No. 19229

UNITED STATES OF AMERICA, FRANCE and FEDERAL REPUBLIC OF GERMANY

Agreement on research participation and technical exchange in the in-pile CABRI and annular core pulsed reactor (ACPR) research programmes related to fast reactor safety (with appendices and memorandum of understanding of 2 and 19 May and 22 June 1978). Signed on 2 May, 7 and 22 June 1978, 11 and 25 January, 2 February, 5 March and 2 May 1979

Authentic texts of the Agreement and the memorandum of understanding: English, French and German.

Authentic text of the appendices: English.

Registered by the United States of America on 7 November 1980.

ÉTATS-UNIS D'AMÉRIQUE, FRANCE et RÉPUBLIQUE FÉDÉRALE D'ALLEMAGNE

Accord de participation aux recherches et d'échange technique dans les programmes de recherche effectués dans CABRI et dans le réacteur pulsé à cœur annulaire (ACPR) relatifs à la sûreté des réacteurs à neutrons rapides (avec appendices et mémoire d'interprétation des 2 et 19 mai et 22 juin 1978). Signé les 2 mai, 7 et 22 juin 1978, 11 et 25 janvier, 2 février, 5 mars et 2 mai 1979

Textes authentiques de l'Accord et du mémoire d'interprétation : anglais, français et allemand.

Texte authentique des appendices : anglais.

Enregistré par les États-Unis d'Amérique le 7 novembre 1980.

AGREEMENT[1] ON RESEARCH PARTICIPATION AND TECHNICAL EXCHANGE BETWEEN THE COMMISSARIAT À L'ÉNERGIE ATOMIQUE (CEA) AND THE KERNFORSCHUNGSZENTRUM KARLSRUHE GmbH (KfK) AND THE UNITED STATES NUCLEAR REGULATORY COMMISSION (USNRC) IN THE IN-PILE CABRI AND ANNULAR CORE PULSED REACTOR (ACPR) RESEARCH PROGRAMS RELATED TO FAST REACTOR SAFETY

The Contracting Parties,

Considering that the United States Nuclear Regulatory Commission (USNRC) and the Senior Partners of the CABRI project, the Commissariat à l'Energié Atomique (CEA) and Kernforschungszentrum Karlsruhe GmbH (KfK):

(*a*) Have a mutual interest in cooperation in the field of nuclear safety research conducted in special facilities such as CABRI and the Annular Core Pulsed Reactor (ACPR);

(*b*) Have the firm intention to enter, or have entered into bilateral arrangements for the exchange of information related to reactor safety;

(*c*) Have the mutual objective of extending and improving selected agreed-upon forms of technical exchange and cooperation, including detailed participation by one party in specific projects of the other party; and

(*d*) Have expressed their intention to participate in a technical exchange involving the Joint CABRI Project sponsored by the CEA and the KfK, and the USNRC-funded ACPR Fast Reactor Safety Research Program,

Now, therefore, do agree as follows:

Article I. OBJECTIVE

The CEA and KfK (the Senior Partners of the CABRI project, hereinafter called the CABRI Party) and the USNRC, in accordance with the provisions of this Agreement and subject to the applicable laws and regulations in force in the respective Countries of the signatory parties, will join together for jointly directed research in the CABRI project (described in Appendices 1 and 2, or as amended) and in the ACPR fast reactor safety research program (described in Appendices 3 and 4, or as amended).

Article II. SCOPE OF RESPONSIBILITY OF CABRI PARTY

2.1. The CABRI Party, in consideration of the technical benefits received by its participation in the ACPR program and by its receipt of information under this Agreement, agrees to permit the USNRC to participate in the CABRI project, in accordance with the provisions of this Agreement.

2.2. Subject to the availability of appropriated funds, the CABRI Party agrees to provide the necessary personnel, materials, equipment, and services for the performance of the CABRI project, as described in Appendices 1 and 2, or as amended.

2.3. The CABRI Party agrees to make available to the USNRC, to the maximum permissible extent, all technical information and knowledge relevant to the planning and implementation of the CABRI project, including access to all experimental data and results of analyses generated in the CABRI project during the period of this Agreement.

[1] Came into force on 22 June 1978 by signature, in accordance with section 5.1.

Such technical information shall include but not necessarily be limited to the CABRI Feasibility Study and CABRI notes, the latter of which constitute internal technical reports of the CABRI project. Proprietary or other privileged information contemplated to be transmitted under this Agreement will be treated in accordance with the provisions of article IV.

2.4. The CABRI Party agrees to permit the USNRC to be represented at technical meetings of the CABRI Joint Committee* (hereinafter called the Joint Committee) by a permanent observer, who may be accompanied by one or two experts for consideration of special topics. The permanent observer is permitted to take part in the discussions of the Joint Committee and to make suggestions, but without right of vote in decisions of the Joint Committee.

2.5. In addition, the CABRI Party agrees to permit the USNRC to be represented by the USNRC permanent observer at meetings of any of the scientific working groups installed by the Joint Committee. The USNRC observers are permitted to take part in the discussion of the scientific working groups and to make suggestions, but without right of decision. A limited number of appropriate experts from USNRC may also attend these scientific meetings for discussion of special topics.

2.6. The CABRI Party further agrees to permit the USNRC to delegate mutually agreed upon technical experts for participation in the conduct and analysis of the CABRI program work performed at the facilities of the CEA and KfK. The CEA and KfK shall agree in writing upon the person to be delegated, and the purpose and term of such delegation, in advance of each delegation of personnel. In addition, a separate personnel assignment agreement shall be signed between the home organization of the assigned expert and the organization to which the expert has been assigned. Such assigned personnel shall be integrated into the scientific and technical work of the CABRI program. In this context, and to the extent permitted by such separate personnel assignment agreements, the assigned personnel shall have appropriate access to the facility and to all documents concerning the CABRI program, and shall have the right to participate in technical discussions of the CEA and KfK on the preparation, implementation and evaluation of the CABRI experiments. Their tasks shall be defined in such a way that sufficient time will be available to the assigned personnel for appropriate reporting to the USNRC about the CABRI program.

2.7. It is further agreed that visits of USNRC reactor safety experts to the KfK and CEA facilities where work is being performed in the framework of the Joint CABRI Project shall be facilitated as necessary to assure the progress of work. Such visits shall be arranged with the mutual consent of the parties involved and upon receipt of adequate notice by the appropriate authorities of the facilities to be visited.

2.8. It is agreed that should the USNRC request the performance of special tests for inclusion in the CABRI program, the CABRI Party shall, to the best of its ability, undertake implementation of such a request, subject to the negotiation of a separate contract between the parties and to the understanding that the performance of such special tests shall not interfere with the conduct of the CABRI test programs, shall be compatible with the design and operational requirements of the CABRI facility, and shall be programmed in accordance with the decision of the Joint CABRI Committee.

Article III. SCOPE OF RESPONSIBILITY OF USNRC

3.1. The USNRC, in consideration of the technical benefits received by its participation in the CABRI project and by its receipt of information under this Agreement,

* The Joint Committee is a managing board, responsible to the CEA and the KfK for the implementation of the objectives pursued in the Joint CABRI project and for the management of funds. The Joint Committee has regular meetings twice a year.

agrees to permit the CABRI Party to participate in the ACPR in-pile fast reactor safety research program on a basis reciprocal to the USNRC participation in CABRI.

3.2. Subject to the availability of appropriated funds, the USNRC agrees to provide the necessary personnel, materials equipment and services for the performance of the ACPR fast reactor safety research program, as described in Appendices 3 and 4, or as amended. The scope of the USNRC program covers the full range of applicable fuel cycles of fast reactor concepts.

3.3. The USNRC agrees to make available to the CABRI Party, to the maximum permissible extent, all technical information and knowledge relevant to the planning and implementation of the USNRC-funded ACPR programs, including access to all experimental data and results of analyses generated during the period of this Agreement within the following ACPR in-pile programs: (i) Accident Energetics (including PBE, FCI and EOS if any), (ii) Core Debris Behavior (PAHR Debris Bed and PAHR Molten Pool), (iii) ACPR Up-Grade and (iv) ACPR Fuel Motion Detection System.

3.4. The USNRC agrees to permit the CABRI Party to be represented in the ACPR program Technical Review Groups to which the CEA and the KfK may each send one permanent observer. The permanent observers are permitted to take part in the discussions of the Technical Review Groups and to make suggestions, but without right of decision. A limited number of appropriate experts from CEA and KfK may also attend the Review Group meetings for discussion of special topics.

3.5. The USNRC further agrees to permit the CABRI Party to delegate mutually agreed upon technical experts for participation in the conduct and analysis of the ACPR program work performed at research facilities of the U.S. The USNRC shall agree in writing upon the person to be delegated and the purpose and term of such delegation, in advance of each delegation of personnel. In addition, a separate personnel assignment agreement shall be signed between the home organization of the assigned expert and the organization to which the expert has been assigned. Such assigned personnel shall be integrated into the scientific and technical work of the ACPR program. In this context, and to the extent permitted by such separate personnel assignment agreements, the assigned personnel shall have appropriate access to the facility and to all documents concerning the ACPR program, and shall have the right to participate in technical discussions of the USNRC and relevant contractor staff on the preparation, implementation and evaluation of the ACPR experiments. Their tasks shall be defined in such a way that sufficient time will be available to the assigned personnel for appropriate reporting to the CABRI Party about the ACPR program.

3.6. It is further agreed that visits of CEA and KfK reactor safety experts to the U.S. facilities where work is being performed in the framework of the ACPR program shall be facilitated as necessary to assure the progress of work. Such visits shall be arranged with the mutual consent of the parties involved and upon receipt of adequate notice by the appropriate authorities of the facilities to be visited.

3.7. It is agreed that should the CABRI Party request the performance of special tests for inclusion in the ACPR program, the USNRC shall, to the best of its ability, undertake implementation of such a request, subject to the negotiation of a separate contract between the parties and to the understanding that the performance of such special tests shall not interfere with the conduct of the USNRC test programs, shall be compatible with the design and operational requirements of the ACPR facility, and shall be programmed in accordance with the decision of the USNRC.

3.8. It is understood that should the CABRI Party request visits or assignments of personnel, or the performance of special tests in facilities owned or operated by U.S. government agencies other than the USNRC, prior written approval of the terms of governing such visits, assignments or requests for special tests must be obtained from the concerned government agency. The ACPR facility is owned by the U.S. Department of Energy.

Article IV. EXCHANGE OF SCIENTIFIC INFORMATION AND USE OF RESULTS OF PROGRAM

4.1. Subject to the other provisions of this article, the parties agree that knowledge and information developed or transmitted under this Agreement may be given wide distribution. Except as may be noted hereinafter, such knowledge and information may be made available to the public through customary channels and in accordance with normal procedures of the parties.

4.2. It is recognized by the parties that in the process of exchanging knowledge or information, or in the process of other cooperation, the parties may provide to each other "industrial property of a proprietary nature." Such property, including trade secrets, inventions, patent information, and know-how, made available hereunder and which bears an appropriate restrictive legend clearly indicating that the property is of proprietary commercial value, shall be respected by the receiving parties. Such property is defined as that which:

(*a*) Has been held in confidence by its owner; and

(*b*) Is of a type which is customarily held in confidence by its owner; and

(*c*) Has not been transmitted by the transmitting party to other entities (including the receiving party) except on the basis that it be held in confidence; and

(*d*) Is not otherwise available to the receiving party from another source without restriction on its further dissemination.

4.3. Recognizing that "industrial property of a proprietary nature," as defined above, may be necessary for the conduct of specific programs included under this Agreement, or may be included in an exchange of information, such property shall be used only in the furtherance of nuclear safety programs in the receiving countries. Its use and dissemination shall, unless otherwise mutually agreed to in writing, be limited as follows:

(*a*) To persons within or employed by the receiving parties for the purpose of activities conducted by such parties, and to other government agencies of the receiving parties; and

(*b*) To organizations having their principal operations in the countries of the receiving parties engaged in the design, development, construction or operations of fast reactors. These organizations may pass the knowledge, information, and results to other organizations having their principal operations outside the country of the receiving parties where the recipient is bound to them by a license agreement in the field of the design, development, construction or operation of fast reactors;

The preceding sentence is deemed to permit the CEA and the KfK to pass such knowledge, information and results to R&D organizations in Italy, Belgium and The Netherlands with which they have information exchange agreements in effect, notwithstanding the absence of a licensing agreement. Moreover, the information disseminated to any organization under subparagraph (*b*) above, shall be pursuant to an agreement of confidentiality.

4.4. It is further recognized by the parties that in the process of exchanging information, or in the process of other cooperation, the parties may transmit "other information of a confidential or privileged nature" which is protected from public disclosure in the country providing the information. Such information transmitted and received in confidence, which bears an appropriate restrictive legend clearly indicating that the information is of a privileged or confidential nature, shall be respected by the receiving party.

4.5. The use and dissemination of such "other information of confidential or privileged nature" shall be limited to that set forth in subparagraph (*a*) of paragraph 4.3, unless otherwise mutually agreed to in writing.

4.6. No publication of data or results related to the Joint CABRI Project shall be made by the receiving parties without the express written authorization of the transmitting parties. In any such publication reference shall be made to the Joint CABRI Project.

4.7. The application or use of any information exchanged or transferred between the parties under this Agreement shall be the responsibility of the parties receiving the information, and the transmitting parties do not warrant the suitability of the information for any particular use or application.

4.8. Nothing contained in this Agreement shall require any party to take action which would be inconsistent with its national laws and regulations. If, for any reason, one of the parties becomes aware that it will be, or may reasonably be expected to become, unable to meet the nondissemination provisions of this article, it shall immediately inform the other party. The parties shall thereafter consult to define an appropriate course of action.

4.9. A party receiving from sources outside of this Agreement information without restriction shall not be precluded by anything contained in this Agreement from using or disseminating such information so received.

4.10. Nothing contained in this Agreement should be construed to authorize the exchange of information classified under the national security laws of the transmitting party.

Article V. DURATION OF AGREEMENT AND TERMINATION

5.1. This Agreement shall enter into force upon signature of the parties and, except as noted in paragraph 5.4, shall remain in force throughout the duration of the basic KfK-CEA CABRI Agreement and any extension thereof as required for the completion of the CABRI program described in Appendix 1. A copy of the basic KfK-CEA CABRI Agreement is given in Appendix 5* for information and without being a part of this Agreement.

5.2. If the basic KfK-CEA CABRI Agreement is extended for the purpose of carrying out work additional to that identified in Appendix 1, the present Agreement may also be extended by mutual understandings of the parties.

5.3. Either party may withdraw from the present Agreement after providing the other party written notification 1 year prior to its intended date of withdrawal.

5.4. If the performance of this Agreement is affected by a cause beyond the reasonable control of one or other of the parties involved, for example, because of lack of funds, the party so involved shall not be held liable for the consequences that may result, subject to its having promptly advised the other party of the cause and possible consequences, and its having made its best efforts to limit such consequences. The parties shall examine the changes (if any) that need to be made in the terms of this Agreement to reach an equitable solution. The objective shall be to complete the scope of the technical program.

Article VI. PATENTS

6.1. With respect to any invention or discovery conceived or first actually reduced to practice in the course of the cooperative activities undertaken by the Parties in implementing this Agreement.

* Not printed herein.

6.1.1. If conceived or first actually reduced to practice by personnel of a Party (the Assigning Party) or its contractors while assigned to the other Party (the Recipient Party) or its contractors in connection with an exchange of scientists, engineers and other specialists:

6.1.1.1. The Recipient Party shall acquire all right, title and interest in and to such invention or discovery, and any patent application or patent that may result, in its own country and in third countries; and

6.1.1.2. The Assigning Party shall acquire all right, title and interest in and to such invention, discovery, patent application or patent in its own country.

6.1.2. If conceived by or first actually reduced to practice by a Party or its contractors as a direct result of employing information which has been communicated to it under this Agreement by the other Party or its contractors, but not otherwise agreed to under a cooperative effort covered by paragraph 6.1.3:

6.1.2.1. The Party so conceiving or first actually reducing to practice such invention or discovery shall acquire all right, title and interest in and to such invention or discovery, and any patent application or patent that may result, in its own country and in third countries; and

6.1.2.2. The other Party shall acquire all right, title and interest in and to such invention, discovery, patent application or patent in its own country.

6.1.3. For other specific forms of cooperation, including exchanges of samples, materials, instruments and components for special joint research projects, the Parties shall provide for appropriate distribution of rights to inventions. In general, however, each Party should normally determine the rights to such inventions in its own country, and the rights to such inventions in other countries should be agreed by the Parties on an equitable basis.

6.1.4. Notwithstanding the allocation of rights covered under paragraphs 6.1.1 and 6.1.2, in any case where one Party first actually reduces to practice after the execution of this Agreement an invention, either conceived by the other Party prior to the execution of this Agreement, or made or conceived by the other Party outside of the cooperative activities implementing this Agreement, then the Parties shall provide for an appropriate distribution of rights, taking into account existing commitments with third parties; provided, however, that each Party shall determine the rights to such invention in its own country.

6.1.5. It is understood that after the European Patent Conventions[1] have come into force, either Party may request a modification of this paragraph 6.1 for the purpose of according equivalent rights as provided in paragraphs 6.1.1 through 6.1.4 under the European Patent Conventions.

6.2. The Party owning a patent covering any invention referred to in this article 6.1 shall license the patents to nationals or licensees of the other Party, upon request of such other Party, on nondiscriminatory terms and conditions under similar circumstances. At the time of such a request, the other Party will be informed of all licenses already granted under such patent.

6.3. Each Party shall take all necessary steps to provide the cooperation from its inventors required to carry out the provisions of this Article. Each Party shall assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

[1] See "Convention on the Grant of European Patents, concluded at Munich on 5 October 1973," in United Nations, *Treaty Series*, vol. 1065, p. 199.

Article VII. GENERAL PROVISIONS

7.1. Each party shall bear the costs of its own activities and of its participation in the activities of the other party, and shall control the expenditure of the funds necessary to meet such costs. Activities under this Agreement shall be subject to the availability of appropriated funds.

7.2. Any changes in or amendments to this Agreement shall require the written consent of the contracting parties.

7.3. The USNRC shall not object to the admittance of other partners to the Joint CABRI Project as long as its rights and obligations are not affected by such admittance.

7.4. Wherever the written consent or decision of the KfK and CEA is required in this Agreement, it shall be given in a letter signed jointly by the KfK and CEA.

7.5. The Joint Committee and the USNRC shall designate technical coordinators to settle all pending matters within a reasonable time.

7.6. All questions related to this Agreement arising during its term shall be settled by the parties by mutual agreement.

7.7. The USNRC is informed that the CEA and KfK are the Senior Partners, and that the PNC and UKAEA are the Junior Partners of the CABRI project.

7.8. This Agreement shall be written in the English, French and German languages, each version being equally valid.

7.9. This Agreement shall be known as the CABRI/ACPR Agreement.

7.10. The periodic reviews of this Agreement shall be carried out as part of the regular meetings of the Joint Committee. Once a year, as part of the periodic review, revised cost estimates shall be presented.

7.11. Memorandum of Understanding regarding the detailed implementation of this Agreement is attached.

For the United States Nuclear Regulatory Commission:

By: [*Signed*][1]
Title: Executive Director for Operations
Date: 5.2.78[3]

For the CABRI Party:

Commissariat à l'Energie Atomique,
By: [*Signed*][2]
Title: Chef du Service technique des Marchés et Contrats[4]
Date: 7 June 1978

Kernforschungszentrum Karlsruhe GmbH:
By: [*Signed*]
H. H. HENNIES
Title: Executive Director for Reactor Development and Safety
Date: 22 June 1978

and

[*Signed*]
i.V. G. KESSLER
Title: Director Fast Breeder Project

[1] Signed by Lee V. Gossick.
[2] Signed by Guy Coste.
[3] 2 May 1978.
[4] Chief of the Contracts Office.

APPENDIX 1

EXPERIMENTAL PROGRAM OF THE JOINT CABRI PROJECT

This appendix provides only a general framework for the experimental program. It will be the task of the Joint Committee to:

— Specify the details of each test series,
— Decide upon the studies to be carried out and any modifications to be made at the installation in order to improve the quality of the measurements made,
— Fix the appropriate time schedule.

1. *Objective of the Joint CABRI Project*

1.1. *Target*

The objective of the CABRI test program is to study the behavior of fuel pins of fast sodium cooled reactors in the course of serious reactivity accidents either due or not due to a cooling failure. The results of these tests will be used to develop and elaborate computational programs describing a generalized accident.

In a reactivity accident, special attention must be paid to the following phenomena:

— Migration and rapid movement of the fuel in the solid or liquid state within the fuel pin prior to rupture of the cladding and subsequent axial movement of the fuel, of the cladding and of sodium within the experimental channel after rupture of the fuel pin (ejection effects);
— Determination of the criteria of cladding rupture (failure threshold of the fuel pin);
— Hydraulic behavior of the coolant after fuel pin failure; and
— Thermal interaction between the molten fuel and sodium (pressure peaks, conversion of thermal energy into mechanical energy).

1.2. *Anticipated Measurements*

The main parameters to be measured are:

— Energy stored in the fuel tested and threshold of fuel rod failure;
— Pressure peaks and velocity of the coolant after pin failure;
— Conversion factor of thermal into mechanical energy;
— Dimensions of fuel particles after the test, amount of molten fuel, amount of fission gas released in the test; and
— Axial velocity of fuel particles in the experimental channel and amount of fuel ejected from the experimental channel.

Development efforts required to measure these parameters with the precision indicated in the feasibility study will be undertaken after evaluation and approval by the Joint Committee of the technical and financial consequences. This relates above all to the installation of a hodoscope which shall be taken into account in the project.

2. *Characteristics of Fuel Pins to be Tested*

As a rule, the tests will be effected on one type of pin (the "CABRI Common Test Pin"), whose characteristics will be defined by a committee of experts of the CEA and KfK.

Limitations imposed by the test facility are:

2.1. *Length of Pins*

The fissile part will be 80 cm in length and the pins have an overall length of 150 cm.

2.2. *Nature of the Fuel*

An initial set of at least 10 tests will be performed on fuel pins containing fresh UO_2 fuel up to about mid-1979. Thereafter, at least 20 tests will be performed with irradiated fuel pins. For these, PuO_2/UO_2 mixed oxide will be chosen as fuel, unless it can be proved that for this type of test the behavior of pins containing mixed oxide can be simulated by pins containing UO_2.

2.3. *Number of Pins*

Single-pin tests will be performed. However, the experimental channel can accommodate up to 7 pins of 7.5 mm maximum diameter.

3. *Definition of Tests*

3.1. *Test Conditions in CABRI*

A test sequence involves establishing a steady state condition with nominal flow, followed by a possible reduction in the flow with consequent boiling in the channel, with subsequent initiation of power transient immediately followed by a scram.

The test conditions may vary within the following limits:

(*a*) Preirradiation in PHENIX or PFR:
- — Linear power: from 300 to 450 W/cm.
- — Burnup from 0 to 50,000 MWd/t.

(*b*) Test in CABRI:
- — Maximum linear power under the initial condition of steady state operation: from 450 to 600 W/cm.
- — Energy stored from the condition of steady state operation: from 0.8 to 2 KJ/g.
- — Duration of energy release: between 15 msec and 1 sec.
- — Maximum power: from 10 to 2×10^3 of the initial linear power.

The three latter aspects are interrelated by the kinetics of the driver core.

3.2. *Test Series*

Series A: Primary introduction of reactivity

This test series serves to verify the influence of the different parameters mentioned in the foregoing paragraph in case an abrupt introduction of reactivity took place during reactor operation under rated conditions.

Series B: Cooling accidents

These studies concentrate on what will happen when the pumps coast down in the absence of a scram. For this purpose a fuel pin operating under nominal conditions is subjected first to simultaneous flow and power reduction and then to a power transient simulating the secondary enhancement of reactivity which results from the primary accident.

Besides the parameters already mentioned the influence must be studied of temperature and flow at the moment of transient power occurrence. This study will be restricted by the fact that the beginning of this transient must take place early so that the rig and its instrumentation are still intact.

Series C: Fuel-Coolant interaction heat transfer effects

Studies to examine the heat transfer after destruction of the pin will be defined after completion of Series A and B.

The major part of the tests will be of type A.

As a rule, while the choice of parameters for each test will be defined in the feasibility study, modifications can be introduced by the Joint Committee in the light of results obtained or new requirements.

4. *Time Schedule*

The tests are anticipated to start in the second quarter of 1978. Up to mid-1979 a minimum of 10 tests are planned with fresh fuel. Thereupon and until the end of 1980, a minimum of 20 tests are intended with irradiated fuel to be performed under conditions of normal operation.

In case difficulties arise, a possible delay would be equally distributed between the CABRI and SCARABEE programs carried out in the same facilities and by the same teams.

APPENDIX 2

THE CABRI FACILITY

The essential characteristics of the CABRI facility as described in the feasibility study shall be:

1. *Initial Conditions*

(*a*) Linear power of the fuel pin tested: 600 W/cm during an interval of more than 100 sec.

(*b*) Temperatures of the coolant in the test section:

Inlet—400°C.

Outlet—600°C or boiling under steady state conditions over a minimum duration of 5 sec.

(*c*) Flow: It will be possible to reduce the flow in order to simulate a pump coast-down and a channel blockage over a period limited by the stability of the materials making up the channel and of the instrumentation

2. *Power Excursion Parameters*

The maximum power, pulse width transient period, and energy released in a power excursion are parameters dependent on each other. They are given by the kinetics of the driver core as described in the feasibility study. The values of these quantities for the maximum transient condition are as follows:

(*a*) Power peak in the fuel tested: $P/Po = 2 \times 10^3$,

(*b*) Full width at half maximum (FWHM): $T = 15$ msec.

(*c*) Transient period: about 5 msec.

Other forms of power peaks can be simulated by programming the reactivity injected within the limits of the kinetic and thermal characteristics of the existing core. This programming may be achieved by two successive reactivity ramps, separately controllable, of from 0.5 $/sec to 50 $/sec. The total reactivity reserve of the injection system is 5 $.

3. *Energy*

It must be possible to add an energy of 2.0 KJ/g of UO_2 when using the fuel tested with the enrichment defined below and starting from the initial conditions determined above. The feasibility study reveals that ramps of 50 $/sec are required to obtain this value.

4. *Test Pin Characteristics*

(*a*) Enrichment: Typical of the fast reactors of the PHENIX or SNR type, i.e., 15 to 25% of fissile plutonium in a UO_2/PuO_2 mixed oxide.

(*b*) Fissile length: 800 mm.

(*c*) Overall length: 1500 mm.

(*d*) Pre-irradiation in CABRI: about 10 hours at 500 W/cm.

(*e*) Irradiated pins: Experiments will be possible with irradiated mixed fuel (up to 50,000 MWd/t).

(*f*) Handling: Handling of 1500-mm length pins containing mixed oxide fuel will be possible in the CABRI reactor and in the hot cells of Cadarache as from 1977.

5. *Loop Concept*

The loop will be conceived such that it can accommodate seven pins. A flow of 3.5 m^3/h and a maximum pressure loss of 3 bars will be guaranteed in the test section.

Delayed neutron measurement and direct gamma spectrometry of sodium leaving the loop will be possible.

Neutronradiography of the experimental rig will be possible after withdrawal from the loop.

6. *Data Acquisition*

The adaptation of signals from the instrumentation of the test section and their acquisition will be possible with the performances described in the feasibility study.

APPENDIX 3

ACPR EXPERIMENTAL PROGRAMS

This appendix provides only a general framework for the ACPR experimental program. It will be the task of the U.S. NRC staff, acting after reviews by the contractor and the technical review groups, to:

—Specify the details of each test series,

—Decide upon the studies to be carried out and any modifications to be made at the installation in order to improve the quality of the measures taken,

—Fix the appropriate time scale

1. *Objective of the ACPR Program of In-pile Research*

1.1. *Target*

It is the objective of this program to study the behavior of fuel pins of fast sodium cooled reactors in the course of serious reactor accidents and of fuel debris, both particulate and molten, under a range of post-accident conditions. This program also includes efforts to provide a suitably improved performance of the test reactor (ACPR Up-Grade) and special apparatus to study fuel motion while the test is in progress (ACPR Fuel Motion Detection).

The results of these tests will be used to validate fast reactor accident analysis codes.

Key behavior to be studied include:

—Fuel motion prior to and after fuel failure;

—Movement of cladding and sodium and fission gas associated with fuel failure;

—Threshold of cladding rupture;

—Debris bed heat transfer correlations and over-all thermal behavior;

—Thermal and kinetic characteristics of molten pools of fuel materials; and

—Interaction, both thermal and mechanical, of molten fuel and cladding with sodium.

1.2. *Anticipated Measurements*

The main parameters to be measured are:

—Energy stored in the fuel pins tested and the threshold of fuel rod failure;

—Pressure peaks and bulk sodium displacement versus time after pin failure;

—Conversion factor of thermal into mechanical energy;

—Fuel motion during the transient;

—Post-transient fuel characteristics;

—Debris bed hydraulic characteristics, temperature distribution and power output; and

—Molten pool power output, heat fluxes and attack on crucible materials,

As part of this program, a fuel motion detection system using a Fresnel Zone Plate (FZP) shall be made available for use at the upgraded ACPR to measure fuel motion in fuel pin bundles during a test. Special thermometry methods will be used to determine the temperature distributions in and around debris beds and molten pools of fuel materials.

2. *Characteristics of Fuel Pins to Be Tested*

Fuel to be tested with ACPR program includes special pins similar to the "Cabri Common Test Pin" referred to in Appendix 1, but of a shorter length. In addition, tests will be made with:

—Fresh UO_2, in both pin and debris form;

—Irradiated mixed oxide fuel pins; and,

—Advanced fuel materials, such as UC or UN, or other alternate fuels.

Fuel test bundles of up to seven pins will be tested in the loop. Debris beds of 10-cm in diameter will be tested; molten pools will be slightly smaller.

3. *Definition of Tests*

The range of test conditions are specified in Table 1. These conditions are interdependent and cannot be separately controlled.

Debris beds will use fully enriched fuel and will operate at power levels of up to about 2.5% of normal power, or about 5/W of oxide, representing decay heat.

Table 1. FUEL PIN TEST CONDITIONS IN THE ACPR UPGRADE

Pulse Fluence	1×10^{16} n/cm^2
Minimum Period	2.0 msec
Pulse Mode	Single, multiple or square-wave followed by single pulse
Experiment Cavity	25 cm Diam. × 50 cm Height
Fuel Pin Bundles	1-7 pins
Test Fuel Enrichment (nominal)	1 pin - 14% 7 pin - 14%/21%
Energy Deposition	1 pin - 8500 J/g UO_2 7 pin - 3800
Pin Power Profile (Max/Min)	1 pin - 1.4 7 pin - 1.5/1.2
Fuel Motion Detection	Coded Aperture

3.2. *Test Series*

A. *Prompt Burst Energetic (A-1016 Task 1)*

Prior Year Experience (FY76)

Prior year experience included a series of eight tests on single UO_2 pins in static capsules, five being filled with sodium. Sodium pressures and displacements were measured.

Current Year Program (FY77)

The measured variables are being evaluated to determine the energetics of the fuel and other vapors. Experiments to date indicate that only fuel vapor plays a significant role in the prompt burst failure of fresh UO_2 and that the vapor is rapidly condensed in the surrounding sodium and clad. By the end of FY77, tests are projected on a single UO_2 pin in a static capsule with a multiple pulse that will promote centerline vaporization prior to fuel failure.

Future Program (FY78 *et seq.*)

Experiments (beginning in FY79) on one to seven pins, including pins similar to the "CABRI Common Test Pins," will be conducted. Actual test parameters will be selected to verify failure modes and thresholds detected in earlier tasks in CABRI and TREAT and to establish, by the comparison of one- and seven-pin tests the effects of interaction between pins on fuel motion immediately following failure. Special tests will be run to validate key portions of fuel failure models as they are developed and suitable fuel is available.

Limited loss of flow simulation will be made with single pins to attempt to confirm the hypothesized role of fission gas in causing early dispersal of fuel.

As a rule, the approximate schedule and test conditions will be fixed about a year in advance, but final conditions will be fixed by the relevant NRC Program Manager and the senior investigator after reviews by the Technical Review Group.

B. *Fuel Coolant Interactions (A-1016, Task 5)*

The in-pile experiments will be analyzed to place upper bounds on the conversion of thermal energy in the fuel pin to sodium vapor energy. Estimates from the first series of tests show the upper bound to be very low—of the order of 2×10^4 as the ratio of sodium vapor energy to fission energy deposited in the test pin.

In the upgraded ACPR, this work will be extended to larger bundles, bundles with less sodium sub-cooling, with hot walls and to tests using UC, since a prediction has been made that, under extreme conditions, a strong UC-Na interaction can develop.

Further studies under consideration include phenomenological tests using pre-dispersed systems and tests using molten fuel in bulk.

C. *Debris Bed Studies (A-1181, Task 2)*

Post-Accident Heat Removal (PAHR) Debris bed studies will be undertaken to characterize the thermal behavior of internally heated debris beds to determine their melt-through potential in order to provide information needed for analysis of post-accident containment. The experiments will utilize fission heating and will be performed in-pile using the ACPR in the steady-state mode.

Prior Year Experience (FY76)

The appartus required to perform the in-pile PAHR debris bed experiments was designed and fabricated. This includes the helium cooling loop and the experiment package itself, together with the numerous ancillary equipment required. Testing of the helium loop was completed. The Reactor Compatibility Experiment (RCE) and the Out-of-Pile Systems Test (OPST), which were required to qualify all the appartus for the ACPR, were completed successfully. Detailed planning of the experiment, including the safety evaluation, was completed. Fuel was received.

Current Year Program (FY77)

The initial in-pile debris bed experiment (D-1) will be performed in the ACPR. Successful completion of this experiment will be followed by experiments D-2 and D-3. Evaluation of the results of these tests will allow specification of the parameters for the follow-on experiments which will be scheduled later in the year.

Three different dry-out correlations have been used to predict tests D-1, 2 and 3. Dry-out may occur in test D-3; it is less probable in D-1 and -2 which are at lower powers.

Future Program (FY78)

Because of the ACPR shutdown for the Upgrade, no in-pile experiments are scheduled for this period. Instead, the knowledge gained from the previous experiments will be consolidated and evaluated against the available analyses and correlations; new, improved experiments will be designed, together with improved diagnostic instrumentation.

D. *PAHR Molten Pool Study (A-1181, Task 3)*

PAHR Molten Pool and Molten Pool Diagnostics studies will be conducted to characterize the thermal and kinetic behavior of internally heated molten pools of fuel materials, including fission product retention, and to determine the melt-through potential of such configurations to be used in analysis of post-accident containment. The experimental program will utilize fission heating of UO_2 fuel and will be performed in-core using the Annular Core Pulse Reactor (ACPR) in the steady state mode.

Prior Year Experience (FY76)

The molten pool small capsule design work was completed. The high temperature material compatibility studies were conducted on candidate crucibles and thermal insulation materials. The

Experiment Plan and Safety Analysis were initiated. The enriched UO_2 for in-core experiments and depleted fuel for out-of-core tests were received. The small capsule diagnostics and associated console were ordered. An advanced capability ultransonic thermometer (temperatures to 3300 K, spatial resolution 5 mm) was developed for the large capsule experiment series. Ultrasonic and fission gamma attenuation and imaging techniques for measuring the thickness of melting steel containment were devised, and feasibility studies initiated.

Current Year Program (FY77)

The molten pool small capsule construction and assembly will be completed and the high temperature furnace "proof" test will be conducted. The Experiment Plan and Safety Analysis will be submitted to the ACPR Safety Committee for approval. The diagnostics console will be assembled and checked out. Several fuel-only small capsule experiments and fuel-steel small capsule experiments will be conducted in the ACPR. Development and design of the ultrasonic thermometers will be completed. A diagnostic technique for measuring the melting rate of a steel container will be developed using ultrasonics of fission gamma attentuation. The ultrasonic thermometers will be tested in-core in the small capsule series. Design of the large capsule experiments will be initiated using results from the small capsule series and the diagnostics development program.

Future Program (FY78 *et seq.*)

The large capsule molten pool experiment design will be operated in-core using the upgraded ACPR. The safety analysis and construction will be based on the results from the prior small capsule experiments. The upgraded ACPR will be utilized for this experiment series. The 20 kW helium heat transfer loop will be adapted for use with the molten pool system. The advanced diagnostics developed for these experiments will be used to obtain relative heat flux data and steel erosion rates.

E. *ACPR Fuel Motion Detection (A-1058)*

A Fuel Motion Detection System is to be developed for the Upgraded ACPR. The design of the system will be based upon the experience gained in experiments with shielding, collimation, coded aperture imaging, and time resolved pseudoholography at the ACPR, SPR II and 252Cf facilities. The system will be designed for high spatial and temporal resolution measurements of fuel motion in both transient and steady state experiments, including 1- and 7-pin prompt burst excursion experiments, bed leveling and material separation studies in the post accident heat removal experiments.

If successfully developed, the system is a forerunner of similar systems for other LMFBR safety test facilities such as TREAT, and SAREF. In this sense, it supports both DOE's and NRC's national LMFBR safety program as a diagnostic development effort.

Prior Year Experience (FY76)

Investigations were made of the major feasibility questions which must be answered before the final ACPR system is designed and built. A fission gamma ray source was imaged with 2 mm spatial resolution and a good signal to noise ratio through 5 cm of steel simulating reactor containment. A broad area fuel pin shaped object was imaged with 3 mm resolution. The object was illuminated with a simulated reactor spectrum. Computer reconstructions of the Cf fission gamma source have been obtained. Significant advances in laser reconstruction techniques were made. Collimation and shielding studies were conducted. Image intensifiers and lenses for the active recording system were ordered and some tests for resolution, radiation, effects and gain were made. A series of calculations were carried out which indicated that a fuel motion detection system for ACPR can be built which will provide 2 mm spatial and 100 μs temporal resolution.

Current Year Program (FY77)

The fuel motion detection system configuration will be chosen. This will involve choices of the active system components, the final coded aperture and the reconstruction methods to be used. These choices will be based on the experimental results and on computer calculations. In addition a moving fission gamma ray source will be imaged by the active recording system on the SPR II.

The investigations of methods to reduce undiffracted light contributions to the image will be completed and computer reconstruction methods should have been developed to an adequate degree. These choices will be based on the experimental results and on computer calculations.

Future Program (FY78 *et seq.*)

The fuel motion detection system components, which must be put in place at ACPR during shutdown, will be fabricated and installed. Reevaluation of final system design in light of the final SPR II moving fuel tests will be carried out before final installation and checkout of the ACPR system. The final reconstruction procedures will be worked out with attention to methods of handling large volumes of data efficiently. Finally, the fuel motion detection experiments will be carried out in ACPR. The program will be completed in FY78.

F. *ACPR Upgrade (A-1032)*

The ACPR Upgrade Project will improve the ACPR performance through the incorporation of a new core, an improved control system, and an improved confinement and cooling system, if required. ACPR Upgrade design activities have been in progress since FY 75. Preliminary designs for the high test capacity fuel element, cooling system, confinement structure, and control system have been completed. The initial funding was used in support of fuel element development including in-pile tests with samples of BeO-UO_2 and (UC-ZrC)-graphite. Prototype fuel elements will be fabricated and in-pile experimentation will be conducted for the final core configuration. Extensive calculations will be performed to define core configuration. Extensive calculations will be performed to define core parameteres and to evaluate the upgrade design for testing of multi-pin experiments.

Prior Year Experience (FY76)

Extensive in-pile experiments were conducted with BeO-UO_2, (UC-ZrC)-graphite, and U-$ZrH_{1.5}$ fuel specimens. These tests have shown that cold pressed and sintered BeO-UO_2 and hot pressed or extruded (UC-ZrC)-graphite can survive the temperature environment that will exist in the upgraded core. Fuel element section tests were conducted with conceptual designs for both high heat capacity fuels. Detailed heat transfer and thermal stress calculations were conducted for both high heat capacity fuel elements. The choice of the high heat capacity fuel for the core was made. Extensive transport and Monte Carlo calculations were conducted for both core designs, and the effect of core slots for fuel motion detection experiments was evaluated. The applicability of both core designs for fast reactor safety experiments was evaluated. Cost estimates for both core designs were obtained. The preliminary designs for a 2-megawatt cooling system and containment structure were completed. The decision was made to purchase the new control system from Gulf-General Atomic. The modification of existing safety documentation to account for the changes to the ACPR systems was begun.

Current Year Program (FY77)

All design activities for the ACPR Upgrade will be completed. Prototype fuel experiments will be conducted. The fuel elements, control system, cooling system, and containment structure will be fabricated and installed. The safety documentation for the upgrade will be completed and submitted to ERDA for review and approval. The present ACPR will be shut down and the conversion to the new core will begin near the end of the fiscal year, September 30, 1977.

Future Programs (FY78 *et seq.*)

The installation and testing of all components for the project will be completed and the initial critical experiment will be conducted. The initial testing program for the improved reactor will be completed, and the magnitude of the performance improvement will be determined. Initial fast reactor safety experiments will be performed.

The upgraded ACPR will be utilized for a wide variety of reactor safety experiments, such as, prompt burst excursion, post-accident heat removal, transition phase, and equation of state experiments.

APPENDIX 4

SUMMARY DESCRIPTION OF THE ACPR UPGRADE REACTOR

The ACPR Upgrade reactor design is a modification to the original ACPR reactor (see Table 1, Appendix 3), which has been in operation since 1967. The new design utilizes existing water tank, grid structure, and experiment facilities. The most prominent feature of this reactor is the large (1.23-meter ID) dry irradiation space at the center of the core. The annular core is formed by single fuel elements with their longitudinal axes vertical and arranged in a hexagonal grid around the center cavity. The core nominally consists of 200 fuel elements with six fuel-followed control rods, three poison transient rods with void followers and two fuel-followed safety rods. Design flexibility will accommodate the installation of one additional safety rod if the additional reactivity control is determined to be required. The outer row of fuel is surrounded by nickel reflector elements. The core utilizes high heat capacity $BeO\text{-}UO_2$ fuel elements which take up approximately 5-½ rings of the hexagonal grid.

The self-shut-down pulse characteristics of the ACPR Upgrade are summarized in Table 1. The energy releases in these pulses are self-limiting because of the negative temperature feedback coefficient characteristics of the $BeO\text{-}UO_2$ fuel. In addition to its pulse capability, the reactor can be operated at a steady-state power up to approximately 2.0 MW under conditions of natural convection cooling by the water in the reactor tank. The steady-state characteristics of the ACPR Upgrade are summarized in Table 2.

Table 1. TYPICAL PULSE CHARACTERISTICS OF ACPR UPGRADE NOMINAL 200 ELEMENT* CORE

Reactivity (Dollars)	*Pulse Width at Half Maximum (msec)*	*Maximum Calculated Fuel Temperature $BeO\text{-}UO_2$ (°C)*	*Energy** Release (MW-sec)*
2.70	6.9	1400	390
2.47	7.6	1240	340
2.19	9.0	1060	275
1.78	13.0	800	210
1.37	24.0	570	140

* Includes six fuel-followed control rods and two fuel-followed safety rods.

** Total yield to 10 seconds after pulse.

Table 2. STEADY-STATE CHARACTERISTICS OF ACPR UPGRADE NOMINAL 200 ELEMENT* CORE

Power (kW)	*Total Flux in Cavity (n/cm^2-sec)*	*Maximum Calculated Fuel Temperature ($BeO\text{-}UO_2$) (°C)*
2000	3.2×10^{13}	1200
1000	1.6×10^{13}	685

* Includes six fuel-followed control rods and two fuel-followed safety rods.

The relationships between energy release and fuel temperature and between power level and fuel temperature depend on the number of fuel elements in the core. The use of fewer elements for a given reactor power level results in a higher fuel temperature and a corresponding increase in the loss of reactivity. Thus the temperature values given in Tables 1 and 2 are only typical and apply strictly to the 200 element core.

Each of the reactor fuel elements is positioned in the core individually by an upper and lower grid plate. The core is located in an open pool of water, 3.1 meters in diameter and 8.6 meters deep. The top of the core is approximately 7 meters below the surface of the water, a depth that provides more than adequate radiation shielding. Access to the central irradiation cavity is by a loading tube with a nominal 0.25-meter diameter which extends vertically upward from the center of the core. About midway to the pool surface this tube branches, with the straight section continuing vertically upward to the surface and a branch paralleling the straight section to the surface with an offset of 1.6 meters. The entire tube structure is sealed at the bottom and open at the top. It is ballasted for negative buoyancy and supported in position at the pool surface by a permanent mounting platform extending over the pool. Neutron streaming up the straight vertical branch of the loading tube is prevented by a shield plug which is placed in the tube during operation of the reactor.

The ACPR Upgrade core, plan view, is shown on Figure 1. The figure shows about 5-½ rings of fuel elements surrounding the hexagonal cavity. The third ring contains the control, transient, and safety rod locations. The fuel is a Beryllium Oxide (BeO)—Uranium Oxide (UO_2) sintered ceramic composite material. The ACPR Upgrade fuel element is approximately 35 mm in diameter by 0.51 meter in length. The fuel is contained in a ribbed niobium liner and sealed in an 0.5-mm thick stainless steel cladding. The liner ribs maintain inert-gas filled insulating gaps between the fuel and liner and between the liner and clad. A 2.54-cm long end piece is located at the bottom and a 1.90-cm long end piece at the top end of each element in the fuel region, thus increasing the length of the fuel element (with end fittings) to 0.73 meter. Close packing of the fuel elements in an equilateral triangular array with center-to-center pitch of 41.71 mm produces a spacing of 4.24 mm between elements and a corresponding water flow passage of about 4 × 10 $^{-4}$m^2 in cross sectional area per fuel element.

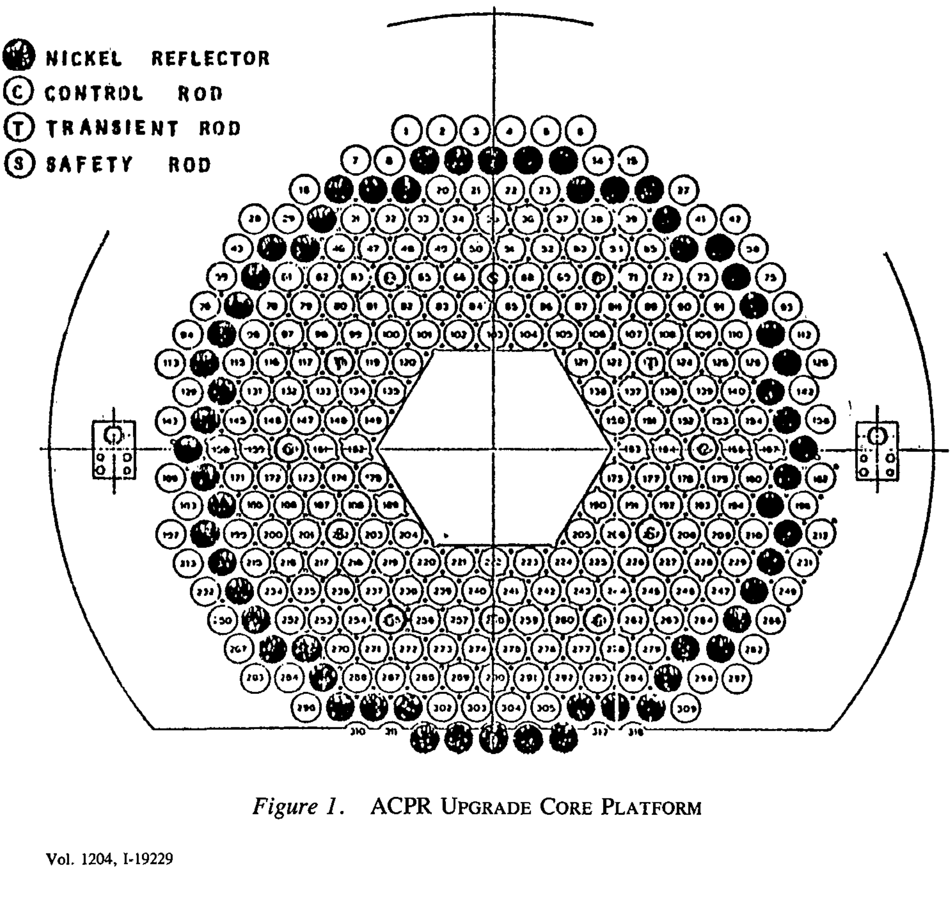

Figure 1. ACPR UPGRADE CORE PLATFORM

An extensive in-pile test program has been conducted to develop the design for the high heat-capacity fuel element. The $BeO-UO_2$ has been operated at 1500°C during in-pile testing without degradation such as severe cracking or powdering. This temperature is substantially below the phase transformation temperature (2050°C) and the melting point of 2450°C of the BeO matrix.

It is important to distinguish the maximum temperatures which may occur in a fuel element from the temperatures which are accessible to measurement. The maximum temperature occurring in a pulse, therefore, must be inferred from the lower temperature readings given by the thermocouple probes. Similar inferences will be used to determine fuel temperatures during steady-state operation.

MEMORANDUM OF UNDERSTANDING

This memorandum records the mutual understanding of the CABRI Party and the USNRC regarding the detailed implementation of the CABRI/ACPR Exchange Agreement.

1. The signatories to the Agreement are the KfK, CEA and the USNRC.

2. Information written by all the partners of the Joint CABRI Project is circulated as "CABRI Notes" and designated by letters and numbers, e.g., C-Mn, K-11, P-mm, etc. All such CABRI Notes exchanged with the USNRC will bear a marking as described below in item 4.

The Junior Partners of the Joint CABRI Project will receive ACPR information only if it is adjudged by the Senior Partners to be relevant to the CABRI program. In that case it will be circulated as a CABRI Note.

3. Information on the CABRI and ACPR programs developed by R&D organizations in Italy, Belgium and The Netherlands, which receive information and knowledge about the CABRI and ACPR programs in accordance with paragraph 4.3 of the Agreement, will be made available and transmitted to the CABRI partners and the USNRC in the form of CABRI Notes.

4. The "CABRI Notes" transmitted to the USNRC will be distributed in accordance with paragraphs 4.2 and 4.3 of the CABRI/ACPR Agreement. The notes will bear the following marking:

> "Restricted distribution—This material is transmitted in confidence under the CABRI/ACPR Agreement and may only be disseminated further in accordance with paragraphs 4.2 and 4.3 of the Agreement."

5. Other information may be transmitted between the parties to the Agreement which is of a confidential or privileged nature. Such information shall be transmitted with the marking:

> "Transmitted in confidence under terms of the CABRI/ACPR Agreement; further distribution shall be in accord with paragraphs 4.4 and 4.5 of the Agreement."

6. The following points of contact for each side are established for all day-to-day negotiations, including arrangements for visits, requests for personnel assignments or requests for special tests:

For CEA: Chef, Département de Sûreté Nucléaire
(Attn: André Schmitt or other representative as designated by CEA)

For KfK: Manager, Projekt Schneller Bruter
(Attn: F. W. A. Habermann or other representative as designated by the KfK.)

USNRC: Director, Office of Nuclear Regulatory Research, USNRC
(Attn: C. N. Kelber or other representative as designated by the USNRC.)

7. The U.S.N.R.C. will make all necessary arrangements for visits, assignments and requests for special tests at ACPR and will do its best to obtain the needed approvals.

The number of scientists assigned to the ACPR program from the Joint CABRI Project for prolonged stay is foreseen to be two or three. Similarly, the number of scientists assigned by the USNRC to the Joint CABRI Project is foreseen to be two or three. This does not affect technical visits or visits for the purpose of conducting special tests.

For the United States Nuclear Regulatory Commission:

By: [*Signed — Signé*][1]
Title: Director, Office of Research

Date: 5/2/78

For the CABRI Party:

Commissariat à l'Energie Atomique,
By: [*Signed — Signé*][2]
Title: Chef du Département de Sûreté Nucléaire[3]
Date: May 19, 1978

Kernforschungszentrum Karlsruhe GmbH:
By: [*Signed*]
H. H. HENNIES
Title: Executive Director for Reactor Development and Safety
Date: 22 June 1978

and

[*Signed*]
i.V. G. KESSLER
Title: Director Fast Breeder Project

[1] Signed by Saul Levine — Signé par Saul Levine.
[2] Signed by Pierre Tanguy — Signé par Pierre Tanguy.
[3] Chief of the Department of Nuclear Safety.