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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, 1982 THROUGH SEPTEMBER 30, 1982**

by
R. F. TURNER

**Prepared under
Contact DE-AT03-76ET35300
for the San Francisco Operations Office
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DATE PUBLISHED: OCTOBER 1982

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1. STATUS SUMMARY

The status of progress on the major milestones for this fourth quarter of FY-82 as defined in Revision 5 of the Subprogram Plan, is summarized in Table 1. The status of the work in each of the Work Breakdown Structure (WBS) elements of the Subprogram is described in section 3 (see Appendix A for the Subprogram WBS). The major milestones for all of 1982 are shown in Table 2.

Technical highlights of the period were:

1. The R2-K13 Fuel Capsule Irradiation test completed in-pile operation at the Studsvik reactor on September 19, 1982. This capsule contained two cells with FRG fuel and two with US fuel. The fission gas release was close to predicted values in all four cells at the end of life. A hot cell examination of the fuel is planned at KFA during the next six months.
2. The HTK-6 Graphite Capsule Irradiation test began operation in the ORNL HFI reactor on July 18, 1982. This is a test of US and FRG graphites at 900°C. The companion HTK-5 capsule has reached 10 of a planned 15 cycles at 600°C.
3. A review of the Subprogram was held on September 29, 1982 at the time of a visit to KFA by A. J. Neylan of GA.
4. Dr. Karl Bongartz has completed his work on fuel performance modeling under PWS-FD-8 while at GA. He is now working primarily on analytical models for carburization of metals in gas-cooled reactor circuits.

TABLE 1
MILESTONE STATUS FOR THE FOURTH QUARTER OF
FY-82 FROM REVISION 5 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 1.1 Complete R2-K13 irradiation	FD-15	6/82	9/82	KFA	Completed
	WBS 1.1 Issue PIE plan for R2-K13	FD-15	8/82	--	KFA	Draft reviewed
	WBS 1.2 Complete exchange and assessment of particles	FD-22	3/82	--	GA/Hobeg	Exchange and measurements completed; report delayed to 1/83
	WBS 1.4 Exchange status reports on SiC	FD-10	9/82	7/82	KFA/ORNL	Exchange done at specialists meeting
	WBS 1.5 Complete test of FRG fuel and issue report	FD-11	6/82	--	GA	Fuel shipped 8/82 from KFA
2.	Fission Product Behavior					
	WBS 2.1 Provide input to fission product data book	FP-2	6/82	7/82	GA	Complete
	WBS 2.2 Exchange calculated data for R2-K12	FP-3	9/82	9/82	GA/HRB	Data exchanged; work continuing
3.	Graphite					
	WBS 3.1 Complete HTK-5 irradiation	GD-1	9/82	--	ORNL	Delayed to 12/82
	WBS 3.1 Complete 300°C Petten irradiation	GD-2	9/82	--	KFA	Delayed to 11/82
	WBS 3.2 Provide improved ASR-IRG for evaluation	GD-11	2/82	--	KFA/SIGRI	Delayed to 12/82

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 specification			
3-3-1	Issue report on S-2020 graphite	GD-12	11/81	GA

2. SIGNIFICANT PROBLEMS

No significant problems are identified at the present time.

3. STATUS OF COOPERATION

3.1. FUEL DEVELOPMENT

3.1.1. Fuel Irradiation Tests, WBS 1.1

One Project Work Statement (PWS) is active in this Work Breakdown Structure (WBS) element, PWS-FD-15 (see Appendix B for all PWS titles). The R2-K13 irradiation was completed September 19, 1982, after 517 full power days. A 48-hour xenon measurement was performed after shutdown. Dismantling at Studsvik was completed on September 24, 1982. Table 3 shows key performance values.

3.1.2. Fuel Process Development, WBS 1.2

One Project Work Statement is active, PWS FD-22. Interim results on the exchange of TRISO coated ThO₂ particle tests were exchanged between Hobeg and GA. A batch of TRISO coated UO₂ particles was laser-drilled at GA and returned to Hobeg for use in evaluating fuel element contamination from defective coatings.

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. Data were exchanged under PWS FD-19 on the correlation of SiC corrosion by fission products during long term annealing conditions.

3.1.4. Pre- and Postirradiation Characterization, WBS 1.4

Three Project Work Statements are active, FD-10, FD-14, and FD-20. PWS FD-10 will be completed later this year when all technical reports are exchanged. PWS-FD-14 was completed by issuing a comprehensive report on Peach Bottom test elements in September 1982. A shipment of irradiated fuel particles from KFA tests No. DR-S6-19, DR-S6-22 and FRJ2-P24 was received at ORNL on August 31, 1982 under PWS-FD-20. Tests in the IMGA and PGA facilities are planned later this year.

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

Two Project Work Statements are active, FD-8 and FD-11. A report on PWS-FD-8 documenting performance models has been drafted for issue later this year. Fuel for a PWS-FD-11 test at GA was received at ORNL from KFA, and will be shipped on to GA. The fuel is from the DR-S6 test.

TABLE 3
CAPSULE R2-K13 PERFORMANCE SUMMARY

	<u>1 (KFA)</u>	<u>2 (GA)</u>	<u>3 (GA)</u>	<u>4 (KFA)</u>
Fuel temp, °C	970	1140	940	760
Burnup, % FIMA				
Mixed oxide	10.3			9.4
UCO fissile		22.2	21.6	
ThO ₂ fertile		4.6	4.3	
Fast fluence,* 10 ²¹ cm ⁻²	8.5	10.0	9.5	6.8
R/B (Kr-85m)	2×10^{-7}	2×10^{-5}	6×10^{-6}	2×10^{-7}

R2-K13 fuel will be shipped to KFA in early October.

*(E > 0.18 MeV).

3.2. FISSION PRODUCT BEHAVIOR

3.2.1. Fission Product Release and Transport

Three Project Work Statements are active, FP-1, FP-2, and FP-5. Under PWS-FP-1, David Hanson and Heinz Nabielek have issued a questionnaire to HRB, Interatom and AVR staffs on the techniques used to analyze tritium transport to the coolant of HTRs.

A paper on fission product transport was written under PWS-FP-2 by Heinz Nabielek of KFA and Ben Myers of GA for presentation at the Gas-Cooled Reactor Symposium in Bristol, England in September 1982.

The FRG task leaders were nominated for PWS-FP-5. They are A. Christ of HRB and H. Nabielek of KFA.

3.2.2. Methods Verification

Two Project Work Statements are active, FP-3 and FP-4, and a third has been initiated, FP-6. The benchmark calculations on metallic release under PWS-FP-3 are proceeding. Discrepancies in the correlation of silver release require further work. The definition of benchmark problem for FP-4 on plateout methods was proposed at a meeting between GA and HRB. PWS FP-6 was proposed as a new task to evaluate in-reactor effects of moisture on fission gas release.

3.3. GRAPHITE DEVELOPMENT

3.3.1. Irradiation Testing

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

Irradiation of graphite materials is continuing at ORNL under PWS-GD-1. Capsule HTK-5 has been exposed to 10 of a planned 15 reactor cycles at a temperature of 600°C. Capsule HTK-6 was inserted into the reactor in July 1982 for a planned exposure of 7 reactor cycles at 900°C.

Under PWS-GD-2, the irradiation of graphite materials in Petten continued at 300°C. The replacement of the Petten reactor vessel is scheduled to start in late 1983.

Under PWS-GD-4, the GC 07/31 creep irradiation test in Petten continued at 900°C. Completion is expected in December 1982. The broken creep specimen from GC 9 test was shipped to ORNL in August 1982.

The testing of graphites in ORR under PWS GD-9 is delayed by reduced funding.

3.3.2. Characterization of Properties

Two Project Work Statements are active in this area, PWS GD-10 and GD-11. The delivery of improved ASR-IRG graphite is delayed to December 1982.

3.3.3. Graphite Design Data and Specifications

One Project Work Statement is active, PWS GD-12, with no progress to report this period. A proposed PWS on graphite corrosion modeling, PWS-GD-15, is under review.

3.3.4. Performance Assessment, Modeling, and Verification

There is no active Project Work Statement in this area. Proposals to reinstate PWS-GD-5 on Structural Design Criteria, and to initiate PWS-GD-14 on Graphite Material Modeling are under review.

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. Shamasundar, B. I., et al., "HTGR Fuel Performance Basis," GA-A16767, May 1982.
2. Myers, B. F., et al., "The Behavior of Fission Product Gases in Fuel Materials," GA-A13723, October 1977.
3. Myers, B. F., and R. E. Morrissey, "The Measurement and Modelling of Fission Gas Release from HTGR Fuel," GA-A15018, December 1978.
4. Montgomery, F., "Fission Product/SiC Reaction in HTGR Fuel," unpublished data, 1981.
5. Bullock, R. E., and J. L. Kaae, "Performance of Coated Oxide Particles Gettered with ZrC," GA-A16624, June 1982.
6. Myers, B. F., "Examination of Bastek's Cesium Release Data," unpublished data, September 1982.
7. Scott, C. B., et al., "Summary Report on Selection of Reference LEU/Th Fuel System," unpublished data, April 1982.
8. Scheffel, W. E., "Capsule R2-K13 Post Irradiation Exam Procedure," unpublished data, September 1982.
9. Myers, B. F., "Fission Gas Release," unpublished data, September 1982.
10. Adams, C. C., Status Report on US/FRG TRISO Coated Particle Process Studies," unpublished data, September 1982.
11. Kania, M. J., et al., "Comparison of US and FRG PIE Procedures for Coated Particle Fuels," ORNL/TM-8346, August 1982.
12. ORNL Staff, Monthly HTGR Program Reports for June, July, and August, 1982.

Reports received from FRG during the reporting period:

1. Pott, G., "Bestrahlungen in R2 in Studsvik," ZBB/TN/11/82, June 1982.
2. Nabielek, H., "Results from Annealing Experiments with Irradiated Fuel Spheres," HBK-TN-11/82, July 1982.
3. Schulze, R. E., and H. A. Schulze, "Graphitische Matrixwerkstoffe für Kugelförmige HTR Brennelemente," Jül 1702, February 1981 and Jül 1752, December 1981.
4. HBK Projekt, "Vierteljahresberichte," 2 Quartal 1982, July 1982.
5. HBK Projekt, "Bestrahlungsexperiment - Information," 2 Und 3/82," HBK-IB-15/82, August 1982.

6. Reitsamer, G., and G. Falta, "Postirradiation Examination of Experiment DR-K5 Sphere 12," CH-308/82, July 1982.
7. KFA Staff, "Projektbericht 1981 des Projektes Hochtemperaturreaktor - Brennstoffkreislauf," 1982.
8. Nabielek, H., and D. Mindermann, "USA/FRG Umbrella Agreement for Fuel, Fission Products and Graphite Subprogram; Quarterly for April - June 1982," (II/82), KFA-HBK-IB-14/82, August 1982.

6. CONCLUSIONS

The exchange is continuing satisfactorily. The assignments of Dr. Bongartz to General Atomic and Mr. Hanson to KFA have been particularly beneficial in the development of technical data of mutual benefit. The continuation of irradiation testing has continued to be a strong part of the program. Increased emphasis on verification of performance methods has strengthened the exchange.

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
	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	Completed
	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 Comparison of tritium design methods	GA	In progress
	FP-2 Fission product data handbook	KFA	In progress
	FP-5 Fission gas release model	GA	In progress
2-2	Methods verification		
	FP-3 Verification of fission product design methods and codes	GA	In progress
	FP-4 Fission product plateout code verification	GA	In progress
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-9 Irradiation of KFA side reflector and core support graphite in ORR	GA	Delay to FY-84

APPENDIX B (CONTINUED)

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