temperatures), including simulation tests at Asse (see the above September 29-30 summary); and Task 3- to perform the experiments at Asse. Summaries of the agreements under the remaining technical areas of the Bilateral Agreement, including low-level waste, TRU waste, decontamination and decommissioning waste, WIPP/FRG activities, and spent fuel storage activities are presented in Attachments E1-14 through E1-18, respectively. A copy of the Bilateral Agreement for the period 1986-1988 resulting from the October 2-3 meetings is presented in Attachment E1-19. This document contains a brief summary of the geologic disposal agreement. The formal agreement between the SRPO and the GSF/IfT as a result of the September 29-30 meeting is presented in Attachment E1-20.

ASSE MINE VISIT: (October 1, 1986)

On October 1, 1986, several of the personnel* in the DOE delegation visited the Asse Salt Mine to obtain 1) a better understanding of the type of activities and associated configurations utilized by the FRG to evaluate salt as a media for geologic disposal of radioactive waste, and 2) an update on the plans to utilize the mine for future experiments. The GSF presented a brief overview of the activities performed at the mine, stating that it was purchased in 1964 for 700K DM. Other historical information is presented in Attachment E1-21. GSF indicated that the firm of Pheonix and Sisson was contracted in the 1970's to construct the second deep shaft to meet FRG mine safety laws. The GSF is currently extending the original shaft to the depth of approximately 950 meters (original depth is approximately 800 meters) for the initiation of new tests associated with the disposal of pelletized low-level waste (see test description below). It is expected that the work will be completed in March, 1987. All experiments to date have been performed at the 800 meter level, including the Brine Migration Experiments, the source container experiments, and the in-situ creep experiments. The scheduled HLW experiments will also be performed at this depth.

The GSF is developing a new method for the treatment and packaging of low- and intermediate-level waste. It is planned to mix the waste (previously solidified with cement and placed into dry storage at the facility surface

*Geologic Disposal and Headquarters personnel includes: R. Wu (SRPO), D. Cattran (ONWI), J. Strahl (Weston), C. Cooley (OPO), T. McIntosh (DP)

in the form of 0.5 mm beads) with cement to form small pellets, and subsequently to inject the pellets down a borehole to a cavity being excavated in the salt (adjacent to the shaft being excavated to 950 m).

The actual tour of the mine required approximately two hours. The GSF exhibited all tests associated with the salt related geologic disposal program (i.e. the Brine Migration Test), the in-situ creep experiment, previous work performed with low-level waste, a demonstration of the excavating machines being utilized to expand the mine, and the position configuration of the HLW tests expected to be performed in support of the FRG program. Several members of the touring party obtained photographs of the more salient features of the mine and related tests.

GORLEBEN BRIEFING/SITE VISIT (October 3, 1986)

On October 3, 1986, the DOE representatives visited the Gorleben proposed repository site for an update on the current status of the activities being performed at the site. The German Company for Construction and Operation of Waste Disposal Facilities (DBE) provided an overview of the current activities. The current strategy of the FRG is to construct and utilize this facility for HLW disposal, since it has concluded that the best site would never be chosen with the selection of more than one site for characterization. The current siting activities, which satisfy the FRG mining laws, do not address nuclear material disposal requirements. The position established for implementation of the current site work -

especially the excavation, construction and exploration activities associated with the shafts - is based on the fact that the facility is currently being utilized for mining technology development purposes.

In addition, it is the BMFT position that the facility will not need to address nuclear issues prior to license application in 1992. A lawsuit has been submitted, which, if accepted by the courts, will require the DBE to stop work pending modification to consider issues regarding the disposal of nuclear waste. If enforced, the current site activities would stop. It is expected that, with the current schedule, the Gorleben facility will cost approximately 1 billion DM (approximately $500,000,000 U.S. 1986 dollars).

The site activities being currently performed are considered as part of Phase 2, or site investigation. This phase was initiated in June, 1983, with work associated with shaft excavation. To excavate the shafts first required ground freezing through the fracture zone to approximately 280 meters below the surface. Subsequent to the completion of freezing operations. Shaft 1 excavation was initiated on September 18, 1986. As of October 3, 1986, the shaft had been excavated to approximately 70 meters. It is expected that all shaft work to horizon, including Shaft 2, will be completed in 1989 and that at-horizon activities will be completed by 1992, at which time the license application will be submitted. With this schedule it is currently anticipated that waste will not be emplaced prior to the year 2000. Additional information associated with the activities being performed and planned for the Gorleben site is presented in Attachment E1-22.

Subsequent to the briefing, a tour of the facility was completed, including observation of Shaft 1 excavation, Shaft 2 freezing operations, freezing equipment facility, and the shaft elevator system. Several of the DOE representatives obtained photographs of the facilities and operations.

GORLEBEN SPENT FUEL/LLW STORAGE FACILITIES: (October 3, 1986)

A tour of the German Fuel Reprocessing Companies (DWK) Gorleben Spent Fuel/Low Level Waste Storage Facility was completed by K. Wu (SRPO), C. Cooley (OPO), D. Cattran (ONWI), and J. Strahl (Weston) on October 3, 1986.

KARLSRUHE AND JUELICH NUCLEAR RESEARCH CENTERS: (October 6 and 8, 1986)

Visits and tours of the Karlsruhe Nuclear Research Center (KfK) and Juelich Nuclear Research Center (KFA) were made by K. Wu of SRPO and D. Cattran (ONWI) a separate trip report covering these activities is being submitted through SRPO.

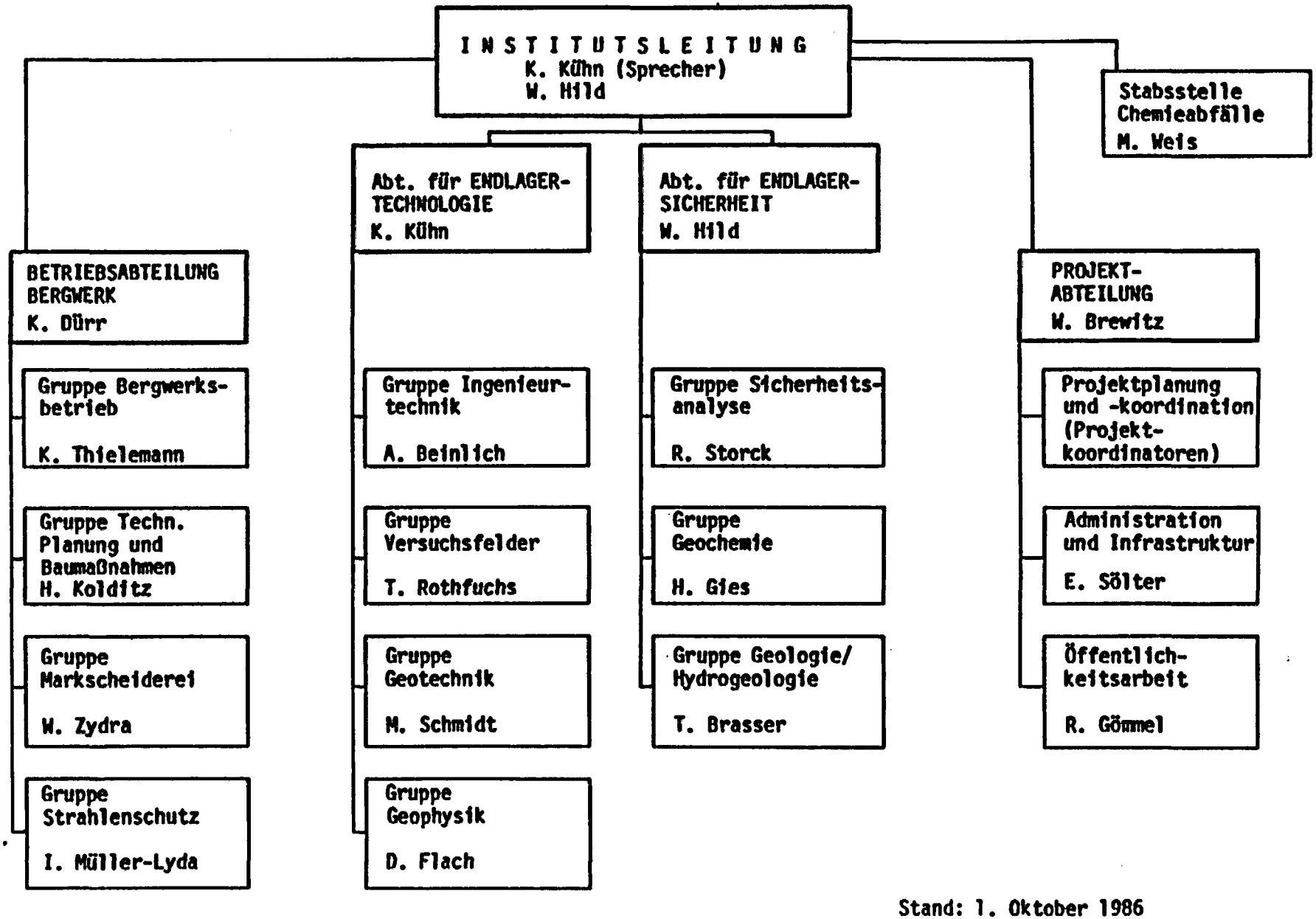
Attachment E1-1

US-GERMAN BILATERAL MEETING, BRAUNSCHWEIG

September 25, 1986

| Name | Institution |
|---|---|
| K. Kuhn | GSF |
| T. Rothfuchs | GSF |
| H. Brucher | KFA |
| M. Weg | DBE |
| H. Fischer | DBE |
| W. Hansel | GSF |
| K. Durr | GSF |
| M. Wallner | BGR |
| P. Brennecke | PTB |
| H. Herbert | GSF |
| N. Jockwer | GSF |
| D. Cattran | UNWI |
| J. Strahl | WESTON |
| L. Tyler | SNL |
| K. Wu | SRPO |

# INSTITUT FÜR TIEFLAGERUNG




Stand: 1. Oktober 1986

Attachment E1-2

# APPENDIX D

Minutes of Overall U.S. DOE/FRG BMFT Technical Exchange and Cooperative Agreement, October 2-3, 1986.

Minutes of U.S./FRG Bilateral Technical Meeting -- Disposal of Radioactive Wastes, September 29-30. 1986

RECORD OF THE US/DOE-FRG/BMFT WASTE MANAGEMENT COOPERATIVE

PROGRAM PLANNING AND REVIEW MEETING AT GORLEBEN, FRG

October 2 - 3, 1986

In conformance with the terms of the Technical Exchange and Cooperative Agreement between the United States Department of Energy (US DOE) and the Federal Republic of Germany Bundesministerium fuer Forschung und Technologie (FRG BMFT) in the field of management of radioactive wastes, representatives of the US DOE and FRG BMFT met at Gorleben, FRG on October 2 - 3, 1986 for the purpose of:

1) reviewing US and FRG activities in the area of radioactive waste management, including geologic disposal, spent fuel storage, transportation and decontamination and decommissioning;

2) reviewing US DOE and FRG BMFT technology exchange activities taking place since the previous planning meeting in the fall of 1984; and

3) reviewing and approving plans for continued cooperation under the bilateral agreement for the next two years. The meeting was co-chaired by the Principal Coordinators, Dr. R. P. Randl, FRG BMFT, and Mr. C. R. Cooley, US DOE.

Plans for future cooperation were developed for each of the topical areas prior to this planning meeting by the Technical Coordinators for presentation at the meeting. Plans for exchanges on spent fuel storage and transportation were developed at the US/FRG information exchange meeting held in Seattle, Washington on April 11, 1986. Plans for exchanges on high-level, low-level and alpha waste management and decontamination and decommissioning were developed at meetings held in association with the International Topical Meeting on Low-, Intermediate-, and High-Level Waste Management and Decontamination and Decommissioning held at Niagara Falls, NY on September 9 - 14, 1986. Plans for future exchanges on low-level waste mangement were also developed by the Technical Coordinators through an exchange of letters. Plans for continued cooperation on geologic repository development were prepared at a two-day meeting in Braunschweig, FRG on September 29 - 30, 1986.

The proposed future activities were discussed and approved by the Principal Coordinators. Both parties agreed the technical exchanges have been proceeding well, have been equitable and have been highly beneficial to both parties. The next planning meeting was scheduled tentatively for the fall of 1987 in the U.S. subject to an assessment by the Principal Coordinators of the need for a meeting in one year.

The Principal Coordinators agreed that the appropriate mechanism for arranging future exchanges and visits is through informal contacts between the parties and formal notification of the visit through the Principal Coordinators at least 6 weeks prior to the visit. Improvements in the distribution of documents will be sought through an updated listing of individuals who should receive documents as part of the exchange. Further emphasis on exchanges involving public information and institutional and regulatory matters will be encouraged to keep each party informed.

The specific plans developed during the bilateral planning meeting are provided in the following paragraphs.

The Principal Coordinators will continue to rely on the Technical Coordinators and individual contacts to organize and carry out the plans agreed upon in this meeting.

GENERAL

Cooperative technology exchange activities will continue under the US DOE/FRG BMFT Technical Exchange and Cooperative Agreement in the Field of Management of Radioactive Wastes.

Principal Coordinators:

FRG: Rolf Randl (BMFT)

US: Carl Cooley (DOE Office of Civilian Radioactive Waste Management)

**

HIGH-LEVEL WASTE (HLW) TREATMENT

Technical Coordinators:

FRG: Karl-Dieter Kuhn (WAK)

US: Ted McIntosh (DOE/NE) - Civilian Wastes

Gerald Daly (DOE/DP) - Defense Wastes

The exchanges taking place since the last planning meeting have included reciprocal visits, document exchanges, workshops and extended assignments of technical staff to the other party's facilities. Ten visits were made by US teams to FRG facilities which included KfK, WAK, DWK, Lahde, Pamela, KFA and HMI; thirteen visits were made by FRG teams to US facilities which includes Savannah River, Idaho, Hanford, and West Valley. Workshops were conducted on the topics of HLW vitrification chemistry, design criteria for vitrification facilities, operating experiences with vitrification systems and waste acceptance criteria. Extended visits included the assignment of two FRG staff at West Valley for six week periods, of one US staff to HMI for seven months, and two US staff to the Pamela project for a three week period.

** Reciprocal visits will continue subject to the approval of the Principal Coordinators. Improvements in the control of the document exchanges will be sought by the Technical Coordinators through an updating of distribution lists.

The US DOE through Battelle (PNL) is currently producing glass logs for FRG BMFT experiments. Although this activity is behind schedule and over budget, the consensus of US DOE and FRG BMFT is that a way should be found to complete the production of the canisters as originally planned. US DOE and FRG BMFT agreed to pursue supplemental funding and advise each other by mid-October 1986. FRG BMFT agreed that the proposed delivery schedule of October 1987 was acceptable. US DOE will provide a request to FRG BMFT for $1.3 million to complete payment of the currently authorized funding.

FRG is currently fabricating special Castor-type casks for shipment of the glass logs from PNL to the Asse mine. A license for the shipping cask has been received from FRG authorities but a license from US authorities has not been obtained as yet. FRG needs shipment of the glass logs from Hanford to the Asse mine. US DOE will look into the status of approval of the special FRG casks by US authorities and attempt to expedite approval of the cask for shipment of the glass logs. US DOE will also look into the status of general acceptance by the US regulatory authorities of the FRG licensed cask for shipment of spent fuel. US DOE will try to identify problems in obtaining approval of the FRG cask and advise BMFT on means to resolve the problems.

The following workshops were tentatively planned:

June 1987 at Mol, Belgium - Operational Experiences

Fall 1987 at HMI in Berlin - Glass Characterization

Spring 1988 in the US - Future Developments in HLW Immobilization and Related Processes

It is also planned to arrange for the assignment of US staff members to Pamela during radioactive operation and to consider other long-term assignments for technology exchange.

ALPHA WASTE TREATMENT

Technical Coordinators:

FRG: Volker Schneider (Alkem)

US: Joe Coleman (DOE/NE) - Civilian Wastes

Mike McFadden (DOE/AL) - Defense Wastes

The technology exchange on alpha waste treatment has continued in an active manner since the last bilateral planning meeting including exchange of documents, visits to facilities and the conduct of four workshops and five specialists' meetings. The workshops include one on incineration at Arnheim, NL, one on immobilization in cement at Hanau and one on waste minimization at Savannah River. The specialists' meetings covered the topics of waste management technologies and systems issues, operational waste processing, alpha waste management, storage tank technology, advanced size reduction facilities, glovebox design, assay systems and liquid waste treatment.

Proposed future technology exchanges on alpha waste management include cooperative preparation of a document and one workshop. The cooperative document will be a review of methodologies for reducing the generation of nuclear waste. Contributors will be identified by May 1987 and the document will be completed by October 1988. The proposed workshop will address operational experience with compactors, incinerators, and remote handling systems. Plans and dates for the workshop will be completed at a meeting of Technical Coordinators in the spring of 1987.

LOW-LEVEL WASTE TREATMENT AND DISPOSAL

Technical Coordinators:

FRG: Reinhard Kraemer (KfK)

US: Scott Hinschberger (DOE/ID)- Civilian Wastes

Gerald Daly (DOE/DP) - Defense Wastes

The technology exchange on low-level waste management has consisted of visits to each party's facilities. The focus of these visits has been on waste treatment and storage facilities. This level of exchange has been adequate and equitable to both parties.

Since the previous planning meeting in the fall of 1984, the major accomplishments have included:

1) a tour of the low-level waste treatment and disposal facilities at Savannah River and West Valley by a delegation from the FRG;

2) a tour of low-level waste treatment and storage facilities at KfK by a delegation from the US DOE and US NRC.; and

3) a meeting of US DOE and FRG BMFT representatives in Washington, DC to discuss current document exchange distribution lists and planned workshops.

Activities for 1987 and 1988 are planned to include:

1) additional visits by technical staff to each party's waste treatment, storage and disposal facilities;

2) exchange of available technical documents; and

3) at least one technical workshop on waste form performance in 1987.

Three areas were identified as potential exchange topics for the near future. These are:

1) Gaining a better understanding of treatment, storage and disposal of intermediate-level wastes concerning responsibilities for greater than Class "C" low-level wastes.

2) Sharing information on low-level waste treatment.

3) Providing a forum for FRG experts to explain mined cavities for low-level waste disposal technology and practices to US states and regions required to evaluate low-level waste disposal in mined cavities.

GEOLOGIC DISPOSAL

Technical Coordinators:

FRG: Klaus Kuhn (GSF/IfT)

US: K.K. "Roger" Wu (DOE/SRPO) - Civilian Wastes

Richard Crawley (DOE/ALO) - Defense Wastes/WIPP

Active exchange of technology on geologic disposal has continued since the previous planning meeting in August 1984. Much has been accomplished through joint workshops, technical studies, visits and information exchange. Three joint workshops were conducted on the topics of: 1) Waste Package Materials Corrosion, May 1985, in the FRG; 2) Rock Mechanics, February 1985 in the US; and 3) Sealing and Backfilling of a Salt Repository, September 1986, in the US. The major cooperative technical study ongoing in the past two years is the Asse Brine Migration Test. In this period, numerous accomplishments were made, including preparation of joint reports on 1984 and 1985 activities, release of quarterly data reports, development and implementation of a post-test plan, visits of two DOE staff members to Asse, arrangements for shipment of salt core samples to the US for geochemical and geomechanical tests, and development of plans for studies of radiation effects in salt.

Exchange activities planned for the next two years under a newly extended Project Agreement include the continuation of analysis of data from the Asse Brine Migration Test and testing by both parties of natural rock salt for radiation effects using facilities currently under contract in the US to the SRPO. Technical Coordinators will also initiate planning considerations for additional testing in Asse on geotechnical instruments, package emplacement and room backfilling and room sealing. Possible expansion of geochemical modelling on intact salt creep and crushed salt consolidation will also be considered. Geochemical cooperation will also be discussed.

The cooperation between the FRG and the WIPP program over the past years has been very beneficial to the WIPP program. Specific areas of cooperation have been in rock mechanics laboratory testing, modeling, in situ and laboratory testing of waste package canister materials. The cooperation has been in the form of information exchange by onsite visits for rock mechanics code evaluation, rock mechanics creep testing, and rock mechanics in situ testing. Technical information exchanges have also occurred at workshops on the mechanical behavior of salt, salt constitutive model development, repository plugging and sealing, and waste package material corrosion.

The WIPP desires to continue interactions in these areas with added emphasis on the facility sealing, backfill behavior, radioactive effects on salt and in situ testing with radioactive sources.

The following workshops were agreed upon by both BMFT and DOE to be held during the forthcoming year: 1) Geotechnical Instrumentation and Measurement

Techniques, 2) Repository Near Field Geochemical Behavior, and 3) Radionuclide Migration.

Over the past two years 23 staff members have participated in exchange visits; these exchanges will be continued. One US staff member will be given a long-term assignment in the FRG to improve technology exchange on the high-level waste disposal program and participate in FRG activities, as feasible and appropriate.

An FRG scientist will be assigned to the US Salt Repository Project. Other exchanges will be arranged through the Principal Coordinators as appropriate.

It was also agreed that there is an area of mutual benefit in the exchange of public information materials and outreach programs.

DECONTAMINATION AND DECOMMISSIONING

Technical Coordinators:

FRG: Walter Diefenbacher (KfK)

US: Clarence Miller (DOE/RL)

An active exchange of D & D information has ensued following the autumn 1984 planning meeting. Remote tool design and waste management specialists from the FRG have made extended visits to the West Valley Demonstration Project, and US specialists have studied FRG decommissioning projects at Niederaichbach, Gundremmingen, Lingen and Karlsruhe. Frequent exchanges of status reports on the major decommissioning projects have kept participating countries abreast of project progress and of R & D work being conducted for these projects.

In the area of new techniques development, the entire spectrum of dismantlement demolition techniques development for KKN Neideraichbach is of interest to the US. These developments include the remote handling equipment for dismantlement of the moderator tank and the thermal shield. Opportunities for US participation in demonstration workshops and observation of in-plant use of the equipment are being provided. Progress reports on R & D for explosive dismantlement of concrete biological shields of the KKN Niederaichbach and other reactors are being provided to the US. Explosive demolition of reactor biological shields and other heavy structures is being considered by the US.

Progress of the Shippingport Station Decommissioning Project (SSDP) work is being followed closely by the FRG. Site visits have been made by several D & D specialists in the autumn of 1986. Future visits are planned in the autumn of 1987. The SSDP is demonstrating one-piece removal of the reactor vessel and barge transportation of this and other components to the Hanford Site for burial. Also of major interest to the FRG are US developments in techniques for measuring very low levels of radioactivity. Information on relevant work being conducted at DOE national laboratories is being provided to the FRG.

The main vehicles for information exchange will continue to be site visits and documents. Participation in workshops and equipment demonstrations will also be pursued in conjunction with US specialists' visits to the FRG in the spring of 1987, and FRG specialists' visits to the US in the autumn of 1987. An

exchange of personnel for the more critical aspects of the Shippingport and Neideraichbach projects will be considered at an appropriate time. The areas of mutual interest, as outlined previously in the autumn 1984 planning meetings, remain valid for the next two years' planned activities.

SPENT FUEL STORAGE

Technical Coordinators:

FRG: Helmut Geipel (BMFT)

US: Keith Klein (DOE/RW)

The attendees at the Third US DOE/FRG BMFT Spent Fuel Information Exchange held in Seattle, Washington on April 8 - 10, 1986 reached a consensus that the information exchange has been beneficial to both countries. Spent fuel storage programs underway in both countries justify continuation of the information exchange. The following topics are of special interest:

1) operational phases of dry storage

2) dry storage technology requirements

3) rod consolidation technology developments.

The participants agreed that the next formal exchange on spent fuel will occur in the spring of 1988, adjacent to the Fourth International Spent Fuel Storage Meeting, to be hosted in the FRG. However, if earlier needs for interaction are identified, arrangements should be made through the Technical Coordinators. Special topics suggested at the meeting included FRG cask drop tests and the safety aspects of nodular cast iron. Technical exchange is expected to become more active in the area of transportation.

October 3, 1986

Gorleben, FRG

FEDERAL REPUBLIC OF GERMANY
BMFT

Rolf Randl

UNITED STATES OF AMERICA
DOE

Carl Cooley

Minutes of the
US/FRG Bilateral Technical Meeting - Disposal of Radioactive Wastes
Braunschweig, September 29 and 30, 1986

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Participants:

USA:

| | | |
|---|---|---|
| D. Cattran | (ONWI) | |
| J. Strahl | (Weston) | |
| R. Wu | (US/DOE, SRPO) | |
| L. Tyler | (SNL) | |

FRG

| | | |
|---|---|---|
| K. Kühn | (GSF/IfT) | |
| K. Dürr | (GSF/IfT) | 9/29 |
| N. Jockwer | (GSF/IfT) | |
| H. Herbert | (GSF/IfT) | |
| W. Hänsel | (GSF/IfT) | |
| T. Rothfuchs | (GSF/IfT) | |
| A. Nies | (GSF/IfT) | 9/30 |
| M. Wallner | (BGR) | |
| P. Brennecke | (PTB) | 9/29 |
| H. Schneider | (PTB) | 9/30 |
| G. Grübler | (DBE) | 9/30 |
| M. Weg | (DBE) | |
| H. Fischer | (DBE) | 9/29 |
| H. Brücher | (KFA) | |

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1. Welcome

Welcome adress by K. Kühn and R. Wu. The agenda as proposed by IfT was accepted (see attachment 1).

2. Summary of GSF + BGR / SRPO + SNL Accomplishments under Current Bilateral Agreement

2.1 Workshops
2.2 Technical Studies
2.3 Visits
2.4 Information Exchange

A summary of GSF, BGR, SRPO and WPO /SNL accomplishments under current Bilateral Agreement was given by K. Kühn, M. Wallner, R. Wu and L. Tyler.

3. "Brine Migration Test" in the Asse salt mine

3.1 Joint Summary

A brief overview of the joint US/FRG Brine Migration Test in the Asse mine was given by T. Rothfuchs. A summary Project Report was distributed to the participants.

3.2 Extension of Project Agreement
3.3 Analysis of Data
3.4 Post-Test Investigations of Salt Samples

The US proposal for extension of the Project Agreement for another two years was discussed with the following results:

- FRG agrees to extend the Project Agreement for the next two years.

- IfT intends to issue a final project report by mid 1987 taking into account the currently performed laboratory investigations on samples obtained from the test field. The post-test plan will be provided to SRPO. The remainder of the post-test activities will be published as separate reports.

- Further laboratory investigations on irradiated samples will be made within the next two years and published in separate reports.

- R. Wu described a letter from ONWI which defines their sample request. As requested by R. Wu, the samples should be sent to ONWI. The samples will be distributed for rock mechanics, geochemics and radiation effects testing. SRPO will provide a test plan to IfT for review.

-R. Wu and T. Rothfuchs agreed to meet in Columbus, Ohio, in spring 1987 to discuss the test results and layout of a joint final report.

4. <u>Study of Radiation Effects in Salt</u>

4.1 Use of Samples from Brine Migration Test
4.2 Current and Future Contracts of ONWI with Paul Levy (Brookhaven National Laboratory)
4.3 Program Proposal by Hermann Gies and Paul Levy

R. Wu indicated that SRPO is investigating the radiation effects on salt at BNL through February 1987. Additional funding is reserved for reminder of Fiscal Year 1987.

It was agreed to establish a plan for future investigations on irradiated salt samples comprising BMFT-samples, other Asse samples and Gorleben samples in the frame of the existing Project Agreement. The German as well as the US repository conditions are to be taken into account.

4.4 Interest/Participation by ECN, Netherlands

A participation of the Netherlands in this program is not yet possible as there is presently no bilateral agreement between the US and the Netherlands. US / DOE will further investigate the possibility of a multinational agreement with the Netherlands.

5. Possible Future Joint Testing Programs

5.1 Test Disposal of High-Level Glass Blocks in the Asse Salt Mine
5.2 Test Disposal of Medium-Level Waste and HTR-Fuel Elements in the Asse Salt Mine

Both WPO / SNL and SRPO are interested in obtaining test data as they become available.

5.3 Simulated Spent Fuel Package Emplacement and Room Backfill Test
5.4 Dam Test in the Asse Salt Mine
5.5 Backfilling and Sealing Tests at WIPP

Based on the laboratory modeling and in situ test progress for backfill behaviour and seal testing, it is important to define a close cooperation between FRG and WPO / SNL in 1987.

For the area of repository seals, the cooperation should be the exchange of details for laboratory and field test concepts and plans, model development and prediction, and laboratory and field results.

For drift backfill the exchange of information should be the test objectives and plans, techniques and instrumentations and model development.

The SRPO intends to participate in the test plan design and development of simulated spent fuel package emplacement and room backfill test, the dam test and backfill and sealing tests at Asse. A project agreement covering these activities may be required. WPO / SNL, due to planning of similar tests, will compare test techniques, instrumentation, and results as they become available for the simulated spent fuel package emplacement and room backfill test.

6. Site Characterization Programs

6.1 Gorleben

This item will be presented during the plenary session at the Gorleben site.

6.2 WIPP
6.3 Deafsmith County

Short presentions were given by L. Tyler and R. Wu.

7. GSF-Review on Experiments in the Flooded Hope Salt Mine

A detailed presentation was given by H.-J. Herbert.

## 8. Cooperative Laboratory Programs including Modelling

### 8.1 Geomechanics

Cooperative work in the past between BGR and WPO / SNL was considered very successful. SRPO is currently cooperating with BGR in geomechanic activities, specifically in the code comparison calculations.

BGR and WPO / SNL specifically will cooperate in:

- Common Laboratory Program on samples from both WIPP and Gorleben sites.
- Comparison of computer code results with benchscale tests and underground mesurements obtained at WIPP and Asse.

Both SRPO and WIPP / SNL will continue further evaluation and comparison of computer codes with BGR.

### 8.2 Geochemistry

H.-J. Herbert presented the brine investigation program of IfT. With regard to further cooperation L. Tyler proposed that H.-J. Herbert should contact Steve Lambert, K. Stein and Krumhansel at SNL.

N. Jockwer presented the geochemical and mineralogical investigation program on rock salt performed at IfT. George Wicks, SNL, and M. Molecke, SNL, could be contacted about the MIIT test program results and applicability.

A cooperation program on the mentioned items will be worked out by H.-J. Herbert and N. Jockwer and forwarded to SNL and SRPO.

## 9. Workshops

9.1 Backfilling and Sealing (September 23 - 25, 1986)
9.2 Performance Assessment (proposed for 1987)
9.3 Geotechnical Instrumentation and Measurement Techniques (Proposed for 1987)
9.4 Geochemical Data Generation and Geochemical Modelling
9.5 Waste Packaging

- A workshop was held in Albuquerque from September 23 - 25, 1986. Results from this workshop were not known in detail. L. Tyler indicated a high interest in the "heated backfilled room" and "dam-construction" tests at the Asse mine.
- The understanding of Performance Assessment and Geochemical Modelling was discussed in detail.

It was agreed to perform the following workshops in 1987:

- Geotechnical Instrumentation and Measurement Techniques.
  Contact persons are: H. Kalia (SRPO-Leader), T. Rothfuchs (IfT) and D. Munson (SNL). The workshop will be held in the FRG.

- Respository Nearfield Geochemical Behaviour.
  Contact persons: N. Jockwer (IfT), Jim Nowak (WIPP), J. Kircher (SRPO-Leader of Workshop). The workshop will be held in the US.

- An additional bilateral workshop was proposed by H. Schneider (PTB). From September 14 - 18, 1987 a Seminar on radionuclide migration organized by the University of München will be held in Munich.

In addition, the following workshops have been discussed beyond 1987:

- Performance Assessment.
  Contact persons are: R. Storck (IfT), R. Anderson (SNL), SRPO contact to be determined.

- Salt constitutive models and their predictive capabilities.
  Contact persons are: D. Munson (WIPP / SNL), M. Wallner (BGR, Leader of workshop), SRPO contact to be determined. This workshop should be performed by a very limited number of experts only.
  The workshop is to be performed in May 1988 in the FRG.

- Waste Packaging.
  This workshop will be discussed during the plenary session at the Gorleben site.
  Contact persons are: K.-D. Closs (KfK), M. Molecke (WIPP / SNL), SRPO contact to be determined.

- Waste acceptance criteria.
  H. Schneider (PTB) offered a workshop based on the experiences obtained from the acceptance criteria developed for the Konrad mine.
  The US participants explained their interest in acceptance criteria for High Level Waste.
  Contact persons are: H. Schneider (PTB), J. Jackson (WIPP / SNL), SRPO contact to be determined.

10. <u>International/National Symposia and Meetings</u>

- Waste Management Meeting, Tucson, March 1 - 5, 1987.
- Natural Analogs in Rad Waste Disposal, Brussels, April 28 - 30, 1987.
- Zechstein-Symposium on Salt Geology, Hannover, April 28 - May 30, 1987.
- IAEA Int. Symposium, Back End of the Fuel Cycle, Vienna, May 11 - 15, 1987.
- ISRM Symposium, Montreal, Canada, September 1987.

## 11. Personal Exchange

### 11.1 Long-Term Staff Assignment

In January 1987, H.-J. Herbert will be sent to the USA for one year. He will work at the University of Arizona at Tempe and at the University of California at Riverside.

SRPO will send a US represntative to the FRG-IfT-Office in Braunschweig for a minimum of one year.

### 11.2 Medium-Term Assignment to Perform Special Investigations/Studies

### 11.3 Short-Term Visits

Medium-term and short-term visits are to be continued. The FRG will develop a procedure to ensure that US visits are defined well in advance to enhance accomodations.

## 12. Information Exchange

### 12.1 Listing of Available Computer Codes

### 12.2 Updated Document Distribution List

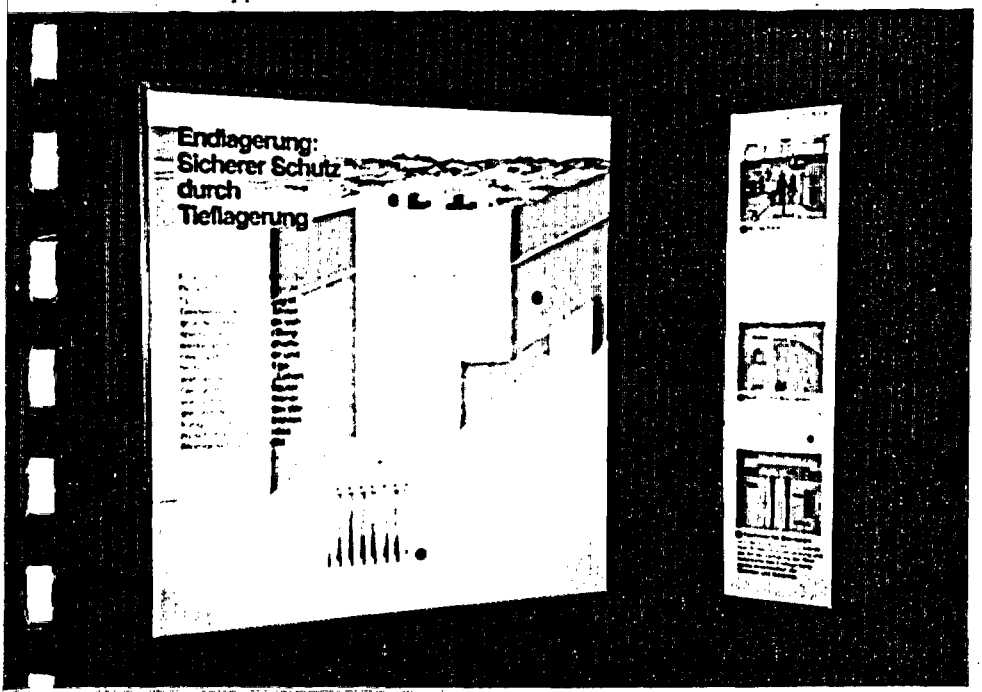
### 12.3 Public Information Program

It was also agreed that there is an area of mutual benefit in the exchange of public information materials and outreach programs. Particular interest was expressed by SRPO on publications and films relating to the shaft freezing and construction work at Gorleben, the brine migration and other underground tests at Asse, and salt pile management. SRPO also wishes to arrange a tour of these FRG facilities for state officials, community leaders and members of the public.

# APPENDIX E

## SELECTED PHOTOGRAPHS AND SLIDES

Gartow Public Information Office, Signing Bilateral Agreement at Gorleben, the Gorleben Exploratory Shaft Facility, Asse Salt Mine, and Federal Institute for Geosciences and Natural Resources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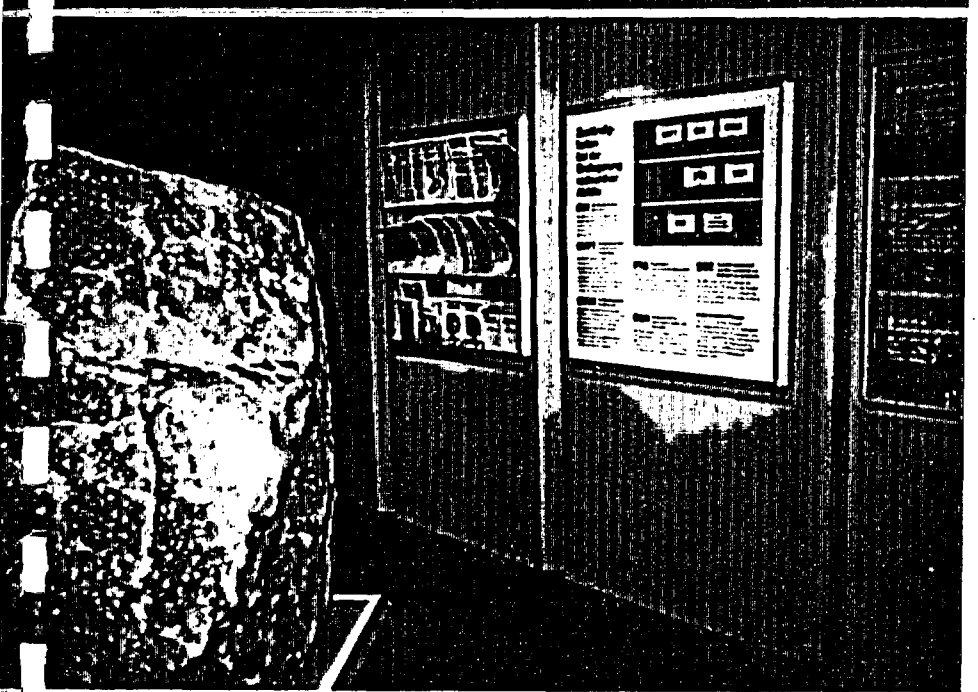
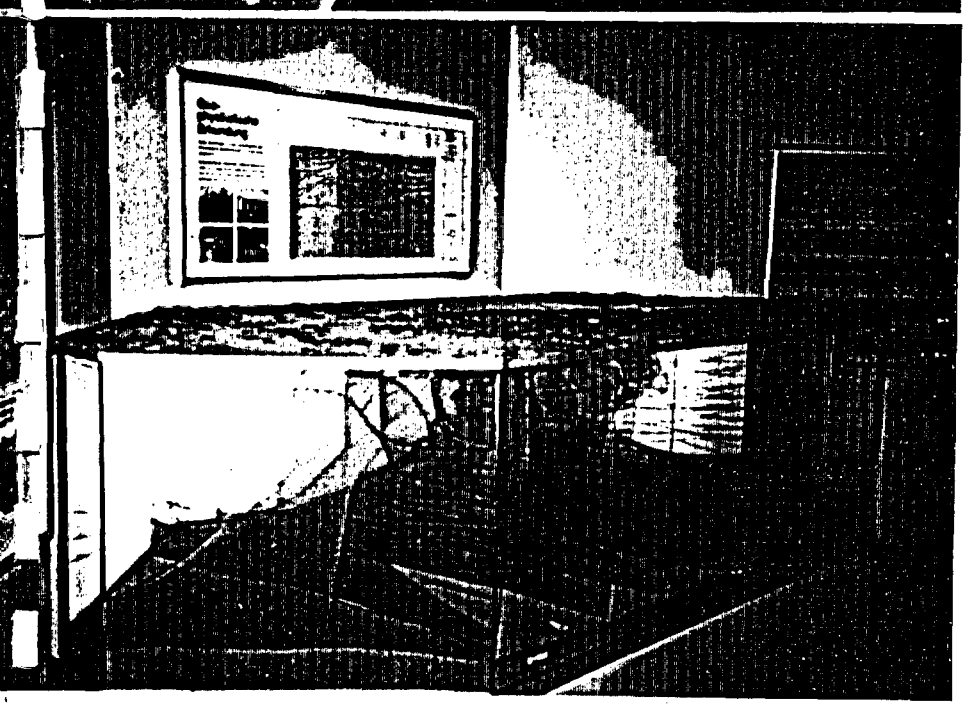
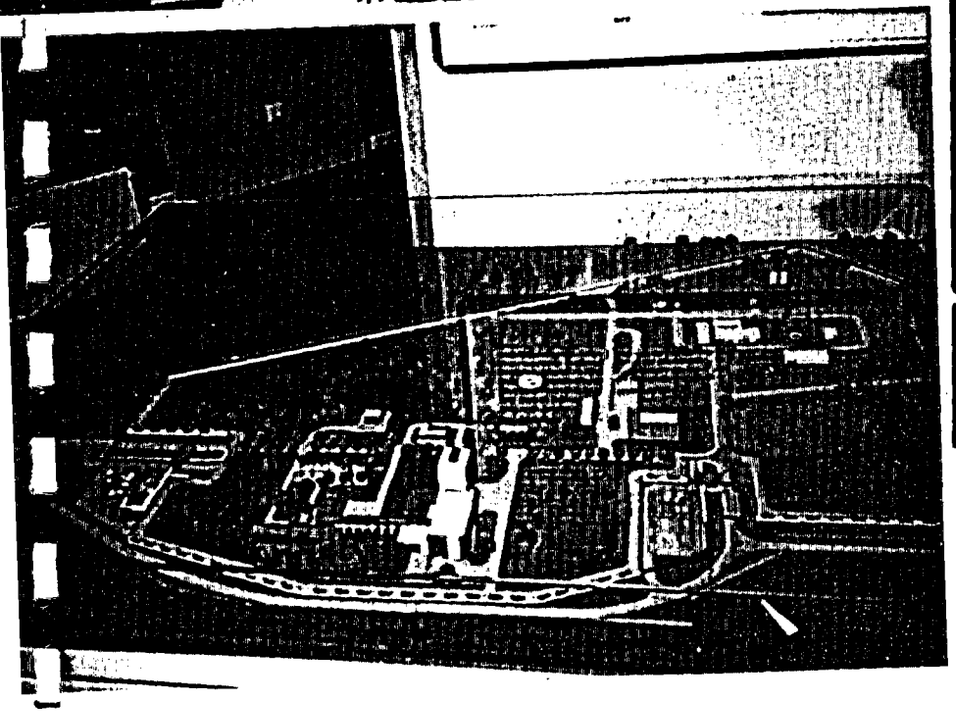
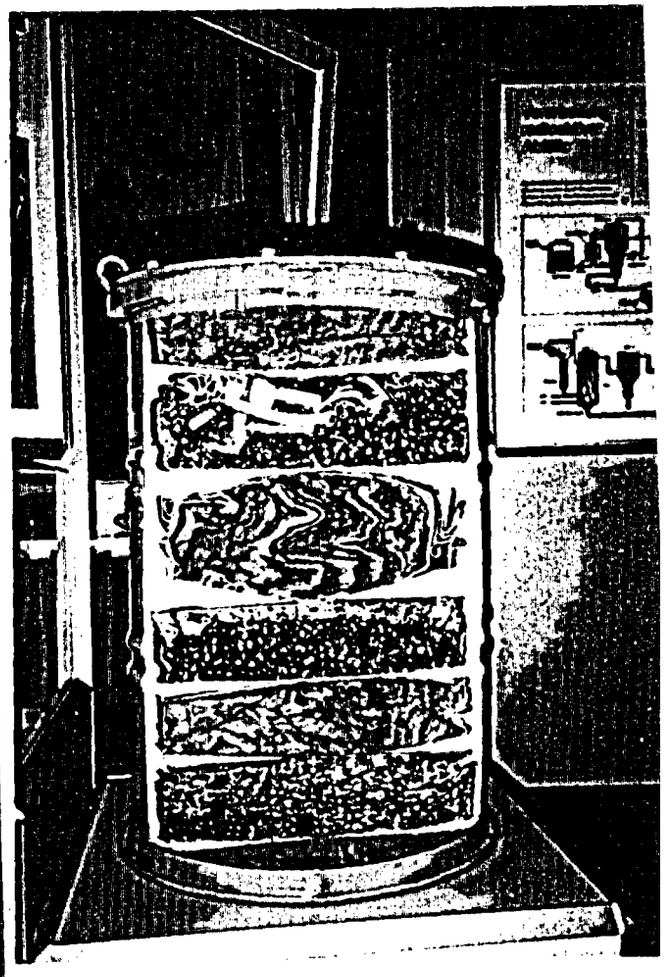


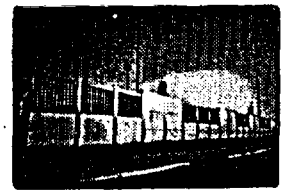


Zeitlicher Überblick





Gorleben fence w/ water cannon



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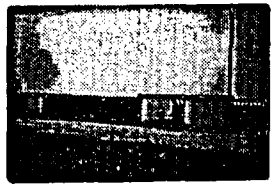
Gorleben fence, guard, dog



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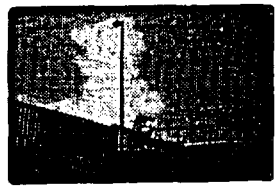
Gorleben fence + water cannon



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Gorleben shaft construction

10/86

Gorleben shaft head frame

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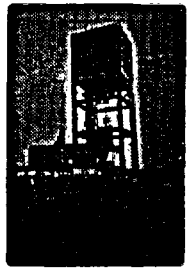
Gorleben shaft head frame



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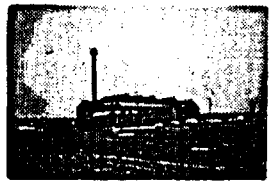
Gorleben admin. buildings



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Gorleben grounds + pond

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start of 2nd shaft at Gorleben

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Public info office at Gärtow

Asse Mine above ground

Asse Mine above ground

Asse Mine
above ground

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Asse Mine
core facility

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Asse Mine

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Asse Mine
drilling new drift

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Cores tested
at BGR

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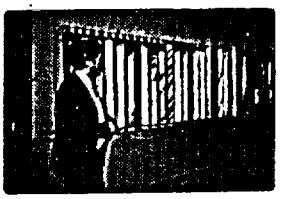
Core facility +
display at BGR



Hannover, FRG
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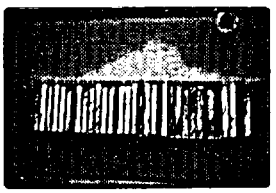
Core display
at BGR, Hannover



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core facility at
BGR, Hannover

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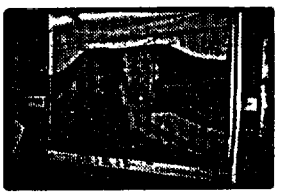
BGR display



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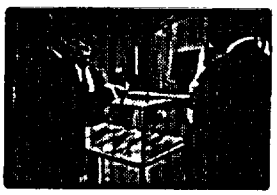
BGR display
dome xsection



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BGR display
dome xsection

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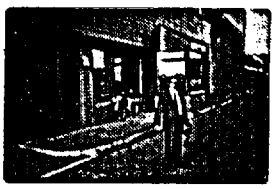
Roger Wu outside
core facility



at BGR, Hannover
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# APPENDIX F

## OVERVIEW OF THE FRG ACTIVITIES ON SPENT FUEL DISPOSAL

K. D. CLOSS AND K. EINFELD

Paper to be presented at Second International Conference on Waste Management, Winnipeg, September 1986

# OVERVIEW OF THE FRG ACTIVITIES ON SPENT FUEL DISPOSAL

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ABSTRACT

As stipulated by the German Atomic Energy Act, reprocessing is the reference waste management route for LWR's in the FRG. Spent fuel disposal is being developed in addition to the realization of the reference concept. A pilot conditioning and encapsulation plant will be built at Gorleben and a large repository related R&D program is under way. The aim of the ongoing program on spent fuel disposal is that the results will be available early enough to be incorporated in the licensing procedure of the Gorleben repository which will start as soon as the results of the underground investigations show that the salt dome will be suitable for disposal.

## 1 INTRODUCTION

Electricity generation by nuclear power has become of increasing importance in the Federal Republic of Germany. Within the last four years, the installed nuclear power plant capacity has doubled. Light water reactors (LWR) with an overall net capacity exceeding 17 GWe are on line in 1986, contributing more than 35% to the total supply of electricity. Moreover, gas-cooled and sodium-cooled demonstration reactors with a capacity of 330 MWe are in operation, one more reactor (SNR 300, 280 MWe) is under construction.

Four additional LWR's (5 GWe) are in an advanced stage of construction so that a net LWR capacity of 22.3 GWe is expected for 1990. There are plans for four more LWR's (5 GWe), so that a total capacity of about 27.5 GWe would be reached by the turn of the century.

## 2 WASTE MANAGEMENT POLICY

Back-end fuel cycle installations are operated by private companies in the FRG. However, the Federal Government is responsible for radioactive waste disposal. The German waste management policy relies on the polluter-pays-principle. All cost of the back-end of the nucear fuel cycle including disposal are apportioned to the kWh of nuclear generated electricity.

### 2.1 Reference Concept

Reprocessing is the reference waste management route for LWR's in the FRG. The basis for the German waste management policy is the German Atomic Energy Act of 1959. This law binds all participants in the nuclear fuel cycle

- to safely recover and recycle the resources contained in spent fuel or
- to classify the material as radioactive waste and to dispose it of safely, only if recycling is either scientifically or technically not feasible or economically not justifiable.

Germany's involvement in the field of reprocessing dates back to 1959 when it was one of the 13 founding members of the OECD joint venture EUROCHEMIC, a reprocessing plant at Belgium which was operated between 1966 and 1974. In 1971, the German pilot reprocessing plant, WAK, became operational at Karlsruhe. Up to now, this plant has reprocessed more than 170 Mg of spent fuel successfully.

The realization of large scale reprocessing did not proceed without setbacks. In May 1979, the pursuit of realization of a large back-end fuel cycle center at Gorleben based on a 1400 Mg U/yr reprocessing plant was abandoned for political reasons by the Government of Lower-Saxony. With this decision, the Federal Government's plan of an integrated back-end fuel cycle center with colocation of all fuel cycle installations, including the repository had to be given up.

In September 1979, the Federal Government and the Governments of the Federal States decided to adjust the principal rules of spent fuel and waste management in the FRG to the new situation. The concept of a closed fuel cycle with reprocessing was maintained, but colocation of the individual back-end fuel cycle facilities was no longer pursued. This 1979 waste management policy was supported by all major political parties in the FRG.

In the following years, several Federal States agreed to formal site selection and licensing procedures for a reprocessing plant with a politically limited maximum capacity of 350 Mg U/yr. In January 1985, the Federal Government confirmed that reprocessing would remain the reference waste management concept for LWR's in the FRG whereby special reference was made to the legal situation (Atomic Energy Act, proven and demonstrated technology) as well as to long term aspects (U-savings, option for breeder reactors). The Government was vindicated in its decision by the findings of the German Alternative Fuel Cycle Evaluation which did not exhibit decisive advantages of direct disposal over fuel reprocessing /1, 2/. This decision was - contrary to the 1979 waste management policy - no longer supported by the Federal States governed by Social Democrats for po-

litical reasons.

In February 1985, DWK, a company jointly owned by all German utilities operating nuclear power reactors, decided to build the reprocessing plant at Wackersdorf/Bavaria.

Large progress has been made in the FRG during the last years in closing the nuclear fuel cycle via reprocessing and recycling. The status is as follows (see Fig. 1).

- A spent fuel interim storage facility has been completed at Gorleben, one is under construction at Ahaus/Northrhine-Westfalia, and a third will be built as an entrance storage for the reprocessing plant at Wackersdorf. Each of them has a capacity of 1500 Mg uranium.

- Vitrification of high active liquid reprocessing waste has been and will be further demonstrated at the PAMELA vitrification plant at Mol/Belgium. The PAMELA concept has been developed in the FRG.

- Reprocessing contracts with COGEMA and BNFL have been signed by German utilities for almost 4600 Mg uranium. All wastes arising from reprocessing might be returned to the FRG for disposal.

- The first construction permit has been granted for the Wackersdorf reprocessing plant, and site preparatory work is under way. The plant will have a maximum annual throghput of 500 Mg uranium. Cold and hot start-up of the plant is expected for 1993 and 1995, respectively.

- About 60 Mg of mixed oxide fuel have been fabricated, most of which has been or is being

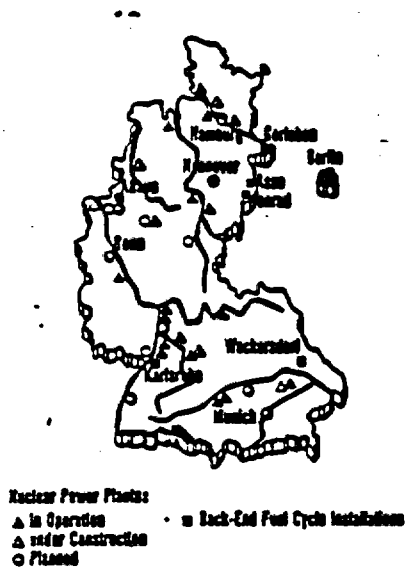


FIGURE 1: NUCLEAR POWER PLANTS AND BACK-END FUEL CYCLE INSTALLATIONS IN THE FRG

- Various disposal techniques for low and medium level waste have been demonstrated at the underground laboratory ASSE salt mine in Lower-Saxony between 1967 and 1978. Large-scale demonstration of the emplacement of heat-producing medium and high level waste will start in 1987/88.

- Licensing procedure is under way in Lower-Saxony for the KONRAD repository, a former iron ore mine. Nuclear waste with negligible heat production will be disposed of in this repository. The license for construction and operation is expected in 1988 and 1990, respectively.

- Exploratory shaft sinking works have begun at the Gorleben salt dome (see Fig.2). Underground exploration will last until 1992. If the salt dome turns out to be suitable for disposal, the operational start-up of the first German repository for heat producing nuclear waste is foreseen for the turn of the century.

As indicated by this record, the stage is set for closure of the nuclear fuel cycle in the FRG by the turn of the century.

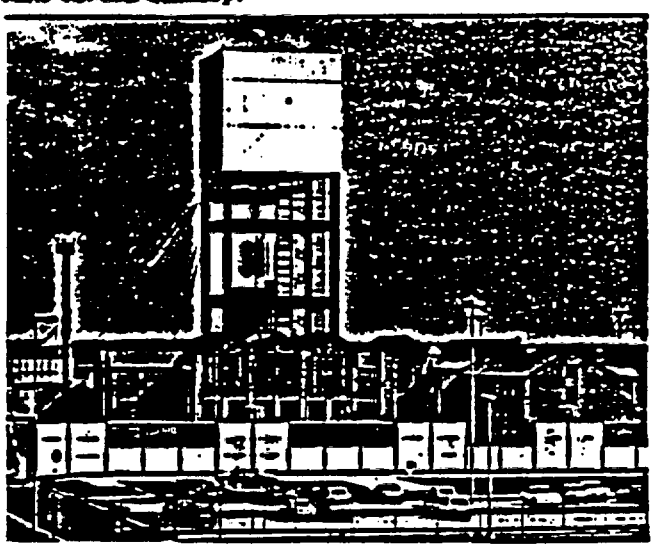

FIGURE 2: EXPLORATORY SHAFT SINKING WORKS AT GORLEBEN

## 2.2 Spent Fuel Disposal

Spent fuel disposal without reprocessing has been under investigation in the FRG since 1979. The basis for those investigations was the earlier mentioned waste management policy decision of 1979 agreed upon by the Heads of both the Federal Government and the States. This decision stated that in addition to the realization of the reprocessing fuel cycle alternative back-end fuel cycle concepts, such as direct disposal of spent fuel without reprocessing, were to be investigated enabling a judgement by 1985, whether or not direct disposal might offer decisive advantages over reprocessing.

Between 1981 and 1984, the Federal Ministry of Research and Technology (BMFT) supported the R&D program "Alternative Spent Fuel Management and Disposal Techniques", which was coordinated by the Karlsruhe Nuclear Research Center (KfK). Within this program, Nukem and DWK developed the concept of a production scale conditioning and encapsulation

plant and designed casks for spent fuel disposal. DBE[1], the company which will construct and operate waste repositories on behalf of the federal agency PTB[2], designed the repository for spent fuel.

Within this program, the technical feasibility of spent fuel disposal has been demonstrated in principle. In addition, a comprehensive comparison of the two waste management options with and without reprocessing has been performed resulting in the following findings: As far as the status of technology is concerned, reprocessing constitutes proven technology in the FRG, whereas spent fuel conditioning and encapsulation is in the development stage. With respect to radiological safety, the comparison revealed that the radiological impact of direct disposal is generally somewhat lower than for reprocessing, but the difference is judged minor when discussing the absolute values and comparing them to natural radiation exposure. Cost of direct disposal of spent fuel seem to be lower than in the case of the reprocessing route. Finally, with regard to safeguarding a repository for spent fuel, some unresolved issues exist presently. As mentioned already, it was concluded that direct disposal of spent fuel has not significant advantages over reprocessing /1,2/.

The results of this evaluation formed the basis for the already cited decision the Federal Government made in January 1985 as to how to proceed with direct disposal. It was stated that spent fuel disposal without reprocessing should be developed to technical maturity for those fuel elements for which reprocessing is either technically not feasible or economically not justifiable. That concerns, first of all, the thorium fuel elements from the German gas-cooled pebble-bed reactors, and, moreover, LWR fuel which is not within the scope of the Wackersdorf reprocessing plant specifications.

For the time being, it is almost impossible to project the amount of spent LWR fuel which might be disposed of without reprocessing. But an upper limit can be derived: Taking into account a net LWR capacity of 27.5 GWe in the year 2000, about 600 to 700 Mg of spent fuel will be discharged annually from LWR's by the turn of the century, depending on the burnup of the fuel. Up to 500 Mg of spent fuel with a minimum cooling time of 7 years will be reprocessed in the Wackersdorf reprocessing plant per year. Under these boundary conditions, an amount of spent fuel in the range 100 to 200 Mg remains uncommitted beyond the turn of the century. There are several possibilities to treat this amount of spent fuel: The throughput of the Wackersdorf reprocessing plant could be increased, new contracts with foreign waste management companies could be signed, or the fuel could be disposed of directly.

The activities already initiated or planned with respect to the development of spent fuel disposal to technical maturity will be described in the next two sections.

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1) Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH, Peine

2) Physikalisch-Technische Bundesanstalt, Braunschweig

## 3 TECHNICAL CONCEPT FOR SPENT FUEL CONDITIONING AND ENCAPSULATION

Within the R&D program "Alternative Spent Fuel Management and Disposal Techniques" the reference concept for spent fuel disposal was the emplacement of large and heavily shielded disposal casks in tunnels of a repository mine located in a salt dome (see Fig. 3). The main characteristics of this concept were as follows: Three intact fuel elements were sealed in a gastight canister, the dry storage bin. The disposal canister, surrounding the dry storage bin, consisted of a canister body and a corrosion protection which guaranteed an absolute confinement of the spent fuel for some hundred years. The lost shielding was designed such as to allow the workers to handle the packages hands-on in the repository.

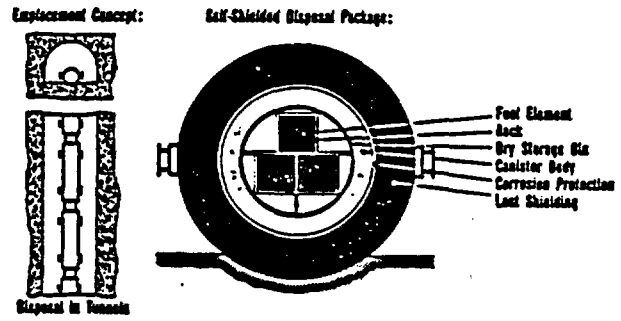


FIGURE 3: FORMER REFERENCE CONCEPT FOR SPENT FUEL DISPOSAL

In the meantime, cask development work was continued by DWK on their own, and a very flexible system was designed dubbed the POLLUX Cask System /3/. This system can be used for all kinds of fuel elements. In addition to disposal, the cask system allows also for transport in the repository and long-term interim storage with an option of reopening the cask in case reprocessing is deemed desirable.

The POLLUX containment concept, shown in Fig. 4, is built up by multiple barriers with regard to specific design criteria.

The disposal cask assures:

- gas tightness by means of a screwed primary lid and a welded secondary lid
- protection against mechanical loads and impacts. The dominant mechanical load is given by the pressure in the geologic repository
- protection against corrosion of salt brines in the geologic repository. The protection against corrosion is assured with Hastelloy C4 resurfacing by welding.

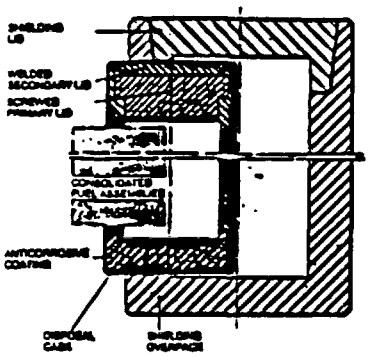

FIGURE 4: POLLUX CONTAINMENT CONCEPT

The shielding overpack assures:

- shielding of gamma- and neutron-radiation under transport, storage and related accidental conditions
- mechanical protection under operational and Type B(U)-test conditions, and shock absorber function for the inner disposal cask.

The POLLUX loading and closing procedure is characterized by the following steps, as shown in Fig. 5:

- transport of empty POLLUX into hot cell
- loading waste form into POLLUX
- closing disposal cask by screwing in primary lid within the hot cell
- transport of POLLUX out of the hot cell to welding gantry with shielding overpack, closed by a temporary shielding lid
- closing steel containment of disposal cask by welding secondary lid in direct operation mode, using welding gantry
- closing anticorrosive coating in direct operation mode, using welding gantry
- closing shielding overpack by screwing in shielding lid.

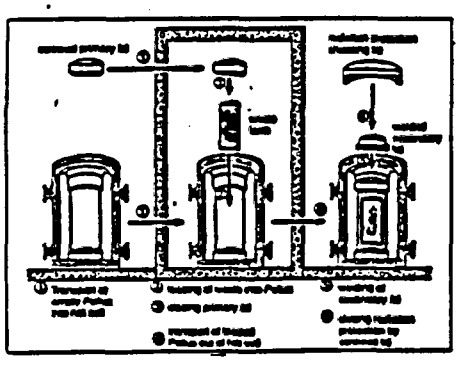

FIGURE 5: POLLUX LOADING AND CLOSING PROCEDURE

A large laboratory program is under way to qualify the concept and the materials for later application. As an example, the coating of the disposal cask with Hastelloy C4 resurfacing by welding is shown in Fig. 6.

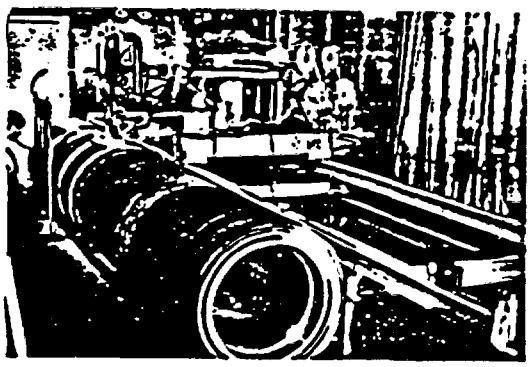

FIGURE 6: POLLUX: COATING OF DISPOSAL CASK HASTELLOY C4 RESURFACING BY WELDING

The resulting POLLUX design for consolidated pins from 8 PWR fuel assemblies is shown in Fig. 7. The fuel rods are enclosed in canisters which form a hollow cylinder in the disposal cask. In this way, temperature peaks in the centre are avoided. This space is used to accommodate the compacted skeletons of the fuel assemblies. The cask is designed to accept fuel three years after discharge from the reactor. In this case, the total heat load is 20 kW and the surface dose rate 20 mrem/h. Some more characteristic data are shown in Table 1:

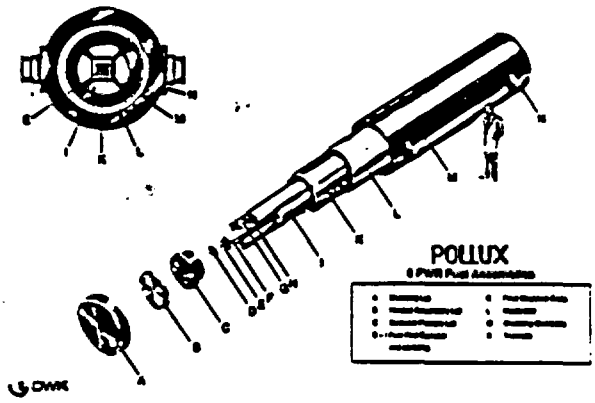


FIGURE 7: POLLUX 8 PWR FUEL ASSEMBLIES

Besides this reference concept with large and heavily shielded packages, a back-up concept is being pursued which results in smaller spent fuel canisters. In this case the disassembled fuel pins have to be cut into pieces of about 1 m length. As can be seen from Table 1, the small spent fuel packages have the same outer dimensions as the canisters for vitrified reprocessing waste. The advantage is that the same handling and emplacement technique can be used in the repository as for vitrified waste, namely the emplacement of the canisters into 300 m deep boreholes, drilled in the floor of the disposal galleries.

TABLE 1: CHARACTERISTICS OF LWR DISPOSAL PACKAGES

| | Spent Fuel Package | | HLW Package |
|---|---|---|---|
| | Large | Small | |
| Length (m) | 5.35 | 1.33 | 1.33 |
| Diameter (m) | 1.57 | 0.43 | 0.43 |
| Weight (Mg) | 64 | 1.8 | 0.5 |
| Number of fuel-elements | 8 | 0.5 | 2.2 |
| Heat Load (kW)* | 6.5 | 0.4 | 2.0 |
| Surface Dose rate (mrem/h)* | < 20 | < $10^6$ | $10^8$ |
| Emplacement concept | Tunnel | Borehole | Borehole |

* 10 years after discharge from LWR

In May 1986, DWK initiated the licensing procedure for a pilot conditioning and encapsulation plant enabling the encapsulation of all kinds of spent nuclear fuel in different disposal casks. The POLLUX system described above is used as the reference concept. This plant will be built at Gorleben near the site of the interim storage facility. According to the present time schedule, the cold and hot operation could start in 1992 and 1994, respectively.

## 4 REPOSITORY RELATED R&D

Contrary to spent fuel conditioning and encapsulation, the repository related R&D will be further supported by the BMFT. The R&D program "Direct Disposal of Spent LWR Fuel" is coordinated again by KfK. Major contributions to the program are made by DBE, GSF[1], BGR[2] and KfK.

Up to now, the planning for a repository in the Gorleben salt dome was concentrated on accommodating reprocessing waste but it did not take into account the emplacement of large and heavy spent fuel packages. Even a small number of spent LWR fuel elements intended for direct disposal could entail major changes in both the aboveground and underground design and of the repository. With respect to the reference concept, the mining authorities have pointed out that the feasibility of direct disposal is to be demonstrated before a license for industrial scale deployment could be granted.

Thus, the main thrust of the program lies with the demonstration of the safe and reliable handling of large and heavy canisters in a repository on a 1:1 scale. Emphasis is also laid on the investigation of special thermal and rock mechanics aspects of the tunnel emplacement concept as well as on the layout and optimization of a repository for both reprocessing waste and conditioned spent fuel.

Figure 8 shows the logistics for POLLUX casks in the repository. In the repository shaft area, the cask is loaded on a rail transport vehicle. The loaded vehicle is slid into the cage and then lowered to the emplacement level. Since the shaft has a diameter of 7.5 m, the 5.4-m long POLLUX cask can be transported in the cage in a horizontal position. Railbound transport takes place as far as to the emplacement tunnel. A hoisting apparatus is installed at the position where the cask is to be disposed of. After the transport vehicle has reached this position, the cask is lifted a few centimeters, the vehicle is pulled away, and the cask is lowered on to the floor of the tunnel. Soon afterwards, this part of the tunnel is backfilled with crushed salt.

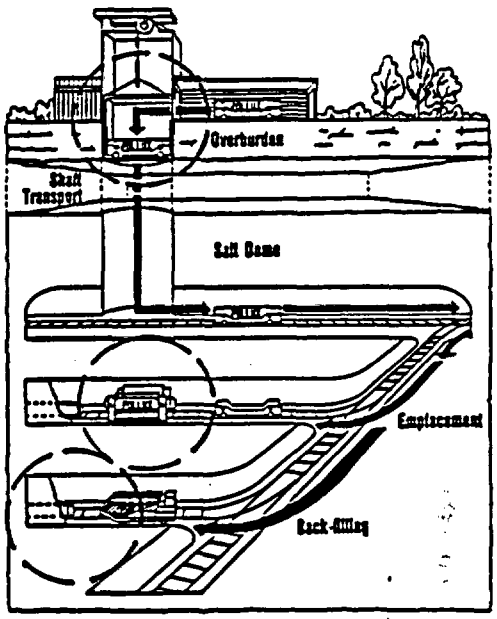


FIGURE 8: LOGISTICS FOR POLLUX CASKS

The three areas in which further R&D with regard to demonstration tests /4/ is necessary, namely shaft transport, underground handling and emplacement, as well as the thermal and mechanical behavior of the back-filled tunnel, are marked on Fig. 8:

1. The shaft transport with loading and unloading of the hoisting cage will be simulated in an aboveground test rig with inactive canisters. Up to now, shaft transport with a payload of 80 Mg (POLLUX + transport vehicle) has not yet been demonstrated, but existing technology can be adapted. The following topics will be investigated, for example: locking of the hoisting cage, pushing the loaded vehicle onto the cage, lokking of the vehicle within the cage, loading of the hoisting cables and hoisting machinery upon release of loaded cage, locking of the loaded cage, unloading of the cage etc.

2. The manipulation of inactive large disposal casks and the demonstration of safe handling will be done above and below ground. The machinery for the transport of the casks into the disposal tunnel as well as for lifting and lowering the canister at the disposal position is to be developed, constructed on a 1:1 scale, and tested. The objective is to obtain general approval for the components under the provisions of the mining law.

1) Gesellschaft für Strahlen- und Umweltforschung, Institut für Tieflagerung, Braunschweig

2) Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

③ Thermal and rock mechanics investigations for the tunnel emplacement concept will be performed with electrically heated canisters in the ASSE underground laboratory, as shown in Fig. 9. For this test, two parallel drifts are excavated, each of which is to accommodate three canisters with an electric power of 8 kW each. The casks are surrounded by crushed salt, using an optimized method of back-filling. Different types of measuring instruments are installed in the crushed salt and surrounding strata in order to record and evaluate all relevant parameters (temperature, pressure, roomclosure rate, heat flow, compaction of the crushed salt etc.) throughout the duration of the test which will last for some years.

Moreover, discussions are going on whether an active test with small spent fuel canisters using the borehole emplacement technique should be performed at the ASSE underground laboratory.

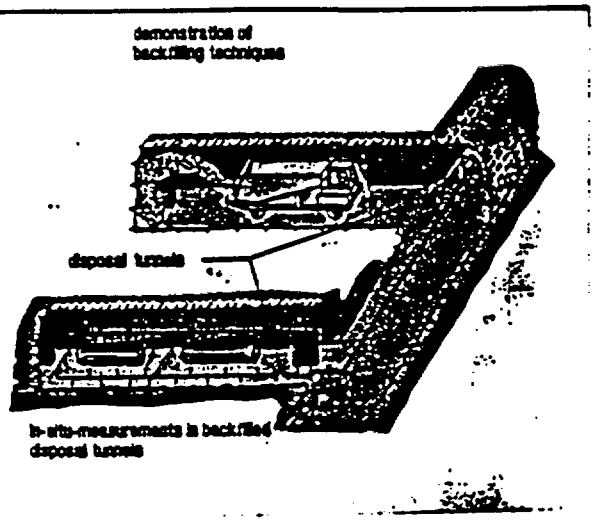


FIGURE 9: THERMAL SIMULATION TEST OF TUNNEL EMPLACEMENT .

Beside the aforementioned demonstration tests, the layout and optimization of all aboveground as well as subsurface process steps with regard to a common repository for both reprocessing waste and conditioned spent fuel is necessary /2/. Different mixes of spent fuel that is going to be disposed of directly and reprocessed, respectively, are the basis for this systems analysis "Dual Purpose Repository". Concept variations are generated by varying cooling times prior to disposal, by conceiving different conditioning and canister concepts, and finally by taking into consideration a number of repository design alternatives and emplacement techniques, such as shown in Fig. 10. The set of repository alternatives will include either tunnel or vertical borehole emplacement as well as a combination of both concepts. Emplacement tunnels and boreholes will be located either in different sectors of the model salt dome or in one common sector. Emplacement of heavy disposal casks will even be studied for tunnels being arranged at different levels of the repository. Conceptual design of the various repository and emplacement concepts will be accompanied by geothermal and thermomechanical calculations. The pros and cons of the system variants will be determined by quantifying the performance criteria "expenditure until technical maturity", radiological safety during routine operation", "long-term safety of the repository", and "cost". The final evaluation will also include the areal requirements of the disposal concepts and aspects of international safeguards.

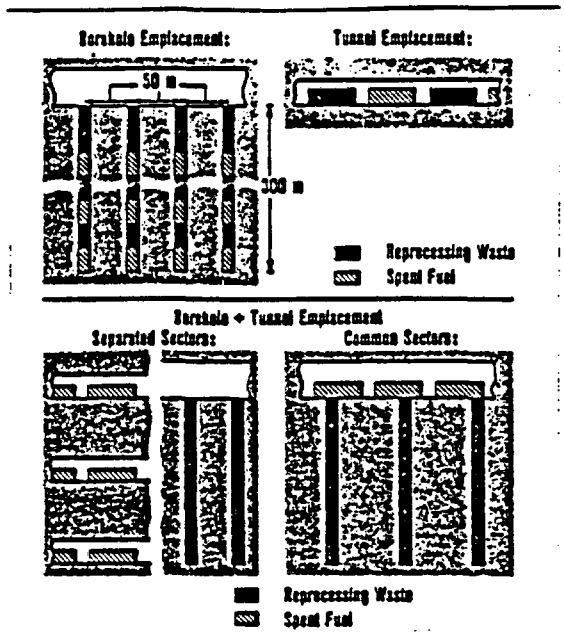


FIGURE 10: EMPLACEMENT CONCEPTS

## 5 CONCLUSIONS

In addition to the realization of the fuel cycle based on reprocessing, spent fuel disposal without reprocessing has been investigated during the last years. After having proven the principal technical feasibility of this waste management route, the program has reached a new phase: During the next years, important aspects of this back-end fuel cycle concept will be demonstrated. For this reason, a pilot conditioning and encapsulation plant will be built at Gorleben and repository related demonstration tests will be performed on a 1:1 scale. The aim of the ongoing program on spent fuel disposal is that the results will be available early enough to be incorporated in the licensing procedure of the Gorleben repository which will start as soon as the results of the underground investigations show that the salt dome will be suitable for disposal.

Large progress has been made in the FRG during the last years in closing the back-end of the fuel cycle, and it is expected that all installations will be completed by the turn of the century. This means that - in addition to the reprocessing and recycling waste management concept - direct disposal of spent fuel not suitable for reprocessing could be introduced as an additive concept for completely closing the backend of the fuel cycle.

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# APPENDIX G

## SELECTION OF CANISTER MATERIALS: ELECTROCHEMICAL CORROSION TESTS OF HASTELLOY C4 AND OTHER NI-CRI-MO ALLOYS IN CHLORIDE CONTAINING SOLUTIONS

I. WOLF AND H. BORT

INTERNATIONAL ATOMIC ENERGY AGENCY

Technical Committee Meeting on Materials Reliability in the Back-End of the Nuclear Fuel Cycle.

Vienna, IAEA Headquarters, 2-5 Sept. 1986
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# SELECTION OF CANISTER MATERIALS: ELECTROCHEMICAL CORROSION TESTS OF HASTELLOY C4 AND OTHER NI-CR (-MO) ALLOYS IN CHLORIDE CONTAINING SOLUTIONS.

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# Selection of Canister Materials: Electrochemical Corrosion Tests of HASTELLOY C4 and other Ni-Cr (-Mo) Alloys in Chloride Containing Solutions


## Abstract

Several Ni-Cr (-Mo) alloys (HASTELLOY C4, INCONEL 625, SANICRO 28, INCOLOY 825, INCONEL 690) were tested by electrochemical methods to characterize their corrosion behaviour in chloride containing solutions at various temperatures and pH-values in respect to their application as canister materials for final radioactive waste storage.

Especially, HASTELLOY C4 which proved to have the highest corrosion resistance of all tested alloys was tested by the following electrochemical methods:

(1) Poteniodynamic measurements to determine the characteristic potentials, passive current densities and critical pitting potentials.
(2) Potentiostatic measurements in order to evaluate the duration of the incubation period at various potentials.
(3) Galvanostatic measurements in order to characterize critical pitting potentials.

As electrolyte 1 m $H_2SO_4$ was used, as parameters temperature, chloride content and pH-value were varied.

Variation of temperature gives the following results: an increase in temperature leads to an increase of the critical passivation current density, the passive potential bandwidth decreases slightly and the passive current density increases with rising temperature.

The addition of different chloride contents to the $H_2SO_4$ solution shows the following effects: the critical passivation current density and the passive current density increase with increasing chloride concentration and both, the critical pitting potentials and the pitting nucleation potentials, shift towards negative values.

As third parameter the pH-value was varied. As expected, an increase of the pH-value extends the passive region to more negative values, the passive current density decreases. The variation of the pH-value does not affect the critical pitting potential.

All tested alloys showed a clearly limited resistance against pitting corrosion phenomena.

However, the best corrosion behaviour is shown by HASTELLOY C4, which has of all tested alloys the lowest passivation current density and the largest potential region with protection against local corrosion phenomena.

## 1. Introduction

The aim of the presented work was to find a ranking order for a group of alloys in respect to their corrosion behaviour when applied for the production of waste packages for final storage of high radioactive waste. Several Ni-Cr (-Mo) alloys (HASTELLOY C4, INCONEL 625, SANICRO 28, INCOLOY 825, INCONEL 690) were tested by electrochemical methods to characterize their corrosion behaviour in chloride containing solutions at various temperatures and pH-values in respect to their application as canister materials for final storage especially in rock salt formations.

The high level radioactive waste considered is the one left by the reprocessing of spent fuel elements from which the fissile and fertile nuclides have been extracted in view of their recycling. This waste is immobilized by incorporating it in an inert solid, which can be either glass- or ceramic matrix. At the present stage of technology, glasses (i.e. borosilicates) are the only operational process available [1].

The hazardous nuclides are:

- the fission products with a very high activity,
- the uranic and transuranic nuclides with a lower activity but with a much longer life.

Total isolation of the high level waste by disposal in geological stable formations seems to be achievable for 300 to 1000 years. For the period beyond 1000 years, it has been proposed that the isolation be only partial and that the release rate of activity per year should then not be higher than $10^{-5}$ of the total activity [1].

The prevailing concept on which the final waste disposal is based is the so called multibarrier concept:

The first barrier of this concept is the waste form, i.e. the glass matrix, whose functions are to immobilize the radiotoxic elements and to dilute them in order to keep the heat generation at a sufficiently low level.

The second barrier is the canister which provides mechanical support to the waste during the transportation, handling and encapsulation operations and serves as a crucible in which the liquid glass is cast.

The third barrier may be a gamma shield surrounding the canister in order to protect the external space from the gamma-radiation of the waste.

The next barrier is the overpack which encloses all the preceding components. Its purpose is to provide the necessary corrosion resistance to the container.

The backfill placed around the container in the repository and the host rock (salt, granite etc., according to the geology) complete the isolation concept.

## 1.1 Corrosion prevention

In general, the corrosion conditions in the repository are determined by the rock temperatures which may range from about 100 to 200°C, lithostatic pressure, radiation and, in case of final storage in rock salt repositories, high chlorides concentrations. Corrosion damages to the overpack canisters can theoretically be avoided in several ways:

A first one is absolute immunity, i.e. the thermodynamical impossibility of a reaction between the corroding media and the material exposed to it. The only two absolutely corrosion immune metals are gold and platinum; the costs of plating a container are economically not acceptable.

A second way for an alloy to practically avoid corrosion is to develop a superficial layer which protects the underlying metal from further corrosion; such an alloy is usually called corrosion resistant. Aluminium alloys, stainless steels, Ni- based alloys which are the subject of this investigation as already mentioned above, Zr- based alloys and Ti- based alloys have been considered as overpack materials which are economically acceptable.

A third way is the so called corrosion allowance concept. If the overpack material corrodes without developing a protective layer, it can nevertheless be used provided it corrodes at a known rate which is low enough to allow a material thickness to be corroded away during the specified life time of the overpack without breaching the container. Cast iron, carbon steels and iron belong to this class of materials which are called consumable materials.

## 1.2 Testing conditions

The aim in selecting testing conditions for the candidate materials is to obtain results which allow valid prediction for the container [2].

Electrochemical measurements are suitable for decreasing the duration of testing and are able to classify the performance, i.e. the corrosion behaviour of the materials in situ.

### 1.2.1 Classification of the corrosion processes

Corrosion damages can be classified into two main categories: general corrosion which is mainly observed in high temperature reactions and localized corrosion, more typical for wet corrosion processes.

General corrosion affects uniformly the surface of the specimen and during a given length of time transforms the same thickness of initial metal or alloy into corrosion products. If these are eliminated as fast as they are formed, the corrosion rate is then controlled by the supply of the corroding agent. They may also accumulate on the specimen surface forming a corrosion layer which may protect more or less the underlying alloy from further corrosion, the material is then corrosion-resistant under these specific conditions.

Localized corrosion processes are subdivided into several categories: pitting and crevice corrosion, grain boundary, galvanic and stress corrosion.

### 1.2.1.1 Pitting corrosion

This is the phenomenon in which the destruction of the alloy proceeds at discrete points of the surface. In the first case, it is characterized by an induction period during which no pitting is observed, followed by a propagation period during which the pit grows at a catastrophic rate [1]. These two characteristics of pitting corrosion resistant alloys poses a difficult problem for the application of these materials to overpack: how to suppress the initiation and/or propagation of pits and how to assess the induction period in real service.

Pitting corrosion can occur only within a definite potential range lying within the passive range. With the exception of active pit bottom areas the alloy surface is passive [3].

Electrochemical methods have been widely used in examining pitting behaviour of iron and steels in media containing aggressive ions, like e.g. $Cl^-$-ions [4]. Starting from the active range, the sample becomes passive with increasing potential (fig. 1) and is then subjected to pitting corrosion. The potential value where pitting is observed first, is called the pitting nucleation potential $E_{np}$ (fig. 1). The initial stages of pitting may be caused by several mechanisms [5]: incorporation of aggressive ions into the preformed passive oxide is able to cause pitting initiation, adsorption of anions on the oxide surface or simply destruction of the oxide film may start the pitting process (fig. 2).

Transition into the pitting range is not sharply defined. The pits occurring at first may be repassivated completely at potentials below a certain value, called the pitting potential. At potentials changing into the pitting range beyond this value [3], the repassivating effect of the pits decreases while the rate of growth increases and finally, stable pits occur in the alloy surface.

## 2. Experimental

A computerized experimental equipment was used for the investigations; the electrochemical cell with working electrode, counter electrode and reference electrode is shown in fig. 3.

As electrolyte 1 m $H_2SO_4$ was used, as parameters temperature, chloride content and pH-value were varied. The electrolytes were prepared from deionized water and reagent grade chemicals and were deareated with hydrogen for 1 h.

The materials tested and the experimental conditions are summarized in table 1. Besides the chemical composition, the pitting resistance equivalent "PRE" (i.e. weight % Cr + 3 × weight % Mo) is listed in the last column of the table.

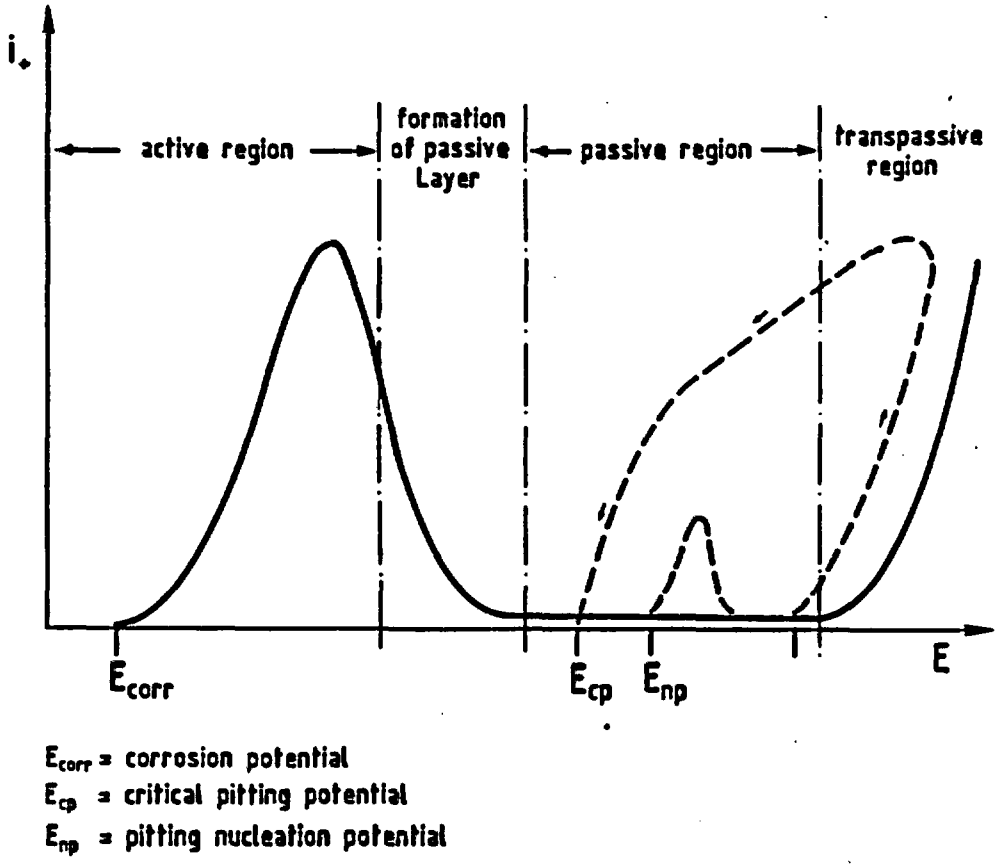


Fig. 1: Schematics of a Current-Density-Potential Curve with Positions of Pitting Potentials.

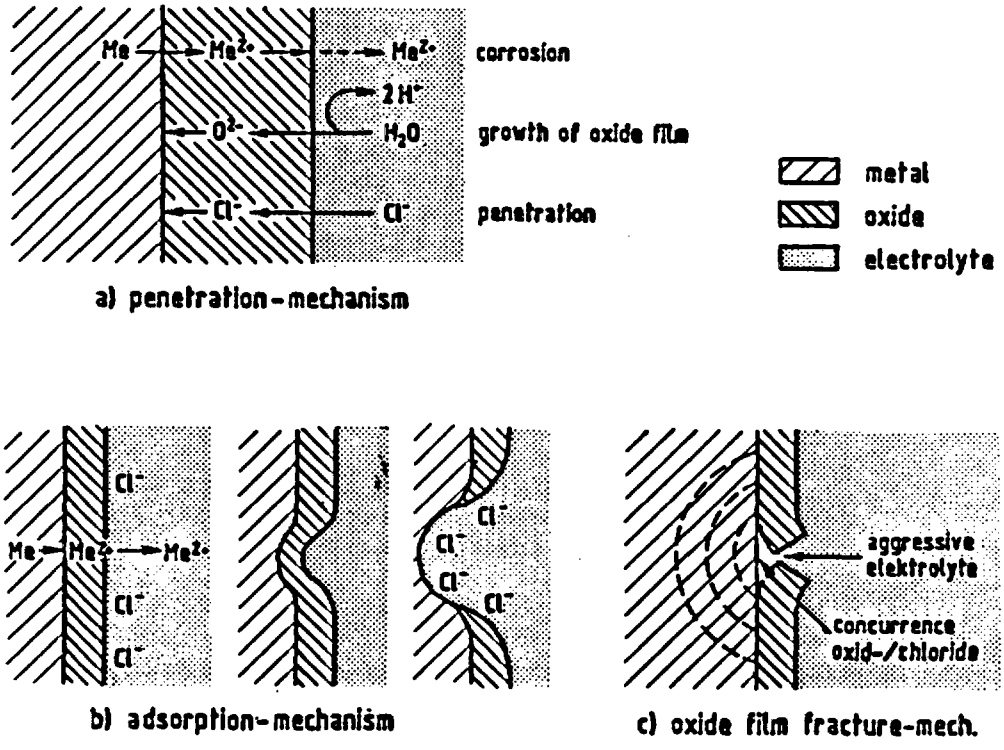


Fig. 2: Schematics of possible initial stages of pitting:

a) Incorporation of Anions into the Oxide,
b) Adsorption of Anion Islands on the Oxide Surface,
c) Destruction of the Oxide Film by Fracture

Tab. 1: Composition of alloys and experimental conditions.

Chemical composition of the tested alloys

| Alloy | weight % | | | | | | | | | | | PRE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | Si | Cu | Fe | Mn | Cr | Ti | Al | Co | Mo | Ni | wt% Cr + 3·wt% Mo |
| HASTELLOY C4 | 0,003 | 0,02 | - | 0,53 | 0,13 | 15,65 | 0,24 | - | 0,1 | 15,31 | (68,0) | 61,6 |
| INCONEL 625 | 0,02 | 0,26 | 0,02 | 2,33 | 0,05 | 22,6 | 0,12 | 0,12 | - | 9,04 | (62,7) | 49,7 |
| SANICRO 28 | 0,011 | 0,61 | 0,97 | (35,8) | 1,67 | 26,72 | - | - | - | 3,42 | 30,74 | 37 |
| INCOLOY 825 | 0,009 | 0,22 | 1,98 | 31,0 | 0,13 | 22,18 | 0,8 | 0,16 | 0,63 | 3,28 | (39,4) | 32 |
| INCONEL 690 | 0,01 | 0,3 | - | 10,26 | 0,42 | 29,1 | 0,29 | 0,22 | - | - | (59,4) | 29 |

PRE = pitting resistance equivalent

Experimental conditions:

*Temperature range:* 300 K ≤ T ≤ 365 K

Electrolyte : 1 m $H_2SO_4$ + x m KCl, x = 0, 0.2, 0.5, 1.0, 2.0 / $H_2$ (≥ 99,999 %) / different pH - values

Surface finish : 1200 SiC wet grit

Reference electrode : $Hg/Hg_2SO_4, K_2SO_4$ (sat.), $E_{NHE}$ = +648 mV

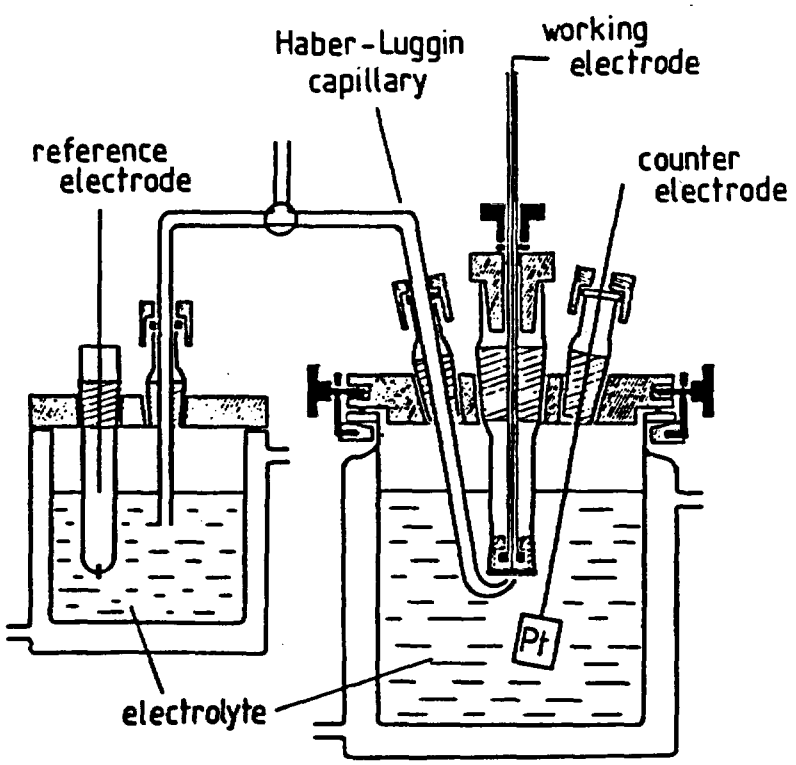


Fig. 3: Schematics of the electrochemical cell

The electrochemical techniques used for the investigation of the different alloys were:

- Measurements of the open circuit potential (free corrosion potential) for 1 h before any polarization routine was applied.
- Potentiodynamic polarization measurements to obtain current density - potential curves (scan rate dE/dt = 0.2 mV/s) and thus to determine characteristic potentials, passive current densities, and critical pitting potentials.
- Potentiostatic measurements in order to get current density - time dependences, and thus to evaluate the duration of the incubation period of pitting at various potentials.
- Galvanostatic measurements to obtain potential - time dependences in order to characterize critical pitting potentials.

## 3. Results

At first, temperature dependences of the current density - potential curves were determined for the different alloys. The current density - potential curve of HASTELLOY C4 in pure $H_2SO_4$ with the temperature as parameter (fig. 4) is representing the various characteristics such as height of active peak, active/passive transition, passive current density and passive/transpassive transition. The increase in temperature leads to an increase of the critical passivation current density, the passive potential bandwidth decreases slightly and the passive current density increases with rising temperature.

Fig. 5 shows the temperature dependence of the current density - potential curves for HASTELLOY C4 in a 1 m $H_2SO_4$ + 0.5 m KCl solution. At higher temperatures a hysteresis in the curves indicates the appearance of pitting corrosion processes.

The criteria for the evaluation of the pitting resistance of the five tested alloys were:

- current density in the passive range,
- shape of the hysteresis in the current density - potential curves, if there was pitting corrosion,
- incubation time of pitting,
- critical pitting potentials, and
- microscopic inspection of the surface of the specimen after electrochemical polarization (hereby also determining whether crevice corrosion at the edges of the specimen had occurred or not).

From these criteria, an evaluation of the ranking order of the tested alloys was possible which is in accordance to the PRE - values given in table 1. The pitting resistance decreases in the following order of alloys: HASTELLOY C4 > INCONEL 625 > SANICRO 28 > INCOLOY 825 > INCONEL 690.

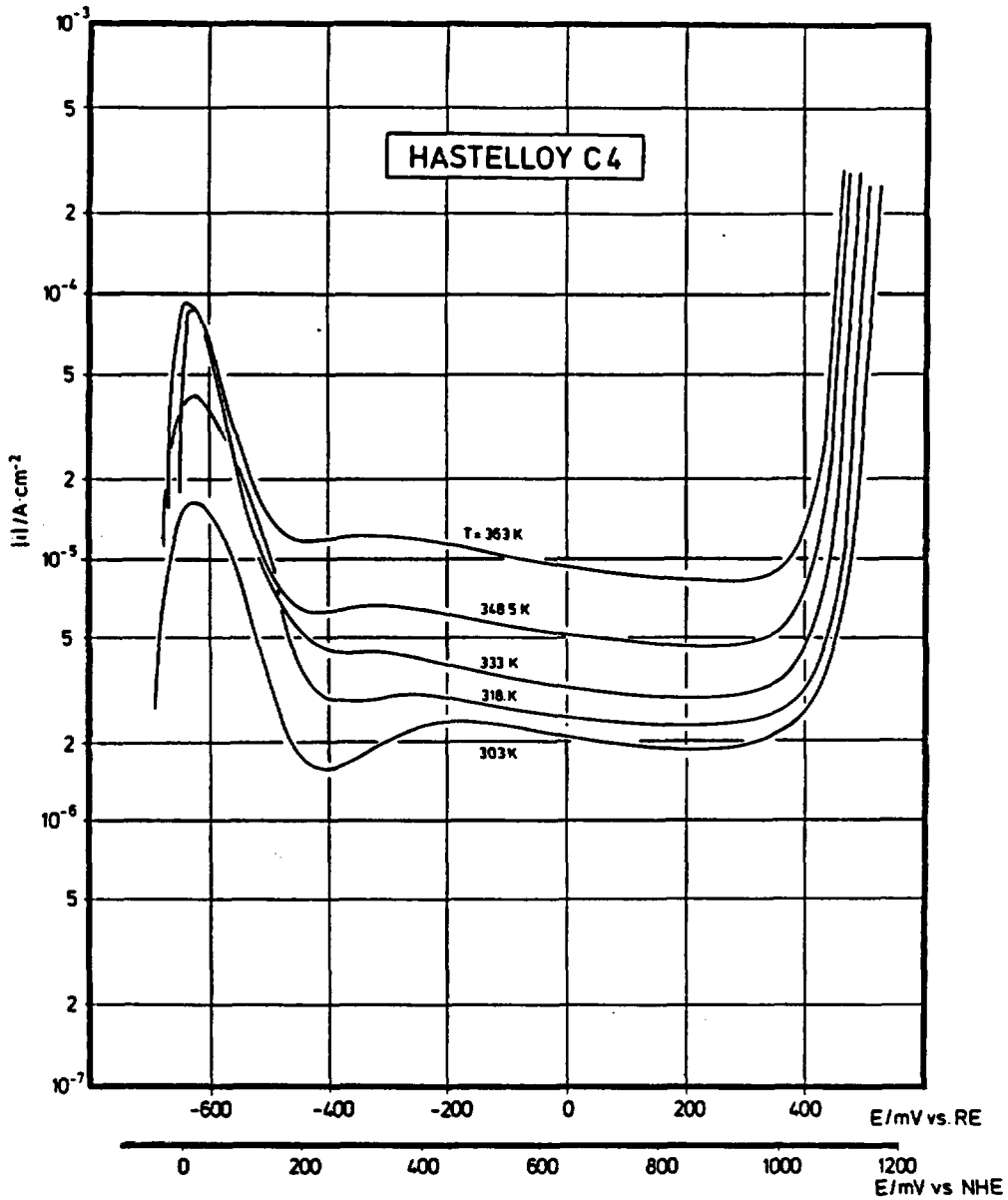


Fig. 4: Potentiodynamic Current-Density-Potential Curves
($dE/dt = 0.2\ mVs^{-1}$)
System: HASTELLOY C4 / 1 m $H_2SO_4$ / $H_2$

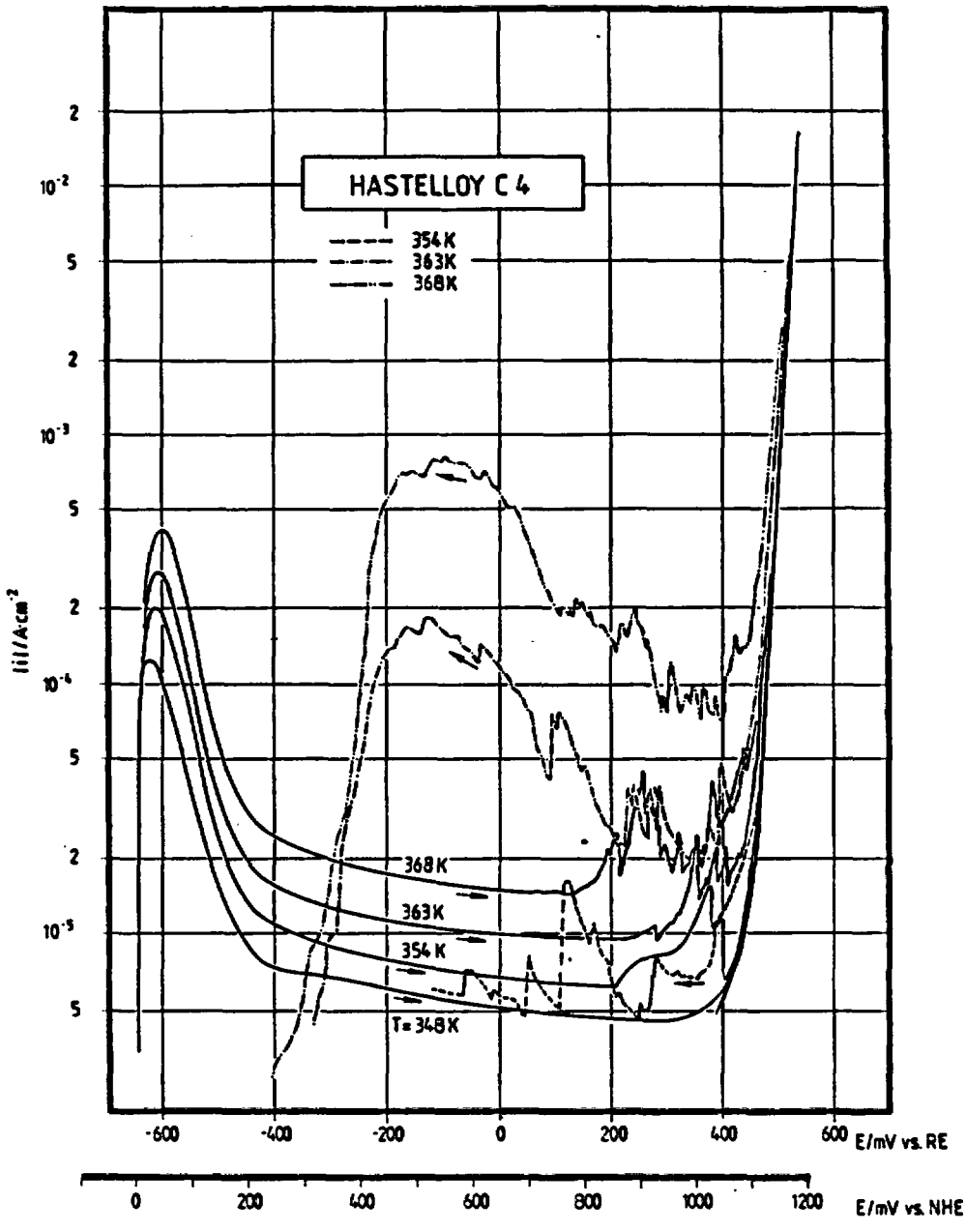


Fig. 5: Potentiodynamic Current-Density-Potential Curves
($dE / dt = 0.2\ mVs^{-1}$)
System: HASTELLOY C4 / 1 m $H_2SO_4$ + 0.5 m KCl / $H_2$

The further investigations were focussed on HASTELLOY C4 and INCONEL 625, which in so far proved to have the highest corrosion resistance of the fice alloys. As parameters the chloride concentration and the pH-value of the electrolyte were varied. The addition of different chloride contents to the $H_2SO_4$ showed the following effects: the critical passivation current density and the passive current density increase with increasing chloride concentration and both, the critical pitting potentials and the pitting nucleation potentials shift towards negative values (fig. 6 and 7).

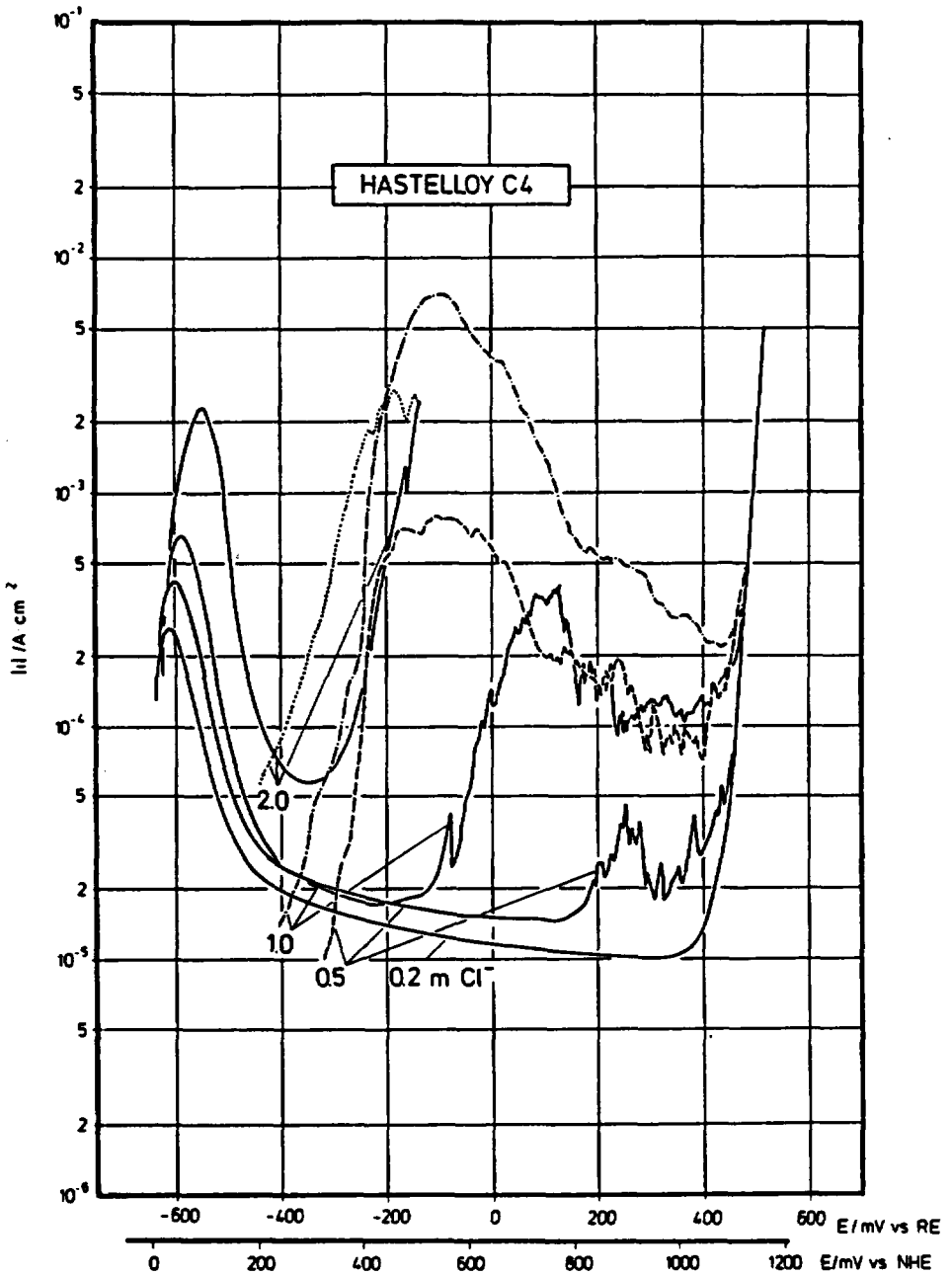


Fig. 6: Potentiodynamic Current-Density-Potential Curves ($dE/dt = 0.2\ mVs^{-1}$)
System: HASTELLOY C4 / 1m $H_2SO_4$ + xm KCl, x = 0.2, 0.5, 1.0, 2.0 / $H_2$ / T = 367 K

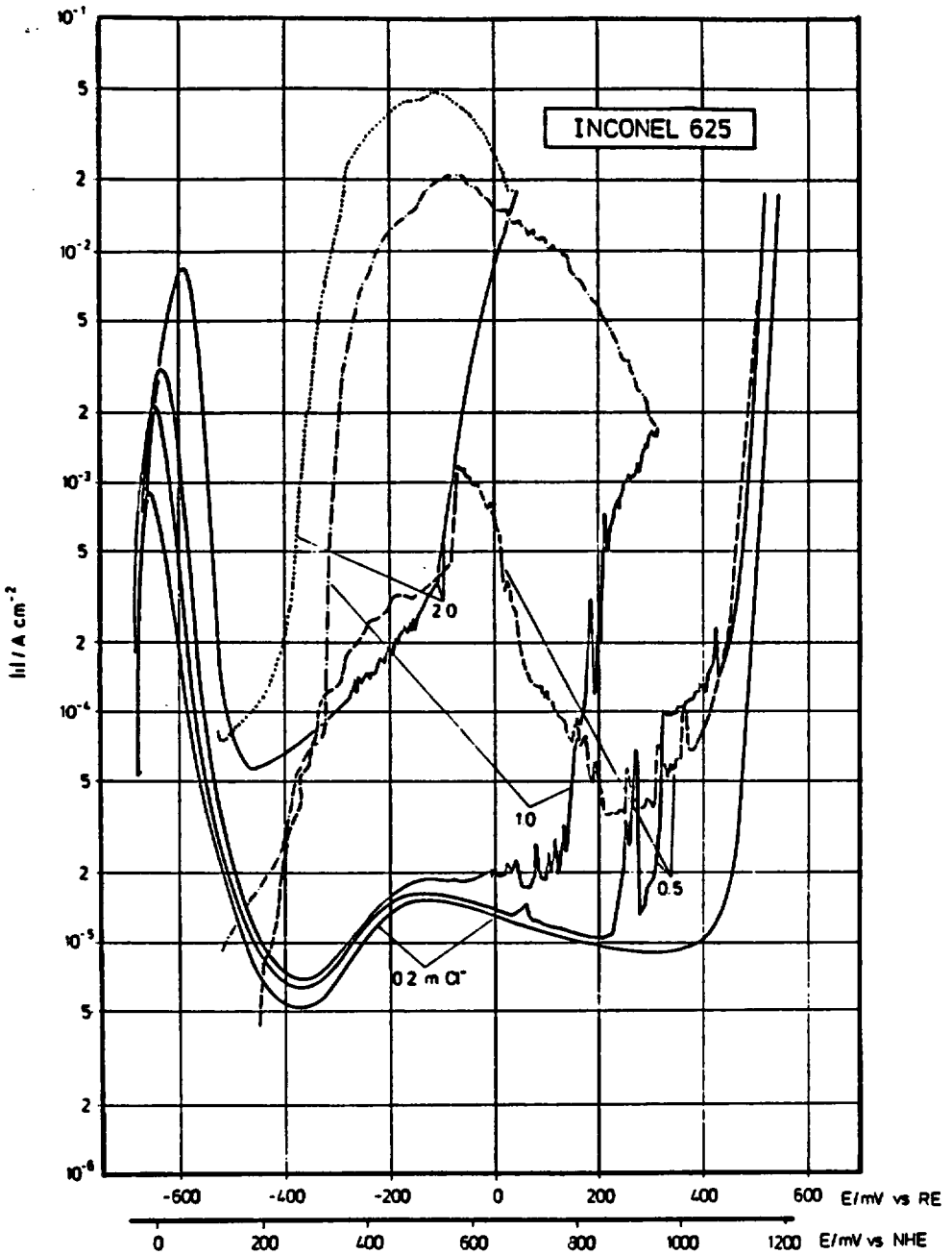


Fig. 7: Potentiodynamic Current-Density-Potential Curves
($dE/dt = 0.2\ mVs^{-1}$)
System: INCONEL 625 / 1m $H_2SO_4$ + xm KCl,
x = 0.2, 0.5, 1.0, 2.0 /$H_2$ / T = 367 K

As next parameter the pH-value was varied. As expected, an increase of the pH-value extends the passive region to more negative values, the passive current density decreases. The variation of the pH-value does not affect the critical pitting potential, as can be seen from fig. 8.

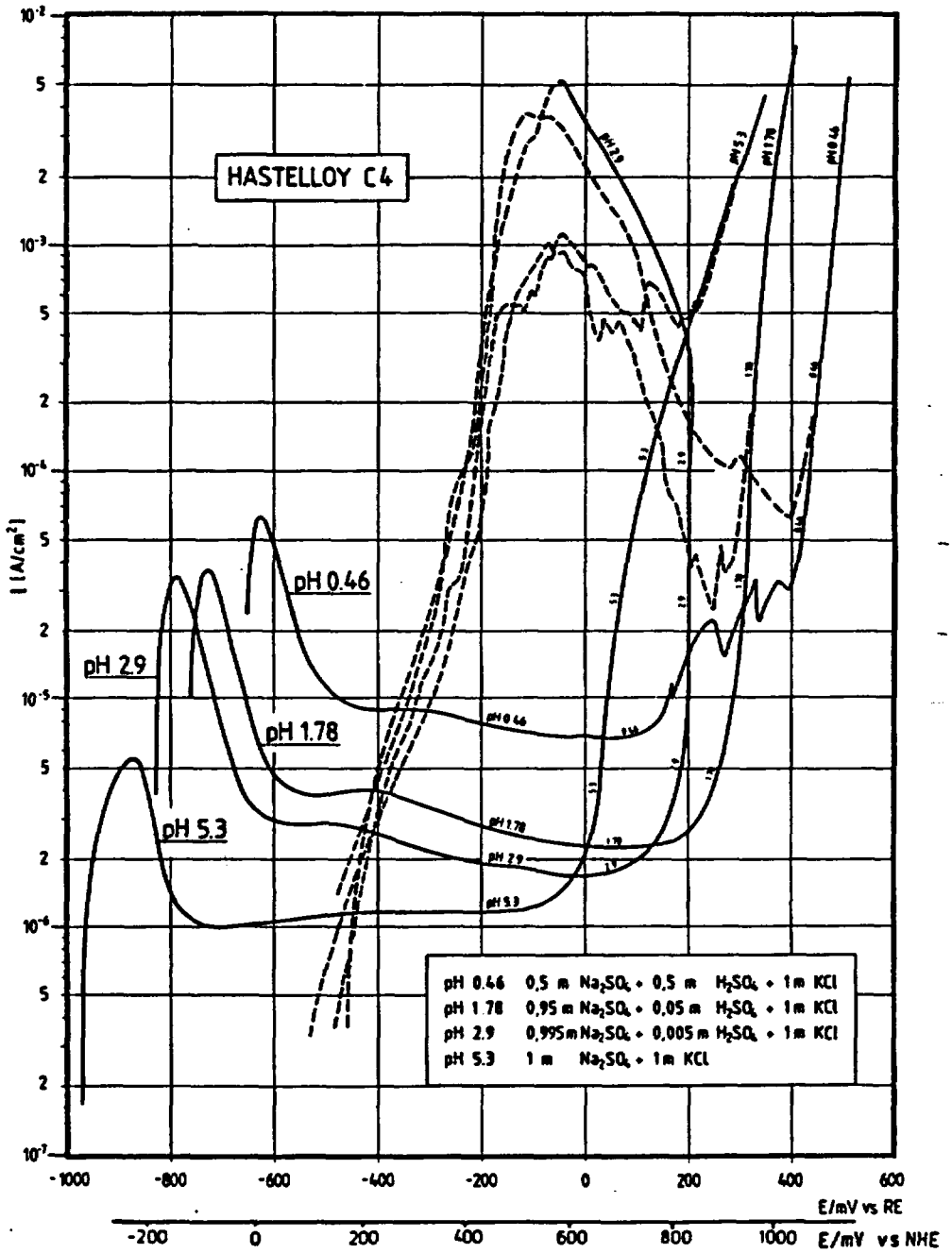


Fig. 8: Potentiodynamic Current-Density-Potential Curves ($dE/dt = 0.2\ mVs^{-1}$)
System: HASTELLOY C4 / x m $H_2SO_4$ + y m $Na_2SO_4$ + 1 m KCl / $0 \leq x \leq 1$, $x + y = 1$ / $H_2$ / T = 367 K

## 4. Conclusions

All tested alloys showed a clearly limited resistance against pitting corrosion phenomena.

However, the best corrosion behaviour is shown by HASTELLOY C4, which has of all tested alloys the lowest passivation current density and the largest potential region with protection against local corrosion phenomena.

Further investigations will now be directed towards the corrosion allowance concept, i.e. electrochemical corrosion testing of low carbon steels under various conditions will be performed.

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# APPENDIX H

## R&D WORK ON GEOLOGIC DISPOSAL OF DISSOLVER SLUDGES, CLADDINGS, AND SPENT HTGR FUEL ELEMENTS IN THE FEDERAL REPUBLIC OF GERMANY

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INTERNATIONAL ATOMIC ENERGY AGENCY

INTERNATIONAL SYMPOSIUM ON THE SITING, DESIGN AND CONSTRUCTION OF UNDERGROUND REPOSITORIES FOR RADIOACTIVE WASTES

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# R&D WORK ON GEOLOGIC DISPOSAL OF DISSOLVER SLUDGES, CLADDINGS, AND SPENT HTGR FUEL ELEMENTS IN THE FEDERAL REPUBLIC OF GERMANY

## ABSTRACT

The Bundesminister für Forschung und Technologie (BMFT, Federal Ministry for Research and Technology) is sponsoring a project at the Kernforschungsanlage Jülich (KFA, Juelich Nuclear Research Centre) entitled "MAW and HTR Fuel Element Test Disposal in Boreholes". The aim of this project is to develop a technique for the final disposal of (1) dissolver sludge, (2) cladding hulls/structural components and (3) spent HTR fuel elements in untubed boreholes in salt, and to test this technique in the abandoned Asse salt mine, including safety calculations and safety engineering demonstrations. The project is divided into the sub-projects I "Disposal/sealing technique" and II "Retrievable disposal test". In sub-project I, prototypical components for the disposal of MAW packages in boreholes and for the sealing of these boreholes in a final repository will be developed, fabricated and tested inactively in the Asse. The conceptual design of the components will be completed at the end of 1986. In sub-project II, the gas release from the MAW packages will be determined in a hot-cell experiment, and the safe underground handling of MAW and spent HTR fuel elements will be demonstrated by a retrievable test disposal with real waste packages in the Asse, using well-known or slightly modified handling components. Installation of the hot-cell experiment is being completed, the start of the retrievable test disposal is scheduled for the middle of 1987. The overall project comprises a period from 1983 to 1992. Implementation of the project involves the Bundesanstalt für Geowissen-

schaften und Rohstoffe (BGR, Federal Geological Survey), the Physikalisch-Technische Bundesanstalt (PTB, Physical-Technical Fed. Inst.), the Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen (DWK, German Company for Spent Fuel Element Reprocessing), and the Gesellschaft für Strahlen- und Umweltforschung (GSF, Radiation and Environmental Research Company), under scientific and technical guidance of KFA.

## 1. INTRODUCTION

The evidence of the basic safety engineering feasibility of final disposal concepts for radioactive waste requires the development and prototype testing of new techniques. Final disposal techniques for low and medium active waste (LAW, MAW) with negligible heat generation have been developed and are part of the Federal Republic of Germany's conceptual design for the final disposal of those types of waste. For radioactive waste with perceptible heat generation like high-active waste (HAW), certain types of MAW, and spent fuel elements from high-temperature reactors (HTR-FE), corresponding techniques still have to be provided for final disposal in salt formations [1]. The corresponding R&D programmes are conducted by GSF and KFA, with the Inst. für Tieflagerung (Deep Disposal Inst.) of GSF being responsible for the HAW disposal test in the Asse mine [2].

With respect to the final disposal of heat-generating MAW (dissolver sludge, cladding hulls/structural components) from reprocessing and of spent HTR-FE, the BMFT has charged the Institut für Chemische Technologie der Nuklearen Entsorgung (Institute of Chemical Technology for Nuclear Waste Management) at the KFA with the development of the so-called MAW borehole technqiue. In this connection work is being performed

in a project entitled "MAW and HTR Fuel Element Test Disposal in Boreholes".

## 2. OBJECTIVES AND BOUNDARY CONDITIONS

The main objective of the project mentioned above is to develop a technique for the final disposal of heat-generating MAW and spent HTR-FE in untubed vertical boreholes in salt, and to test this technique under real conditions in a salt mine.

In order to achieve this objective, the project has been divided into two sub-projects with the following main working items:

I Disposal/sealing technique
- development of components for the MAW borehole technique which may be used in Germany's final repository at Gorleben
- cold testing (i.e. without real waste) of the prototypic components in the Asse.

II Retrievable disposal test
- determination of gas release from MAW packages
- retrievable test disposal with real waste packages in the Asse.

The technical boundary conditions and the timetable of the project are determined by the plans for the Gorleben repository, the conditions in the Asse test facility, and the waste packages available.

From PTB's timetable made up for the repository in Gorleben involving presentation of the safety report in 1992, it follows that basic results of the project must be available in early 1990.

Due to the specific licensing conditions of the Asse salt mine it must be guaranteed that the radioactive waste packages disposed of experimentally can be reliably retrieved at all times, and that they will be removed from the Asse after termination of the 5 years test disposal.

Waste packages for the retrievable disposal test are available from the Wiederaufarbeitungsanlage Karlsruhe (WAK, Karlsruhe reprocessing plant) and from the high-temperature gas-cooled AVR reactor in Juelich.

## 3. IMPLEMENTATION

The project is being jointly planned and implemented by KFA and GSF, under the scientific and technical guidance of KFA. GSF is acting as applicant for implementation of the in-situ test in the Asse, and is responsible for mining and geotechnics. PTB (planning of the Gorleben repository) and DWK (Operator of the reprocessing plant) are also involved. This guaranties that the results of the project can be included to the fullest possible extent in planning the Gorleben final repository. In addition, BGR is responsible for geomechanical computations.

In-situ testing will be conducted in the abandoned Asse salt mine near Wolfenbuettel in the State of Lower Saxony in the northern part of Germany. Fig. 1 represents a simplified view of the 800 m-level of the Asse, where the tests will take place. Two separate MAW test drifts "EV" and "BV" for the two sub-projects are foreseen there in the older rock salt Na2. Depth and surroundings correspond to the plans for the Gorleben repository. Although being nearly, the HAW test field doesn't have any thermal influence on the MAW test.

### 3.1 Disposal/sealing technique

The technique for the final disposal of MAW and HTR-FE packages in vertical boreholes,in salt and for the sealing of these boreholes is designed bearing in mind its commercial application in a final repository. The basis for the design are the plans for the Gorleben repository and the reference concepts for the MAW packages developed by the DWK as waste producer.

It is assumed ,that the spent fuel elements arising from the two gas-cooled HTR's being in operation in Germany will be disposed of in the type of package mentioned above. Hence, the same disposal/ sealing technique can be used.

In order to simplify the operation of the planned final repository, the MAW borehole technique and the HAW borehole technique, the latter of which is subject of the HAW disposal test [2], will have to be standardized.

Fig. 2 illustrates the disposal and sealing technique for MAW with its main components, which will be designed, fabricated, and tested: 400 l standard drums with cemented waste are lowered out of a transport cask into a 300 m-deep vertical borehole, using a disposal machine, which is equipped with a grapple system. Apart from the lowering-phase, the borehole is closed with a slide. If necessary, the annular gap between the drum and the wall of the borehole may be filled with crushed salt, and the stacking forces may be dissipated into the borehole wall, using a simple spreading device positioned between a certain number of packages.

When the borehole is filled with waste drums up to 10 m below the drift, the slide will be removed, and a plug will be inserted. The plug has to provide

for radiation shielding as well as sealing against radioactive gases (during normal operation) and brine (in case of an accident). As indicated in Fig. 2, the plugging system may simply consist of crushed salt covered with a slab of salt concrete, but more complex constructions might become necessary for reasons of radiation protection of the personnel.

This MAW borehole technique will be tested in situ in the MAW test drift BV with its 3 boreholes V1-V3, using prototypic components for handling and inactive dummies for the MAW packages.

Borehole V1, having a depth of 10 m, serves to demonstrate the gas tightness of the final disposal plug as a function of time at a relevant temperature. For this purpose, inactive test gases like hydrogen and krypton will be injected at the bottom of the borehole, and the migration of these gases through the plug will be measured.

Borehole V2 will be operated without a plug and is envisaged for control measurements.

Borehole V3 has a depth of about 30 m and serves to demonstrate the commercial feasibility of the disposal and sealing technique. Inactive 400 l-drums will be emplaced using the prototype technique, and the borehole will be sealed with the plug. The mechanical properties of the plug will be determined from samples taken by core drilling.

In order to simulate a temperature level of about 70°C in the salt relevant for the final repository during the operating phase of a MAW disposal drift, electric heaters will be installed around the boreholes. Pressure built-up, borehole convergence and temperatures will be measured and compared with computations predicting these parameters.

### 3.2 Retrievable disposal test

The safe underground handling and emplacement of MAW and HTR-FE is demonstrated in a retrievable disposal test with a limited number of radioactive waste packages. The test design is influenced by the specific situation in the Asse salt mine and the waste packages available. As far as possible, well-known components which have already been applied in the Asse will be used.

200 l standard drums with MAW are available from reprocessing of PWR fuel with a burn-up of 39 GWd/t. As an example, Fig. 3 shows schematically the drum with structural components of two of those fuel elements. The structural components are fixed with cement in a removable insert, which is used due to the inevitable surface contamination during the filling procedure in the WAK. The outer drum is equipped with a lid having a lifting ring, which is compatible with an existing grapple system.

With the same design, two drums with Zircaloy cladding, and three drums with dissolver sludge on a filter unit will be available for the disposal test. Here, total activities, surface dose rates, and heat production for those waste drums are smaller than the numbers given in Fig. 3.

In addition, four stainless-steel cans with spent spherical fuel elements from the german high-temperature test reactor AVR will be available for the retrievable disposal test. Fig. 4 illustrates the design of the can which is currently being used for dry intermediate storage, and gives characteristic data.

One main objective of the project's investigations is to quantify the release of radioactive and non-radioactive gases from the waste packages, which

could affect the radiological as well as the working safety of the personnel and the environment. Tritium, krypton-85 and hydrogen have to be taken into consideration. Hence, prior to the in-situ disposal test the reprocessing waste packages will be checked for at least one year in an hot-cell experiment in the KFA. The six 200 l-drums will be put separately into gas-tight overpacks and checked for the gases mentioned above. Electrical heating of the overpacks to simulate the temperature in a borehole in a final depository is provided, the temperature inside the waste drums will be checked by resistance thermometers. Similar measurements have already been done for the fuel element cans.

After the hot-cell testing, the waste packages will be emplaced for up to five years during the retrievable disposal test. Fig. 5 illustrates the MAW test drift EV, where the in-situ testing will take place. Five boreholes with a depth of 10 m each and a diameter of 1 m are foreseen.

Borehole E5 (precursory test) serves for optical inspection of the borehole convergence. Inspection will start at least one year before the start of the radioactive in-situ test itself. As well as borehole E1 (reserve), this borehole is operated without radioactive waste.

The remaining boreholes accomodate the radioactive waste packages with dissolver sludge (three in borehole E2), cladding hulls and structural components (three in borehole E3), and spent HTR fuel elements (four in borehole E4), which will be removed from the Asse after the completion of the test. These boreholes are closed with a slide. Measuring lines are led into cabinet racks, which are connected to a computer-supported data logging in an air-conditioned measuring container.

Fig. 6 shows as an example the equipment of borehole E3. The reliable retrieval of the disposed MAW packages at all times during the test has to be guaranteed. Due to the relatively small borehole convergence expected at a temperature less than 55°C, this is achieved by stacking the packages in an open storage rack, and with a sufficiently dimensioned annular gap between the rack and the untubed borehole wall. Convergence has been pre-calculated by geomechanical computation, the diameter of the remaining gap will be surveyed during the disposal test by redundant distance meters. Temperature and concentration of gases (hydrogen, tritium, krypton) in the borehole will be measured together with the inclination of the rack during the disposal test.

## 4. TIMETABLE

The general timetable of the project is given in Fig. 7. It is oriented towards the PTB structure plan for the Gorleben repository, which requires presentation of basic results of this project in early 1990. The status of the project as of March 1986 is as follows:

In sub-project I, the conceptual design of prototypic components will be finished in most parts at the end of this year. Inactive testing of the prototypes in the Asse is scheduled to start in late 1987.

In sub-project II, the modified components are designed and in parts fabricated. The hot-cell experiment is installed and ready for starting. The test drift EV in the Asse is being excavated. According to current planning, starting of the fully-active disposal test is scheduled for the second half of 1987.

## REFERENCES


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[2] KÜHN, K., ROTHFUCHS, T., "High-level radioactive waste test disposal, Asse salt mine, Fed. Rep. of Germany", High-Level Nuclear Waste Disposal (ANS Int. Topical Meeting, Pasco, 1985) PNL, Richland, WA, to be published.

## List of Figures

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FIG. 7: Timetable of the project

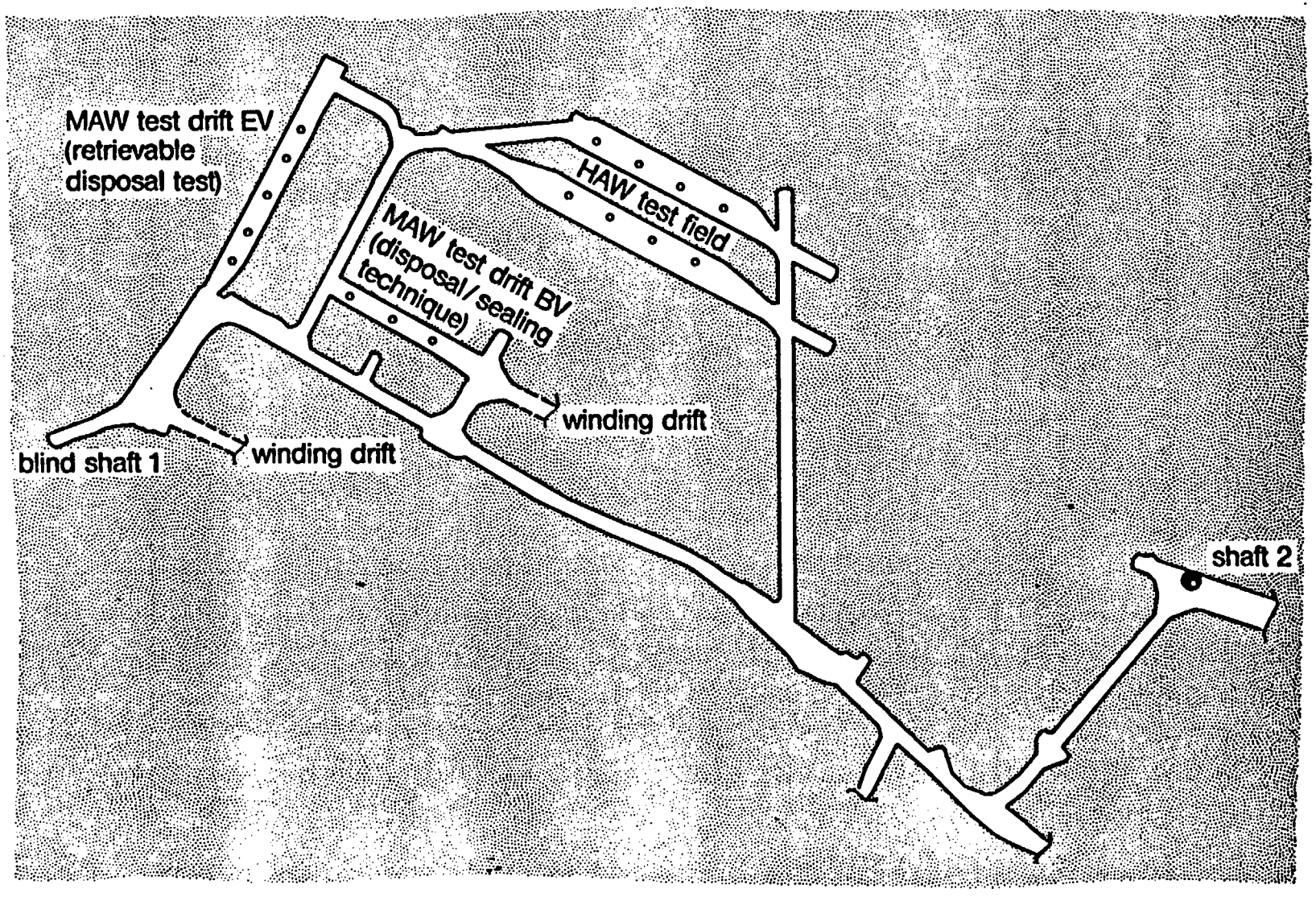



FIG. 1: Test drifts at the 800 m level of the Asse salt mine

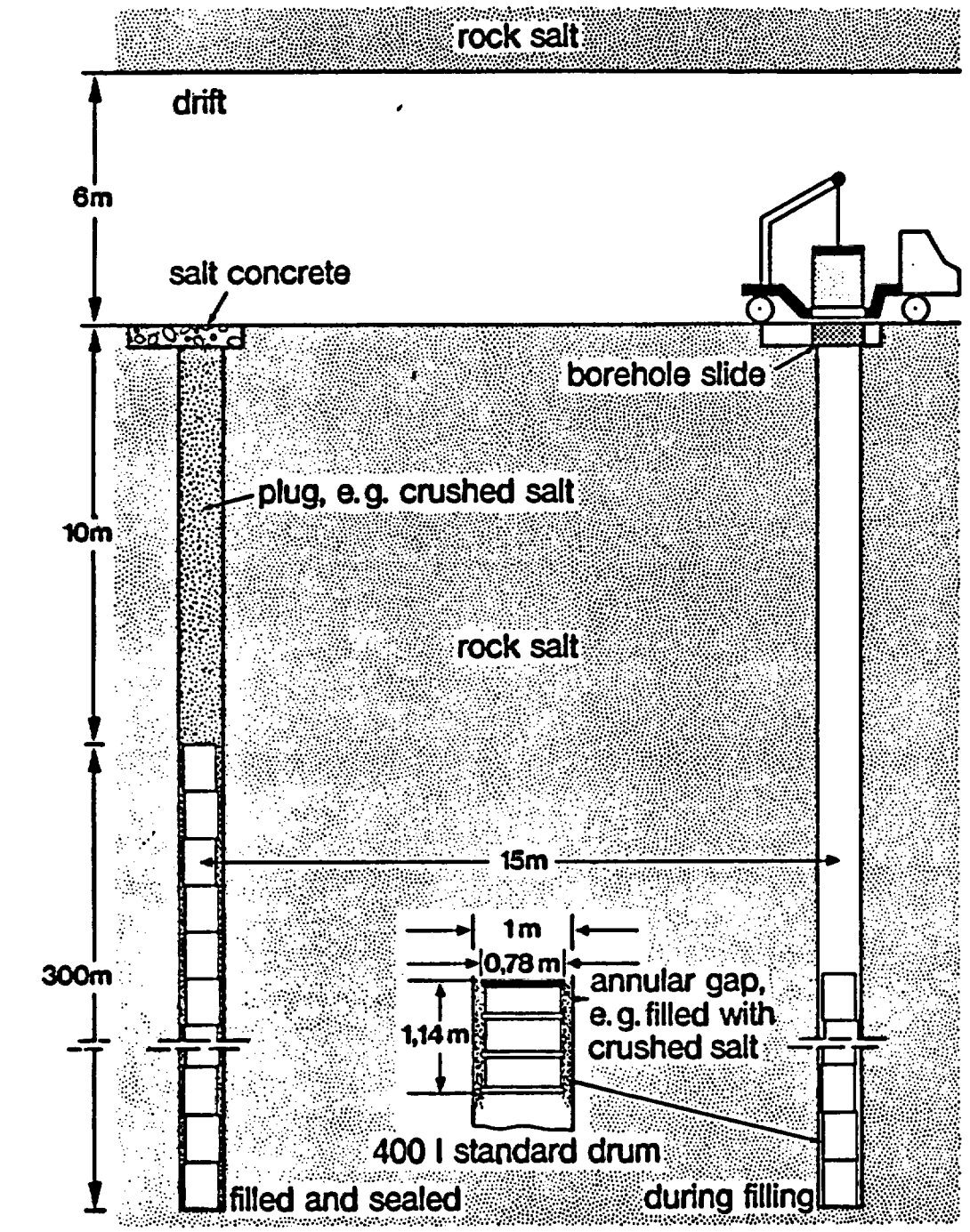
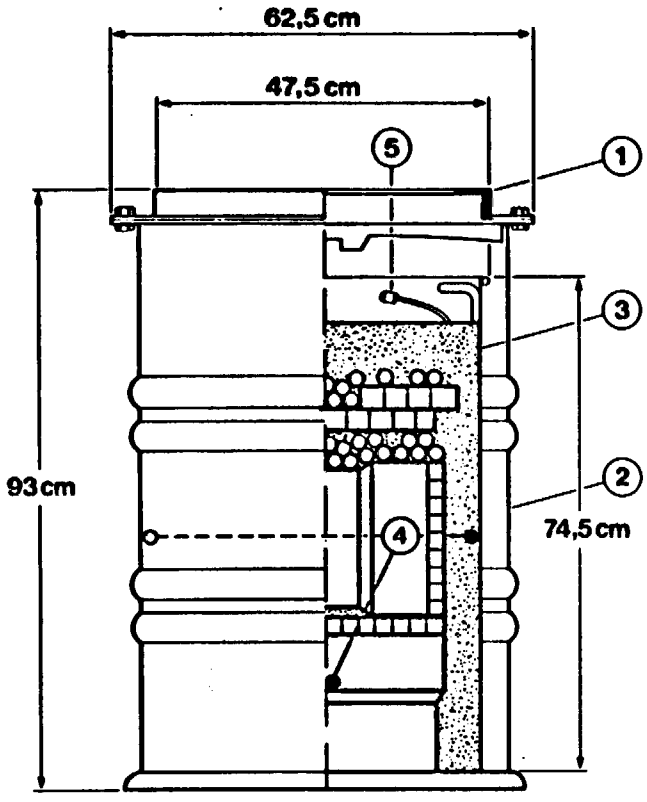



FIG. 2: Untubed vertical boreholes for final disposal of heat-producing MAW and HTR-FE




① lid with lifting ring
② 200 l drum
③ removable insert
④ resistance thermometer
⑤ plug-type connection

| | |
|---|---|
| content: | max. 105 kg structural components |
| mass: | 500 kg |
| total activity: | $3{,}9 \cdot 10^{14}$ Bq/drum* |
| surface dose rate: | 600 Gy/hour* |
| heat production: | 98 W/drum* |

*2 PWR fuel elements, 5 years after discharge

FIG. 3: Retrievable disposal test: 200 l standard drum with structural components fixed with cement

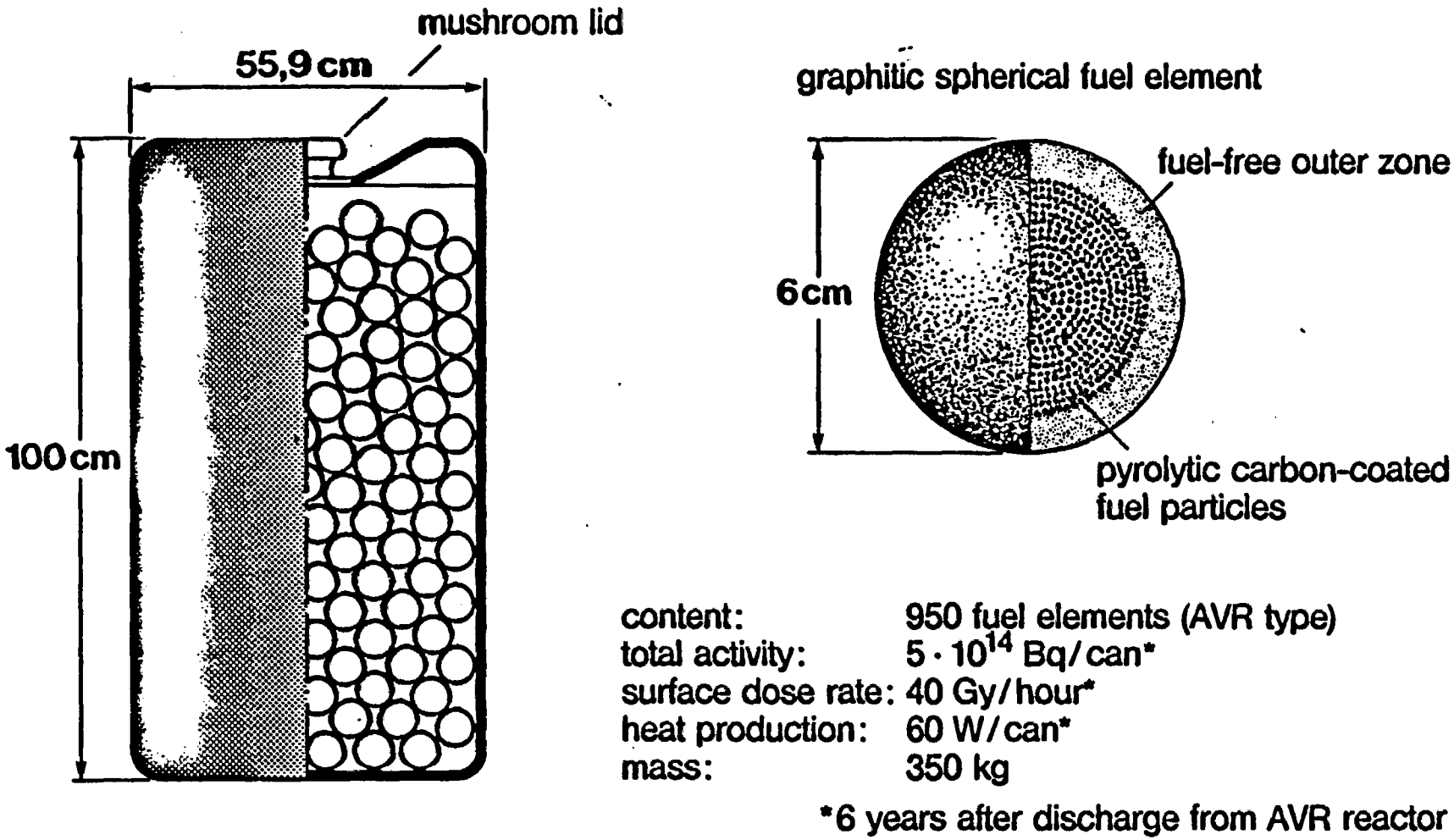
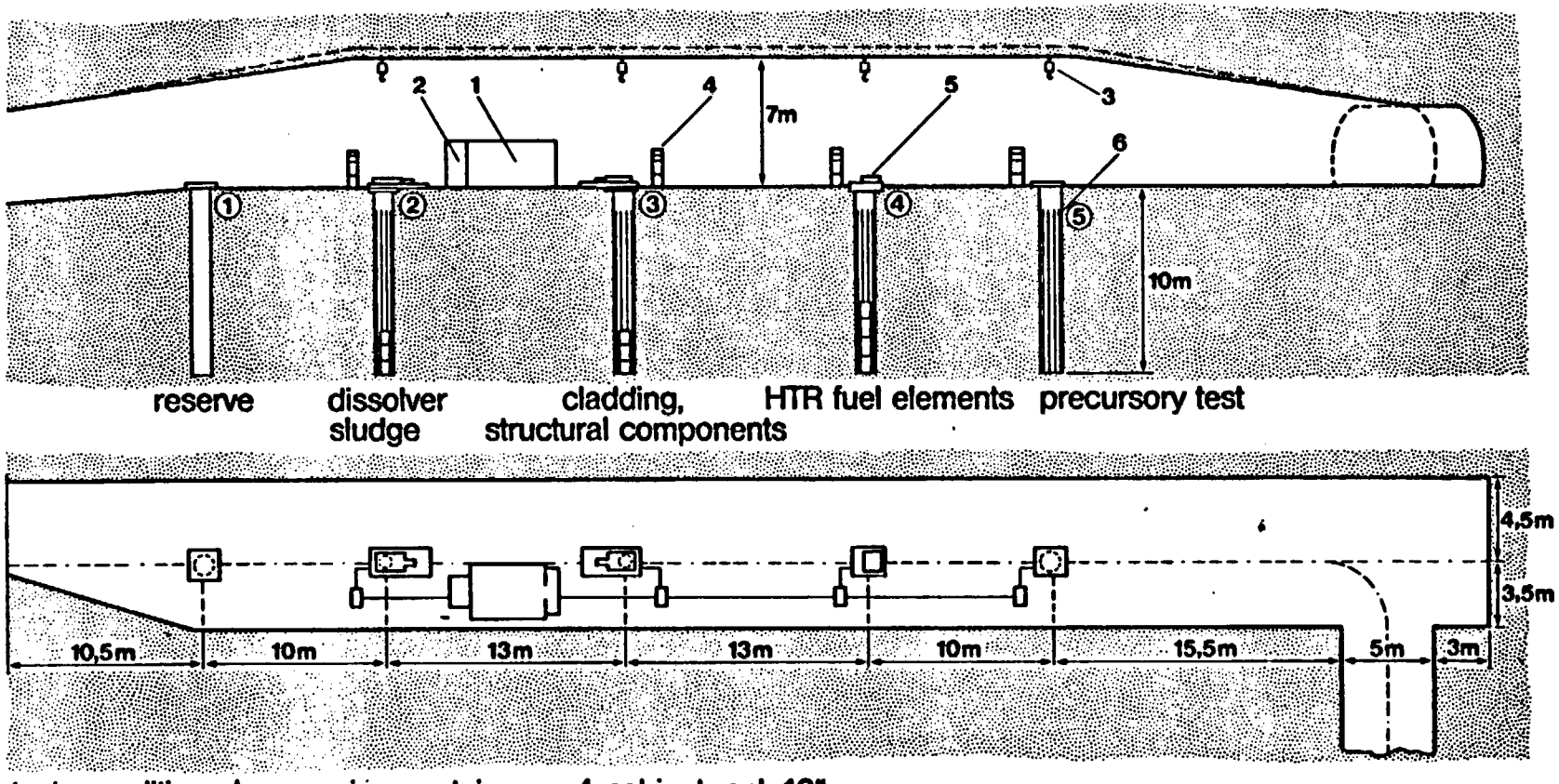



FIG. 4: Retrievable disposal test: stainless steel can (AVR-TL type) with spent HTR fuel elements




1 air-conditioned measuring container
2 entrance lock
3 crane
4 cabinet rack 19"
5 borehole slide
6 storage rack

FIG. 5: Schematic view of the MAW test drift EV (retrievable disposal test)

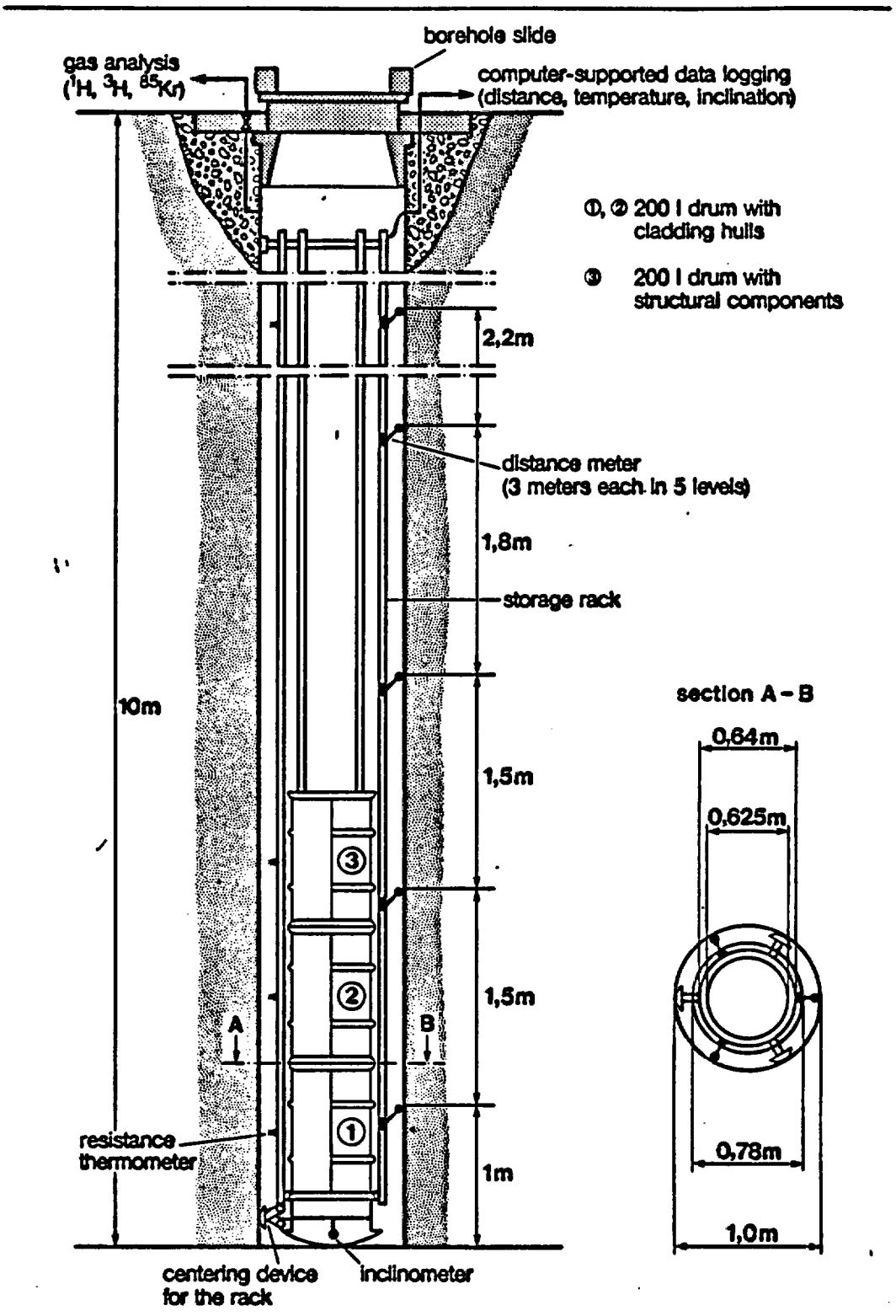



FIG. 6: Equipment of borehole E3 in the MAW test drift EV (retrievable disposal test with three waste drums containing cladding hulls/structural components)

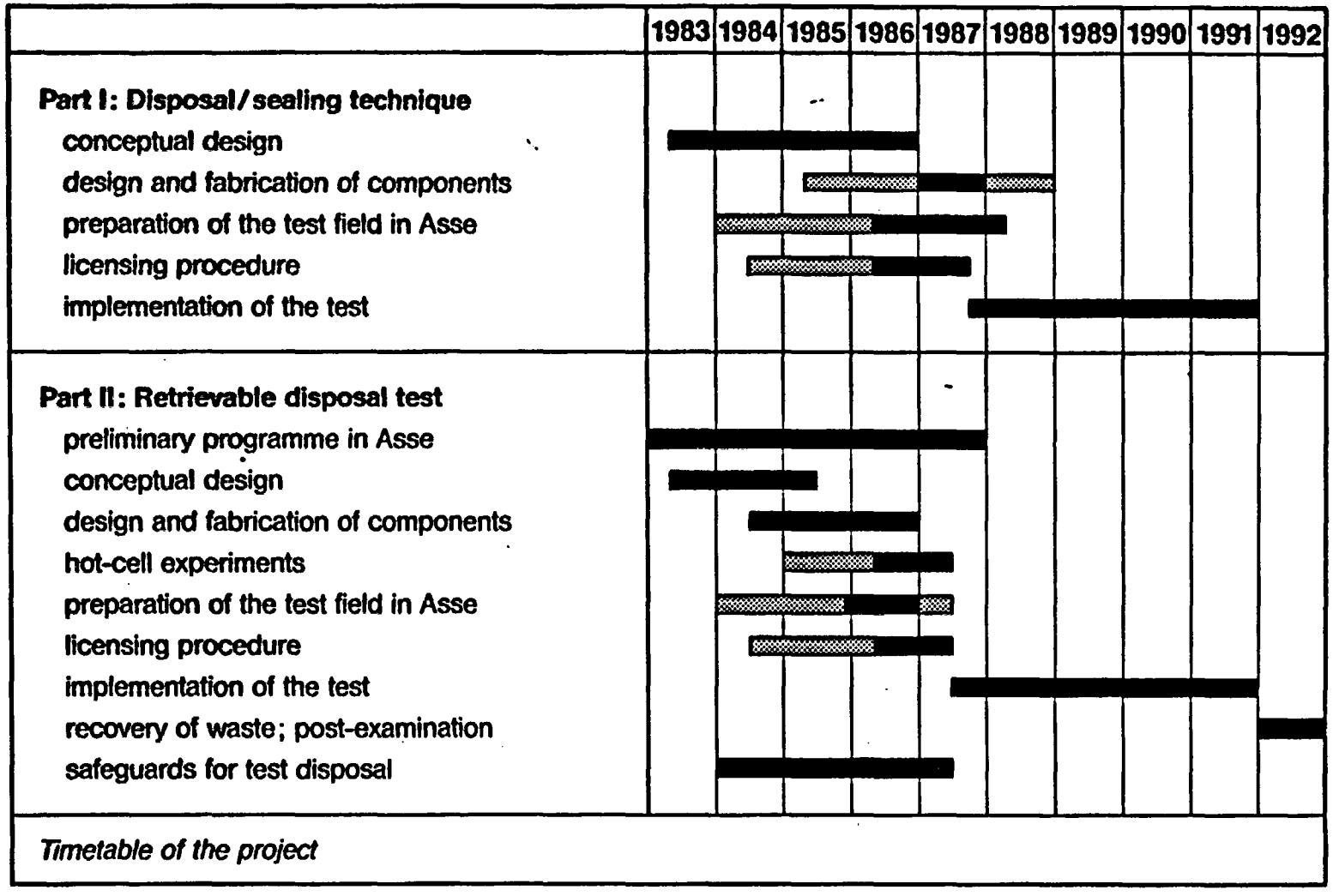



FIG. 7: Timetable of the project

# APPENDIX I

## U.S. DOE VISIT TO CEN/SCK MOL FACILITY

J. STRAHL

## ENCLOSURE 3

## USDOE VISIT TO CEN/SCK MOL FACILITY: (October 9, 1986)

On October 9, 1986, a group of DOE personnel and contractors visited the disposal R&D facility in Mol, Belgium, to obtain information on the current status of activities being performed in Boom clay. This information will assist in the identification of any work which may be of interest to the OCRWM disposal program. Participants in the Mol briefing and visit are presented in Attachment E3-1. The U.S. participants responsibilities are defined in Enclosures 1 and 2.

A. Bonne of the Nuclear Energy Research Center (CEN/SCK) provided the U.S. group with an overview of the activities in support of the Mol facility. He indicated that the National Institute for Radioactive Wastes and Fissile Materials (ONDRAF/NIRAS) is responsible to identify the requirements for the R&D program. He further added that the Commission of the European Communities has not been a major contributor to the Mol activities recently and is not involved in the radionuclide migration experiments being performed at the facility. The Mol facility is currently considered an R&D laboratory chartered to test the feasibility of Boom clay to adequately serve as a media for the disposal of HLW.

If the site proves acceptable from an R&D standpoint, the CEN/SCK will submit a license application for the disposal of HLW at Mol. It is currently anticipated that the site could be recategorized as a repository within the next five years. The Compagnie Generale des Matieres Nucleaires (COGEMA), currently reprocessing the Belgium fuel, may transport the HLW to the CEN/SCK by the early 1990's. Thus, a storage facility may be required at the site.

Further, assuming that the site proves to be acceptable for the disposal of HLW, another shaft will be excavated. It is currently envisioned that the shaft will be larger than the first and placed near the BELGOPROCESS to enhance receipt/handling of waste. It is expected that construction on this shaft will be initiated within the next two years (1988). The CEN/SCK is further considering the option of placement of HLW in the final excavated tunnel rather than in canister placement holes off the tunnel, since studies show that heat dissipation and nuclide retention is more effective in this configuration. Vertical emplacement of HLW canisters adjacent to the tunnel will not be used. Based on past experience, the CEN/SCK expects to freeze only that portion of the shaft which penetrates the aquifer. Conventional techniques will be utilized for excavation.

A. Bonne indicated that work at the Mol site was initiated in 1974 (Project HADES) to test clay as a media for the disposal of HLW. The seven issues being addressed by this program are identified in Attachment E3-2 along with the overall schedule of the program. The work expected to be performed in preparation for the testing and acceptance of HLW is presented in Attachment E3-3. The average depth of Boom clay is 270 meters. The experiments are being performed at a depth of approximately 230 meters. The

original shaft and horizon tunnel were excavated in clay which was frozen to ease the excavation process. The results of this work show that freezing is not necessary for most segments of the excavation and actually induced adverse expansion stresses. The CEN/SCK is currently performing several in-situ experiments, including leaching tests, migration tests, and canister corrosion tests. The experimental drift test being developed is currently being performed in cooperation with the French National Agency for Radioactive Waste Management (ANDRA). The CEN/SCK maintains a license to use Co-60 for testing at Mol. It is expected that radioactive in-situ tests will be initiated in 1987.

Unlike the U.S. process, the CEN/SCK does not require the development of detailed test procedures prior to activity implementation. The CEN/SCK developes the test procedures subsequent to the evaluation of completed activities. In addition, the results of current activities will be utilized to support the development of the Belgium Concept and Safety Report (SAFIR) being prepared by ONDRAF/NIRAS. This report, to be submitted in 1987, will discuss the validity of utilizing the option of clay disposal for HLW, although it will not specifically address the suitability of the Mol facility. The SAFIR will establish a position on the disposal concept and materials to be utilized for a canister overpack.

A. Bonne stated that only the first 20 meters of the second tunnel (to accommodate HLW) will be lined with steel. Subsequently, interlocked sliding steel tunnel liners will be used in the remainder the tunnel. These frames should adjust to external clay pressures. The CEN/SCK expects the facility activities to be sufficiently complete to accept HLW by 2020.

Dr. Neerdael provided the group with a brief overview of the Mol site geology, indicating that the Boom clay is approximately 100 meters thick. The elevation at the Mol site lies between 180 and 280 meters and the Mol experimental gallery is located at an elevation of 224 meters. The Mol access shaft, constructed with a concrete liner, required one year to complete (two separate pours). The ground was frozen for all the Phase 1 activities, including excavation of the shaft and the original 30 meter horizontal gallery. The frozen clay attracted free water in portions of unfrozen clay, creating a layer of ice on the tunnel steel lining. The new experimental drift was excavated without freezing. No adverse effects were encountered. It is currently expected that the next 5 meter diameter tunnel will be constructed without freezing the clay. Measurements have shown that the freezing technique results in a 3 cm displacement of clay, whereas subsequent equilibrium displacements of 24 mm have occurred in the experimental drift with no freezing. The east end of the original 5 meter diameter gallery is open to obtain direct measurements in clay (extensometers). Additional experiments being performed at the site include: 1) In-situ heater experiments with radioactive material; 2) Groundwater age profile; and 3) In-situ corrosion experiments. The corrosion experiments are expected to be performed over a five year period starting in November, 1986. 64 specimens, including 20 types of alloys, will be tested. The French will participate in the alloy experiments commencing in 1988.

The group subsequently toured the underground portion of the facility. Several members of the group obtained photographs of the construction and testing activities. Most members commented on the relatively small size of the facility, especially the main gallery, questioning the capability of the facility to accommodate HLW.

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Box 12