# AGREEMENT ON A COLLABORATIVE PELLET FUELING PROGRAM AS PART OF THE COOPERATION ON FUSION RESEARCH AND DEVELOPMENT BETWEEN THE UNITED STATES DEPARTMENT OF ENERGY AND THE JOINT EUROPEAN TORUS (JET) JOINT UNDERTAKING

Whereas an Agreement for Cooperation Between the European Atomic Energy Community and the United States Department of Energy on behalf of the United States Government in the Field of Controlled Thermonuclear Research (hereinafter referred to as the "DOE-EURATOM Fusion Agreement") was concluded on December 15, 1986 with the objective to help maintain and intensify cooperation and collaboration in magnetic fusion research and development,

Whereas the Council of the European Communities on May 30, 1978 established the Joint European Torus (JET) Joint Undertaking, whose aim is to construct, operate and exploit, as part of the Community Fusion Program, a large torus facility of the tokamak-type in order to extend the parameter range applicable to controlled thermonuclear fusion experiments up to conditions close to those needed in a thermonuclear reactor,

Whereas, Article III, paragraph 2 of the DOE-EURATOM Fusion Agreement provides for arrangements to be made between DOE and the JET Joint Undertaking,

Whereas the JET Joint Undertaking is within the framework of the EURATOM Fusion Programme of the European Atomic Energy Community (hereinafter referred to as "EURATOM"),

Whereas the United States Department of Energy (hereinafter referred to as "DOE") and the JET Joint Undertaking, (hereinafter referred to as JET), each having capabilities which can assist each other in their effort to advance the status of research and development of magnetic fusion energy as a potential energy source, desire to work together in a collaborative program of mutual interest and benefit,

DOE and JET (hereinafter referred to as the "Participants") agree to a collaborative Pellet Fueling Program as follows:

## ARTICLE 1

### Objective

1.1 The objective of the Pellet Fueling Program is to investigate the influence of pellet injection on long-pulse ohmic and additionally, i.e., auxiliary, heated plasmas in the JET device over two operational periods between major shutdowns for the mutual benefit of the Participants.

1.2 The Pellet Fueling Program shall be operated jointly by the Participants under the DOE-EURATOM Fusion Agreement.

1.3 This Agreement is not intended to diminish or duplicate any existing agreements between DOE and EURATOM or multilateral agreements to which DOE and EURATOM are parties.

## ARTICLE 2

## The Pellet Fueling Program

2.1 The Pellet Fueling Program shall consist of plasma fueling and refueling experiments by pellet injection on the JET device by means of a jointly built and operated Pellet Injection System. The Pellet Injection System consists of the pellet launcher, control systems, mechanical structures, electrical systems, vacuum systems, cryogenic systems and other ancillary equipment needed for installation and interface of the launcher to the JET device, and the operation of the launcher.

2.2 The primary scientific objectives of the Pellet Fueling Program shall be to investigate and explore:

1) Raising the central density and probing density limits in high temperature plasmas in order to optimize plasma confinement, that is, the density-confinement time product;

2) Fueling requirements necessary to sustain the conditions described in objective 1) above.

2.3 The topics to be addressed in support of the scientific objectives include:

pellet ablation, penetration and deposition profiles;

plasma particle and energy transport in pellet fueled discharges using available codes and models;

impurity behavior (accumulation, dilution, flushing, and removal of ash);

plasma density build-up with minimum gas fueling in order to minimize wall interaction;

density profile and heat deposition profile interaction in conjunction with neutral beam heating and, particularly, localized Ion Cyclotron Resonant Heating (ICRH) and

pellet injection for diagnostic purposes.

The order is not intended to indicate the priority.

2.4 DOE shall be responsible for:

2.4.1 Providing a three (3) - barrel, multiple-repetitive pellet launcher system for hydrogen and deuterium pellets of sizes according to the choice of barrels to be delivered not later than 1 May 1987 with a best effort to deliver sooner. The launcher system shall have nominal capability of delivering fuel pellets with not less than 6, 8, or 10 pellets per tokamak pulse for a corresponding barrel choice of 6,4 or 2.6mm diameter, with a repetition rate of $5s^{-1}$ for the smallest pellets, less for others, and with pellet velocities typically around 1.5 $Kms^{-1}$. The launcher system shall include the guns, extruders, vacuum enclosure, launcher-mounted controls and instrumentation, gas supply manifold, control and instrumentation cabling, including termination boxes, local control and instrumentation racks, control room computer for remote control and data acquisition, and associated documentation.

2.4.2 Technically managing the launcher system throughout the operational phase and decommissioning process. Every reasonable effort shall be made consistent with paragraph 2.4.3 below to provide a high degree of operational availability.

2.4.3 Supporting a team at JET at an annual level of effort of approximately 4 man-years 1) for planning and coordination of the effort prior to injector installation, 2) during installation of the injector at JET, and 3) while experiments are being conducted on the JET device. Following completion of the experimental operating period, continued DOE support shall be provided for further data analysis as deemed necessary by DOE.

2.4.4 Designating Oak Ridge National Laboratory (ORNL) to implement the design, fabrication, integrated testing, delivery, installation, and integrated checkout at JET of the launcher system.

2.4.5 Testing of the launcher system, before its delivery to the JET site, in accordance with the mutually agreed test standards developed under paragraph 2.6.1.

2.5 JET shall be responsible for:

2.5.1 Complementing and connecting the DOE launcher system to the JET device and providing ancillary equipment, particularly the vacuum interface and services, necessary to operate the launcher system.

2.5.2 Providing assistance in installation and maintenance (services, manpower, and consumables) and the means for operation (services and consumables) which are required to utilize the launcher system.

2.5.3 Providing during the experimental period (approximately 3 years) a pellet team comparable in number to the DOE team to carry out the plasma fueling and refueling experiments.

2.5.4 Executing the Joint Experimental Plan (described in Article 3) accepted by the JET Director. That plan shall include providing a minimum of 20% of machine time for experiments using the launcher system. Of this 20%, half shall be dedicated to pellet injection experiments only; half shall be warranted pellet time, i.e., the pellet experiment shall be operating fully, but in support of other experimental work being conducted on JET. Additional time for pellet injection experiments shall be at the discretion of the JET Director.

2.5.5 Providing a set of plasma diagnostics mutually agreed to by the Program Coordinators (of Article 3 below) and adequate to analyze pellet ablation and plasma behavior during pellet injection and the usual evaluation analyses.

2.5.6 Providing, during pellet injection experiments, the JET device with the capability of additional heating of 10-15MW of neutral beam power to the plasma and 15-20MW of ICRH power to the plasma, both available for plasma flat-tops on the order of 5-10 seconds. Limited x-point operation will be available.

2.6 DOE and JET shall have joint responsibility for:

2.6.1 Developing mutually agreed standards for the testing of the launcher system to be done prior to delivery to the JET site.

2.6.2 Developing the design and interface control specification as mutually agreed and developing the installation and commissioning procedures for final, integrated checkout at the JET device.

2.6.3 Developing on a timely basis the Joint Experimental Plan for the Pellet Fueling Program.

2.6.4 Commissioning and operating the Pellet Injector System at the JET device and carrying out the Joint Experimental Program.

2.6.5 Providing the on-site team with data analysis codes, simultaneous access to the data and analysis results and equal access to archived data from pellet and reference shots.

## ARTICLE 3

## Management

3.1 Each Participant shall appoint one of the two Program Coordinators who shall jointly be responsible for management of the Pellet Fueling Program, approval of the respective experimental teams, proposing and recommending a Joint Experimental Plan to their respective authorities for the Pellet Fueling Program, and preparation of reports to the Coordinating Committee established under the DOE-EURATOM Fusion Agreement.

3.2 One member of the DOE team shall be appointed by DOE as the on-site team leader. That person shall be responsible for the management of the DOE supplied on-site resources, including equipment, for the Pellet Fueling Program. JET shall appoint one member of the JET team in an adequate line management position to be responsible to interface with the DOE team leader on all management questions and to take appropriate action.

3.3 When pellet operations at the JET device commence under this Agreement, JET shall establish a Topic Group for this work; the Topic Group is part of and subordinate to the JET Experimental Committee which advises the JET Director on the overall Experimental Plan for the JET device. Each Participant shall appoint an on-site co-leader for this Topic Group. For representation on the JET Experimental Committee these co-leaders shall serve on a rotating basis for a mutually agreed term. The co-leaders shall be responsible for developing a Joint Experimental Plan and proposing to the JET Director the execution of that Plan at the JET Experimental Committee.

3.4 The Program Coordinators are also responsible for the periodic review of the technical context in which the Pellet Fueling Program is undertaken. If that technical context undergoes significant changes affecting the purpose, direction, priority, and/or scope of the Pellet Fueling Program, then the Program Coordinators have the responsibility to inform the DOE-EURATOM Coordinating Committee and to seek appropriate guidance.

3.5 Scientists, engineers and technicians on assignment from the U.S. to JET under this agreement shall be invited to participate in all internal JET meetings concerned with planning the JET experimental program insofar as these planning meetings are related to the Pellet Fueling Program.

## ARTICLE 4

## Information

4.1 The DOE team can output onto tape data generated in joint DOE-JET pellet and reference shots and can transport these data to the U.S. for analysis. These data, however, remain the property of EURATOM and should be protected accordingly from third party access.

4.2 Papers based on theoretical and experimental investigations written under this Agreement must be approved by both Participants before being sent to a publisher. Such publications shall normally be issued in the form of joint reports by the individuals who contributed to the investigations and will be handled in accordance with Articles 3 and 5 herein. Each Participant shall have equal access to data developed from the joint Pellet Fueling Program. These publications are to be clearly marked with the following caption: "This work has been performed under a collaboration agreement between the JET Joint Undertaking and the U.S. Department of Energy." Other publications that make use of the unpublished results of the Joint Pellet Fueling Program should make reference to this Joint Program in an acknowledgment.

ARTICLE 5

Articles V, VI, VII, VIII, IX, X, XI, XII, XIII, XIV and XVI of the US-EURATOM Fusion Agreement are hereby incorporated by reference.

ARTICLE 6

Termination

6.1 This Agreement shall enter into force upon signature and shall continue in force for an initial period through December 31, 1991 or the end of the JET project, whichever comes first. The Agreement may be amended or extended by written agreement of each of the Participants as long as the DOE-EURATOM Fusion Agreement is in force.

6.2 If necessary, this Agreement may be terminated at any time at the discretion of either Participant upon one year advance notification in writing by the Participant asking to terminate the Agreement. Such termination shall be without prejudice to the rights that may have accrued under this Agreement to either Participant up to the date of the termination.

6.3 In the event that, during the period of this Agreement, the nature of either Participant's magnetic fusion program should change substantially, whether this be by substantial expansion, reduction or transformation, or by amalgamation of major elements with the magnetic fusion program of a third Participant, either Participant shall have the right to request revisions in the scope and terms of this Agreement.

Done in duplicate at Brussels this 5 day of May 1987.

FOR THE UNITED STATES
DEPARTMENT OF ENERGY

John Clarke
(Signature)

JOHN CLARKE
(Printed Name)

ASSOCIATE DIRECTOR
(Title)
OFFICE OF ENERGY RESEARCH
U.S. D.O.E.

FOR THE JOINT EUROPEAN TORUS
JOINT UNDERTAKING

P. H. Rebut
(Signature)

Paul-Henri REBUT
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Director du JET
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