DOE/HTGR-86-124

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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, 1986 through September 30, 1986

AUTHORS/CONTRACTORS

GA TECHNOLOGIES INC.

APPLIED TECHNOLOGY

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CONTRACT DE-AC03-84SF11962

DECEMBER 1986

DOE/HTGR–86–124
GA–C18650

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Issued By:
GA Technologies Inc.
P.O. Box 85608
San Diego, California 92138

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GA Project 7700

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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 "High Temperature Reactor (HTR) Implementing Agreement" of the United States/Federal Republic of Germany Umbrella Agreement for Cooperation in Gas-Cooled Reactor (GCR) Development. The status is described relative to the commitments in the "Subprogram Plan for Fuel, Fission Products, and Graphite," Revision 11, July 1986. The work described was performed during the period July 1 through September 30, 1986 in the High-Temperature Gas-Cooled Reactor (HTGR) Technology Program at Oak Ridge National Laboratoy, the HTGR Technology Program at GA Technologies Inc. (GA), and the Project HTR-Brennstoffkreislauf of the Entwicklungsgemeinschaft HTR at Kernforschungsanlage GmbH (KFA), Julich; Hochtemperatur Reaktorbau GmbH, Mannheim; Internationale Atomreaktorbau, Bensberg; Hochtemperaturreaktor Brennelement Gesellschaft, Hanau; and SIGRI, Meitingen.

The requirements for 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

Table 1 summarizes the status of progress on the milestones for the third quarter of CY-86, as defined in Revision 11 of the Subprogram Plan. Table 2 shows the major milestones for all of 1986. Section 3 describes the status of the work in each of the work breakdown structure (WBS) elements of the subprogram. (See Appendix A for a diagram of the subprogram WBS.)

Technical highlights for the period were as follows:

1. The status of all tasks in the subprogram was reviewed during a visit of Dr. Balthesen, Dr. Kirch, and Dr. Theenhaus of KFA to GA on September 17, 1986. The subprogram continues to be a valuable area of exchange for both the USA and the FRG. Discussions were held on possible expanded exchanges on reactor safety technology and on tests in the AVR plant. The expanded exchanges will be discussed in a meeting of USA representatives to KFA in October 1986.

2. The exchange of fuel kernel and coated particle samples between GA and HOBEG has been continued in order to define techniques to reduce defective fractions and to improve quality control methods. Two batches of TRISO coated $(Th\text{-}U)O_2$ were fabricated with low defect levels at GA on kernels supplied by HOBEG. Quality measurements will be compared at GA and HOBEG by sending samples to HOBEG. (PWS-FD-22)

3. The HFR-B1 capsule test in Petten reactor is important for defining the effects of hydrolysis on the release of fission gases from oxycarbide and oxide fuels. The HFR-B1 capsule is completely fabricated and is awaiting insertion into the Petten

TABLE 1
MILESTONE STATUS FOR THE THIRD QUARTER OF CY-86 FROM REVISION 11 OF THE SUBPROGRAM PLAN

PWS	Milestone (No.)	Due Date	Completion Date	Responsible Party	Status
1. Fuel Development					
FD-11	No milestone due				
FD-20	Complete IMGA and PGA on KFA particle set number 3 (5)	7/86	--	ORNL	Delayed by equipment repairs; now expected for completion in 12/86
	Issue review of results of set 3 (7)	9/86	--	KFA	Delayed until M/S 5 completed; expected in 3/87.
FD-22	No milestone due				
2. Fission Products					
FP-1	Issue final report on comparisons (6)	9/86	--	GA	Delayed to 11/86 by priority on staff
FP-2	No milestone due				
FP-3	Issue report on GA fuel in R2-K-13 (8)	7/86	--	GA	Delayed to 11/86 by priority on staff
FP-4	Issue report on validation of plateout (8)	9/86	--	GA	Analysis performed as sceduled, but report delayed to 12/86 by inconsistent code output requiring corrections in code.
FP-5	No milestone due				
FP-7	No milestone due				
FP-8	Insert HFR-B1 in Petten (5)	9/86	--	KFA	Delayed to 1/87 by change in staff at Petten and late delivery of instruments
	Supply HRB 17/18 operation data (6)	7/86	7/86	GA	Completed

TABLE 1 (Continued)

PWS	Milestone (No.)	Due Date	Completion Date	Responsible Party	Status
3. Graphite					
GD-1	No milestone due				
GD-2	No milestone due				
GD-4	No milestone due				
GD-5	Issue draft of FRG design criteria (3)	6/86	7/86	KFA	Three reports received, partially meeting milestone
GD-10	Ship improved ASR-IRG to ORNL	7/86	--	SIGRI	Delayed by preparation of specimens
GD-12	No milestone due				
4. Coolant Chemistry					
CC-1	Issue report on analysis of SAPHIR	9/86	--	GA	Analysis completed; report delayed to 12/86 by inconsistent code ouput requiring corrections in code.
5. Reactor Safety					
SR-1	No milestone due				

TABLE 2
MAJOR MILESTONES IN THE COOPERATIVE SUBPROGRAM FOR 1986
(Revision 11)

	WBS Element and Milestone	PWS	Due Date	Responsible Party
1.	Fuel Development			
	Complete IMGA and PGA set 3 fuels	FD-20	7/86	ORNL
2.	Fission Product Behavior			
	Insert HFR-B1 in Petten reactor	FP-8	9/86	KFA
3.	Graphite			
	Begin HFIR irradiation of FRG graphite	GD-1	1/88	ORNL

test reactor. A revised test specification for the HFR-B1 capsule was issued (Doc. MHTGR-86-084); this defines the data handling and reporting requirements during operation of the capsule. (PWS-FP-8)

2. SIGNIFICANT PROBLEMS

There are continuing delays in meeting schedules by both sides. All milestones were updated during the May 1986 subprogram review, yet most were late in the subsequent quarter. Overall there is progress in the exchange, although milestones continue to be delayed as a result of staffs being assigned to higher priority tasks within the national programs.

3. STATUS OF COOPERATION

3.1. FUEL DEVELOPMENT

3.1.1. Fuel Irradiation Tests, WBS 1.1

The objective of this work area is to test US and FRG fuel under near real-time conditions. One project work statement (PWS) is active, FP-8. (See Appendix B for a list of all active PWS titles.) FP-8 is a test of coated particle fuel with some exposed kernels, to quantify the effects of hydrolysis on fission gas release.

The document no. HTGR-86-084, "Capsule HFR-B1 Test Specification and Procedure" was sent to KFA and Petten from GA. This document includes the requirements for data handling and reporting for the HFR-B1 capsule. Startup of the capsule was delayed to January 1987 because of changes in the technical staff at the Petten reactor and delays in delivery of instrumentation. The effect of the delay will be a later validation of the model for hydrolysis of fuel kernels. This will not affect completion of conceptual designs.

3.1.2. Fuel Process Development, WBS 1.2

The objective of this work area is to exchange information on process development and to compare quality control measurement techniques.

One PWS is active, FD-22. This is a task to characterize the effects of kernel shape and coater batch size on coated particle defects. TRISO coatings were applied at GA to two batches, 10 kg each, of (TH-U)O_2 kernels which had been shipped to GA from HOBEG earlier in

the year. Samples of these two batches will be shipped to HOBEG for comparison of coating quality with GA measurements.

3.1.3. Fuel Design Data and Specification, WBS 1.3

The objective of this work area is to exchange information on fuel specifications and data files.

No PWS is active.

3.1.4. Pre- and Post-irradation Characterization, WBS 1.4

The objective of this work area is to exchange results on the post-irradiation examination of fuel specimens.

One PWS is active, FD-20, under which the IMGA and PGA analyses of FRG set 3 coated particle samples are being examined at ORNL. During this period, an equipment breakdown of the IMGA unit has caused a delay. The equipment repairs were completed, and work was resumed on examining the Set 3 samples. About 25% of the fuel has been examined. Completion is expected by December 1986.

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

The objective of this work area is to develop models for the performances of coated particle fuel during both normal and accident conditions.

One PWS is active, FD-11, for the testing of fuel under hypothetical overheating conditions. Activity consisted of communications on the model for transport of metallic fission products through SIC during a heat-up event. One model assumes bulk diffusion through

the SiC. A second model assumes transport through corrosion paths in the SiC. Further work is required for resolution of which model is most applicable.

3.2. FISSION PRODUCT BEHAVIOR

3.2.1. Fission Product Release and Transport, WBS 2.1

The objective of this work area is to develop basic release, diffusion and sorption data necessary for calculating fission product transport.

Three PWSs are active, FP-1, FP-2, and FP-5. An analysis was performed at GA comparing tritium design data from KFA, HRB, and GA. This is to be issued under FP-1 by a report in November 1986.

There was no activity on FP-2 and FP-5 during this period.

3.2.2. Methods Verification, WBS 2.2

The objective of this work area is to reduce the uncertainties in computer codes used to calculate fission product release and plateout.

Three PWSs are active, FP-3, FP-4, FP-7. A report was written on the validation of the GA PADLOC code using FRG and U.S. data from FP-4. There are high degrees of scatter in the plateout distributions calculated. These are being checked after revisions to the code. The report is expected by December 1986.

There was no activity on FP-3 and FP-7.

3.3. GRAPHITE DEVELOPMENT

3.3.1. Irradiation Testing, WBS 3.1

The objective of this work area is to obtain data on the changes in dimensions and mechanical properties of graphite from irradiation exposure.

Three PWS s are active, GD-1, GD-2, GD-4. There was no activity to report during this period.

3.3.2. Characterization of Properties, WBS 3.2

The objective of this work area is to characterize performance properties of graphite, particularly the effects of oxidation.

One PWS is active, GD-10. There was no activity to report during this period.

3.3.3. Graphite Design Data and Specification. WBS 3.3

The objective of this work area is to define the specifications for graphite for acceptance/rejection during procurement.

One PWS remains active, GD-12. There was no activity to report for this period.

3.3.4. Performance Assessment, Modeling, and Verification, WBS 3.4

The objective of this work area is to develop structural design criteria for core and reflector graphites.

One PWS remains active, GD-5, for exchange of structural design criteria. Three reports were issued by HRB on modeling techniques for

volume-dependent physical properties in graphite. These reports partially fulfill a milestone by HRB to issue a draft document on a definition of the design criteria used for HTR reflector and core support graphites.

3.4. COOLANT CHEMISTRY

While not a part of the Fuel, Fission Products, and Graphite Subprogram, the work on coolant chemistry is coordinated and reported in this management area.

3.4.1. Plateout Data Exchange, WBS 4.1

The objective for this work area is to exchange experimental data on the plateout of fission products in operating reactors and test loops.

One PWS is active, CC-1, for exchange of loop data. A validation analysis was completed as GA using plateout data from SAPHIR and VAMPYR loops at KFA. The results are not consistent, and are being reevaluated with revisions in the PADLOC code. A report is expected by December 1986.

3.5. SAFETY RESEARCH

While not a part of the Fuel, Fission Products, and Graphite Subprogram, the work on Safety Information is coordinated and reported in this management area.

3.5.1. PCRV and Containment Response to Severe Accidents, WBS 5.1

The previously agreed milestones on PWS-SR-1 were completed in January 1986. Discussions were held with KFA staff members in a meeting at GA in September 1986 on possible future safety tasks.

4. PROGRAMMATIC CHANGES

There were no changes in the Fuel, Fission Products, and Graphite Subprogram.

5. REPORTS EXCHANGED

The following reports were sent to FRG during the reporting period:

1. Ketterer, J.W., "Capsule HFR-B1 Test Specification and Procedure," Report No. HTGR-86-084, August 1986.

2. GA Staff, "US/FRG Fuel, Fission Products and Graphite Quarterly Report for Period January through March 31, 1986, Document No. HTGR-86-040.

The following reports were received from FRG during the reporting period:

1. HBK Staff, "Fission Product Diffusion Coefficients," Report No. HBK-IB-01/86, January 1986.

2. Proksch, E., A. Stirgl and H. Nabielek, "Carbon Monoxide Formation in UO_2 Kerneled HTR Fuel Particles," Journal of Nuclear Materials, 129 (1986) pg. 83-90.

3. Nabielek, H., and R. F. Turner, "US/FRG Umbrella Agreement; Fuel, Fission Products and Graphite Subprogram Plant (Revision 11), No. KFA-HBK-1B-09/86, July 1986.

4. HBK Staff, Quarterly Report, Q1 1986 (no date).

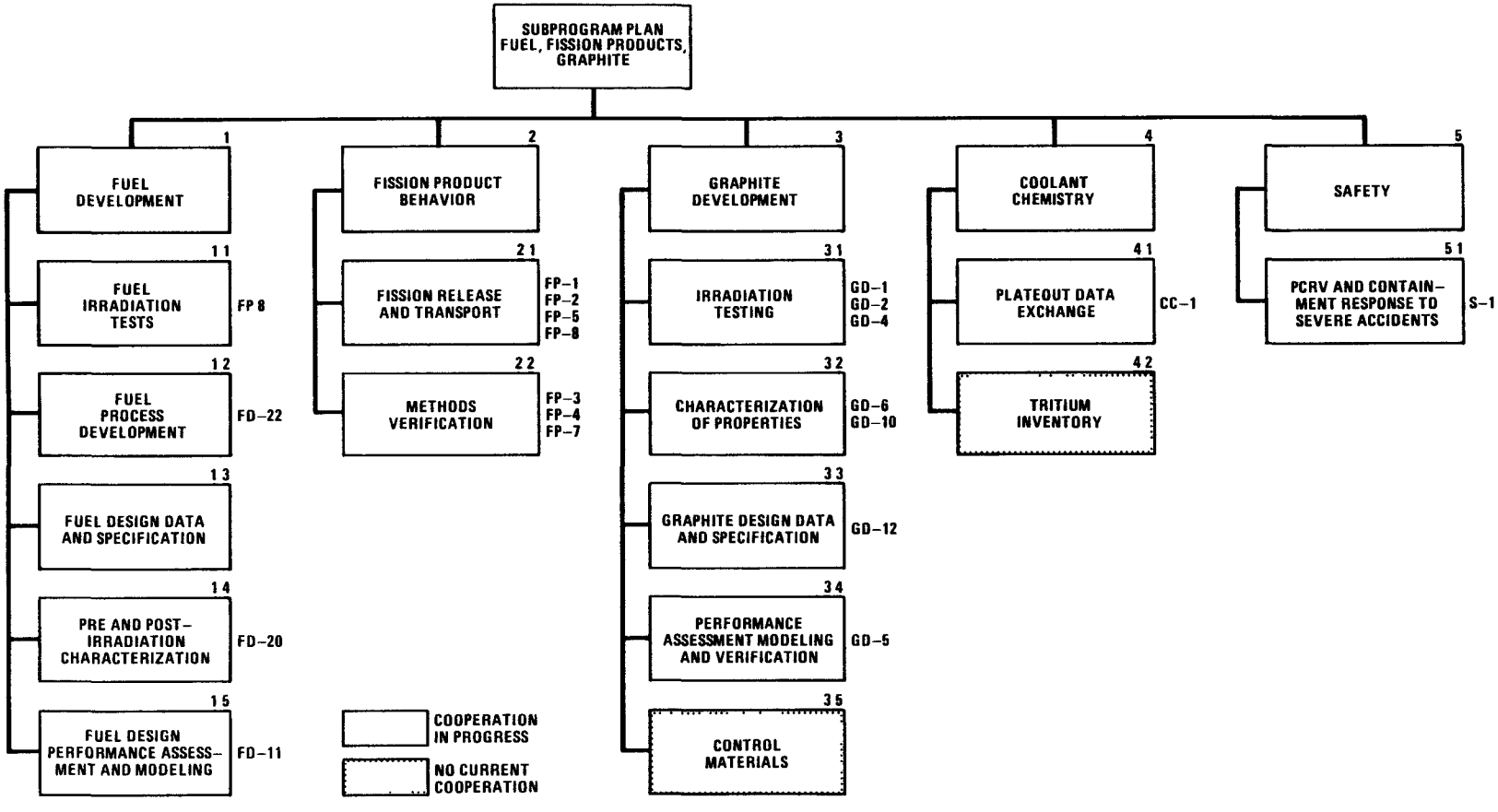
5. HBK Staff, Projektbericht 1985 (no date).

6. Brennelementversorung und Entsorgung (papers from Aachen Technical Meeting) (no date).

6. CONCLUSIONS

The most active technical areas this quarter were on fission product transport methods validation, preparations for the Petten HFR-B1 capsule test and TRISO coating process development. The cooperation continued to be valuable to both sides.

APPENDIX A
SUBPROGRAM PLAN WORK BREAKDOWN STRUCTURE


SUBPROGRAM PLAN
FUEL, FISSION PRODUCTS, GRAPHITE
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FUEL DEVELOPMENT
11
FUEL IRRADIATION TESTS
FP 8
12
FUEL PROCESS DEVELOPMENT
FD–22
13
FUEL DESIGN DATA AND SPECIFICATION
14
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FD–20
15
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FD–11
2
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FISSION RELEASE AND TRANSPORT
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FP–2
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APPENDIX B
ACTIVE PROJECT WORK STATEMENTS

APPENDIX B
ACTIVE PROJECT WORK STATEMENTS

WBS Element and Title		Lead Org.
1.	Fuel development	
1.1	None	
1.2	Fuel process development	
	FD-22 Coated particle and QC process development	GA
1.3	None	
1.4	Pre- and post-irradiation characterization	
	FD-20 Coated particle analysis by IMGA/PGA	ORNL
1.5	Fuel design, performance assessment, and modeling	
	FD-11 Testing of GA and HBK fuel under hypothetical accident conditions	GA
2.	Fission product behavior	
2.1	Fission release and transport	
	FP-1 Comparison of tritium design methods	GA
	FP-2 Fission product data handbook	KFA
	FP-5 Fission gas release model	GA
	FP-8 Fission product release test in Petten	KFA
2.2	Methods verification	
	FP-3 Verification of fission product design methods and codes	HRB
	FP-4 Fission product plateout code verification	GA
	FP-7 Evaluation of coolant gas activity in AVR/FSV	HRB

	WBS Element and Title	Lead Org.
3.	Graphite development	
3.1	Irradiation testing	
	GD-1 KFA graphite irradiation experiment in HFIR at Oak Ridge	ORNL
	GD-2 Irradiation of GA side reflector graphite in HFR Petten	KFA
	GD-4 Graphite creep tests in Petten	KFA
3.2	Characterization of properties	
	GD-10 Study of the oxidative strength loss of KFA core support graphite ASR-1R	ORNL
3.3	Graphite design data and specifications	
	GD-12 Characterization of core support structure graphite for acceptance/rejection strength tests in purchase specifications	GA
3.4	Performance assessment modeling and verification	
	GD-5 Strucytural design criteria for graphite in GCR	GA
4.	Coolant chemistry	
4.1	Plateout data exchanger	
	CC-1 Plateout data exchange	GA
5.	Safety	
5.1	PCRV and containment response to severe accidents	
	SR-1 PCRV and containment response to severe accidents	GA