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**US/FRG UMBRELLA AGREEMENT
FOR COOPERATION IN GCR DEVELOPMENT**

**FUEL, FISSION PRODUCTS, AND GRAPHITE
SUBPROGRAM**

**QUARTERLY STATUS REPORT
FOR THE PERIOD
JULY 1, 1981 THROUGH SEPTEMBER 30, 1981**

**by
R. F. TURNER**

**Prepared under
Contract DE-AT03-76ET35300
for the San Francisco Operations Office
Department of Energy**

DATE PUBLISHED: OCTOBER 1981

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DISTRIBUTION OF THIS REPORT

ABSTRACT

This report describes the status of the cooperative work being performed in the Fuel, Fission Product, and Graphite Subprogram under the "HTR-Implementing Agreement" of the United States/Federal Republic of Germany Umbrella Agreement for Cooperation in GCR Development. The status is described relative to the commitments in the "Subprogram Plan for Fuel, Fission Products, and Graphite," Revision 3, April 1981. The work described was performed during the period July 1, 1981 through September 30, 1981 in the HTGR Base Technology Program at Oak Ridge National Laboratory, the HTGR Fuel and Plant Technology Programs at General Atomic Company, and the Project HTR-Brennstoffkreislauf of the Entwicklungsgemeinschaft HTR at KFA Julich, HRB Mannheim, HOBEH Hanau and SIGRI Meitingen.

The requirement for and format of this Quarterly Status Report are specified in the "HTR Implementing Agreement" Procedures for Cooperation. Preparation of the Quarterly Report is alternated between GA and KFA.

1. STATUS SUMMARY

The status of progress on the major milestones, as defined in Revision 3 of the Subprogram Plan, is summarized for the fourth quarter of FY-81 in Table 1. The status of the work in each of the Work Breakdown Structure (WBS) elements of the Subprogram is described in the following sections (see Appendix A for the Subprogram WBS).

The semiannual Subprogram Management meeting was held in San Diego on September 8 and 9, 1981. Separate meetings on technical progress were held at San Diego and Oak Ridge before and after the Subprogram Management Meeting. The revised table of major 1982 milestones from the Subprogram Meeting is shown in Table 2.

Technical highlights of the period were:

1. First successful Core Heat-up Simulation Test on German Fuel (PWS FD-11)
2. Completion of evaluations of SiBISO coatings for fuel particles (PWS FD-9).
3. Exchange of information on graphite fatigue was reactivated (PWS GD-7).
4. Technical papers were written for presentation at the Colloquium on Fission Product Transport in Graphite to be held November 9-11, 1981 in Berlin (PWS FP-2).
5. Continued successful operation of fuel capsule R2K13 (PWS FD-15).

TABLE 1

**MILESTONE STATUS FOR THE FOURTH QUARTER OF FY-81
FROM REVISION 3 OF THE SUBPROGRAM PLAN**

MILESTONE		PWS	DUE DATE	COMPLETION DATE	RESPONSIBLE PARTY	STATUS
1. FUEL DEVELOPMENT						
1.1.1	ISSUE INTERIM OPERATING REPORT ON R2K13	FD-15	9/81	9/81	GA	COMPLETED
1.1.2	PIE PROPOSAL FOR R2K13	FD-15	12/81	-	KFA	IN PROGRESS (FOR 3/82)
1.4.1	EXCHANGE PROGRAM OUTLINES	FD-10	4/81	6/81	KFA	COMPLETED
1.4.2	COMPLETE FINAL REPORT	FD-12	9/81	9/81	ORNL/KFA	COMPLETED
1.4.3	COMPLETE FINAL REPORT	FD-13	9/81	9/81	ORNL/KFA	COMPLETED
1.4.4	REPORT GAMMA SPECTR. RESULTS	FD-14	4/81	-	GA	FUNDING DELAYED TO 1983
1.4.5	ISSUE SUMMARY REPORT ON SiBISO	FD-9	5/81	9/81	GA	COMPLETED
1.5.2	NOTE ON RESULTS FOR R2K13 FUEL	FD-8	6/81	-	KFA	DELAYED TO 10/81
1.5.3	REPORT ON COMPARISONS WITH IRRADIATION RESULTS	FD-8	9/81	9/81	GA	COMPLETED

(CONTINUED)

TABLE 1 (CONTINUED)

MILESTONE		PWS	DUE DATE	COMPLETION DATE	RESPONSIBLE PARTY	STATUS
1.5.5	COMPLETE TEST OF FRG FUEL TO 2500°C AND ISSUE REPORT	FD-11	9/81	9/81	GA	COMPLETED
2. FISSION PRODUCT BEHAVIOR						
2.1.1	PROVIDE INPUT TO JOINT GA/KFA DATA BOOK	FP-2	8/81	11/81	GA	DELAYED TO 11/81
2.1.2	COMPLETE DATA ON DIFFUSION AND SORPTION	FP-1	9/81	-	ORNL	SERVICES ON LI MEASUREMENT AGREED UPON
2.2.1	EXCHANGE BENCHMARK RESULTS	FP-3	6/81	-	GA/HRB	DELAYED TO 12/81
3. GRAPHITE						
3.1.1	UPDATE PWS	GD-1	11/80	9/81	ORNL/KFA	COMPLETED
3.1.2	INSERT 300°C CAPSULE	GD-2	4/81	4/81	KFA	COMPLETED
3.1.3	RESULTS FROM HTR-4 AND HTU-1	GD-1	6/81	-	ORNL	DELAYED
3.1.4	DRAFT TEST PLAN FOR OG-6	GD-9	9/81	-	GA	FUNDING DELAYED; OG-6 PLANNED FOR 1983

(CONTINUED)

TABLE 1 (CONTINUED)

MILESTONE		PWS	DUE DATE	COMPLETION DATE	RESPONSIBLE PARTY	STATUS
3.1.5	COMPLETE IRRADIATION OF CREEP CAPSULE	GD-4	OPEN	-	KFA	PROGRAM CHANGED TO CAPSULES WITHOUT DIRECT READOUT.
3.2.1	PROVIDE IMPROVED ASR-IRG FROM SIGRI	GD-11	6/81	-	KFA	INITIAL LOT SHOWED HIGH OXYDATION; DELAYED TO 2/82
3.2.2	COMPLETE CORROSION TESTS	GD-10	1/81	-	ORNL	AWAITING NEW SAMPLES
3.2.3	COMPLETE MECHANICAL TESTING OF CORRODED GRAPHITE	GD-10	8/81	-	ORNL	AWAITING NEW SAMPLES
3.2.4	INITIAL REPORT ON STRENGTH AND OXY-DATION OF TS GRAPHITE	GD-11	9/81	9/81	GA	COMPLETED
3.3.1	PROVIDE CREEP DATA	-	8/81	-	KFA	DELAYED TO 11/81
3.3.2	REVIEW CREEP DATA	-	12/81	6/81	GA	COMPLETED
3.3.3	PRELIM. SPECIFICATION FOR CORE SUPPORT POST	GD-12	6/81	-	GA/SIGRI	DATA EXCHANGED ON EXISTING GRADES, MILESTONE DELAYED TO 12/81

TABLE 2
MAJOR MILESTONES IN THE COOPERATIVE SUBPROGRAM
FOR 1982 (REVISION 4, SEPTEMBER 1981)

WBS ELEMENT AND MILESTONE		PWS	DUE DATE	RESP. PARTY
1	FUEL DEVELOPMENT			
1-1	FUEL IRRADIATION TESTS			
1-1-1	COMPLETE IRRADIATION OF CAPSULE R2K13	FD-15	6/82	KFA
1-1-2	PIE PLAN FOR R2K13	FD-15	8/82	KFA
1-2	FUEL PROCESS DEVELOPMENT			
1-2-1	COMPLETE EXCHANGE AND MEASUREMENT OF COATED PARTICLES.	FD-22	3/82	GA/HOBEG
1-3	FUEL DESIGN DATA AND SPECIFICATION			
1-3-1	DOCUMENT HBK IRRADIATION, 1977-82	FD-21	12/82	KFA
1-4	PRE AND POSTIRRADIATION CHARACTERIZATION			
1-4-1	EXCHANGE STATUS REPORTS ON SiC	FD-10	9/82	KFA/ORNL
1-5	FUEL DESIGN, PERFORMANCE ASSESSMENT AND MODELING			
1-5-1	COMPLETE TEST OF FRG FUEL AND ISSUE REPORT	FD-11	6/82	GA
2	FISSION PRODUCT BEHAVIOR			
2-1	FISSION PRODUCT RELEASE AND TRANSPORT			
2-1-1	PROVIDE INPUT TO FISSION PRODUCT DATA BOOK	FP-2	6/82	GA
2-2	FISSION PRODUCT METHODS VERIFICATION			
2-2-1	EXCHANGE CALCULATED RELEASE DATA FOR R2-K12	FP-3	9/82	GA/HRB

(CONTINUED)

TABLE 2 (CONTINUED)

MAJOR MILESTONES IN THE COOPERATIVE
SUBPROGRAM FOR 1982 (CONTINUED)

WBS ELEMENT AND MILESTONE		PWS	DUE DATE	RESP. PARTY
3	GRAPHITE DEVELOPMENT			
3-1	IRRADIATION TESTING			
3-1-1	REPORT ON 400° AND 600°C IRRAD.	GD-2	11/81	KFA
3-1-2	ISSUE SUMMARY REPORT ON HTK-1, 2, 3	GD-1	11/81	ORNL/KFA
3-1-3	DELIVER SPECIMENS FOR 300°, 400°, 500°, 600°C TEMP.	GD-2	12/81	GA
3-1-4	COMPLETE EXAM OF CREEP SPECIMEN	GD-4	12/81	KFA/GA/ORNL
3-1-5	START 500°C IRRADIATION WITH TS-1621	GD-2	6/82	KFA
3-1-6	COMPLETE HTK-6 IRRADIATION	GD-1	6/82	ORNL
3-1-7	COMPLETE HTK-5 IRRADIATION	GD-1	9/82	ORNL
3-1-8	INSERT HTK-7 AND 8 CAPSULES	GD-1	10/82	ORNL
3-1-9	COMPLETE 300°C IRRAD. WITH HLM	GD-2	9/82	KFA
3-2	CHARACTERIZATION OF PROPERTIES			
3-2-1	PROVIDE IMPROVED ASR-1RG FROM SIGRI FOR EVALUATION	GD-11	2/82	KFA
3-3	GRAPHITE DESIGN DATA AND SPECIFICATION			
3-3-1	ISSUE REPORT ON S-2020 GRAPHITE	GD-12	11/81	GA

2. SIGNIFICANT PROBLEMS

There are currently no problems directly within the scopes of the subprogram, other than delays which are reflected in the milestone tables.

There is a significant uncertainty in the funding for the total programs on both sides for the coming year.

3. STATUS OF COOPERATION

3.1 FUEL DEVELOPMENT

3.1.1. Fuel Irradiation Tests

There is one active Project Work Statement in this Work Breakdown Structure (WBS) element, PWS FD-15 (see Appendix B for all active PWS titles). The R2K13 capsule continues to operate well in the Studsvik Reactor. The fuel performance data results are arriving promptly. The currently predicted date for reaching full exposure is June 1982.

3.1.2. Fuel Process Development

There is one active Project Work Statement, PWS FD-22. A work scope and time schedule has been agreed upon for transfer of ThO₂ kernels for coating process studies.

3.1.3. Fuel Design Data and Specification

Two Project Work Statements have been initiated in this area, PWS FD-19 on Performance Data Sheets, and PWS FD-21 on Design and Specification Data Files for use in the computerized data base. KFA work on PWS FD-19 is directed towards cooperation and support of a new data manual in '82/'83. Interfaces to GA's storage and retrieval system will be reviewed under PWS FD-21 during a visit by Maly in January 1982.

3.1.4. Pre- and Postirradiation Characterization

Three Project Work Statements were completed in this area during the past quarter, and three others are currently active. The completed ones are PWS FD-9, FD-12 and FD-13. FD-10 is continuing as an information exchange between KFA, ORNL and GA. The investigation of SiC coatings from GA, ORNL, KFA and HOBEG was continuing. Three German batches were studied at ORNL (ORNL/GCR-81/13). In addition to investigations of batches fabricated at ORNL, a number of SiC batches from GA were characterized at ORNL and KFA, using SEM, TEM, SAXS, x-ray diffraction and Raman spectroscopy. For information exchange, Peter Krautwasser (KFA, currently assigned to ORNL) visited GA on July 22-23, 1981. His assignment to ORNL will be extended to June 1982.

FD-14 is to include gamma spectroscopic examination of irradiated fuels. Work at GA on this PWS is delayed to 1983 because of funding constraints. FD-20 includes continuing IMGA, PGA and probe measurements of FRG particles.

3.1.5. Fuel Design, Performance Assessment and Modeling

One Project Work Statement was completed during the quarter, PWS FD-8, and one is active, PWS FD-11. Accident condition testing on GA and HBK fuels has been delayed, but is scheduled for 1982 and 1983.

3.2 FISSION PRODUCT BEHAVIOR

3.2.1. Fission Product Release and Transport

There are two active Project Work Statements in this area, FP-1 and FP-2. KFA intends to send matrix graphite to ORNL for measurement of Li contaminations under FP-1. ORNL will use available techniques, but will not perform new development work. Data sheets are being prepared under FP-2 at both KFA and GA for a Fission Product Data Handbook. A meeting under FP-2 is scheduled for November 1981 at KFA.

3.2.2. Methods Verification

Verification of codes is proceeding under PWS FP-3. An exchange of personnel is planned for 1982 under this PWS. Agreement has not been reached on a proposed exchange of plateout and liftoff methods verification data (proposed PWS CC-1)

3.3. GRAPHITE DEVELOPMENT

3.3.1. Irradiation Testing

There are four active Project Work Statements in this area. The plan for Tests at ORNL under PWS GD-1 was expanded to include HTK-7 capsule at 600°C and HTK-8 capsule at 900°C in 1982. The space will be divided so that HTK-7 contains 1/3 US and 2/3 FRG graphites, while HTK-8 contains 2/3 US and 1/3 FRG graphites.

The irradiation of reflector graphites is continuing at Petten under PWS GD-2. The creep test at Petten under PWS GD-4 is being revised so that direct strain readout will not be measured. The revised design is intended to resolve the problem of fracture of specimens during testing. The broken creep sample from GC9 will be sent to GA for further examination.

The testing of graphites in ORR under PWS GD-9 is uncertain in the coming year because of uncertainty in funding the OG series.

3.3.2 Characterization of Properties

There are two active Project Work Statements in this area, PWS GD-10 and GD-11. In addition, oxydation tests may be performed at GA on a reinstatement of GD-6 when new specimens of ASR-1RG become available. GD-10 is under review by ORNL, and may include testing of ASR-1RG when new specimens are delivered. The GD-11 schedule is under review as a result of no funding in 1982.

3.3.3. Graphite Design Data and Specifications

One Project Work Statement is active, PWS GD-12. Milestones for this PWS will be determined after an exchange of reports on S-2020 and V-483-T production graphites.

3.3.4. Performance Assessment, Modeling and Verification

There is no active Project Work Statement in this area. Ideas for a cooperative exchange will be considered for submittal of a PWS at the spring 1982 Subprogram Meeting.

3.3.5. Control Materials

There is no work underway in this area.

4. PROGRAMMATIC CHANGES

There were no programmatic changes in management or agreement scope during this quarter.

5. REPORTS EXCHANGED

Reports sent to FRG during the reporting period:

1. GA Staff, HTGR Generic Technology Program Semiannual Report for the Period Ending September 30, 1980, No. GA-A16127.
2. GA Staff, HTGR Fuel Technology Program Semiannual Report for the Period Ending March 31, 1981, No. GA-A16333.
3. Kovacs, W. J., Characterization of Defective SiC Coatings in TRISO HTGR Fuel Particles, April 1981, No. GA-A16215.
4. Status Report on UO₂ 350 um Kernel Fabrication, GA unpublished data by D. T. Young, July 1981.
5. GA Staff, HTGR Plant Technology Program Semiannual Report for the Period Ending March 31, 1981, No. GA-A16339.
6. Ketterer, J. and R. Bullock, Capsule HRB-15B Postirradiation Examination Report, June 1981, No. GA-A15940.
7. GA Staff, Round Robin Optical Measurements of Preferred Orientation in Nearly Isotropic Pyrocarbon, No. GA-A15291.
8. Goodin, D. T., Single Model for the Performance of Heu/Leu Fissile and ThO₂ Fertile Fuel Under Hypothetical Accident Conditions, No. GA-A16291.
9. ORNL Monthly Program Reports for June, July and August 1981.
10. ORNL Staff, HTGR Annual Report for 1980, No. ORNL-5753, August 1981.
11. ORNL Staff, Capsule HT-34 Final Report, No. ORNL/TM-7674, August 1981.
12. ORNL Staff, Preliminary Development of Internal Gelation Flow Sheets for Preparing (Th/U)₂O₃ Spheres, No. ORNL/TM-7280, August 1981.
13. Preirradiation Report of GA Fuel for Capsule R2-K13, GA unpublished data by C. A. Young, April 1980.
14. In-pile Fission Product Release, GA unpublished data and code by B. F. Myers, May 1981.
15. Prediction of In-pile Cesium Release, GA unpublished data by B. F. Myers, Feb. 1981.
16. Price, R. V., Irradiation Induced Creep in Graphite, No. GA-A 16402, 1981.
17. Haas, P. D., et al, Preliminary Development of Internal Gelation Flow Sheets, No. ORNL/TM/7280, 1981.
18. Teigs, T. N., et al, Performance of Particles in HT-34, No. ORNL/TM/7674, Aug. 1981.

Reports received from FRG during the reporting period:

1. HBK Staff, Program Status of the HTR in FRG, April 1981.
2. Bongartz, K., P. Lupton & H. Shuster, Model to Predict Carburization Profiles in High Temperature Alloys, Metallurgical Transactions, November 1980.
3. Bongartz, K. and H. Nabielek, Preprint of Paper on Coated Particle Modeling for SMIRT Conference, April 1981.
4. Schleifer, F., A. Naoumidis and H. Nickel, Influence of Oxide Forming Fission Products on Thermochemical Behavior of Uranium Oxide Fuel, March 1981, No. JUL-1711.
5. Benz, R., X-ray Diffraction Analysis of SiC Coatings in some TRISO Coated Particles, May 1981, No. IRW-TN-5/81.
6. Mehner, A. W., KFA SiC Characterization Program, May 1981, No. HBK-TN-16/81.
7. Benz, R., K. Lesten and A. Schirbach, High Temperature Testing of TRISO coated (ThU)O₂ Particle Types HT 150-160, HT 162-167, EO 1607 and EO 1674, April 1981, No. IRW-TN-44/81.
8. Benz, R., A. Naoumidis and J. Rothmann, Identification of Si in Small Quantities of SiC and TRISO Coated Nuclear Fuel, April 1981, No. IRW-TN-41/81.
9. Derz, H., and W. Kaef, REM-Untersuchung von SiC Bruchstucken, May 1981, No. IRW-TN-64/81.
10. Schulze, R., and H. Schulze, Graphitische Matrix Materialien Fur Kugelformige HTR-Brennelemente, February 1981, No. JUL-1702.

6. CONCLUSIONS

The exchange is continuing satisfactorily. The continuation of irradiation test programs continues to be of strong importance to both sides of the exchange. Tentative agreement has been reached for Dr. K. Bongartz to be assigned from KFA to GA for nine months under the Fuels Program, starting November 1981, and for a further nine months to ORNL under the Materials Program. Agreement has been reached for D. L. Hanson to be assigned from GA to KFA for one year under the Fission Product Program, starting in January 1982.

The Project Work Statements were rewritten in a one-page format for all active PWSs during the September 1981 Subprogram Meeting.

APPENDIX A

APPENDIX B

ACTIVE PROJECT WORK STATEMENTS

WBS ELEMENT AND TITLE	LEAD ORG.	STATUS
1. FUEL DEVELOPMENT		
1-1 FUEL IRRADIATION TESTS		
FD-15 COOPERATIVE FUEL ELEMENT IRRADIATION TEST OF GA AND HBK FUEL (R2K13)	KFA	IN PROGRESS
1-2 FUEL PROCESS DEVELOPMENT		
FD-22 COATED PARTICLE AND QC PROCESS DEVELOPMENT	GA	IN PROGRESS
1-3 FUEL DESIGN DATA AND SPECIFICATION		
FD-19 PERFORMANCE DATA SHEETS	KFA	DELAY EXCHANGE TO '82/'83
FD-21 DESIGN & SPECIFICATION DATA FILES	KFA	IN PROGRESS
1-4 PRE- AND POSTIRRADIATION CHARACTERIZATION		
FD-10 CHARACTERIZATION & QC TECHNIQUES FOR SiC COATINGS	KFA	IN PROGRESS

(CONTINUED)

APENDIX B (CONTINUED)

WBS ELEMENT AND TITLE	LEAD ORG.	STATUS
FD-14 GAMMA SPECTROSCOPIC EXAMINATION OF HTGR FUEL ELEMENTS	GA	IN PROGRESS
FD-20 COATED PARTICLE ANALYSIS BY IMGA	ORNL	IN PROGRESS
1-5 FUEL DESIGN, PERFORMANCE AND MODELING		
FD-11 TESTING OF GA AND HBK FUEL UNDER HYPOTHETICAL ACCIDENT CONDITIONS	GA	IN PROGRESS
2. FISSION PRODUCT BEHAVIOR		
2-1 FISSION PRODUCT RELEASE AND TRANSPORT		
FP-1 H-3 TRANSPORT IN HTR PRIMARY CIRCUIT	ORNL	LIMIT TO Li MEASUREMENT
FP-2 FISSION PRODUCT DATA HANDBOOK	KFA	IN PROGRESS
2-2 METHODS VERIFICATION		
FP-3 VERIFICATION OF FISSION PRODUCT DESIGN METHODS AND CODES	GA	IN PROGRESS
CC-1 VERIFICATION OF PLATEOUT METHODS	GA	WORK STATEMENT APPROVAL REQUIRED
3. GRAPHITE DEVELOPMENT		
3-1 IRRADIATION TESTING		
GD-1 KFA GRAPHITE IRRADIATION EXPERIMENT IN HFIR AT OAK RIDGE	ORNL	IN PROGRESS
GD-2 IRRADIATION OF GA SIDE REFLECTOR GRAPHITE IN HFR PETTEN	KFA	IN PROGRESS

(CONTINUED)

APENDIX B (CONTINUED)

WBS ELEMENT AND TITLE	LEAD ORG.	STATUS
GD-4 CONTINUATION OF GRAPHITE CREEP TEST IN HFR PETTEN	KFA	IN PROGRESS
GD-9 IRRADIATION OF KFA SIDE REFLECTOR & CORE SUPPORT GRAPHITE IN ORR	GA	DELAY TO FY-82
3-2 CHARACTERIZATION OF PROPERTIES		
GD-6 OXYDATION OF CORE SUPPORT POST GRAPHITE	GA	REINSTATE
GD-10 STUDY OF THE OXIDATIVE STRENGTH LOSS OF KFA CORE SUPPORT GRAPHITE ASR-1R	ORNL	UNDER REVIEW
GD-11 CHARACTERIZATION & EVALUATION OF KFA CORE SUPPORT GRAPHITE ASR-1R FOR OXIDATION CHARACTERISTICS	GA	UNDER REVIEW
3-3 GRAPHITE DESIGN DATA AND SPECIFICATIONS		
GD-12 CHARACTERIZATION OF CORE SUPPORT STRUCTURE GRAPHITE FOR ACCEPTANCE/REJECTION STRENGTH TESTS IN PURCHASE SPECIFICATIONS	GA	IN PROGRESS
GD-7 FATIGUE DAMAGE MODELING	GA	CONSIDER REINSTATING