HTGR

USA/FRG UMBRELLA AGREEMENT FOR COOPERATION IN GCR DEVELOPMENT

Fuel, Fission Products and Graphite Subprogram

Part I: Management Meeting Report
Part II: Revised Subprogram Plan (Revision 10)

AUTHORS/CONTRACTORS

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MASTER

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GA Project 7700

MAY 1986

USA/FRG UMBRELLA AGREEMENT
FOR COOPERATION IN GAS COOLED REACTOR DEVELOPMENT

Fuel, Fission Product and Graphite Subprogram

PART I
Meeting Report

Semiannual Subprogram Management Meeting

November 20-22, 1985

Participants

GA: D. Goodin	DOE: J. Fox
W. Gorholt	L. Lanni
D. Hanson	R. Ng
S. Inamati	
H. Jones	KFA: G. Kaiser
J. Ketterer	
B. Myers	ORNL: W. Eatherly
A. Neylan	J. Jones
W. Scheffel	M. Kania
O. Stansfield	K. Kasten
R. Turner	
GCRA: S. Pennfield	
H. Stewart	

1. OBJECTIVES

- Review and update the Subprogram Plan for Fuel, Fission Products, and Graphite (FFPG) for approval by the funding agencies.
- Review the status of the cooperation and resolve outstanding problems.

2. RESULTS

2.1 The highlights of the cooperative FFPG exchange were reviewed for the period from 1978 through 1985. Overall, the FFPG subprogram has been very effective in strengthening the development programs of both countries.

2.2 The Subprogram Plan, Revision 9, from March 1985, was updated and approved by the respective USA and FRG Subprogram Managers. This update included the following:

- Status of active Project Work Statements (Appendix A)
- The list of completed Project Work Statements (Appendix B)
- Subprogram cost table (Appendix C)
- Travel requirements (Appendix D)

2.3 The active Project Work Statements in the following areas were reviewed and revised (Appendix E):

- Fuel Development (FD)
- Fission Products (FP)
- Graphite Development (GD)
- Coolant Chemistry (CC, associated area)
- Safety Research (SR, associated area)

This appendix also contains a draft Project Work Statement for review.

2.4 The cooperation is judged to be proceeding in a satisfactory manner in the majority of the Project Work Statements. Exceptions were noted where delays have been significant.

2.5 Seven Project Work Statements were completed during this period. These are FD-14, FD-15, GD-6, GD-9, GD-11, GD-15, and CC-2.

3. AGREEMENTS AND COMMITMENTS

3.1 The Progress in Coolant Chemistry and Safety Research Project Work Statements will be coordinated by HBK Project within KFA.

3.2 The US will offer test results on the high temperature performance tests of fuel in HRB-21 capsule in exchange for data from the HFR-B1 Petten Test. This will be the first high temperature testing of improved LEU fuel in the US Program.

3.3 All technical reports in the future FRG Program which contain US "Applied Technology" information shall be issued only as HBK reports.

3.4 Portions of the ORNL Monthly Status reports which contain information on Project Work Statements activities will be sent to KFA for information. The information will be prepared by ORNL for approval by DOE prior to transmittal.

3.5 The host subprogram manager shall issue a revised draft of the Subprogram Plan within six weeks of a subprogram meeting. The comments on the draft shall be returned by the corresponding manager within three weeks, and an edited version signed off by the host country within another three weeks.

- 3.6 Proposals for future cooperation will be exchanged four weeks in advance of each subprogram management meeting.
- 3.7 Copies of completed Project Work Statements will be included in an appendix of the Subprogram Plan.

4. ACTION ITEMS

- 4.1 A confirmation will be provided by KFA that the R2-K13 irradiation test report on US fuel specimens can be issued as an HBK document (PWS-FD-15).
- 4.2 GA will provide operational data from the HRB 17/18 tests necessary for monitoring the performance of the HFR-B1 test. (PWS-FP-8)
- 4.3 GA will prepare a list of technical data needed from HBK on the Laminar II loop in order to complete a validation calculation for the plateout code. (PWS-FP-4)

5. FUEL TRANSPORTS

PWS FD-11: Arrange shipment of three irradiated HRB-15A fuel rods from GA to KFA in June 1986.

PWS FD-20: Ship set 4 fuel samples from KFA to ORNL in May 1986.

PWS-FD-22: Ship unirradiated ThO₂ kernels from HOBEG to GA in February 1986.

6. NEXT MEETING

The next meeting is planned for May 1986 at KFA, Julich.

8. APPROVAL OF REVISION 10 OF THE FFPG SUBPROGRAM PLAN

US SUBPROGRAM MANAGER

R. F. Turner 22 Jan '86

R.F. Turner Date

FRG SUBPROGRAM MANAGER

Heinz Nabielek 16 Jan '86

H. Nabielek Date

USA/DOE/HTR

R. N. Ng 21 Feb 86

R.N. Ng Date

FRG/BMFT/PTH

E. Balthesen 15.4.86

E. Balthesen Date

USA/DOE/Converter Reactor

F. X. Gavigan 2/21/86

F.X. Gavigan Date

FRG/KFA

R. Theenhaus 2.5.86

R. Theenhaus Date

USA/FRG UMBRELLA AGREEMENT
FOR COOPERATION IN GAS-COOLED REACTOR DEVELOPMENT

Fuel, Fission Products and Graphite Subprogram

PART II
Subprogram Plan

Revision 10

December 1985

SUBPROGRAM PLAN
"FUEL, FISSION PRODUCTS AND GRAPHITE"

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1. INTRODUCTION, PURPOSE, AND SCOPE

This Subprogram Plan describes cooperative work in the areas of HTR fuel and graphite development and fission product studies that is being carried out under the US/FRG/Swiss Implementing Agreement for cooperation in Gas Cooled Reactor development. Only bilateral US/FRG cooperation is included, since it is the only active work in this subprogram area at this time. The cooperation has been in progress since February 1977. A number of Project Work Statements have been developed in each of the major areas of the subprogram, and work on many of them is in progress.

The overall purposes of cooperation in this subprogram area are as follows:

- To advance the state of HTR technology by broadening the available base of personnel and facilities
- To reduce duplication of R&D efforts and reduce overall program costs
- To help prepare a basis for broader future cooperation on the high temperature gas cooled reactor
- To provide back-up fuel and graphite material to reduce risk in the National Programs

The following specific areas are included in the scope:

- Fuel Development
- Graphite Development
- Fission Product Release
- Fission Product Behavior outside the Fuel Elements*

*Progress in Project Work Statements in Coolant Chemistry are being reported in an appendix to the Quarterly Reports of the Fuel, Fission Products and Graphite Subprogram.

2. NATIONAL SUBPROGRAM RATIONALE

The US and FRG Program strategies are summarized below. The table contains the present reference concepts, which are described for the US in Part 2.1 and for the FRG in Part 2.2. The long-term option for both sides is the HEU-fuel cycle. Finally, the planning base is shown which covers the near term development goals.

2.1 US-PROGRAM

CONCEPT	FUEL	GRAPHITE
REFERENCE	LEU - Th/U-fuel cycle <ul style="list-style-type: none"> • 20% enriched uranium, once-through • 350 μm UCO-kernel • 500 μm ThO₂-kernel • TRISO-coating • Prismatic fuel element 	<u>Fuel element and replaceable reflector</u> - extruded near isotropic petroleum coke graphite <u>Core support blocks</u> - molded, fine grained, petroleum coke graphite <u>Core support posts</u> - molded, fine grained, petroleum coke graphite <u>Permanent side reflector</u> - extruded petroleum coke graphite
LONG-TERM OPTION	HEU - Th/U-fuel cycle <ul style="list-style-type: none"> • Feed 93%/Breed-System • 200 μm fissile kernel • 500 μm ThO₂ • ZrC barrier possible • Prismatic fuel element 	
PLANNING BASE	<ul style="list-style-type: none"> • Selected Reference LEU fuel system 9/81 • Preliminary Safety Information Document in 1986 	Conceptual design fixed 9/1985 Preliminary Safety Information Document in 1986

2.2 FRG-PROGRAM

CONCEPT	FUEL	GRAPHITE
REFERENCE	LEU - U/Pu-fuel cycle <ul style="list-style-type: none"> • 6-13% enrichment • 500 μm UO_2-kernel • TRISO-coating • Spherical fuel element 	<u>Inner reflector</u> - extruded semiisotropic pitch coke <u>Backup</u> - vibrational molded isotropic pitch coke <u>Core support blocks</u> - vibrational molded pitch coke <u>Core support posts</u> - isotatically molded pitch coke <u>Hot gas ducts</u> - vibrational molded pitch coke
LONG-TERM OPTION	HEU - Th/U-fuel cycle <ul style="list-style-type: none"> • >90% enrichment • 500 μm (Th,U)O_2 kernel • TRISO-coating • Spherical fuel element 	
PLANNING BASE	<ul style="list-style-type: none"> • LEU fuel definition, first production charge 1980 • LEU fuel qualification, evolution of fuel specification by 1985-1986 	Process and product specification, final production lots by 1985 Qualification and irradiation behavior up to expansion phase from 300° - 750°C by 1988

3. COOPERATIVE SUBPROGRAM DEFINITION

3.1 Cooperative Subprogram Rationale

The individual US and FRG national programs have many similarities in structure, data requirements, and objectives in spite of the significant differences in reactor systems and fuel cycles. The fuel and graphite development programs involve four phases:

- Design definition
- Material qualification
- Performance verification
- Implementation

The status of specification development, process development, and irradiation testing in each of these phases is outlined in Table 3-1. The development of design data and specifications is an iterative process with each of the above phases representing a complete iteration. The steps involved in the development of design data and specifications are shown schematically in Fig. 3-1. Although fuel and graphite materials for the THTR and Fort St. Vrain reactors are fully developed and qualified, because of changes in design requirements and fuel cycles many of the materials for advanced reactors are at the definition and qualification phases. This is particularly true for LEU fuel, more irradiation stable graphites for prismatic fuel elements and pebble bed reflectors, and stronger more oxidation resistant graphites for the core support structures.

Although a considerable amount of work has been done on fission product transport, the trend to lower enrichments results in increased emphasis on the behavior of fission products such as silver and palladium and of plutonium. The programmatic emphasis on advanced HTR applications such as process heat plants also places more emphasis on reducing fission product release and on improving and verifying the predictive methods as

TABLE 3-1
PHASES OF FUEL AND GRAPHITE DEVELOPMENT

DEVELOPMENT PHASES PROGRAM ASPECT	Design Definition	Material Qualification	Performance Verification	Implementation
Specification	working design	preliminary specification	specification	final specification
Process development	laboratory scale	engineering scale	pilot plant	production scale
Irradiation performance	screening test	qualification test	proof test	demonstration or surveil- lance test

Fig. 3-1. Schematic illustration of the steps involved in fuel and graphite development

well as on a better understanding of fission product plateout in the primary circuit.

The US and FRG national programs in each of these areas can benefit from the cooperative program. A structure for the cooperation that is compatible with each of the national programs is presented in the following section.

3.2 Work Breakdown Structures and Identification of Areas for Cooperation

Potential areas for US/FRG cooperation in fuel development, fission product behavior and graphite development, are illustrated in Table 3-2. Areas in which cooperation is active are denoted with PWS numbers. The Project Work Statement does not include necessarily the entire area.

In the fuel development tasks, cooperation is proceeding in all significant areas. Differences in fuel element concepts limit cooperation in the fuel process area to kernels, coatings, and quality assurance technique development.

Cooperation in the fission product tasks is progressing in both the areas of release date and of methods verification.

In graphite development, cooperation is also well advanced. Cooperation has been initiated in the areas of graphite oxidation, mechanical testing, and fracture mechanics, and most important of all, in the preparation of graphite specifications. There is no cooperation at the present time in the area of control materials investigation.

The Work Breakdown Structure for the cooperative work is shown in Fig. 3-2. The currently identified or approved Project Work Statements are shown alongside their appropriate WBS element.

TABLE 3-2
AREAS FOR COOPERATION IN GERMAN AND AMERICAN PROGRAMS

FRG Program \ US Program	GA	ORNL
HBK Fuel Development	FD-11,22, FP-1,2,3,4,5,7,8	FD-20
HBK Graphite Development	GD-2,4,5,12	GD-1,10
HTA Safety	SR-1	
HTA Plateout	CC-1

Fig. 3-2. Work breakdown structure for US/FRG cooperation in fuel and graphite development and fission product studies

Cooperation is proceeding in all areas of the cooperative program WBS except graphite control materials development. The establishment of degree of commonality in the documentation and verification of materials data and models used in licensing procedures is an ultimate goal of the cooperation.

The following are brief summaries of the scope of work in each WBS element of the cooperative program.

1. FUEL DEVELOPMENT

- 1-1 Fuel Irradiation Tests - includes capsule tests performed under accelerated conditions in test reactors, and real time testing in prototype reactors such as Fort St. Vrain and AVR. Postirradiation examination and surveillance element irradiations are also included.
- 1-2 Fuel Process Development - includes work associated with kernel productions, coating, fuel bodies, and fuel element manufacture. All associated quality control and quality assurance work is included.
- 1-3 Fuel Design and Specification - includes the development of coated particle design data and fuel element product specifications compatible with fuel performance and fission product release criteria, and establishment of data file and fuel design and performance manuals.
- 1-4 Pre- and Postirradiation Characterization - includes both preirradiation and postirradiation measurements made on kernels, coatings, coated particles, and fuel elements. This includes all postirradiation examination (PIE) work on specimens from irradiation capsules.
- 1-5 Fuel Design, Performance Assessment, and Modeling - includes fuel stress modeling, the development of performance models, and verification of design and performance models through comparisons between predictions and experiments, especially irradiation tests.

2. FISSION PRODUCT BEHAVIOR

- 2-1 Fission Product Release and Transport - includes studies of the release of fission products from the coated particles and transport through the graphite fuel element. Model development is also covered under this task.
- 2-2 Methods Verification - includes verification of the validity of the fission product release and transport models through comparison of model predictions with actual measurements in independent experiments.

3. GRAPHITE DEVELOPMENT

- 3-1 Irradiation Testing - includes work to determine the effect of irradiation on graphite properties, as well as in-pile creep measurements.
- 3-2 Characterization of Properties - includes measurement of mechanical and physical properties, graphite oxidation studies, impurity concentration determinations, and evaluation of statistical variations in graphite properties.
- 3-3 Graphite Design Data and Specification - includes the development of design data, specifications, and standards to ensure that graphites meet all applicable performance criteria.
- 3-4 Performance Assessment, Modeling, and Design Verification - includes the development of performance models and design methods, based on the evaluation of test data, to predict graphite behavior in service and to verify models by comparison of predictions and experimental observations.
- 3-5 Controls Materials - includes work parallel to that described above for graphites containing concentrations of neutron absorbing isotopes that are used as control and poison materials.

3.3 Mutual Interests and Benefits

Although the HTR concepts and the fuel cycles in the two countries differ significantly, there is a broad area of common technology for an effective cooperation. Materials, phenomena of interest, and test requirements have sufficient similarities that significant benefits can be realized from international cooperation and information exchange. The perceived interests in and benefits of cooperation are summarized below:

INTERESTS

- Design and layout of fuel and graphite irradiation experiments and utilization of test reactors
- Improvement in postirradiation examination methods
- Progress in fission product model development and code verification
- Improvement in fuel design and performance modeling

- Improvement in coating layers by development, exchange and utilization of characterization methods/devices, and impact on process parameters
- Testing of core support blocks/columns out-of-pile (corrosion, strength)
- Fracture mechanics (stress calculations, experimental demonstration, model/code development)
- Design data and specifications

BENEFITS

Current

- Provision of test facilities not available in one country; reduction of irradiation capsule requirements by sharing space in capsules with different objectives
- Exchange of results from unique irradiation experiments and improvement of reliability of methods, codes, and models
- Establishment of common understanding in irradiation behavior and fission product transport, broadening of data base by comparison of test results
- Access to and improved utilization of irradiation facilities, PIE techniques, and equipment
- Strengthening of technical base through joint reviews of technology and joint programs
- Provisions of access to particular technical strengths or capabilities in one country

Future

- Establishment of common data base for materials properties, irradiation performance, and fission product transport
- Verification of experimental techniques and postirradiation examination techniques
- Increased confidence in results generated in the National Programs by exchange of results of generic interest
- Finally, establishment of common guidelines for the documentation and verification of material data and models used in licensing procedures

In an overall sense, the principal benefits are: (1) reduction of risks in the development programs through broadening of available skills, experience, and facilities, and through the provision of backup materials, and (2) reduction of costs through more efficient utilization of facilities in the cooperating countries and through reduction in the duplication of R&D efforts.

4. COOPERATIVE SUBPROGRAM EXECUTION

4.1 Structure and Status of the Current Cooperation

Major milestones on the cooperative subprogram for 1985-86 are listed according to WBS element in Table 4-1. Milestone dates and responsible parties are included. The milestones are cross-referenced to the applicable Project Work Statements which are included in Appendix E. A summary of the status of the active Project Work Statements is included in Appendix A. A list of completed Project Work Statements is included as Appendix B.

A table of 1986 costs (Fiscal Year for the US and Calendar Year for the FRG) for the Fuel, Fission Products, and Graphite National Programs is given in Appendix C. Incremental costs that directly result from the cooperation are included. All costs are given in 1985 US dollars. An exchange rate of 3.0 DM/\$ was assumed. Appendix D summarizes personnel delegations and travel requirements in 1986 for this subprogram area.

TABLE 4-1
MAJOR MILESTONES IN THE COOPERATIVE PROGRAM FOR 1986
(Revision 10 from November 1985)

PWS	MILESTONE	ORG.	DUE DATE
FD-11	14. Issue joint report on fuel performance model	GA	12/85
FD-15	15. Issue final report for R2-K13	GA	12/85
FD-20	5. Complete IMGA and PGA on set 3 fuels	ORNL	03/86
FP-8	4. Insert HFR-B1 in Petten	KFA	open
GD-1	8. Issue graphite report for HTK series	ORNL	01/86

4.2 Planning and Management

The cooperative work in the near term will center around the Project Work Statements that have already been developed. In the longer term broadening of the cooperation in the following will be considered:

- Fuel process development
- Fuel design data and specification
- Graphite design data and specification, and
- Control materials development

Proposals have been made in several of these areas.

Overall management in this area is provided by the Subprogram Managers, H. Nabielek for the FRG, and R. F. Turner for the US. The Subprogram Managers are responsible for overall coordination of the cooperative programs in this subprogram area for their respective countries. This includes the following:

- Prepare, maintain, and update the Subprogram Plan consistent with the HTR Implementing Agreement
- Ensure that commitments in the Subprogram Plan are met in a timely manner
- In conjunction with other program and technical groups, recommend additional areas for cooperation within the subprogram area
- Coordinate new Project Work Statement proposals with the responsible organizations
- Prepare quarterly reports on the status of the cooperative work

- Maintain a record of all documents exchanged
- Coordinate foreign travel related to the cooperative work in this subprogram area

The Subprogram Managers will coordinate the activities related to the cooperation in the various organizations in the National Programs. In the US program this includes the HTGR Technology Program at GA and the HTGR Base Technology Program at Oak Ridge National Laboratory. The FRG program is performed by the Project "Hochtemperaturreaktor-Brennstoffkreislauf (HBK)" in the Entwicklungsgemeinschaft HTR, which consists of the following partners: HOBEG, HRB, INTERATOM, KFA, NUKEM, SIGRI, Ringsdorffwerke.

Subprogram Manager meetings shall be held twice per year to monitor progress on approved cooperative work, plan and coordinate new cooperative work, resolve problems with the cooperation, coordinate travel as required for the cooperation, and update the Subprogram Plan. The meetings shall be held alternately in the US and Germany, and will be scheduled to coincide with other planned travel whenever possible. Where possible and appropriate, representatives from key participating organizations shall participate in the Subprogram Manager meetings. Minutes shall be prepared for each Subprogram Manager meeting. The minutes shall provide a record of all significant changes to the Subprogram. They will also include conclusions and recommendations from the meeting. The revised Subprogram Plan shall be approved by representatives of the respective funding agencies after being approved by the Program Managers of the participating organizations.

4.3 Information Exchange

Information exchange shall be carried out in conformance with the "HTR Implementing Agreement." The results of all cooperative work shall be documented in sufficient detail to enable review and understanding by the

respective parties and to provide suitable documentation to meet the needs of engineering design and licensing. The results of the cooperative work shall be freely available to the participants. Documentation requirements shall be enumerated in each Project Work Statement.

Administrative and programmatic aspects of the program shall be documented in the Subprogram Plan, the Subprogram Quarterly Status Report, and in minutes of the Subprogram Manager meetings. These documents shall be Category I - Freely Available.

APPENDIX A
PROJECT WORK STATEMENT STATUS, DECEMBER 1985

<u>PWS NO.</u>	<u>TITLE</u>	<u>STATUS/ COMMENTS</u>
FUEL DEVELOPMENT:		
FD-11	Testing of GA and KFA Fuel Under Hypothetical Accident Conditions	In progress
FD-20	Coated Particle Analysis by IMGA/PGA	In progress
FD-22	Coated Particle Process Development	In progress
FISSION PRODUCT TRANSPORT:		
FP-1	Tritium Design Data	In completion
FP-2	Fission Product Data Book	In completion
FP-3	Verification of Release Codes	In completion
FP-4	Fission Product Plateout Code Verification	In completion
FP-5	Fission Gas Release Model	In progress
FP-7	Evaluation of Coolant Gas Activity	In completion
FP-8	GA Test in Petten (HFR-B1)	In progress
GRAPHITE DEVELOPMENT:		
GD-1	Graphite Irradiation in HFIR	In progress
GD-2	Irradiation of Reflector Graphite in Petten	In progress
GD-4	Graphite Creep Tests in Petten	In completion
GD-5	Structural Design Criteria for Graphite	In completion
GD-10	Oxidative Strength Loss	In completion
GD-12	Characterize Graphites for Purchase Specs	In completion
COOLANT CHEMISTRY (associated):		
CC-1	Plateout Data Exchange	In completion
SAFETY RESEARCH (associated):		
SR-1	PCRV and Containment Response to Severe Accidents	In progress

APPENDIX B
COMPLETED PROJECT WORK STATEMENTS

<u>NUMBER</u>	<u>TITLE</u>	<u>RESP. ORG.</u>
FD-1	Critical Evaluation of LEU Performance Data	GA/ORNL/KFA
FD-2	KFA Fuel Tests in HFIR	ORNL/KFA
FD-4	Postirradiation Examination of Accelerated Capsule Test R2-B1 and Evaluation	KFA
FD-5	PIE of Real-Time LHTGR Qualification Test DR-GB2 with Large Size Specimens	KFA
FD-6	Test of FRG Fuel in FSV Test Elements	GA
FD-8	Development of Stress Analysis in the Design of Coated Particles	GA/KFA
FD-9	Testing of GA and KFA Particles with Improved Coatings	GA/KFA
FD-10	Characterization and QC Techniques for SiC	KFA
FD-12	Quantify Irradiation Induced Permeability in PyC	ORNL
FD-13	Comparison of US and FRG PIE Procedures for Failed Particle Determination	ORNL
FD-14	Gamma Spec Examination of HTGR Fuel Elements	GA/KFA
FD-15	Cooperative Irradiation of GA Fuel by HBK	GA/KFA
FD-19	Performance Data Sheets	KFA
FD-21	Design and Specification Data Files	KFA/GA
FP-6	In-Reactor Effects of Moisture on Fission Gas Release	GA/AVR
GD-3	Analysis of Data on the Effects of Temperature History on Irradiation Behavior of Graphites	GA/KFA
GD-7	Fatigue Damage Modeling	GA
GD-8	Evaluation of Filler Coke Used in SIGRI Experimental Graphites	GA
GD-9	Irradiation of Graphites in ORR	GA/ORNL/KFA
GD-11	Characterization of Side Reflector and Support Graphites for Oxidation	GA/STGRI
GD-13	Experimental Work and Analysis of GS-1 Large Block Experiment	KFA
GD-15	Graphite Corrosion Modeling	GA/HRB/KFA/IA
CC-2	Tritium Mass Balance in FSV	KFA/GA

APPENDIX C
SUBPROGRAM COST TABLE (INCREMENTAL COSTS)

<u>COST BREAKDOWN</u>		<u>FRG Costs</u> <u>CY 1986</u>	<u>US Costs</u> <u>FY 1986</u>
FUEL			
Cooperative activities	k\$	108	145
Irradiation units	IU	0	0
FISSION PRODUCTS			
Cooperative activities	k\$	107	132
Irradiation units	IU	136	0
GRAPHITE			
Cooperative activities	k\$	20	5
Irradiation units	IU	72	0
COOLANT CHEMISTRY			
Cooperative activities	k\$	0	0
SAFETY RESEARCH			
Cooperative activities	k\$	0	0
PROGRAM TOTAL			
Total cooperative activities	k\$	235	282
Total irradiation units	IU	208	0
Total travel	k\$	2	6
Total personnel exchange	k\$	0	0

APPENDIX D
1986 TRAVEL REQUIREMENTS

US	(1) (3)											
FRG	J	F	M	A	M	J	J	A	S	O	N	D
	(2)											

<u>Delegate</u>	<u>Destination</u>	<u>Costs (k\$)</u>	
		<u>FRG CY 86</u>	<u>US FY 86</u>
(1) Ketterer	Petten	0	3
(2) Vernfondeen	GA	2	0
(3) Turner	KFA	0	3

1986 LONG-TERM ASSIGNMENTS

US												
FRG	J	F	M	A	M	J	J	A	S	O	N	D

<u>Delegate</u>	<u>Destination</u>	<u>Costs (k\$)</u>	
		<u>FRG CY 85</u>	<u>US FY 85</u>
None			

APPENDIX E

PROJECT WORK STATEMENTS ACTIVE IN 1985-1986 (NOVEMBER 1985)

REVISION 9	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-5															
DATE March 1985			PWS NO. FD-8															
1. TITLE Development of Stress-Analysis Models for the Design of Coated Particles 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / D. T. Goodin KFA / R. Bornschein		CATEGORY (Circle one) I II III IV																
3. OBJECTIVES: 1. To develop analytical stress-analysis models for particle design 2. To determine SiC coating strength		I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Coated particle models are applicable to reactor designs in each country. The combination of GA and KFA efforts in this field are expected to lead to improved capabilities.																		
5. SCHEDULE AND MILESTONES:																		
MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS															
1. Document KFA model	KFA	09/80	Completed, JOL-1686															
2. Document GA model	GA	09/80	Completed 11/80, GA Doc. No. 905397															
3. Perform benchmark calculations on R2-K13 Fuel Particles	KFA/GA	03/81	Completed 04/81, GA Doc. No. 905987															
4. Review of burst strength measurements	GA	03/81	Completed 12/80, GA Doc. No. 905719															
5. Report on comparisons with irradiation results	GA	09/81	Completed 09/81															
6. Perform measurements on SiC rings from HOBEK particles and issue report	KFA	12/81	Completed 11/83, KFA Report Jü1-1871															
7. Complete report on joint GA/KFA particle model	GA	12/82	Completed 02/83, GA-A16807															
8. Supply 3 particle batches for SiC defect characterization	HOBEK	07/84	Completed 07/84															
9. Issue results of failure calculations for HBK tests	GA	08/83	Completed 04/83, GA Doc. No. 906814															
10. Issue summary of kernel gas release and impact on predictions	GA	12/84	Combined into milestone 5 of FP-5															
11. Determine SiC defect fraction of HOBEK fuel	GA	12/84	Shifted to PWS FD-22 Completed March 1985															
6. TRAVEL REQUIREMENTS:		9. INCREMENTAL COSTS																
7. DOCUMENTS/DELIVERABLES:		<table border="1"> <tr> <td></td> <td>FRG CY 85</td> <td>U.S. FY 85</td> </tr> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>0</td> <td>1</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td>0</td> <td>0</td> </tr> <tr> <td>TOTAL COST</td> <td>0</td> <td>1</td> </tr> <tr> <td>IRRAD UNITS</td> <td>0</td> <td>0</td> </tr> </table>			FRG CY 85	U.S. FY 85	LABOR (MAN YEARS/SK)	0	1	OTHER COSTS (\$K)	0	0	TOTAL COST	0	1	IRRAD UNITS	0	0
	FRG CY 85	U.S. FY 85																
LABOR (MAN YEARS/SK)	0	1																
OTHER COSTS (\$K)	0	0																
TOTAL COST	0	1																
IRRAD UNITS	0	0																
8. REMARKS: PWS completed																		

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-3
DATE November 1985			PWS NO. FD-11

1. TITLE Testing of GA and KFA HTGR Fuel under Hypothetical Accident Conditions 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / D. Goodin KFA / H. Nabelek	CATEGORY (Circle one) I II III IV
3. OBJECTIVES: 1. Independent verification of US and FRG accident condition fuel performance models. 2. Develop generic model describing fuel performance under accident conditions. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Provide independent verification of each participant's data base and develop larger generic data base resulting in significant cost savings to respective programs.	ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.
5. SCHEDULE AND MILESTONES:	

MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
7. Complete testing of KFA fuel and issue GA final report	GA	12/82	Completed 03/83, GA Doc. 906866
8. Ship GA R2-K13 fuel to KFA for CHST	GA	04/83	Completed 06/83
9. Complete comparative CHST and issue report	KFA	09/83	Testing completed 05/83; report completed 01/84 (HBK-13-2/84)
10. Complete CHST on GA R2-K13 particles and rods	KFA	12/83	Complete 12/83, GA Doc. 907404/1
11. Issue joint report on CHST to 2500°C	GA	09/84	Completed 09/84; GA Doc. 907628
12. Complete 100h test at 1600°C on KFA samples	GA	09/84	Test on DR-56 completed 09/83
13. Core heatup simulation tests on HRB 15A rods	KFA	10/86	On schedule
14.* Issue joint report on unified US/FRG normal and accident condition fuel performance models	GA	12/85	On schedule
15. Ship spheres from AVR for later heating tests	KFA	Open	Due date to be defined 05/86
16. Heatup of rods with artificially defective particles (HFR-B1)	KFA	06/88	To be coordinated with PWS 77-8

6. TRAVEL REQUIREMENTS: 7. DOCUMENTS/DELIVERABLES: GA to ship three HRB 15A Rods to KFA 8. REMARKS: *Major Milestone	9. INCREMENTAL COSTS		
		FRG CY 86	U.S. FY 86
	LABOR (MAN YEARS/SK)	70	20
	OTHER COSTS (\$K)	10	0
	TOTAL COST	80	20
	IRRAD UNITS	0	0

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-4															
DATE November 1985			FWS NO. FD-14															
1. TITLE Gamma Spectroscopic Examination of HTGR Fuel Elements		CATEGORY (Circle one) I II III IV																
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / W. J. Scheffel KFA / H. U. Brinkmann		I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																
3. OBJECTIVES: 1. To establish fluence correction for recalibrated Peach Bottom thermocouples by γ -scan of FTE-18 fuel bodies. 2. To outline use of collimators. 3. To establish $\pm 5\%$ accuracy in γ -scan measurements.																		
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS):																		
5. SCHEDULE AND MILESTONES:																		
MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS															
1. Send inventory measurements to GA	KFA	02/79	Completed, IRW-TN-23/79															
2. Submit counting accuracies to GA	KFA	09/79	Completed, IRW-TN-98/79															
3. Submit collimator design to KFA	GA	09/79	Completed, GA-A14726															
4. Ship KFA Zuchtperle to GA	KFA	02/81	Completed															
5. Report FTE-18 temperatures with P.B. Summary Report	GA	02/82	Completed 09/82															
6. Report γ -scan of FSV Segment 2 fuel element	GA	09/83	Completed 09/83, GA Doc. 9070791/1															
7. Perform FSV Segment 3 fuel γ -scanning	GA	06/84	Completed 06/84															
8. Report results of FSV Segment 3 fuel γ -scanning	GA	04/85	Completed 07/85, GA Doc. HTGR-85-052 Completed July 1985															
6. TRAVEL REQUIREMENTS:		9. INCREMENTAL COSTS																
7. DOCUMENTS/DELIVERABLES:		<table border="1"> <tr> <td></td> <td>FRG CY 85</td> <td>U.S. FY 85</td> </tr> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>0</td> <td>1</td> </tr> <tr> <td>OTHER COSTS (SK)</td> <td>0</td> <td>0</td> </tr> <tr> <td>TOTAL COST</td> <td>0</td> <td>1</td> </tr> <tr> <td>IRRAD UNITS</td> <td>0</td> <td>0</td> </tr> </table>			FRG CY 85	U.S. FY 85	LABOR (MAN YEARS/SK)	0	1	OTHER COSTS (SK)	0	0	TOTAL COST	0	1	IRRAD UNITS	0	0
	FRG CY 85	U.S. FY 85																
LABOR (MAN YEARS/SK)	0	1																
OTHER COSTS (SK)	0	0																
TOTAL COST	0	1																
IRRAD UNITS	0	0																
8. REMARKS: FWS completed																		

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-1
DATE November 1985			PWS NO. FD-15

1. TITLE Cooperative Fuel Element Irradiation Test of GA/HOBEG Fuel by the HBK Project 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: KFA / A. W. Mehner GA / W. J. Scheffel 3. OBJECTIVES: To demonstrate acceptable performance of fuel in an integral test of full fluence and burnup. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Perform long term capsule irradiation tests in the Studsvik R2-K series. A typical rig contains both GA and HOBEG fuel bodies. 5. SCHEDULE AND MILESTONES:	CATEGORY (Circle one) I II III IV I I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Complete R2-K13 irradiation	KFA	06/82	Delayed to 09/82
2. Issue PIE plan for R2-K13	KFA	08/82	Completed 12/82
3. Ship fuel rods to GA	KFA	04/83	Completed 04/83
4. Complete TRIGA measurements on rods	GA	05/83	Completed 05/83
5. Issue interim R2-K13 report	GA	02/84	Completed 04/84, GA Doc. 907404/1 (GCRB-84-2)
6. Complete IMGA measurements	ORNL	03/84	Completed 04/84, GA Doc. 907404/1
7. Issue joint draft KFA/GA report for R2-K13	GA	12/84	Completed 11/84
8.* Issue joint KFA/GA final report for R2-K13	GA	12/85	Completed 11/85, GA Doc. HTGR-85-668 Completed November 1985

6. TRAVEL REQUIREMENTS:	9. INCREMENTAL COSTS		
7. DOCUMENTS/DELIVERABLES:		FRG CY 85	U.S. FY 85
	LABOR (MAN YEARS/SK)	20	20
	OTHER COSTS (\$K)	5	0
	TOTAL COST	25	20
	IRRAD UNITS	0	0

8. REMARKS: PWS completed

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-4
DATE November 1985			PWS NO. ED-20

1. TITLE Coated Particle Analysis by IMGA/PGA	CATEGORY (Circle one) ① II III IV		
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <u>ORNL / M. J. Kanis</u> <u>KFA / H. Nabielek</u>	I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.		
3. OBJECTIVES: Measure failed particle fractions and gas content of irradiated samples of FRG coated particles.			
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): ORNL will use existing IMGA and PGA systems to evaluate selected batches of particles, in accordance with a test plan agreed between ORNL and KFA.			
5. SCHEDULE AND MILESTONES:			

MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Complete IMGA on batches from HBK set No. 1	ORNL	12/82	Completed 12/81, ORNL/GCR-82/5
2. Provide fission product inventory data on IMGA set 2	KFA	07/83	Completed by letter to Kanis, 09/83
3. Issue IMGA data on particle set 2	ORNL	03/84	Completed 05/84: letter, Kanis to Nabielek
4. Complete PGA on particle set 2	ORNL	03/84	Completed 04/84: letter, Kanis to Nabielek
5.* Complete IMGA and PGA on HBK set 3 fuels	ORNL	03/86	
6. Select particle set 4	KFA	03/86	
7. Issue review of results of set 3	KFA	05/86	
8. Ship spheres from AVR for later heating tests	KFA	Open	Review in May 1986
9. Ship set 4 particles to ORNL	KFA	05/86	

6. TRAVEL REQUIREMENTS:	9. INCREMENTAL COSTS		
7. DOCUMENTS/DELIVERABLES:		FRG CY 86	U.S. FY 86
	LABOR (MAN YEARS/\$K)	10	110
	OTHER COSTS (\$K)	10	0
	TOTAL COST	20	110
	IRRAD UNITS	0	0

8. REMARKS: *Major Milestone

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 143
DATE November 1985			PWS NO. ED-21

1. TITLE Design and Specifcation Data Files	CATEGORY (Circle one) I II III IV		
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: KFA / R. Bornschein GA / W. Scheffel	I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.		
3. OBJECTIVES: Establish the scope, extent, and sequence for exchange of evaluated data to go into a computerized data base.			
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Data from out-of-pile characterization, irradiation tests, and performance tests would be assembled in a format for consistent storage in a long term data base.			
5. SCHEDULE AND MILESTONES:			
MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Define PWS	KFA/GA	10/80	GA reports and sample data transmitted
2. Presentation of GA storage system	GA	02/83	Completed 02/83
3. Issue report on GA system	GA	04/83	Completed 04/83
4. Presentation of KFA storage system	KFA	08/83	Completed 08/83
5. Document HBK irradiations with HEU 1977-1982	KFA	08/83	Completed 09/83, HBK-13-05/83
6. Input R2-K12 data to GA retrieval system	KFA	09/83	Completed 09/83
7. Supply irradiation document list for input to KFA literature search	GA	04/84	Completed 06/84, LTR GEN-GA/KFA-0538
8. Supply preirradiation and operating data for HFR-P4, HFR-K3, FRJ2-K13	KFA	11/84	Completed 11/84

6. TRAVEL REQUIREMENTS: W. J. Scheffel to KFA 10/84	9. INCREMENTAL COSTS		
7. DOCUMENTS/DELIVERABLES:		FRG CY 86	U.S. FY 86
8. REMARKS: PWS completed	LABOR (MAN YEARS/\$K)	0	0
	OTHER COSTS (\$K)	0	0
	TOTAL COST	0	0
	IRRAD UNITS	0	0

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-2
DATE November 1985			PWS NO. FD-22

1. TITLE Kernel, Coated Particle and QC Process Development	CATEGORY (Circle one) I II III IV																	
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / O. Stansfield HOEG / W. Heit	I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																	
3. OBJECTIVES: Investigate the influence on coated particle quality of classifying kernels, varying batch size, and using coaters and coating procedures of various types; exchange information on process development and compare QC measurements.																		
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Coating of GA supplied ThO ₂ kernels in different batch sizes. Using standard processes HOEG will coat classified and nonclassified kernels. GA will coat in 2 different batch sizes. GA and HOEG will exchange coated particle samples for comparison of coating quality and technique. They will exchange process, operational, and quality data on UO ₂ kernels. Benefit will be better quality product made more economically.																		
5. SCHEDULE AND MILESTONES:																		
MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS															
1. Deliver ThO ₂ kernels	GA/ORNL	09/81	Completed 12/81															
2. Update exchange of processing information	GA/HOEG	10/81	Completed during GA visit to HOEG 07/81															
3. Complete classifying and coating of comparative batches	GA/HOEG	12/81	Completed 04/82															
4. Laser fall HOEG UO ₂ TRISO particles	GA	10/82	Completed 10/82															
5. Issue report on GA evaluation of particles coated at HOEG	GA	03/83	Completed 05/83															
6. Determine free U from contamination and from particle failure	HOEG	12/83	Cancelled due to lack of funding															
7. Coat HOEG (Th,U)O ₂ kernels	GA	12/83	Completed 02/84															
8. Issue report on characterized particles	GA	09/83	Completed 03/84, GA Doc. 907091/2															
9. Ship GA coated HOEG kernels to HOEG	GA	01/84	Deleted															
10. Ship GA coated GA kernels to HOEG	GA	01/84	Completed 05/84															
11. Characterize GA coated HOEG and GA kernels including tabling	HOEG	11/84	Completed 10/84, HEK Quarterly, 10/84															
12. Issue report on GA tests designation	GA	04/85	Completed GA Doc. 907091/2															
13. Ship kernels for coating development at GA	HOEG	02/86																
14. Ship TRISO-coated samples to HOEG	GA	12/86																
15. Fabricate sample pebbles with GA particles	HOEG	06/87																
16. Measure burn-leach fraction in pebbles	HOEG	09/87																
6. TRAVEL REQUIREMENTS:	9. INCREMENTAL COSTS																	
7. DOCUMENTS/DELIVERABLES:	<table border="1"> <tr> <td></td> <td>FRG CY 86</td> <td>U.S. FY 86</td> </tr> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>0</td> <td>10</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td>8</td> <td>5</td> </tr> <tr> <td>TOTAL COST</td> <td>8</td> <td>15</td> </tr> <tr> <td>RRAD UNITS</td> <td>0</td> <td>0</td> </tr> </table>				FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	0	10	OTHER COSTS (\$K)	8	5	TOTAL COST	8	15	RRAD UNITS	0	0
		FRG CY 86	U.S. FY 86															
	LABOR (MAN YEARS/SK)	0	10															
	OTHER COSTS (\$K)	8	5															
	TOTAL COST	8	15															
RRAD UNITS	0	0																
8. REMARKS:																		

REVISION	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE DRAFT		WBS NO.																	
DATE November 1985			PWS NO. FD-24																	
1. TITLE US/FRG Accident Condition Models			CATEGORY (Circle one) I II III IV																	
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: KFA/K. Verfondern GA /D. Goodin			I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																	
3. OBJECTIVES: Develop and update joint accident condition performance models.																				
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): US and FRG accident condition models for fuel have a common functional basis. Model updates are to be exchanged and evaluated for joint applicability.																				
5. SCHEDULE AND MILESTONES:																				
MILESTONE		RESP ORG	DUE DATE	PRESENT STATUS																
1. Transmit recommended fuel performance model updates.		GA	3/86																	
2. Establish and transmit revised set of diffusion coefficients.		KFA	6/86																	
3. Transmit model revision recommendations based on new annealing data.		KFA	12/86																	
6. TRAVEL REQUIREMENTS: Verfondern travel in 1986 to discuss basis for model updates and diffusion coefficient revisions			9. INCREMENTAL COSTS																	
7. DOCUMENTS/DELIVERABLES: Documents describing updates/revisions			<table border="1"> <tr> <td></td> <td>FRG CY 86</td> <td>U.S. FY 86</td> </tr> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>2</td> <td>2</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td>2</td> <td>-1</td> </tr> <tr> <td>TOTAL COST</td> <td>4</td> <td>2</td> </tr> <tr> <td>IRRAD UNITS</td> <td>NONE</td> <td>NONE</td> </tr> </table>				FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	2	2	OTHER COSTS (\$K)	2	-1	TOTAL COST	4	2	IRRAD UNITS	NONE	NONE
	FRG CY 86	U.S. FY 86																		
LABOR (MAN YEARS/SK)	2	2																		
OTHER COSTS (\$K)	2	-1																		
TOTAL COST	4	2																		
IRRAD UNITS	NONE	NONE																		
8. REMARKS:																				

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 2-1																												
DATE November 1985			PWS NO. FP-1																												
1. TITLE Tritium Design Data 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / D. L. Hanson HRB / K. Röllig IA / P. Steinwarz KFA / D. Stöver 3. OBJECTIVES: To develop an understanding of tritium behavior, including production and permeation. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Data are to be generated to define the H-3 sources in graphite material. Comparison will be made of methods for predicting tritium transport to coolant. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I ② III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																													
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS																												
1. Evaluate whether services on Li-6 measurement in graphite should be requested from ONRL	KFA	10/81	Measurements at ORNL not required. KFA, SIGRI, and HOEG now have capability for lower detection limits																												
2. Issue questionnaire on tritium design methods on release to coolant	GA	07/82	Completed 09/82																												
3. Issue responses to questionnaire	KFA	09/83	Completed by letter Nabielek to Hanson 09/83																												
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5. Respond to report by Achaya	HRB	01/86																													
6. Issue final report on comparisons	GA	Open																													
6. TRAVEL REQUIREMENTS: 7. DOCUMENTS/DELIVERABLES: 8. REMARKS: To be completed with milestone 6		9. INCREMENTAL COSTS <table border="1"> <thead> <tr> <th></th> <th>FRG CY 86</th> <th>U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>1</td> <td>0</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td>0</td> <td>0</td> </tr> <tr> <td>TOTAL COST</td> <td>1</td> <td>0</td> </tr> <tr> <td>IRRAD UNITS</td> <td>0</td> <td>0</td> </tr> </tbody> </table>			FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	1	0	OTHER COSTS (\$K)	0	0	TOTAL COST	1	0	IRRAD UNITS	0	0													
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE	WBS NO. 2-1
DATE November 1985		PWS NO. FP-2

1. TITLE Development of Fission Product Data Book 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <div style="margin-left: 40px;"> <u>KFA / H. Nabielek</u> <u>GA / B. F. Myers</u> </div> 3. OBJECTIVES: <div style="margin-left: 40px;">Develop a common Fission Product Data Book</div> 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): <div style="margin-left: 40px;">The book will be a source of data for calculations of fission product release from HTR cores. Data from US and FRG will be integrated into a consistent set.</div> 5. SCHEDULE AND MILESTONES:	CATEGORY (Circle one) <div style="text-align: center;"> I II III IV </div> I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Agreement on formats and structure of data book	KFA/GA	07/80	Completed 07/80
2. Preliminary diffusion data for Cs, Ag, Sr in kernel and coating	KFA	10/80	Completed 10/80
3. GA input to HBK reference set	GA	08/81	Completed 11/81
4. Issue draft data sheets	KFA	09/81	Completed (KFA-HBK-IB-11/81)
5. Issue No. 1 version of data book	GA	07/82	Completed 07/82, GA Doc. 906348
6. Issue interim recommendation on Cs, Sr, and Ag	KFA	04/83	Completed 07/83, HBK-IB-01/83, Table 3.3.12
7. Issue recommended Cs values	KFA/GA	02/84	Completed 02/84, HBK-TN-1/84
8. Issue joint fission product data book	KFA	09/84	
9. Revise and consolidate joint fission product data book	GA	Open	Completed 05/84, HBK-IB-05/84 and GA Report 906348/2

6. TRAVEL REQUIREMENTS: 7. DOCUMENTS/DELIVERABLES: 8. REMARKS: <div style="margin-left: 40px;">To be completed with milestone 9</div>	9. INCREMENTAL COSTS <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th></th> <th style="text-align: center;">FRG CY 86</th> <th style="text-align: center;">U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>OTHER COSTS (SK)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>TOTAL COST</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>IRRAD UNITS</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	0	0	OTHER COSTS (SK)	0	0	TOTAL COST	0	0	IRRAD UNITS	0	0
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 2-2																																								
DATE June 1984			PWS NO. FP-3																																								
1. TITLE Verification of Fission Product Design Methods and Codes 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <u>HRB / K. Röllig</u> <u>GA / D. Hanson</u> 3. OBJECTIVES: 1. Assessment of validity of fission product release codes. 2. Identification of potential improvements to codes. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Independent code verification. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																									
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE	WBS NO. 2-2
DATE November 1985		PWS NO. FP-4

1. TITLE Fission Product Plateout Code Verification 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <div style="margin-left: 40px;"> <u>GAC / D. Hanson</u> <u>HRB / K. Rölliig</u> </div> 3. OBJECTIVES: <ol style="list-style-type: none"> 1. Compare GA (PADLOC) and HRB (RADAX) plateout codes. 2. Assess validity of fission product plateout distribution codes by analysis of reactor operating data and out-of-pile experiments. 3. Identify potential improvements in plateout methods. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): <ol style="list-style-type: none"> 1. Independent verification of fission product plateout design methods. 2. Broadened plateout data base. 5. SCHEDULE AND MILESTONES:	CATEGORY (Circle one) <div style="text-align: center;"> I II III IV </div> I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Definition of benchmark problem including sensitivity analysis (I131, Cs137, Sr90 in FSV after Cycle 1)	GA	06/82	Completed 09/82
2. GA provide exchange of benchmark results	GA	12/82	Completed 03/83
3. HRB provide response of benchmark results	HRB	12/83	Completed 06/84, GHRA 000761
4. Compile data from LAMINAR loop and transfer to GA, Part I (INC-800)	HRB	12/82	Completed 01/83
5. Compile data from FSV Cycle 2 and transfer to HRB	GA	09/82	Completed 02/83
6. Exchange calculated results and compare with measurements	GA	09/84	Summary tables sent to Rölliig 02/84
7. Issue compilation of LAMINAR, Part II	HRB	04/85	Need new date
8. Issue joint status report on validation of plateout distribution codes	GA	Open	3 months after Milestone 7
9. Issue GA analysis of LAMINAR I	GA	07/84	Completed 09/84
10. Issue final report	GA	Open	

6. TRAVEL REQUIREMENTS: 7. DOCUMENTS/DELIVERABLES: 8. REMARKS: To be completed with milestone 10	9. INCREMENTAL COSTS <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">FRG CY 86</th> <th style="text-align: center;">U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td style="text-align: center;">2</td> <td style="text-align: center;">50</td> </tr> <tr> <td>OTHER COSTS (SK)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>TOTAL COST</td> <td style="text-align: center;">2</td> <td style="text-align: center;">50</td> </tr> <tr> <td>IRRAD UNITS</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	2	50	OTHER COSTS (SK)	0	0	TOTAL COST	2	50	IRRAD UNITS	0	0
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 2-1																																																												
DATE November 1985			PWS NO. FP-5																																																												
1. TITLE Fission Gas Release Model 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / B. F. Myers KFA / H. Nabielek HRB / A. Christ 3. OBJECTIVES: 1. Review existing models and data 2. Recommend interim model 3. Recommend additional tests if required 4. Confirm gas release model 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Interpretation of fuel performance in irradiation tests and predictions used in reactor core design require improved models for the release of fission gases. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																																													
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REVISION 9	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 2-2																				
DATE March 1985			PWS NO. FP-6																				
1. TITLE In-Reactor Effects of Moisture on Fission Gas Release 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / R. D. Burnette AVR / K. Kruger 3. OBJECTIVES: Verification of GA models concerning the effect of hydrolysis on gas release after the AVR ingress incident 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): The model predictions for gas release from hydrolyzed fuel are based mainly on laboratory work and may be pessimistic for in-pile applications. Realistic values derived from R/B measurements in AVR before and after the water ingress in 1978 are expected to be significant for reactor design purposes. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																					
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 2-2																
DATE November 1985			PWS NO. FP-7																
1. TITLE Evaluation of Coolant Gas Activity in AVR/FSV 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <u>HRB / A. Christ</u> GA / D. I. Hanson AVR / K. Kruger 3. OBJECTIVES: 1. Analysis of gas activities relevant to reactor conditions 2. Calculation with existing models 3. Identification and interpretation of differences 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Independent verification of gas release models for reactor operating conditions 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																	
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS																
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	FRG CY 86	U.S. FY 86																	
LABOR (MAN YEARS/SK)	3	0																	
OTHER COSTS (\$K)	0	0																	
TOTAL COST	3	0																	
IRRAD UNITS	0	0																	

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 1-1
DATE November 1985			PWS NO. FP-8

<p>1. TITLE GA Fission Product Test in HFR Petten</p> <p>2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS:</p> <p style="margin-left: 40px;">KFA / A. W. Mehner GA / J. W. Ketterer</p> <p>3. OBJECTIVES:</p> <p style="margin-left: 20px;">Under near real-time conditions,</p> <ol style="list-style-type: none"> 1. Measure temperature dependence of gas release 2. Measure metal release from particles and graphite 3. Measure hydrolysis/oxidation effects 4. Irradiate piggyback samples for cross calibration 5. Irradiate UCO/ThO₂ fuel rods for CHST <p>4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS):</p> <p style="margin-left: 20px;">500 full power day irradiation in HFR Petten with GA reference UCO/ThO₂ TRISO fuel</p> <p style="margin-left: 20px;">Cell 1: 900°C constant temperature, 20% FIMA fissile particles</p> <p style="margin-left: 20px;">Cell 2: 900°-1200°C, thermal cycle, 20% FIMA fissile particles</p> <p style="margin-left: 20px;">Cell 3: 800°-1050°C, thermal cycle, 10-100 ppm H₂O, 24-26% FIMA fissile</p> <p>5. SCHEDULE AND MILESTONES:</p>	<p>CATEGORY (Circle one)</p> <p style="text-align: center;"> ☒ I II III IV </p> <p>I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY.</p> <p>II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT.</p> <p>III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES.</p> <p>IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.</p>
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Test specification	GA	05/84	Completed 05/84, GA Doc. 907480/1
2. Complete sample fabrication	GA	10/84	Completed 05/85
3. Ship samples to Petten	GA	09/85	Completed 08/85
4. Issue preirradiation report	GA	06/85	Completed 08/85
5.* Insert in Petten HFR	KFA	Open	Depends upon approval for insertion
6. Supply HRS 17/18 operational data	GA	01/86	
7. Complete irradiation	KFA	Open	
8. Complete postirradiation examination	KFA**	Open	
9. Issue PIE report	GA	Open	

<p>6. TRAVEL REQUIREMENTS:</p> <p style="margin-left: 20px;">Ketterer visit to Petten during HFR-81 startup</p> <p>7. DOCUMENTS/DELIVERABLES:</p> <p style="margin-left: 20px;">Test plans, irradiation reports, PIE report, and final report.</p> <p>8. REMARKS:</p> <p style="margin-left: 20px;">*Major Milestone</p> <p style="margin-left: 20px;">**Contingent on KFA program 1988</p>	<p>9. INCREMENTAL COSTS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">FRG CY 86</th> <th style="text-align: center;">U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td style="text-align: center;">20</td> <td style="text-align: center;">80</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td style="text-align: center;">70</td> <td style="text-align: center;">0</td> </tr> <tr> <td>TOTAL COST</td> <td style="text-align: center;">90</td> <td style="text-align: center;">80</td> </tr> <tr> <td>IRRAD UNITS</td> <td style="text-align: center;">136</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	20	80	OTHER COSTS (\$K)	70	0	TOTAL COST	90	80	IRRAD UNITS	136	0
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REVISION 10 DATE November 1985	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE	WBS NO. 3-1 PWS NO. CD-1
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<p>1. TITLE KFA Graphite Irradiation Experiment in HFIR</p> <p>2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <u>ORNL / W. Eatherly</u> <u>KFA / G. Haag</u></p> <p>3. OBJECTIVES: Determine the irradiation performance of FRG candidate reflector graphites through a series of irradiations in HFIR at ORNL.</p> <p>4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Samples of FRG graphites would be included along with US graphites in capsules HTK-5 through HTK-8. This is a continuation of testing after five earlier capsules.</p> <p>5. SCHEDULE AND MILESTONES:</p>	<p>CATEGORY (Circle one) I II III IV</p> <p>I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY.</p> <p>II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT.</p> <p>III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES.</p> <p>IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.</p>
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Capsule HTK-4 (715°C) inserted	ORNL	08/80	Completed 04/80
2. Capsule HTK-4 removed (9 cycles)	ORNL	04/81	Completed 04/81
3. Report results of capsules HTK-4 and HTU-1	ORNL	06/81	Discussion at ORNL, 06/81 Discussion at KFA, 11/84
4. Capsule HTK-5 (600°C) inserted	ORNL	10/81	Completed 12/81
5. Capsule HTK-6 (900°C) inserted	ORNL	10/81	Completed 07/82
6. Capsule HTK-6 removed	ORNL	06/82	Completed 02/83
7. Capsule HTK-5 removed	ORNL	09/82	Completed 12/82
8. Document total test results of HTK-series	ORNL	01/86	
9. Capsules HTF-1 (600°C) and HTF-2 (900°C) inserted	ORNL	05/83	Completed 05/83
10. Capsule HTF-3 (600°C) inserted	ORNL	06/83	Completed 06/83
11. Capsules HTF-1 to -3 removed	ORNL	09/83	Completed 09/83
12. Document results HTF-1 through -3	ORNL	08/84	Completed 08/84, ORNL monthly report
13. Issue summary report HTF-1-3	ORNL	Open	Depends upon data interpretation
14. Further irradiation tests including ASR-1RS, ASR-1RG, ATR-2E	ORNL	Open	Depends upon funding of capsule series

<p>6. TRAVEL REQUIREMENTS:</p> <p>7. DOCUMENTS/DELIVERABLES:</p> <p>8. REMARKS:</p>	<p>9. INCREMENTAL COSTS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">FRG CY 86</th> <th style="text-align: center;">U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">5</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>TOTAL COST</td> <td style="text-align: center;">0</td> <td style="text-align: center;">5</td> </tr> <tr> <td>IRRAD UNITS</td> <td style="text-align: center;">None</td> <td style="text-align: center;">None</td> </tr> </tbody> </table>		FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	0	5	OTHER COSTS (\$K)	0	0	TOTAL COST	0	5	IRRAD UNITS	None	None
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OTHER COSTS (\$K)	0	0														
TOTAL COST	0	5														
IRRAD UNITS	None	None														

REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-1																																																											
DATE November 1985			PWS NO. GD-2																																																											
1. TITLE Irradiation of GA Side Reflector Graphites in HFR Petten 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: KFA / G. Haag ORNL / W. Eachery 3. OBJECTIVES: Determine the irradiation performance of GA side reflector graphite for temperature range 300° to 600°C by inclusion of US graphites in KFA experiments GG 12, 13, 15, and 16. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Samples of US graphite TS-1621 would be included along with FRG graphites in GG 15/16 experiments series to obtain data up to full exposure for GA side reflector. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																																												
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE	WBS NO. 3-1
DATE November 1985		PWS NO. GD-4

1. TITLE Graphite Creep Tests in Petten 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: <div style="margin-left: 40px;"> <u>KFA / G. Haag</u> <u>ORNL / W. Eatherly</u> </div> 3. OBJECTIVES: <div style="margin-left: 40px;"> To perform direct readout strain measurements of creep in tension on H-451 graphite </div> 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): <div style="margin-left: 40px;"> Data of use to both sides by producing continuous secondary creep curve. </div> 5. SCHEDULE AND MILESTONES:	CATEGORY (Circle one) <div style="text-align: center;"> I II III IV </div> I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.
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MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Sample terminated due to fracture (out-of-pile)	KFA	05/81	Completed 05/81
2. Report on fracture	KFA	07/81	Completed 06/81
3. GA summary report on all creep data	GA	07/81	Completed 08/81
4. Examination of creep specimen by GA	GA	09/81	Transport delayed to 06/82
5. Begin 900°C creep experiment without direct readout	KFA	12/81	Completed 12/81
6. Results on first irradiation step available	KFA	05/82	Completed 10/82
7. Start 2nd irradiation test at 900°C	KFA	05/82	Completed 06/82
8. Issue report on 2nd irradiation	KFA	03/86	Completed 11/85
9. Start 3rd irradiation test at 900°C	KFA	02/86	
10. Results on 3rd irradiation step	KFA	12/86	

6. TRAVEL REQUIREMENTS: 7. DOCUMENTS/DELIVERABLES: <div style="margin-left: 40px;">Irradiation reports.</div> 8. REMARKS: <div style="margin-left: 40px;"> Program shifted to new capsules without direct strain readout. PWS to be completed with milestone 10 </div>	9. INCREMENTAL COSTS <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">FRG CY 86</th> <th style="text-align: center;">U.S. FY 86</th> </tr> </thead> <tbody> <tr> <td>LABOR (MAN YEARS/SK)</td> <td style="text-align: center;">7</td> <td style="text-align: center;">0</td> </tr> <tr> <td>OTHER COSTS (SK)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>TOTAL COST</td> <td style="text-align: center;">7</td> <td style="text-align: center;">0</td> </tr> <tr> <td>IRRAD UNITS</td> <td style="text-align: center;">12</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		FRG CY 86	U.S. FY 86	LABOR (MAN YEARS/SK)	7	0	OTHER COSTS (SK)	0	0	TOTAL COST	7	0	IRRAD UNITS	12	0
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-4																								
DATE November 1985			PWS NO. GD-5																								
1. TITLE Structural Design Criteria for Graphite in Gas-Cooled Reactor 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / W. Gorholt HRB / A. Schmidt 3. OBJECTIVES: - Rules for the evaluation of stresses and strain in irradiated and unirradiated graphite components - Design rules for graphite components of the various classes 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Criteria acceptable to designers and regulatory authorities in both FRG and US. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II <u>III</u> IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																									
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-2																																								
DATE November 1985			PWS NO. GD-6																																								
1. TITLE Corrosion Characteristics of Core Support Graphite 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: ORNL / J. P. Sanders KFA / W. Katscher SIGRI / D. Mindermann 3. OBJECTIVES: Determine corrosion behavior of US and FRG core support graphite under accelerated operating and accident conditions. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): To characterize the corrosion response of FRG V 483 T2 and US Stackpole 2020 in ORNL-CFTL and KFA-HOVA. US H 451 will also be examined in HOVA pending the adaptability to the loop. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																									
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-1																				
DATE November 1985			PWS NO. GD-9																				
1. TITLE Irradiation of FRG Reflector and Suport Graphites in ORR 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / G. B. Engle KFA / G. Haag 3. OBJECTIVES: Determine irradiation behavior of FRG candidate graphites at temperatures of 900° and 1100°C in OG capsule series. Physical properties and strength changes would be measured. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): FRG samples would be included along with US samples in this test series. The high temperature results would be correlated with lower temperature results from HFR Petten. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																					
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-2															
DATE November 1985			PWS NO. GD-10															
1. TITLE Study of Oxidative Strength Loss of Core Support Graphite ASR-1RG 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: ORNL / W. Eatherly SIGRI / D. Mindermann 3. OBJECTIVES: Include candidate FRG support graphites in oxidation testing at ORNL. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): The studies supplement measurements made on US graphite, and would provide a better understanding of the process involved in oxidation. The test would support licensing date in FRG. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I (II) III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																
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DATE November 1985			PWS NO. GD-11																																			
1. TITLE Characterization of KFA Side Reflector and Core Support Graphites for Oxidation Characteristics 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / G. B. Engle SIGRI / D. Mindermann 3. OBJECTIVES: To measure comparative oxidation rates for FRG and US graphites. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): The results will provide a data base for licensing procedures in the US and FRG. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I (II) III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																				
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DATE November 1985			PWS NO. GD-12																																
1. TITLE Characterization of Core Graphites for Acceptance/Rejection Strength Tests in Pruchase Specifications 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / H. Jones KFA / D. Mindermann 3. OBJECTIVES: To prepare specifications for different core support graphites on the basis of strength measurements. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Work should provide a common criterion for specifying graphites in FRG and US. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																	
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO. 3-3															
DATE November 1985			PWS NO. GD-15															
1. TITLE Graphite Corrosion Modeling		CATEGORY (Circle one)																
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / H. Jones KFA / R. Moormann		I II III IV																
3. OBJECTIVES: 1. Comparison of design methods for graphite corrosion analysis under normal operating conditions. 2. FRG technical review of GA 2-D corrosion model.		I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Development of improved calculational methods for predicting the effects of graphite corrosion on structural performance of graphite core components under normal conditions.																		
5. SCHEDULE AND MILESTONES:																		
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1. Send new GA 2-D corrosion model to cognizant FRG organizations	GA	TBD	Closed out 11/85															
2. Issue comments on physical and chemical adequacy of model	KFA	TBD																
3. Review model methodology and issue comments	HRB	TBD																
6. TRAVEL REQUIREMENTS:		9. INCREMENTAL COSTS																
7. DOCUMENTS/DELIVERABLES: FRG comments on GA corrosion model		<table border="1"> <tr> <td></td> <td>FRG CY 85</td> <td>U.S. FY 85</td> </tr> <tr> <td>LABOR (MAN YEARS/SK)</td> <td>0</td> <td>0</td> </tr> <tr> <td>OTHER COSTS (\$K)</td> <td>0</td> <td>0</td> </tr> <tr> <td>TOTAL COST</td> <td>0</td> <td>0</td> </tr> <tr> <td>IRRAD UNITS</td> <td>0</td> <td>0</td> </tr> </table>			FRG CY 85	U.S. FY 85	LABOR (MAN YEARS/SK)	0	0	OTHER COSTS (\$K)	0	0	TOTAL COST	0	0	IRRAD UNITS	0	0
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO.
DATE November 1985			PWS NO. EC-1

1. TITLE Plateout Data Exchange	CATEGORY (Circle one) I II III IV		
2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / D. Hanson KFA / N. Iniotakis	I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.		
3. OBJECTIVES: Expand the US and FRG HTR plateout bases by exchange of existing data.			
4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): Exchange IRS reports and data on VAMPYR 1, SAPHIR, and SMOC for GA reports and data on FSV plateout, PADLOC, and liftoff and for ORNL reports and data on iodine sorption on graphite and steel.			
5. SCHEDULE AND MILESTONES:			

MILESTONE	RESP ORG	DUE DATE	PRESENT STATUS
1. Exchange plateout reports and data	GA/KFA	12/83	Completed 06/84
2. Issue report on analysis of VAMPYR	GA	07/84	Completed 07/84
3. Issue follow-up questions on exchange reports	GA	09/84	Completed 09/84
4. Issue report on GA analysis of SMOC	GA	09/84	Completed 09/84
5. Issue report on GA analysis of SAPHIR	GA	Open	Depends on funding release
6. Issue report on evaluation of US plateout data	KFA	Open	Milestone was from Rev. 8

6. TRAVEL REQUIREMENTS:	9. INCREMENTAL COSTS		
7. DOCUMENTS/DELIVERABLES:		FRG CY 86	U.S. FY 86
	LABOR (MAN YEARS/SK)	0	0
	OTHER COSTS (\$K)	0	0
	TOTAL COST	0	0
	IRRAD UNITS	0	0

8. REMARKS: This PWS is part of the KFA/GA-cooperation on tritium and plateout. PWS to be completed with milestone 6
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REVISION 10	SUBPROGRAM FUEL, FISSION PRODUCTS AND GRAPHITE		WBS NO.																																																			
DATE November 1985			PWS NO. CC-2																																																			
1. TITLE Tritium Mass Balance in the Primary System of Fort St. Vrain 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: KFA / M. Helmbold GA / R. D. Burnette 3. OBJECTIVES: Expand the US and FRG operational experience of HTGR plants by exchange of tritium concentration data and establishing the plant mass balance. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): The measurements of primary circuit coolant tritium activity allow the estimate tritium release rates and sorption capacity of the graphite structures thus establishing the plant mass balance for tritium. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																																				
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DATE November 1985			PWS NO. SR-1																																									
1. TITLE PCRV and Containment Response to Severe Accidents 2. PARTICIPATING ORGANIZATIONS/TASK MANAGERS: GA / S. B. Inamati KFA / J. Altes 3. OBJECTIVES: Exchange GA computer code on the containment atmosphere response for experimental data on PCRV concrete under core heatup conditions. 4. SUMMARY OF TASK (MUTUAL INTEREST, BENEFITS): This task will provide, in part, the design data needs identified for the HTGR by GA and will provide added capabilities to perform safety evaluations at KFA. 5. SCHEDULE AND MILESTONES:		CATEGORY (Circle one) I II III IV I. ADDITIONAL WORK PERFORMED BY ACTING PARTY ON REQUEST FROM AND PRIMARILY FOR THE BENEFIT OF THE OTHER PARTY. II. ADDITIONAL WORK ON REQUEST FROM OTHER PARTY BUT RESULTING IN SUBSTANTIAL MUTUAL BENEFIT. III. NORMAL WORK PERFORMED BY ACTING PARTY WHICH RESULTS IN INFORMATION OF DIRECT VALUE TO THE PROGRAMS OF BOTH COUNTRIES. IV. WORK PERFORMED BY ACTING PARTY BUT GENERATES INFORMATION FOR EXCHANGE.																																										
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