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

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

**QUARTERLY STATUS REPORT
FOR THE PERIOD
JANUARY 1, 1982 THROUGH MARCH 31, 1982**

**by
R. F. TURNER**

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

DATE PUBLISHED: APRIL 1982

GENERAL ATOMIC COMPANY

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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 4, September 1981. The work described was performed during the period January 1, 1982 through March 31, 1982 in the HTGR Base Technology Program at Oak Ridge National Laboratory, the HTGR Fuel and Plant Technology Programs at General Atomic Company (GA), and the Project HTR-Brennstoffkreislauf of the Entwicklungsgemeinschaft HTR at KFA Julich, HRB Mannheim, HOBEG Hanau, and SIGRI Meitingen.

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

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1. STATUS SUMMARY

The status of progress on the major milestones, as defined in Revision 4 of the Subprogram Plan, is summarized for the second quarter of FY-82 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).

Technical highlights of the period were:

1. Mr. David L. Hanson began a one-year assignment from GA to KFA as a technical specialist. He is working in the area of fission product transport validation. Dr. Karl Bongartz is continuing his assignment from KFA to General Atomic, and Dr. Peter Krautwasser is continuing his assignment at ORNL (PWS FD-8, FD-10 and FP-2).
2. Benchmark calculations for verification of fission product release codes were exchanged between GA and HRB (PWS FP-2).
3. Fuel capsule R2-K13 was shut down during the entire period while the Studsvik reactor was undergoing licensing tests. Start-up is scheduled for May 4, 1982 (PWS FD-15).
4. A Specialists Meeting on SiC characterization was organized for June 1982 (PWS FD-10).
5. The graphite capsules HTK-5 and HTK-6 were fabricated and HTK-5 started up at ORNL (PWS GD-1).
6. The graphite creep irradiation experiment in Petten designed for no direct readout was started up (PWS GD-4).

TABLE 1
MILESTONE STATUS FOR THE SECOND QUARTER OF
FY-82 FROM REVISION 4 OF THE SUBPROGRAM PLAN

<u>Milestone</u>	<u>PWS</u>	<u>Due Date</u>	<u>Completion Date</u>	<u>Responsible Party</u>	<u>Status</u>
1. Fuel Development					
WBS 1.2 Complete coating of comparative batches of particles	FD-22	12/81	3/82	GA/KFA	Completed
WBS 1.2 Complete exchange and measurement of CP characteristics	FD-22	3/82	—	GA/KFA	Delayed to 7/82
WBS 1.3 Define conditions for sharing computer data bases	FD-21	3/82	—	KFA/GA	Delayed by deferral of Maly trip
WBS 1.4 Complete IMGA on batches of HBK fuel	FD-20	12/81	1/82	ORNL	Completed
WBS 1.4 Report FTE-18 temperatures	FD-14	2/82	—	GA	Rescheduled to 9/82
2. Fission Product Behavior					
WBS 2.2 Exchange benchmark results	FP-3	6/81	2/82	GA/HRB	Completed for R2-K12 data; exchange started on FRJ2-K11
3. Graphite					
WBS 3.1 Report on HTK-1 through 4	GD-1	6/81	—	ORNL	
WBS 3.1 Startup HTK-5 and 6	GD-1	10/81	12/81	ORNL	HTK-5 started, HTK-6 delayed
WBS 3.1 Report on 400°/600°C HLM data	GD-2	11/81	—	KFA	Preliminary results transmitted; report delayed
WBS 3.1 Deliver TS-1621 specimens	GD-2	12/81	1/82	GA	Completed
WBS 3.1 Examine creep specimens	GD-4	12/81	—	KFA/GA/ORNL	Specimens not received
WBS 3.1 Begin 900°C creep test at Petten	GD-4	12/81	11/82	KFA	Started as planned
WBS 3.2 Provide improved ASR-IRG from SIGRI	GD-11	2/82	—	KFA	Delayed
WBS 3.3 Preliminary specification for core support post	GD-12	11/81	—	GA/SIGRI	Data exchange delayed

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

<u>WBS Element and Milestone</u>		<u>PWS</u>	<u>Due Date</u>	<u>Responsible Party</u>
1	Fuel Development			
1-1	Fuel irradiation tests			
1-1-1	Complete irradiation of capsule R2-K13	FD-15	6/82	KFA
1-1-2	Pie plan for R2-K13	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
3	Graphite Development			
3-1	Irradiation testing			
3-1-1	Report on 400° and 600°C irradiation	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 temperature	GD-2	12/81	GA
3-1-4	Complete examination 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 irradiation 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

The shutdown of the Studsvik reactor (at the end of December 1981) for examination of vessel embrittlement causes a concern for the program, because the operation of fuel capsule R2-K13 is delayed. The current estimated startup date is May 4, 1982.

3. STATUS OF COOPERATION

3.1. FUEL DEVELOPMENT

3.1.1. Fuel Irradiation Tests, WBS 1.1

One Project Work Statement is active in this Work Breakdown Structure (WBS) element, PWS FD-15 (see Appendix B for all active PWS titles). The R2K13 capsule has been shut down during the entire quarter for examination of the embrittlement of the Studsvik reactor vessel. The current forecast for startup is April 19, 1982.

3.1.2. Fuel Process Development, WBS 1.2

One active Project Work Statement is active, PWS FD-22. Batches of ThO₂ kernels were coated at both General Atomic and Hobeg to determine the sources of defect fractions. Samples of the coated particles will be exchanged for completion of Quality Control measurements.

3.1.3. Fuel Design Data and Specification, WBS 1.3

Two Project Work Statements are active, 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 1982-83. The storage and retrieval systems were to be reviewed under PWS FD-21 in January 1982, but this has been delayed by deferral of a trip by Mr. Maly.

3.1.4. Pre- and Postirradiation Characterization, WBS 1.4

Three Project Work Statements are active, FD-10, FD-14, and FD-20. Information on characterization of SiC coatings, under FD-10, is to be exchanged at a specialists meeting set up for June 1982 at KFA. A report on examination of HTGR fuel elements, under FD-14, has been rescheduled for September 1982 in order to levelize funding for the year.

Irradiated material gamma analysis (IMGA) was completed on batches of BISO-coated particles at ORNL under FD-20. These were from compact 1 of FRJ-P22 capsule, from sphere 3 of R2-K10, and from sphere B2 of HFR-K1 capsule.

3.1.5. Fuel Design, Performance Assessment and Modeling, WBS 1.5

Two Project Work Statements are active, FD-8 and FD-11. Dr. Bongartz has performed code modification on both KFA and GA coated particle models. Both codes have been verified against an equivalent case. Currently, the codes are being normalized against data from capsules HT-33, HT-34, and HRB-16. Accident condition testing on General Atomic and HBK fuels under FD-11 has been delayed but is scheduled for late 1982 and 1983.

3.2. FISSION PRODUCT BEHAVIOR

3.2.1. Fission Product Release and Transport

Two Project Work Statements are active, FP-1 and FP-2. No work was performed on FP-1 during this period. Additional data were exchanged between KFA and General Atomic for a Fission Product Data Handbook under FP-2. A first version of the Handbook was assembled. Extended abstracts were prepared of papers on fission product diffusion, which were presented at the Hahn-Meitner Institute Colloquium on Transport of Fission Products, held in November 1982.

3.2.2. Methods Verification

Verification of codes is proceeding under PWS FP-3. Mr. David Hanson began a one-year assignment to KFA in January 1982. The benchmark calculations for verification of release design codes were completed at GA for transmittal to KFA and HRB.

3.3. GRAPHITE DEVELOPMENT

3.3.1. Irradiation Testing

Four active Project Work Statements are active in this area; GD-1, GD-2, GD-4 and GD-9.

Graphite capsules HTK-5 (600°C) and HTK-6 (900°C) were fabricated at ORNL under GD-1. HTK-5 was started up and HTK-6 is planned to start later in 1982. The irradiation of reflector graphites is continuing at Petten under PWS GD-2. The creep test at Petten under PWS GD-4 was revised so that direct strain readout is not measured. The first irradiation step was completed.

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

Two Project Work Statements are active in this area, PWS GD-10 and GD-11. Oxidation tests under GD-10 will be planned at ORNL when new specimens are delivered. The production of ASR-1RG and ASR-1RS graphites for GD-11 has been delayed.

3.3.3. Graphite Design Data and Specifications

One Project Work Statement is active, PWS GD-12. A guideline specification was issued for test specimens of S-2020 graphite.

3.3.4. Performance Assessment, Modeling, and Verification

There is no active Project Work Statement in this area.

3.3.5. Control Materials

There is no work under way 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. Myers, B. F., "Colloquium on Transport of Fission Products in Matrix and Graphite," Trip Report, November 1981.
2. Bullock, R. E., "Irradiation Performance of Experimental Fuel Particles Coated with Silicon-Alloyed Pyrocarbon," General Atomic Company Report GA-A16474, September 1981.
3. Smith, P. D., and R. G. Steinke, "COPAR, A Program to Compute Release of Metallic Fission Products," General Atomic Company Report GA-A14034, December 1981.
4. Hudritsch, W. W., "Fission Product Transport Code TRAMP," General Atomic Unpublished Data, November 1981.
5. Montgomery, F. C., "Test Report on Hydrolysis of HTGR Carbide Fuels," General Atomic unpublished data, September 1980.
6. GA Staff, "Final Summary Report on the Peach Bottom End-of-Life Program," General Atomic Company Report GA-A14404, 1978.
7. ORNL Staff, Monthly Program Reports for December, 1981, January, 1982, and February, 1982.

Reports received from FRG during the reporting period:

1. HBK Staff, "Beshahlungsexperiment-Information 3 and 4/81," No. HBK-IB-18/81, November 1981.
2. HBK Staff, "HBK Vierteljahresberichte," 3. Quartal 1981.
3. Allelein, H. J., "Fission Product Behavior - In Particular Cs-137 in HTR TRISO Coated Particle Fuel," No. Jül-1695, December 1980.
4. Amian, W., "Experimental Investigations on the Migrational Behavior of Silver in Coated Particle Fuels for HTR," No. Jül 1731, August 1981.
5. Thiele, B. A., and A-W. Mehner, "Bestrahlung von TRISO beschichteten Abbrandpartikeln in Test BR2-P18," No. KFA-IRW-IB-11/81, August 1981.
6. Rottmann, et al., "Die Chlorspurenbestimmung in beschichteten Kernbrennstoffteilchen," No. KFA-IRW-IB-15/81, September 1981.
7. HBK Staff, Unpublished Data on Fission Gas Release from Laser-Failed Coated Particles in FRJ2-P25 DIDO Test, 1981.

6. CONCLUSIONS

The exchange is continuing satisfactorily. The assignments of Dr. Bongartz to General Atomic, Dr. Krautwasser to ORNL and Mr. Hanson to KFA have been particularly beneficial in the development of technical data of mutual benefit.

APPENDIX A

APPENDIX B

ACTIVE PROJECT WORK STATEMENTS

	<u>WBS Element and Title</u>	<u>Lead Org</u>	<u>Status</u>
1	Fuel Development		
1-1	Fuel irradiation tests		
	FD-15 Cooperative fuel element irradiation test of GA and HBK fuel (R2-K13)	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 and specification data files	KFA	In progress
1-4	Pre- and postirradiation characterization		
	FD-10 Characterization and QC techniques for SiC coatings	KFA	In progress
	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
	FD-8 Development of stress models for coated particles	KFA	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
	GD-4 Continuation of graphite creep test in HFR Petten	KFA	In progress
	GD-9 Irradiation of KFA side reflector and core support graphite in ORR	GA	Delay to FY-82

APPENDIX B (CONTINUED)

	<u>WBS Element and Title</u>	<u>Lead Org</u>	<u>Status</u>
3-2	Characterization of properties		
GD-6	Oxidation 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 and 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