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ORNL FOREIGN TRIP REPORT

ORNL/FTR-3866

DATE: February 22, 1991

SUBJECT: Report of Foreign Travel of Benjamin F. Myers

TO: Alvin W. Trivelpiece

FROM: Benjamin F. Myers

PURPOSE: At the Joint Research Centre, Petten: to discuss proposed experiments, obtain data for analysis, and discuss issuance of final operating report for experiment HFR-B1. At the KFA Jülich: observe disassembly of HFR-B1 capsules, reach agreement on the postirradiation examination, and discuss plateout and proposed cooperative experiments.

SITES VISITED:

1/28-1/29/91	Joint Research Centre, Petten, The Netherlands
1/30-2/05/91	Forschungszentrum GmbH, Jülich, Germany
2/06-2/07/91	Zentralinstitut für Kernforschung, Rossendorf, Germany
2/08/91	Forschungszentrum GmbH, Jülich, Germany

Travel to the JRC Petten was for the purpose of discussing the analysis of experiment HFR-B1 and obtaining the data necessary for this task. Difficulties at KFA in obtaining a license for shipment of the HFR-B1 capsules to Germany has introduced a delay in the final analysis. The Petten facilities are ideal for conducting proposed experiments on iodine release and diffusion of metallic fission products in graphite. The disassembly of capsules 2 and 3 of HFR-B1 was performed at KFA. The graphite bodies, the fuel compacts that were removed, and the trays of unbonded fuel particles were in unexpectedly good condition. Agreement was reached on the procedures and operations to be performed during the postirradiation examination. Discussions on the annealing experiments at high water vapor pressures were particularly beneficial. In the future, emphasis at the KFA for

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HTR work will be on the safety analysis of the pebble bed reactor. Cooperation with the U.S. is sought, particularly on deposition of fission products and their steam-induced removal in accidents. General discussions involved fission product behavior in the fuel particle and graphite and in air ingress accidents. A visit, sponsored by the KFA, was made to the ZfK (Zentralinstitut für Kernforschung, Rossendorf). This laboratory will build two large loops and study the deposition of fission products and their removal under water ingress conditions. Cooperation with the U.S. is highly desired by this laboratory.

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COMPREHENSIVE TRIP REPORT

INTRODUCTION

The traveler visited the Joint Research Centre (JRC), Petten, The Netherlands, the Forschungszentrum GmbH (KFA), Jülich, Germany; and the Zentralinstitut für Kernforschung (ZfK), Rossendorf, Germany, during the period January 28 through February 9. At JRC, the analysis of the experiment HFR-B1 was discussed; a new schedule for issuance of the final data report was established. Other discussions at JRC concerned the capabilities of Petten to conduct two reactor experiments being proposed under the US/FRG cooperative program and the initial results of a proof test of German fuel spheres. At KFA, the main emphasis was on the disassembly of capsules 2 and 3 of the HFR-B1 experiment and agreement on the examinations and tests to be conducted with the disassembled components. The disassembly of capsule 3 was observed. Extensive discussions were conducted on the work, both experimental and analytical, being conducted in the Institut für Sicherheitsforschung und Reaktor Technologie. A major portion of the experimental work is being conducted at ZfK and a visit to this laboratory, sponsored by the KFA, was made on February 6 and 7. Cooperation with the U.S. on the experimental and analytical work in the safety area was strongly emphasized.

VISIT TO JRC, PETTEN, THE NETHERLANDS

The traveler visited the JRC Petten on January 28-29 and again on February 9 to confer with Dr. R. Conrad.

The Final Data Report

The final data report will not be issued until September 1991. This represents a delay of one year in the HFR-B1 schedule. Difficulties at KFA with obtaining a license for shipping the three capsules of the HFR-B1 experiment from Petten to KFA were the main cause for the delay. The delay in issuance of the report stems largely from the need for the results of the postirradiation examination (PIE) of the fluence detectors, the gamma-scanning wires, and the gamma scans of the graphite fuel bodies. When these data are available, the thermal and neutronic analyses can be completed. Only data from capsules 2 and 3 will be available in a timely manner; capsule 1 has to be shipped to ORNL and the data could be obtained only after the JRC need date. The expected date of reception at JRC from KFA of the fluence detectors is March; the gamma scan wires will be analyzed at KFA and the results sent to JRC; the gamma scans of the graphite bodies has been completed at KFA and the results received by JRC. It is the opinion of Dr. Conrad that the data from capsules 2 and 3 will be sufficient to complete the analyses.

To insure the issuance of the final report on schedule, Dr. Conrad would need assistance for a period of one month by either the traveler or Mr. Burnette who worked at Petten on the HFR-B1 experiment in 1989 and 1990. Beyond the issuance date, no further corrections in the data would be made.

The fission gas release data appearing graphically in Technical Memorandum HFR/90/3082 may be incorrect. The ORIGEN code was used to obtain these data but there were problems with the input parameters. These problems have been discussed at Petten and the code brought in line with previous results at Petten using another procedure. In the final calculations, using the data from fluence detectors, gamma-scanning wires and the gamma scans of the graphite fuel bodies in capsules 2 and 3, two methods will be used, one involving the ORIGEN code and one involving the usual Petten procedure.

Fission Gas Release

In the proof test of German fuel spheres being conducted in the HFR at Petten, very good time resolution (of the order of minutes) in R/B measurements has been achieved. In one of the spheres with one defective particle, a change in temperature (from 800 to 1000°C) through change in the neon content of the sweep gas has resulted in an initial increase and a subsequent decrease to a steady value of the fractional fission gas release (R/B). This behavior has previously been observed in the HRB-17 and -18 experiments conducted at ORNL. In the German sphere without defective particles but only contamination, this initial transient was not observed. These results indicate that the subsequent decrease in R/B is attributable to a slower gas phase diffusion of the krypton and xenon in the pores of the fuel (kernel). A quick calculation by the traveler indicated that the transient effect could be ascribed to the diffusive release of fission gas.

A second, unexplained observation on the sphere with defective particle revealed that, for the isotopes ^{135}Xe and ^{135m}Xe and no others, raising the temperature through addition of neon to the helium sweep gas resulted in a decrease in R/B and vice versa.

Proposed Cooperative Experiments

Proposals for two experiments in the HFR, cooperative efforts by the KFA and ORNL, were further discussed. One experiment would involve the release, deposition and reaction with water vapor of iodine; a reverse flow configuration would permit isolation of released and deposited iodine with means to inject water vapor into the isolation chamber. The other experiment would involve the transport of condensible fission products through graphite at temperatures in the range 800 to 1400°C. The space available in the HFR would be about 30 mm diam by 800 to 950 mm length. The two experiments could be conducted in one or two capsules. The capabilities at Petten, on line gas measurements, removal and insertion

of samples on a cycle basis, experience with graphite machining, gamma counting, the accessible temperature range, water vapor addition and monitoring, gas chromatographic measurements on effluents, construction of some components and overall experience with complicated fission product transport experiments in reactor are well suited, and for some capabilities, uniquely suited to the proposed experiments. Proposals will be written in detail and reviewed by JRC Petten by June 1991 after which they will be submitted at the management meeting on the US/FRG Umbrella Agreement for Cooperation in Gas Cooled Reactor Development in mid 1991.

VISIT TO THE KFA, JÜLICH, FRG

The traveler visited the KFA Jülich in the periods January 30 to February 5 and again on February 8.

The PIE of HFR-B1 at KFA

The PIE of capsules 2 and 3 from the HFR-B1 experiments was begun during the period of the traveler's visit. For capsules 2 and 3, the graphite fuel bodies were removed from the metal containers and appeared to be in good condition without visible damage. The end portions of the metal containers and the heat shields were also in good condition. The graphite bodies were gamma scanned for ^{144}Ce, ^{134}Cs, ^{137}Cs, ^{106}Ru, ^{95}Zr, ^{95}Nb and ^{60}Co and the steel containers for ^{54}Mn, ^{51}Cr, ^{137}Cs, ^{134}Cs and ^{60}Co. The further disassembly of capsule 3 proceeded by removal of the fuel compacts in one of the three fuel holes; the other two fuel holes will be left undisturbed until heating experiments are begun. After removing the screw cap, the top two fuel compacts were removed using a vacuum probe; the bottom two compacts were easily removed by pushing on the bottom plug. The uppermost compact showed about 16 free particles at the top end but otherwise was in excellent condition as were all the surfaces on the other three compacts which showed no such free particles. On closer examination, the surfaces on all compacts were slightly pitted and had small, short, shallow channels on the surfaces apparently independent of the circumferential location. Next, the screw cap from the central (piggyback) hole was removed and ten trays of unbonded particles were recovered with the vacuum probe; all trays were in excellent condition.

The fuel compacts from capsule 3 of the HFR-B1 were in surprisingly good condition as compared to the compacts irradiated in HRB-17 and -18 in spite of the higher water vapor exposure and higher temperatures in the HFR-B1 compacts. In the HFR, the water vapor had to pass through the graphite body to reach the fuel compacts and thus was generally moving perpendicularly to the vertical surfaces of the fuel compacts; whereas in the HFIR (experiments HRB-17, -18), the water vapor was moving parallel to the vertical surfaces between a graphite sleeve and these surfaces. The excessive reaction of the fuel compact matrix material with water vapor in the HFIR experiment, which exposed a large number of fuel particles, occurred at both ends of the fuel compacts, locations at which

relatively large flow disturbances could be expected. Similar relatively large flow disturbances would not be expected to occur in the HFR except perhaps at the top of the uppermost compact; above this position there was a void which could induce a flow disturbance. Consequently, the better condition of the fuel compacts in the HFR experiment may be attributable to a gas flow pattern with weaker disturbances.

The postirradiation examinations and tests as understood and documented by the KFA were carefully reviewed. The major change on which agreement was reached is the following. Each graphite body from capsules 2 and 3 which were to be cut into one-third portions, are now to be cut into one-sixth portions. Four of the six portions will contain two fuel compacts in the same relation to the graphite body as before cutting and two portions will be without fuel compacts, four compacts having been removed as described above. The eight one-sixth fueled graphite bodies will be used in heating tests; the conditions of the heating tests are given in Table 1. The tests in which 1 kPa of water vapor is to be injected will be conducted first; the results of these test will then be used to select the water vapor pressure for the two tests at high pressure. After the heating tests are completed, four fuel compacts rather than two are to be disintegrated; the particular samples are indicated in Table 1.

The configuration of the fuel compacts and graphite bodies in the heating tests was discussed. An arrangement in which the carrier gas with added water vapor flows parallel to and over the vertical wall of the fuel compacts is desired so that, for the tests at 1000°C, reaction of the water vapor with the graphite body does not reduce the intended water vapor concentration. With this arrangement, the temperature dependence of fission gas release at a water vapor pressure of 1 kPa can be evaluated from tests at 800 and 1000°C.

Arrangements have been made to hold weekly telephone conversations on the progress of the PIE of capsules 2 and 3.

Safety Research at KFA

The Institut für Nukleare Sicherheitsforschung (ISF) has now become the Institut für Sicherheitsforschung und Reaktor Technologie (ISR). Prof. Hicken (Bochum) is responsible for the safety research and Prof. Kugeler (Aachen) for the reactor technology. In fact, an addition to the ISF building is under construction. Dr. Moormann and the traveler spoke with Prof. Hicken. A major safety analysis on the pebble bed reactor will be conducted in the next two years. A safety study has been conducted for Fuji Electric under depressurization (dry) conditions and the study will continue for the case of water ingress. Any further PIE of the AVR and the THTR is questionable although there are plans. Also, there is emphasis on experimentation and analysis of air ingress accidents in the HTR. The experimental efforts are continuing ones of Dr. Schenk on heating experiments and Dr. Loeniβen on air oxidation of fuel spheres.

Table 1. Major conditions of the postirradiation heating tests on portions of capsules 2 and 3 of the HFR-B1 experiments

Description of Specimen	Capsule Origin	Water Vapor Pressure (kPa)	T(°C)	Compact Disintegration
1/6 graphite body	2	0	1600	x
1/6 graphite body	2	1	800	
1/6 graphite body	2	1	1000	
1/6 graphite body	2	$10 \leq P \leq 70$	800	x
1/6 graphite body	3	0	1600	x
1/6 graphite body	3	1	800	
1/6 graphite body	3	1	1000	
1/6 graphite body	3	$10 \leq P \leq 70$	800	x

Emphasis is being placed on the primary circuit of the HTR in the interest of reactors with higher outlet temperatures. As the experimental work in the other institutes of the KFA is being terminated, particularly in regard to the primary circuit, the work is being shifted to the ZfK (see below). Prof. Hicken is supportive of the ZfK and would like cooperation with the U.S. in this area. He suggests that a scientist from the ZfK be sent to the U.S. for a short period to confer with scientists at ORNL, General Atomics, and Massachusetts Institute of Technology about construction of loops, deposition of fission products in the primary circuit, and their removal by steam and water. At a later time, there could be a positive feedback based on the work at the ZfK. There are plans for a trip by Prof. Hicken to the U.S. in March.

Prof. Hicken also spoke more generally about the state of nuclear reactors in Germany, including the withdrawal of ABB and the reduction in the Siemens effort to a level consistent with their nuclear responsibilities and compatible with the possibility of an upturn in the nuclear field several years later. The recent coal-fired plant bid against an HTR in the eastern part of Germany was 60% of that for the HTR. Nevertheless, Prof. Hicken ventured that if HTR plants are to be built, they will be built in east Germany as west Germany has sufficient generating capacity; furthermore, he noted that the east has access to the western grid in certain areas.

Technical Discussions at KFA

Prof. Hilpert presented work on the sorption of iodine in graphite using an isopiestic method with an on-line gamma detector to measure the activity of the graphite. Graphite powder was used as the sorbate to insure a large ratio of the surface area of the graphite to that of the container. As the partial pressure of the iodine was raised, a point was reached at which the activity of the graphite began to decrease; the activity continued to decrease when the partial pressure of iodine was held constant. This behavior was attributed to the reaction of the iodine with the metallic impurities in the graphite. Calculations based on knowledge of the impurity content of the graphite and on the occurrence of the formation of volatile metallic iodides were in general agreement with the observed decrease in the activity of the iodine sorbed on the graphite. The initial sorption of the iodine on the graphite was in the range 700 to 1000 nmol/kg graphite. Confirmation of the hypothesis was provided by the use of very pure graphite; with this material, the sorptivity dropped to the range of 1 to 2 nmol/kg graphite. These results indicate that iodine released from the particles and the core, in the case of the prismatic HTR, will enter the primary circuit as metallic iodides and be distributed accordingly. In this way, the metallic fission products retained in the graphite can be removed readily during normal operation as well as under accident conditions. The possibility of iodine being released from the core as metallic iodides has not been considered in safety calculations in the U.S.; in the FRG, no credit is taken for the retention of iodine in their matrix graphite.

A review of work conducted in the safety group with Drs. Moormann and Verfondern touched on the following matters.

1. Experiments on the steam-induced removal of cesium from stainless steel at 250°C gave rates of removal 4 to 5 orders of magnitude higher than earlier studies at ORNL on removal of cesium from Incoloy 800 at water vapor pressures 3 to 14 times higher. The rates of removal in the case of stainless steel were in the range 10^{-5} to 10^{-4}/s under turbulent flow conditions. An experimental and theoretical program was begun on the basis of the large difference of the two experimental results.

2. Experiments at ZfK have been started on the hydrolysis of UO_2 at temperatures between 300 and 700°C. Complementary to this effort are calculations which show that, at temperatures greater than 700°C, the H_2 generated by the oxidation of graphite retards the oxidation of UO_2, leading to the deduction that fission product release is thereby excluded. This calculation also depends on the questionable assumption of a linear relation between the fission gas release and the stoichiometry of uranium oxide. However, recent experiments in the U.S., experiments HRB-17 and -18, demonstrate that only a small degree of oxidation ($< 10^{-5}$) is required to promote the release of significant amounts of fission gases, albeit under irradiation conditions. The significance of neutron irradiation on the release of fission gases under severely hydrolyzing conditions will be evaluated by the planned postirradiation heating experiments at KFA in the PIE of capsules 2 and 3 of the HFR-B1 experiment.

3. In the evaluation of the AVR dust experiments, the activity of iodine on dust was found to be relatively high; iodine preferred to deposit on the readily mobilized dust.

4. A code, FALLDIF, to describe the diffusion of fission products in graphite was developed. The diffusion-trapping model was employed in the code. The effects of the traps on nuclear heating was found to be small even though the cesium source in the graphite increased by a factor of 5.

5. The corrosion resistance of SiC-covered fuel spheres was tested in air between 700 and 1500°C. At 1250°C, after 70 h in air, the weight loss of the coated fuel sphere was only about 1%.

6. Dr. Schenk will be examining a fuel sphere that has been subjected to a fast reactivity transient of 1 ms in the Russian facility, ARGUS. The Russians have subjected coated fuel particles to a reactivity transient with sufficient energy input to reach the melting point of UO_2. Ten such transients did not affect the fission product transport in coated fuel particles.

7. Mr. Dannert of the IRE gave a presentation on thermochemistry and transport in coated fuel particles.

Proposed Cooperative Experiments

The proposed cooperative experiments, identified above, were also discussed at KFA. The experiments are desired by the KFA and their participation is not a matter of cost but is "more fundamental." A decision will have been made by March on the participation by the KFA. It was agreed to prepare formal proposals by June, assuming approval by the KFA management, which will be submitted at the management meeting on the US/FRG Umbrella Agreement for Cooperation in Gas Cooled Reactor Development in mid 1991.

The configuration of the samples in the graphite diffusion experiment were considered. The configuration used by K. Mysels at GA was presented by the traveler and found acceptable by the KFA. The KFA would also like to include piggyback samples for measuring the distribution of fission products between SiC and pyrocarbon.

The possibility of enlarging the scope of the iodine release experiment was considered. The experiment, which involves isolating released iodine from defective particles in a chamber in which it has deposited on an alloy surface, could be extended by directing water vapor into this chamber and analyzing the chamber effluent for resuspended or reacted fission products. Such water vapor-induced removal of fission products from the alloy surface could be conducted either in or out of the reactor. This extension would supplement the planned Rossendorf experiments (see below) by providing surfaces with a realistic mix of fission products deposited under irradiation conditions. These experiments could also supplement the yet-to-be approved COMEDIE loop experiment in which steam is added to the carrier gas during a wet depressurization event.

VISIT TO THE ZfK, ROSSENDORF, GERMANY

The traveler visited the ZfK Rossendorf on February 6 and 7 with Dr. Moorman of the KFA. The trip was sponsored by the KFA.

HTR Work at the ZfK

Work on the deposition and removal of deposited fission products in the primary circuit of the HTR is being transferred to the ZfK in Rossendorf. The facilities for doing this work at KFA are being or have been shut down. In addition, work on the oxidation of UO_2 in the temperature range 300 to 700°C will be performed at Rossendorf.

The ZfK is undergoing changes at present including a 50% reduction in the staff (from about 1300 employees) within a year. However, staff

and facilities more than adequate to perform work on fission product behavior in the primary circuit will remain in place. The organizational structure at ZfK, relevant to the HTR work, is as follows: An Institut für Reaktor Technologie whose acting director is Prof. Eichler; Abteilung Metallchemie, headed by Dr. Rettig who is responsible for the HTR work, a group headed by Dr. Stöbel who is responsible for the coordination with KFA and for the construction of the loops, and a ceramic division headed by Dr. Ulmann; work on the oxidation of UO_2 will be conducted by Dr. Teske and Frau Neblung of the latter division.

The ZfK has funding from the Bundesministerium für Forschung und Technologie to construct three loops to be used in the study of the deposition of fission products on primary circuit alloys and the removal of these by interaction with water vapor and by aqueous dissolution. This work is being conducted in cooperation with the KFA through Dr. Moormann. One small loop with a thermochromatographic capability will be used to determine the deposition conditions of cesium and iodine. Two larger loops of the LAMINAR type will be constructed and used to measure deposition and removal of deposited fission products. The work of construction will be done in calendar year 1991. At present, six people are engaged in this task; but during the construction phase, 14 people will be involved. The LAMINAR type loops will be capable of operating at temperatures in the range 300 to 700°C, system pressures up to 0.4 MPa, water vapor pressures up to 0.1 MPa, and Reynolds number up to 10,000. One of these loops will be devoted to experiments with cesium, the other with iodine. The surfaces of the system alloys will be characterized by several methods including an electrogalvanic method with which the oxygen potential in the gas and solid phases can be determined, by Rutherford backscattering, and other techniques available in the solid state physics group. The materials so characterized will include Inconel 800, Inconel 617, and stainless steel.

Also considered during the ZfK visit were the present status of the ZfK plan on fission product behavior during water ingress, the transfer of current knowledge to ZfK, and the possibility of including the work of the ZfK within the US/FRG Umbrella agreement. At a seminar, Dr. Moormann spoke on the topic of fission product release in HTR accidents and the traveler spoke on the topic of fuel hydrolysis in HTR steam ingress events. A translation by the traveler of a draft of the general report by Dr. Moormann to the KFA is presented in Appendix A.

Cooperative Work

The planned work of the ZfK is of great interest to the U.S. The possibility of cooperation of the ORNL and MIT with ZfK on deposition and removal of fission products in the primary circuit should be seriously examined. Further, should the proposed cooperative experiment of the ORNL and KFA on steam-induced removal of deposited iodine be approved, the benefits of cooperation would be enhanced. A rather strong, multi-laboratory effort with considerable flexibility in experimentation and

modeling of fission product behavior in the primary circuit would thus exist. The traveler and Dr. Moormann plan to submit to the management group meeting on the US/FRG Umbrella Agreement in mid 1991, a recommendation that a task be established for US/KFA/ZfK/MIT cooperation. This task could be expanded if the COMEDIE loop experiments were to be included in the cooperative arrangement.

APPENDIX A

A DRAFT OF THE PROCEEDINGS OF THE VISIT OF DR. MYERS/ORNL AND DR. MOORMANN/ISR TO ZfK ROSSENDORF ON 6.-7.2.91

Goals of the Visit were:

- Discussion of the present status of ZfK-plan on fission product behavior during HTR water ingress and further coordination,
- Transfer of KFA as well as ORNL "know how" in the above identified area through a seminar discourse and a workshop,
- Examination of the possibility for introducing the ZfK work into the existing US/FRG cooperative work in the HTR area.

The current status of the (approved by the BMFT for 1991) plan is presented as follows: The current examinations have shown that the requirement for radiation protection in the work on UO_2 oxidation and the thermogradient measurements is not critical; for the larger loops, in contrast, an approved procedure is necessary. These loops should, as set forth in the ZfK internal report of 22.1.91, contrary to the original concept, be separately built for cesium and iodine whereby in any case, the task is begun in this year. The procedures for approval can become part of the total procedure for the ZfK-Urantechnikum (which will encompass the identified loops) that should be completed by the end of the year; to accomplish this, it is required that the completed approval document be submitted to GEL Berlin by 31.3.91. On this basis, the open items to be worked on were identified by KFA for the completion of the approval document and summarized in an action list. The tasks on the action list should be completed by the next meeting (the end of February in Jülich).

The first results of Dr. Teske and Frau Nebelung on the kinetics of the UO_2 oxidation at low temperature (LWR-UO_2) indicate that the assumed kinetic restraint of the oxidation reaction actually occurs.

For the coordination of the cooperative work with the KFA on the ZfK side, Dr. Stöbel is in charge; from the KFA side, Dr. Moormann will look after this task. The Division of Metallchemie (led by Dr. Rettig) will focus on the region of fuel materials (excluding the UO_2 oxidation) in the HTR work of the ZfK.

With the two seminar presentations:

R. Moormann: Fission Product Release in HTR Accidents
B. F. Myers: Fuel Hydrolysis in HTR Steam Ingress Events

was the "know how" transfer begun, which then in the workshop was pursued in the themes:

- accident topology of the HTR with special consideration of water ingress,
- current results on the source term in HTR water ingress,
- models for the establishment of the source term,
- experimental data on plate-out, wash-off, steam-off, UO_2 oxidation, and
- ongoing and planned experiments in the US and KFA as well as model development.

The discussion about a possible US/ZfK cooperation yielded points of contact between the work ongoing in Rossendorf and the following U.S. work:

- the MIT loop DABLE;
- the U.S.-sponsored COMEDIE experiments in Grenoble;
- the experimental and theoretical work on fuel hydrolysis (ORNL, Petten);
- the ORNL laboratory experiments on plate-out and steam-off; and
- the theoretical work on liftoff of plateout activity under water ingress (ORNL, GA).

All participants saw it as meaningful that a ZfK scientist go to the USA for several months to become familiar with and to make available the current know-how applicable to the ZfK-FE program and to make arrangements for a later exchange of information developed in the Rossendorf program. Therefore, the possibility for such a visit will be clarified on the U.S. side (Dr. Myers) as well as on the German side (Prof. Hicken, Prof. Eichler).

APPENDIX B

DOCUMENTS RECEIVED

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APPENDIX C

ITINERARY

Date	Location	Contact	Subject
27.01.91-28.01.91	Knoxville, TN to Bergen, NH		
28.01.91-29.01.91	JCR, Petten	Dr. R. Conrad Dr. J. Thiel	HFR-B1 final report, cooperative experiments
30.01.91-30.01.91	Bergen, NH to Jülich, FRG		
30.01.91-05.02.91	KFA, Jülich	Profs. Hicken, Hilpert, Drs. Mormann, Nabielek, Schenk, Verfondern, Messrs. Bucher, Dannert, Pott, Schröder	PIE of HFR-B1, safety research, technical discussions, cooperative experiments
06.02.91	KFA, Jülich to ZfK, Rossendorf		
06.02.91-07.02.91	ZfK, Rossendorf	Prof. Eichler, Drs. Blochwetz, Rettig, Stöbel, Teske, Frau Neblung, Mr. Boettcher	HTR work at ZfK, cooperative work
07.02.91	ZfK, Rossendorf to KFA, Jülich		
08.02.91	KFA, Jülich	Drs. Moormann, Nabielek, Schenk, Verfondern, Messrs. Bucher, Schröder	PIE of HFR-B1, air and water ingress accidents
09.02.91	KFA, Jülich to Bergen, NH		
09.02.91	JRC, Petten	Dr. R. Conrad	HFR-B1 data, HFR-B1 gamma scans
10.02.91	Bergen, NH to Atlanta, GA		

APPENDIX D

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