DEPARTMENT OF STATE

Washington, D.C. 20520

BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

MAR 26 1981

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Mr. James R. Shea
Director of International Programs
United States Nuclear Regulatory Commission
Room 6714 - MNBB
Bethesda, Maryland

XSNM01780
JRR-4, Japan

Dear Mr. Shea:

This letter is in response to the letter from your office dated January 23, 1981, requesting Executive Branch views as to whether issuance of an export license in accordance with the application hereinafter described would be inimical to the common defense and security of the United States and whether the proposed export meets the applicable criteria of the Atomic Energy Act of 1954, as amended by the Nuclear Non-Proliferation Act of 1978 (P.L. 95-242):

> **NRC No. XSNM01780** — Application by Nissho-Iwai American Corporation for authorization to export to Japan via France 6.361 kilograms of U-235 contained in 31.884 kilograms of uranium in the form of uranium metal enriched to a maximum of 19.9 percent. This low-enriched uranium is to be used in the fabrication of fuel elements by CERCA in France for the Japan Research Reactor No. 4 (JRR-4) in the Tokai Research Center.

The proposed export to the intermediate consignee in France for fabrication of fuel elements would take place pursuant to the Additional Agreement for Cooperation Between the United States and the European Atomic Energy Community (EURATOM) as confirmed in a letter from the Delegation of the Commission of the European Communities, a copy of which is enclosed. EURATOM has adhered to the provisions of its Agreement for Cooperation with the United States.

The proposed export would take place pursuant to the Agreement for Cooperation Between the United States and Japan as confirmed by a letter from the Embassy of Japan, a copy of which is enclosed. Japan has adhered to the provisions of its Agreement for Cooperation with the United States.

The Executive Branch has reviewed the application and concluded that the requirements of the Atomic Energy Act, as amended by the Nuclear Non-Proliferation Act of 1978, have been met and that the proposed export will not be inimical to the common defense and security of the United States. A detailed analysis for Japan was submitted April 30, 1979 for NRC application No. XSNM01435. There has been no material change in circumstances since that submission. A detailed analysis for EURATOM was submitted December 8, 1978 for NRC application Nos. XSNM01212, -01232, -01238 and -01241. In

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view of Executive Order 12295, extending the duration of the period specified in the first proviso to Section 126a(2) of the Atomic Energy Act of 1954, as amended, to March 10, 1982, that detailed analysis remains valid. There has been no other material change in circumstances since that submission .

On the basis of the foregoing, the Executive Branch recommends that the license be issued.

Sincerely,

Louis V. Nosenzo
Deputy Assistant Secretary

Enclosures:
Assurance letters

EMBASSY OF JAPAN
2520 MASSACHUSETTS AVENUE, N.W.
WASHINGTON, D.C. 20008
(202) 234-2266

March 19, 1981

Colonel Vance H. Hudgins
Assistant Director for
Politico-Military Security Affairs
Division of International Security Affairs
Department of Energy
Washington, D.C. 20545

Dear Colonel Hudgins:

Concerning import of the special nuclear material for the facility noted below, this will confirm that the Government of Japan appointed Japan Atomic Energy Research Institute (JAERI) as an authorized person under the terms and conditions pursuant to Article VI of the Agreement for Cooperation between the Government of the United States of America and ·ernment of Japan concerning Civil Uses of Atomic Energy which entere. into force on July 10, 1968, amended by the Protocol on December 21, 1973.

> Fuel for the JRR-4 reactor of JAERI: 6.361 kgs of U-235 (19.95 % maximum enrichment) contained in 31.884 kgs of uranium

Further, it is confirmed that the transfer of the special nuclear material identified above will take place under all the terms and conditions of the Agreement for Cooperation between our Governments, and that the appointee(s) named above have been authorized to receive and possess the material by both Governments.

Also, the Government of Japan confirms that the safeguards and guarantees of the Agreement for Cooperation will always apply to this special nuclear material, except for that material subsequently retransferred with the written approval of the United States.

Sincerely yours,

M. Miyabayashi

Masayasu Miyabayashi
First Secretary (Scientific)

Ref: This is in reference to the case number of XSNM-1780 stated in your letter dated February 3, 1981.

TO : MS. [illegible]
FC # 852 21

DELEGATION OF THE COMMISSION OF THE EUROPEAN COMMUNITIES

March 25, 1981
JM/aks

Mr. John A. Griffin
Director, Division of Politico-
Military Security Affairs
Office of International Security Affairs
Department of Energy
Washington, D. C. 20585

Dear Mr. Griffin:

Subject: NISSHO-IWAI American Corporation's application MACPJ 2647, dated December 30, 1980 for Japan - XSNM 0 1780

We certify that the material mentioned in this application namely 6.361 kg of U-235 contained in 31.884 kg of uranium, and the transfer of this material will be subject to all terms and conditions of the Additional Agreement for Cooperation, dated July 25, 1960, as amended.

Further, we certify that CERCA, Creteil, France, as intermediate consignee, and Japan Atomic Energy Research Institute, Tokyo, Japan, as ultimate consignee, are authorized by EURATOM to receive and possess this material pursuant to the aforementioned Agreement for Cooperation.

The material will be used for fueling of Japan Research Reactor No.4 (JRR-4) in Tokai Research Establishment.

Sincerely,

J. Marchal

J. Marchal
Secretary
Nuclear Supply

cc: Mr. Robin De LaBarre, Department of State
Ms. Betty Wright, Nuclear Regulatory Commission
Mr. K. Yamana, Nissho-Iwai American Corporation

APPENDIX C

U.S. Department of Energy
ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439
Telephone 312/972- 6758

July 31, 1979

Dr. K. L. Mattern
Division of Nuclear Power Development
U. S. Department of Energy
Washington, D. C. 20545

Dear Dr. Mattern:

Subject: Technical Evaluation - Potential Convertibility of the JMTR, JRR-2, and JRR-4 Reactors (Japan) to Reduced Enrichment Fuel

Upon request of the Executive Branch (Ref. 1), ANL has reviewed the HEU Export License Application (Ref. 2), submitted by Transnuclear, Inc., for the Japan Atomic Energy Research Institute (JAERI), and the supporting documents (Refs. 3 through 8) submitted by JAERI in support of their request for HEU (93.3%) to be used in the JMTR, JRR-2, and JRR-4 reactors. Both ANL and JAERI have independently assessed the potential for conversion of each of these reactors from use of fuels containing HEU to use of fuels with reduced uranium enrichments. A summary of the fuel inventory status (Refs. 4 and 8) for each reactor is provided in Attachment 1. Brief technical descriptions of the current JMTR, JRR-2, and JRR-4 reactors, based on the data of Refs. 4 and 5, are provided in Attachments 2, 3, and 4, respectively.

This JAERI export license application (Ref. 2) requests a total of 39.077 kg of uranium (enriched to a maximum of 93.3% in ^{235}U) in the form of uranium hexafluoride. Conversion of the UF_6 to uranium metal will be performed by NUKEM, GmbH, Hanau, Federal Republic of Germany, and fabrication of the uranium metal into fuel assemblies will be performed by Nuclear Fuel Industries Ltd. (NFI), Tokyo, Japan. The usage breakdown (Ref. 3) by reactor is as follows: 27.569 kg U for JMTR, 10.557 kg U for JRR-2, and 0.951 kg U for JRR-4.

This technical evaluation of JAERI reactors includes discussions of the following topics:

1. Current JAERI Reactors
2. Current JAERI Upgrade Plans
3. JAERI Reduced Enrichment Program
4. Technical Evaluations with Reduced Uranium Enrichments
5. ANL/JAERI Joint Study Program
6. Current and Planned JAERI HEU Inventories
7. Conclusion

1. Current JAERI Reactors

JMTR

The JMTR is a multi-purpose tank type materials testing reactor, currently using 93% enriched uranium-aluminum alloy fuel in modified ETR-type elements, and operated by JAERI since 1968 at a power level of 50 MW. As the only materials testing reactor in Japan, JMTR is important to the Japanese nuclear energy development programs since irradiation experiments are performed for the development of its fast reactor, advanced thermal reactor, high temperature, gas cooled reactor, and fusion reactor programs. The JMTR is also used for safety research on light water power reactor fuels and materials, and for the production of radioisotopes.

JMTRC

The JMTRC is a swimming-pool-type critical facility, operated by JAERI since 1965, that is used for reactor physics measurements of nuclear characteristics for JMTR. The reactor currently uses 93% enriched uranium-aluminum alloy fuel in modified ETR-type elements that are similar, but not identical, to those of JMTR. Since the reactor is operated at a power of 100 watts, almost no fuel is consumed, and no HEU has been requested in this export license application for use in JMTRC.

JRR-2

The JRR-2 is a research reactor using heavy water as moderator and coolant, and has been operated by JAERI at a power level of 10 MW since 1960. It uses both MTR-type and cylindrical-type fuel elements, with 93% enriched uranium in uranium-aluminum alloy fuel. The reactor is utilized for experiments in solid state physics research, material and reactor fuel irradiation, radioisotope production, and neutron activation analysis. These activities have served investigators from universities, research institutes, and industry and have contributed to research and development in many fields.

JRR-3

Although this export license application (Ref. 2) does not include a request for enriched uranium for use in the JRR-3 reactor, the characteristics of this reactor are also discussed since plays an important role in JAERI plans for upgrading its reactor facilities. The JRR-3, constructed in 1962, is a 10 MW thermal, heavy water moderated and cooled, tank-type reactor that was operated using natural uranium metallic fuel from 1962 through 1971. From 1972 to 1975, the fuel was changed from natural uranium metallic fuel to slightly enriched uranium oxide fuels. Current JAERI upgrade plans for the JRR-3 are discussed below. The reactor is presently used for experiments in neutron physics, solid-state physics, material irradiation, and radioisotope production.

JRR-4

The JRR-4 is a 3.5 MW swimming pool reactor using MTR-type 93% enriched uranium-aluminum alloy fuel. The reactor was constructed in 1965 to perform shielding studies for the nuclear powered ship "MUTSU." The power level was raised from 2.5 MW to 3.5 MW in 1976. The reactor is presently used for material irradiation, for miscellaneous experiments, and for training of reactor operators.

2. Current JAERI Upgrade Plans

JMTR

There are no current plans for upgrade of the JMTR.

JMTRC

There are no current plans for upgrade of the JMTRC.

JMTR-I

Preliminary calculational studies (Ref. 9) are being performed by JAERI for a possible new research reactor, JMTR-II, at the Oarai Research Establishment.

JRR-2

There are no current upgrade plans for JRR-2. Since 1962, JRR-2 has undergone many repairs and a major modification, completed in 1975 (Ref. 10). Although JRR-2 has been operated in good condition since 1976, corrosion of the thermal shield light water tank is expected to limit its effective operating lifetime to not longer than 10 years. Consequently, the JRR-2 reactor is currently planned to be shut down about 1986, after successful completion of the upgrade plans for JRR-3.

JRR-3

The major limitation of the JRR-3 as a research tool is the low neutron flux resulting from the use of slightly-enriched, uranium oxide, rodded fuel. The upgrade plans (Ref. 10) for JRR-3 as of May 1978 call for use of 93% enriched, uranium-aluminum alloy, cylindrical-type fuel elements similar to those currently used in JRR-2.

The reactor core configuration of the upgraded JRR-3 will be similar to the JRR-2 core, but the power level will be increased from 10 MW to 20 MW. Replacement of the reactor core tank and major improvements in the control rod system, instrumentation systems, cooling system, and experimental facilities are also planned. The upgraded reactor is planned to begin operation in late 1985 (Ref. 10).

JRR-4

A new reactor is presently planned to replace the current JRR-4. Since this new reactor has not been named as yet, and to avoid misunderstandings, the two reactors are referred to here as the "current JRR-4" and the "new JRR-4."

The current JRR-4 has power of 3.5 MW and is located in the No. 1 Pool. The reactor was designed primarily for reactor shielding studies, but it has also been used for radioisotope production, for other irradiation experiments, and for training of reactor operators. Generally, the requirements for shielding studies and for irradiation experiments are not compatible in this core since the very deep reactor tank and structural restrictions limit convenient access for irradiation rigs.

The new JRR-4 will be an open-type core with a power of 10 MW, and will be used primarily for irradiation experiments. The new reactor is planned to be installed at the regular position in the No. 1 Pool after the current reactor has been transferred to the No. 2 Pool in the same building.

In the No. 2 Pool, the current JRR-4 will be operated at a power of 200 kW with natural convection cooling, and will be used primarily for reactor school student training and shielding experiments. One plan considered by JAERI is to continue its operation with the presently-used HEU (93%) fuel at this reduced power level since the reactor might not need to be refueled during its anticipated lifetime.

The schedule as of May 1978 (reproduced from Ref. 10, p. 171) for upgrade of the JRR-3 reactor and assembly of the new JRR-4 reactor are shown in Attachment 5. Under current U.S. export policy, there is no precedent for supply of HEU (93%) for either the JRR-3 reactor or the new JRR-4 reactor.

3. JAERI Reduced Enrichment Program

JAERI has initiated a five year program (Ref. 7) aimed at enrichment reduction from 93% to 45% in the JAERI reactors JRR-2, new JRR-4, and JMTR, and the critical facility JMTRC. A preliminary draft schedule for this program is shown in Attachment 6. Full-core demonstrations with 45% enriched fuel are planned in each reactor beginning in mid-1983. If the demonstrations are successful, 45% enriched uranium fuel is also planned for use in the upgraded JRR-3, which is expected to begin operation in 1986.

Highly-enriched uranium fuels for the research and test reactors at JAERI are currently manufactured in Japan by Nuclear Fuel Industries Ltd. (NFI). NFI currently has a demonstrated capability of fabricating only uranium-aluminum alloy-type research reactor fuel with a maximum uranium density of about 0.77 g/cm^3 (~24 wt.% U). The currently-qualified maximum uranium density for fuels fabricated with powder metallurgy techniques and HEU (93%) is 1.6 g/cm^3 (~42 wt.% U) in the U.S. and 1.3 g/cm^3 (~37 wt.% U) in Europe.

The JAERI draft reduced enrichment program (as of mid-June 1979) involves engineering feasibility and fabricability studies for powder metallurgy fuels with about 1.6 g U/cm^3 (40-42 wt.% U), burnup experiments in Japanese reactors, reactor core design studies, and safety analysis studies. Initial calculational studies (Ref. 6) have been completed and preliminary fuel specifications, for powder metallurgy fuels using 45% enriched uranium and 1.6 g U/cm^3, have been developed for the JMTR, JMTRC, JRR-2, and new JRR-4 reactors. These specifications (taken from Ref. 7) are included as Attachment 7. Full-core demonstration tests in each reactor, both at low power and at rated power, are expected to begin in late-1983. Successful completion of these demonstrations is the stated goal (Ref. 7) of JAERI's draft five-year program.

The draft program shown in Attachment 6 is likely to be revised by JAERI in early August 1979, after discussions in Japan, to incorporate the results of technical discussions between a JAERI delegation and fuel fabricators and developers in the Federal Republic of Germany, France, and U.S. during June and July 1979, and with RERTR Program personnel at ANL on July 11-12, 1979.

The purpose of the JAERI burnup experiments is to provide domestic (Japanese) data on the irradiation behavior and mechanical strength of fuels with high uranium density (~1.6 g U/cm^3) in order to check the validity of foreign data and to obtain the necessary safety approvals by licensing authorities in Japan.

At least some, and possibly all, of the fuel elements for these irradiation tests are currently planned to be manufactured by European fabricators. The role of NFI as a manufacturer of research reactor fuels with reduced uranium enrichment is under evaluation in Japan. Specific fabricators of fuel elements for the full-core demonstration tests have not been determined as yet.

4. Technical Evaluations with Reduced Uranium Enrichments

Enrichment Reduction to 45%

Based on independent studies that have been completed at ANL (Refs. 11 and 12) and at JAERI (Ref. 6), both ANL and JAERI agree that use of fuel with 45% enriched uranium and 1.6 g U/cm^3 (40-42 wt.% U) instead of the currently-used 93% enriched uranium with about 0.7 g U/cm^3 (~22 wt.% U) is technically feasible in the JAERI reactors (including JMTR, JMTRC, JRR-2, JRR-3, and JRR-4), pending the outcome of burnup experiments to be performed in the ORR reactor at ORNL and in JAERI reactor(s), and, possibly, on critical experiments to be performed in the JMTRC.

Burnup experiments on fuel elements fabricated at CERCA in France, NUKEM in the Federal Republic of Germany, and Texas Instruments in the U.S., and containing fuel meat with a uranium density of about 1.6 g U/cm^3 (and 45% enriched U) are currently expected to be completed at ORNL by late-1981 as part of the U.S. RERTR Program. Similar burnup experiments, referred to in the preceding paragraphs, are also planned in Japanese reactors as part of the JAERI Reduced Enrichment Program.

Enrichment Reduction to <20%

Enrichment reduction to <20% in all current and planned JAERI reactors, with the possible exception of the current JRR-4, requires use of the very high uranium density fuels (U_3O_8-Al, UAl_x-Al, U_3Si-Al, U_3Si, UO_2) that are currently under development in the U.S. and in Europe.

Both ANL and JAERI agree that use of fuel with <20% enriched uranium and 1.6 g U/cm^3 (40-42 wt.% U) is not a practical alternative (Refs. 11, 13) for JMTR without significant penalties in reactor performance and fuel cycle costs. Neutronic studies (Ref. 14) performed by JAERI indicate that use of fuel with <20% enriched uranium and 1.6 g U/cm^3 (40-42 wt.% U) is not a practical alternative for JRR-2 without significant penalties in reactor performance and fuel cycle costs. However, initial neutronics and thermal-hydraulics studies, conducted at ANL, indicate that practical alternatives for utilization of <20% enriched uranium may be feasible with fuels with higher uranium densities. Fuel development efforts at ORNL, NUKEM, and CERCA indicate that UAl_x-Al fuels with approximately 2.3 g U/cm^3 (~52 wt.% U) and U_3O_8-Al fuels with uranium densities of about 2.7-3.0 g U/cm^3 (60-64 wt.% U) have a high probability for successful development. Plans are currently in progress for irradiation tests on these fuels.

The JMTR, JRR-2, and JRR-4 reactors currently use U-Al alloy fuels with uranium densities of about 0.67 g/cm^3 (~21.5 wt.% U), 0.69 g/cm^3 (~22 wt.% U), and 0.53 g/cm^3 (~19 wt.% U), respectively. Based on direct fuel meat substitution, the JMTR, JRR-2, and JRR-4 require uranium densities of about 4.5 g/cm^3, 4.0 g/cm^3, and 3.1 g/cm^3, respectively, in their fuel meat in order to match the initial excess reactivity of the current HEU designs. The currently-qualified maximum uranium density for fuels fabricated with powder metallurgy techniques and HEU (93%) is 1.6 g/cm^3 (~42 wt.% U) in the U.S. and 1.3 g/cm^3 (~37 wt.% U) in Europe. Present long-term goals of the RERTR fuel development program are to increase the uranium density to about 2.9 g/cm^3 (~60 wt.% U), 3.6 g/cm^3 (~70 wt.% U), and 6.3 g/cm^3 (~80 wt.% U) in UAl_x-Al, U_3O_8-Al, and U_3Si-Al fuels, respectively. The development work on UAl_x-Al and U_3O_8-Al fuels are extensions of current fuel fabrication technology, and the probability for successful development and demonstration, within the next several years, of these fuels with uranium densities near those specified above is high. The U_3Si-Al fuel is a completely new research and test reactor fuel. Thus, a longer time is required for successful development, demonstration, and commercialization of this fuel, and the probability of success is lower.

Another approach to enrichment reductions to <20% in the JAERI reactors is to redesign the current fuel elements to include a larger volume fraction of fuel. This can be accomplished by increasing the fuel meat thickness and/or simultaneously decreasing the number of fuel plates per element in those reactors that are currently operating below their thermal-hydraulic limits. Initial calculational burnup studies (Refs. 11 and 12) performed at ANL on the JMTR and JRR-2 reactors indicate that longer fuel cycle lengths can be achieved with reduced enrichment fuels than with HEU (93%) fuel if the uranium density is increased to match the initial excess reactivities.

Lower uranium densities are required if the criterion for conversion to LEU fuel is based on matching the fuel cycle length of the HEU design, rather than matching the initial excess reactivity. The optional fuel meat thickness and number of fuel plates per element will depend upon the maximum uranium density with LEU that has been demonstrated and is available on a commercial basis. Careful examinations of the reactor physics, thermal-hydraulics, and safety margins are required in order to evaluate the feasibility of each potential design. These issues are expected to be addressed in a joint study program between ANL and JAERI.

Licensing procedures in Japan are apparently very stringent if changes are made in the reactor design (e.g., uranium enrichment, fuel content, or fuel element design). Burnup tests in JAERI reactors on fuel elements containing LEU fuel will probably be required in order to check the validity of foreign data and to obtain the necessary safety approvals by licensing authorities in Japan.

5. ANL/JAERI Joint Study Program

Technical discussions between ANL and JAERI personnel at ANL on July 11-12, 1979, resulted in a summary (Ref. 15) describing some considerations for a proposed joint study between the ANL/RERTR and the JAERI/RERTR Programs. After discussions and evaluations in Japan during July 1979, a detailed joint study program between ANL and JAERI on reduced enrichment alternatives for JAERI reactors is expected to be developed during August 1979.

Independent feasibility studies on use of 45% enriched uranium with currently-qualified, but yet undemonstrated, fuel fabrication technology (1.6 g U/cm^3) instead of 93% enriched uranium with conventional uranium density have been completed both at ANL and at JAERI. Both laboratories have concluded that use of 45% enriched fuel is feasible in the JAERI reactors (including JMTR, JMTRC, JRR-2, and JRR-4), pending the outcome of burnup experiments to be performed in the ORR and in Japanese reactor(s), and, possibly, on critical experiments that may be performed in the JMTRC.

The joint program that ANL would like to propose for consideration by JAERI includes:

1. An invitation to JAERI representative(s) to observe the burnup tests on fuel elements containing high uranium density (1.6 g/cm^3) and 45% enrichment to be conducted in the ORR reactor from about April-June 1980 until mid-late 1981 as part of the U.S. RERTR Program. Current plans are for irradiation of: two fuel elements containing UAl_x-Al fuel meat fabricated by NUKEM in the Federal Republic of Germany, two fuel elements containing UAl_x-Al fuel meat fabricated by CERCA in France, and four fuel elements containing U_3O_8-Al fuel meat fabricated by Texas Instruments in the U.S. All data from these burnup tests, including post-irradiation examinations, will be made available to JAERI for evaluation and for possible use in obtaining safety approvals in Japan.

It is also anticipated that the irradiation of four fuel elements, two fabricated by CERCA and two by NUKEM, containing thick (~1.5 mm) UAl_x-Al fuel meat with a uranium density of about 2.3 g/cm^3 (~52 wt.% U) and <20% enrichment will be completed by late-1981.

2. A calculational feasibility study on potential use of <20% enriched fuels in all current and planned JAERI reactors. This study would include evaluation of all practical options for redesign of the fuel elements, using thicker fuel meats, in each reactor with fuel types and uranium densities that are expected to be commercially available in the next several years if the U.S. RERTR Program is successful.

6. Current and Planned JAERI HEU Inventories

Current inventories (Refs. 4 and 8) of HEU (93%) for the JMTR, JRR-2, and JRR-4 reactors are included in Attachment 1. In addition, Attachment 8 (Ref. 8) includes a complete schedule with the quantities of HEU (93%) that are estimated by JAERI as interim supplies for each reactor to assure continuity of its operation until the full-core demonstrations with fuel using 45% enriched uranium are begun about October 1983. Note that the new fiscal year in Japan begins in April.

To our best knowledge, the HEU (93%) inventories and schedules in Attachment 8, developed by JAERI, are based on fuel fabrication yields of about 95%. If NFI's yields are actually lower, the total interim supply of HEU might need to be larger (depending on NFI's fuel fabrication losses) in order to meet these schedules if the reactors are operated with their normal power levels, duty factors, and discharge burnups.

JMTR

The annual requirement of fuel elements necessary to assure continuity of JMTR operation is estimated (Ref. 4) by JAERI to be 100 standard fuel elements (279 g ^{235}U/element) and 25 control fuel elements (195 g ^{235}U/element). The annual ^{235}U requirement to manufacture these elements is 34.5 kg if the fuel fabrication yield is 95%.

Currently, 30.7 kg ^{235}U (33 kg U) are being used to fabricate new fuel elements in Japan for the JMTR. Additionally, 32.6 kg ^{235}U (35 kg U) now in the U.S. is scheduled to be shipped (in 7 shipments of 5 kg U each) to Japan during July-November, 1979. This ^{235}U supply of 63.3 kg is sufficient for about 1.8 years (22 months) of normal JMTR operation (from July 1979 through April 1981). In Attachment 8, note that a 2.3 kg U balance is planned to be transferred from this fuel fabrication campaign to a planned concurrent campaign, thus reducing the utilization time for the 63.3 kg ^{235}U by about one month.

The current JAERI export license application (XSNM-1340) requests a total of 25.72 kg ^{235}U (27.569 kg U) to fabricate additional fuel elements for the JMTR. This ^{235}U is sufficient for about 9 additional months of normal operation. If the 2.3 kg U transferred balance is included here, the JMTR could operate on this fuel from April 1981 through January 1982.

Two further export requests for HEU (93%) as interim supplies for JMTR are planned by JAERI. An export license application (XSNM-1408, Ref. 16) requesting 33.2 kg ^{235}U (35.6 kg U) for JMTR was submitted to the NRC on November 3, 1978. A new export license application for 20.5 kg ^{235}U (22 kg U) for JMTR is planned to be submitted. If these export licenses are approved, the 54 kg ^{235}U (58 kg U) will be sufficient for approximately 19 months of normal JMTR operation from February 1982 until about August 1983. The JMTR full-core demonstration using fuel with higher uranium density ($\sim$1.6 g/cm^3) and 45% enriched uranium is currently planned to begin in about October 1983.

JRR-2

Data provided by JAERI for the JRR-2 reactor in Refs. 4, 5, 8, and 17 are apparently inconsistent. Ref. 4 states that an annual requirement of 48 fuel elements (195 g ^{235}U/element) is necessary to assure continuity of JRR-2 operation. If NFI's fuel fabrication yield for JRR-2 elements is 95%, as it apparently is for JMTR elements, an annual requirement of about 9.9 kg ^{235}U results. This value is consistent with the HEU utilization schedule for JRR-2 shown in Attachment 8 (Ref. 8). However, the "Checklist" attachment (Ref. 17) to Export License Application XSNM-1408 (November 3, 1978) states that the annual ^{235}U consumption rate in JRR-2 is 1.9 kg. The average discharge burnup of JRR-2 fuel elements is 25% (Ref. 5). If fuel fabrication losses of 5% are assumed, the annual ^{235}U requirement is then 8.0 kg.

For purposes of this technical evaluation, an annual ^{235}U requirement of 9.9 kg is assumed for JRR-2, with the understanding that the value may be as small as 8.0 kg ^{235}U. Therefore, our conclusions for JRR-2 may have to be revised if, upon request from the Executive Branch, information is provided by JAERI which is in disagreement with this assumption.

As of June 1979, the JRR-2 had about 5.5 kg ^{235}U contained in 28 unirradiated fuel elements. These fuel elements are sufficient for approximately 7 months of normal JRR-2 operation from July 1979 through January 1980. There are currently 11.2 kg ^{235}U (12 kg U) that are being used in Japan to fabricate new fuel elements for JRR-2. These elements are sufficient for about 13 months of normal operation from February 1980 through February 1981. These inventories of 16.7 kg ^{235}U are consistent with the JRR-2 fuel utilization schedule shown in Attachment 8.

The current JAERI export license application (XSNM-1340) requests a total of 9.82 kg ^{235}U (10.557 kg U) to fabricate additional fuel elements for the JRR-2. This ^{235}U is sufficient for about 12 additional months of normal operation from March 1981 through February 1982.

Two further export requests for HEU (93%) as interim supplies for JRR-2 are planned by JAERI. An export license application (XSNM-1408, Ref. 16) requesting 9.9 kg ^{235}U (10.6 kg U) for JRR-2 was submitted to the NRC on November 3, 1978. A new export license application for 5.6 kg ^{235}U (6 kg U) for JRR-2 is planned to be submitted. If these export licenses are approved, the 15.5 kg ^{235}U (16.6 kg U) will be sufficient for approximately 19 months of further normal JRR-2 operation from March 1982 through mid-September 1983. The JRR-2 full-core demonstration using fuel with higher uranium density ($\sim$1.6 g/cm^3) and 45% enriched uranium is currently planned to begin in about October 1983.

JRR-4

Five fuel elements (166 g ^{235}U/element) per year is stated (Ref. 4) by JAERI as the annual requirement necessary to assure continuity of JRR-4 operation. If NFI's fuel fabrication yield for JRR-4 elements is assumed to be 95%, the annual ^{235}U requirement for JRR-4 is approximately 0.9 kg.

As of June 1979, the JRR-4 had 0.33 kg ^{235}U contained in 2 unirradiated fuel elements. There are currently about 0.93 kg ^{235}U (1 kg U) that are being used to fabricate new fuel elements for JRR-4. These inventories are sufficient for about 18 months of normal JRR-4 operation. Evidently, the fuel which is currently in the reactor plus these fresh fuel inventories are sufficient to operate the JRR-4 from June 1979 through March 1981 (See Attachment 8).

The current JAERI export license application (XSNM-1340) requests a total of 0.88 kg ^{235}U (0.951 kg U) to fabricate additional fuel elements for JRR-4. This ^{235}U is sufficient for about 12 additional months of normal JRR-4 operation from April 1981 through March 1982.

Current JAERI upgrade plans (see Section 2) are to replace the current JRR-4 located in the No. 1 Pool, with a new reactor that is planned to utilize powder metallurgy fuel with a uranium density of about 1.6 g/cm^3 and 45% enrichment. The current JRR-4 is planned to be transferred to the No. 2 Pool and operated at a power of 200 kW with natural convection cooling. These modifications are presently scheduled for April 1982 through March 1983.

One additional request for 0.89 kg ^{235}U for use in the current JRR-4 has been submitted by JAERI to the NRC (XSNM-1408, November 3, 1978, Ref. 16). Presumably (see Attachment 8), this fuel is planned to be utilized in the current JRR-4 after the reactor has been transferred to the No. 2 Pool and its power level reduced from 3.5 MW to 200 kW. One plan considered by JAERI is to continue operation of the current JRR-4 with the presently-used HEU (93%) fuel at a power of 200 kW since the reactor might not need to be refueled during its anticipated lifetime.

7. Conclusion

Based on independent studies that have been completed at ANL and at JAERI, both ANL and JAERI agree that use of fuel with 45% enriched uranium and 1.6 g U/cm^3 instead of the currently-used 93% enriched uranium with about 0.7 g U/cm^3 is technically feasible in JAERI reactors (including JMTR, JMTRC, JRR-2, JRR-3, and JRR-4), pending the outcome of burnup experiments to be performed in the ORR reactor at ORNL and in JAERI reactors, and, possibly, on critical experiments to be performed in the JMTRC.

In order to implement enrichment reductions from 93% to 45% in these reactors, JAERI has initiated a five-year draft program involving engineering feasibility and fabricability studies for powder metallurgy fuels, burnup experiments in Japanese reactors, reactor core design studies, and safety analysis studies. Preliminary specifications for fuels with high-uranium-density and 45% enrichment have been developed for each reactor, and full-core demonstration tests are planned in each reactor. A complete preliminary schedule has been developed by JAERI specifying the quantities of HEU (93%) that are required as interim supplies to assure continuity of operation of each reactor until the full-core demonstration tests with 45% enriched fuels are scheduled to begin in late-1983. It might be re-emphasized that the plans and schedules described in this evaluation are preliminary, and that the program is currently being revised by JAERI.

Tentative plans are currently being considered by JAERI for a joint study program with ANL that includes: (1) observation by JAERI representative(s) of burnup tests to be conducted in the ORR reactor at ORNL from about April-June 1980 until mid-late 1981 as part of the U.S. RERTR program, and (2) calculational feasibility studies on potential use of <20% enriched fuels in all current and planned JAERI reactors.

Since fuel with high-uranium-density and reduced enrichment is not currently available, the Executive Branch might consider supplying the JMTR, JRR-2, and JRR-4 reactors with HEU (93%) for the current and subsequent loadings until suitable fuel with reduced enrichment has been demonstrated and is available on a commercial basis.

Sincerely,

J E Matos

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REFERENCES

1. "Request for Technical Evaluation - JMTR, JRR-2, and JRR-4 Reactors," Letter K. L. Mattern, DOE/NPD to A. Travelli, ANL/RERTR, February 14, 1979.

2. HEU Export License Application submitted by Transnuclear, Inc., Falls Church, Va., for the Japan Atomic Energy Research Institute (JAERI), Tokyo, Japan: XSNM - 1340, June 29, 1978 (39.077 kg U, enriched to a maximum of 93.3% in ^{235}U).

3. "END USE STATEMENT for HEU to be used in the JMTR, JRR-2, and JRR-4 Reactors, and old abbreviated form of HEU Checklist summarizing JMTR Fuel Inventory as of May 1, 1978," Attachments to JAERI Export License Application XSNM - 1340 (June 29, 1978).

4. "Checklists of the JMTR, JRR-2, and JRR-4 Reactors, May 1978." These three documents contain the JAERI detailed responses to U.S. requests for information regarding the Technical and Economic Justification of Need for HEU, as outlined in a telegram dispatched by the U.S. Department of State on or about November 1977, or January 1978.

5. "Research, Training, and Test Reactor Directories for the JMTR, JRR-2, JRR-4 Reactors." Attachments to letter from C. Colhoun and H. Muller, NUKEM, GmbH, Hanau, Federal Reppublic of Germany to A. Travelli, Manager, RERTR Program, Argonne National Laboratory, November 28, 1979. These documents contain detailed technical descriptions of the three reactors, based on a technical questionnaire developed jointly by the Argonne National Laboratory and the University of Michigan for the American Nuclear Society.

6. "The Use of Medium Enriched Uranium Fuel for JAERI Research Reactors," November 1978. Document provided by S. Nomura, Director, Office of Planning, JAERI, to A. Travelli, Manager, RERTR Program, ANL, during visit to ANL by JAERI delegation on December 15, 1978. This document describes calculational work done to date by JAERI on reduced enrichment (20%-45%) alternatives for the JMTR and JRR-2 reactors.

7. "JAERI's Intermediate Enriched Fuel Development Program (Draft)," Attachment to letter from R. Oyamada, Deputy Chief, Project Engineering Section, Division of JMTR Project, Oarai Research Establishment, JAERI to A. Travelli, RERTR Program Manager, Argonne National Laboratory, June 19, 1979.

8. "HEU Fuel Schedule for JAERI Reactors (as of June 1, 1979)," Document provided ANL personnel by JAERI delegation during technical discussions at ANL on July 11-12, 1979.

9. Private communication by R. Oyamada, Deputy Chief, Project Engineering Section, Division of JMTR Project, Oarai Research Establishment, JAERI to RERTR Program personnel at ANL, July 11-12, 1979.

10. Y. Miyasaka et. al., "Research Reactor Upgrade Program in JAERI," IAEA-214, pp. 157-181, 1978 (Proceedings of an Advisory Group Meeting on Research Reactor Renewal and Upgrading Programmes Organized by the IAEA, Vienna, Austria, May 23-26, 1978).

References (contd)

11. ANL Internal Memorandum: "Calculations on the Performance of the JMTR Reactor with Low Enrichment Fuel," G. J. DiIorio, November 7, 1978.

12. ANL Internal Memorandum: "Calculations on the Performances of the JRR-2 10 MW D_2O Reactor for Low Enrichment Fuel," M. M. Bretscher, September 29, 1978.

13. Viewgraphs for presentation by R. Oyamada, Deputy Chief, Project Engineering Section, Division of JMTR Project, Oarai Research Establishment, JAERI, to RERTR Program personnel at ANL, July 11-12, 1979.

14. Viewgraphs from presentation by Y. Miyasaka, Deputy Chief, JRR-2 Operation Section, Division of Research Reactor Operation, Tokai Research Establishment, JAERI, to RERTR Program personnel at ANL, July 11-12, 1979.

15. "Considerations for a Proposed Joint Study Between the ANL/RERTR and JAERI/RERTR Programs," Result of technical discussions between ANL and JAERI personnel at ANL on July 11-12, 1979.

16. HEU Export License Application submitted by the Nissho-Iwai American Corporation, New York, N.Y., for the Japan Atomic Energy Research Institute (JAERI): XSNM-1408, November 3, 1978 (47.162 kg U, enriched to a maximum of 93.3% in ^{235}U), and attached END USE STATEMENT for HEU to be used in the JMTR, JRR-2, and JRR-4 reactors.

17. Old abbreviated form of HEU Checklist summarizing JRR-2 fuel inventory as of September 1, 1978: Attachment to JAERI Export License Application XSNM-1408 (November 3, 1978).

Attachment 1

Fuel Inventories of the JMTR, JRR-2, and JRR-4 Reactors
(as of June 1, 1979)

JMTR	kg ^{235}U	kg U	
New Fuel Currently in Process (outside Japan)	32.6[a]	35.0	(in U.S.)
New Fuel Currently on Hand and in Process of Fabrication (in Japan)	30.7[b]	33.0	
Irradiated Fuel in Core	4.3[c]	4.6	
Irradiated Fuel in Storage	65.8[d]	73.8	
Annual ^{235}U and U Requirements	34.5[e]	37.1	
JRR-2			
New Fuel Currently in Process (in Japan)	11.2[b]	12.0	
New Fuel Currently on Hand	5.5[b]	5.9	
Irradiated Fuel in Core	4.7[f]	5.1	
Irradiated Fuel in Storage	10.3[f]	12.1	
Annual ^{235}U and U Requirements	9.9[g]	10.6	
JRR-4			
New Fuel Currently in Process (in Japan)	0.93[b]	1.0	
New Fuel Currently on Hand	0.33[b]	0.35	
Irradiated Fuel in Core	3.3[h]	3.6	
Irradiated Fuel in Storage	3.7[h]	4.2	
Annual ^{235}U and U Requirements	0.87[i]	0.94	

[a] Seven shipments of 5 kg U/shipment between the U.S. and Japan are currently scheduled for July-November 1979.

[b] Ref. 8 (Attachment 8) - "HEU Fuel Schedule for JAERI's Reactors (as of June 1, 1979)."

[c] Refs. 3 and 4 (JMTR). On May 1, 1978, the JMTR loading was 12 standard fuel elements (279 g ^{235}U/fresh element) and 5 control fuel elements (195 g ^{235}U/fresh element), or a total core loading of about 4.3 kg ^{235}U. Normally, a fresh core would contain about 20 standard elements and 5 control elements, or a total core loading of about 6.6 kg ^{235}U.

[d] Ref. 4 (JMTR): As of May 1, 1978.

(e) Based on annual requirements (Ref. 4) for JMTR of 100 standard fuel elements (279 g ^{235}U/element) and 25 control fuel elements (195 g ^{235}U/element) necessary to assure continuity of operation, and an assumed fuel fabrication yield of 95%.

(f) Ref. 4 (JRR-2): As of May 1, 1978.

(g) Based on an annual requirement (Ref. 4) for JRR-2 of 48 fuel elements (195 g ^{235}U/element) necessary to assure continuity of operation, and an assumed fuel fabrication yield of 95%.

(h) Ref. 4 (JRR-4): As of May 1, 1978.

(i) Based on an annual requirement (Ref. 4) for JRR-4 of 5 fuel elements (166 g ^{235}U/element) necessary to assure continuity of operation, and an assumed fuel fabrication yield of 95%.

Attachment 2

JMTR Reactor Description

Reactor Design Description

Reactor Type	Tank-Type MTR
Purpose	Materials Testing, Isotope Production, Fundamental Research
Steady-State Power Level	50 MW
Duty Factor	0.32
Maximum Thermal Neutron Flux Density	$4 \times 10^{18}\ m^{-2} \cdot s^{-1}$
Maximum Fast (>1 MeV) Neutron Flux Density	$4 \times 10^{18}\ m^{-2} \cdot s^{-1}$
Active Core Volume	102 ℓ
Average Volumetric Power Density	490 kW/ℓ
Average Linear Power Density	1.46 kW/cm
Specific Power	7.58 kW/g ^{235}U
Number of Standard Fuel Assemblies	22
Number of Control Fuel Assemblies	5
Moderator, Coolant	H_2O
Reflectors	Be or Al

Fuel Assembly Design Description

Type	MTR, Flat Plates
Uranium Enrichment	93%
Fuel Meat	U-Al Alloy (21.5 wt% U)
Meat Dimensions	0.51 x 61.6 x 750 mm
Clad	Al, 0.38 mm Thick
^{235}U Density in Fuel Meat	0.62 g/cm^3
Plates/Standard Fuel Assembly	19
Plates/Control Fuel Assembly	16
^{235}U/Standard Fuel Assembly	279 g
^{235}U/Control Fuel Assembly	195 g
Average ^{235}U Discharge Burnup	20%

Attachment 3

JRR-2 Reactor Description

Reactor Design Description

Reactor Type	Tank-Type MTR
Purpose	Solid State Physics, Isotope Production, Materials Testing, Fundamental Research
Steady-State Power Level	10 MW
Duty Factor	0.44
Maximum Thermal Neutron Flux Density	$2 \times 10^{18}\ m^{-2} \cdot s^{-1}$ $2 \times 10^{14}\ cm^{-2}\ s^{-1}$
Maximum Fast (>180 keV) Neutron Flux Density	$7 \times 10^{17}\ m^{-2} \cdot s^{-1}$
Active Core Volume	336 ℓ
Average Volumetric Power Density	30 kW/ℓ
Average Linear Power Density	7.0 kW/cm
Specific Power	2.6 kW/g ^{235}U
Number of Standard Fuel Assemblies	24
Number of Control Fuel Assemblies	None
Moderator, Coolant	D_2O
Reflector	D_2O

Fuel Assembly Design Description

Type	MTR, Curved Plates	Cylindrical
Uranium Enrichment	93%	93%
Fuel Meat	U-Al Alloy (23 wt% U)	U-Al Alloy (22 wt% U)
Meat Dimensions	0.51 x 63.5 x 600 mm	0.51 mm (T) x 600 mm Variable Widths
Plates/Standard Fuel Assembly	15 (Inner Plates) 2 (Outer Plates)	5 Concentric Cylinders
Clad	Al, 0.38 mm (Inner Plates) Al, 0.51 mm (Outer Plates)	Al, 0.38 mm Thick
^{235}U Density in Fuel Meat	0.64 g/cc (Inner Plates) 0.21 g/cc (Outer Plates	0.64 g/cc
^{235}U/Standard Fuel Assembly	195 g	195 g
Average ^{235}U Discharge Burnup	25%	25%

Attachment 4

Current JRR-4 Reactor Desc.iption

Reactor Design Description

Reactor Type	MTR, Swimming Pool Type
Purpose	Shielding Studies, Isotope Production, Training
Steady-State Power Level	3.5 MW
Duty Factor	0.10
Maximum Thermal Neutron Flux Density	$3.5 \times 10^{17}\ m^{-2} \cdot s^{-1}$
Maximum Fast (>180 keV) Neutron Flux Density	$8.7 \times 10^{17}\ m^{-2} \cdot s^{-1}$
Active Core Volume	77 ℓ
Average Volumetric Power Density	46 kW/ℓ
Average Linear Power Density	0.2 kW/cm
Specific Power	1.05 kW/g ^{235}U
Number of Standard Fuel Assemblies	20
Number of Control Fuel Assemblies	None
Moderator, Coolant	H_2O
Reflector	Graphite

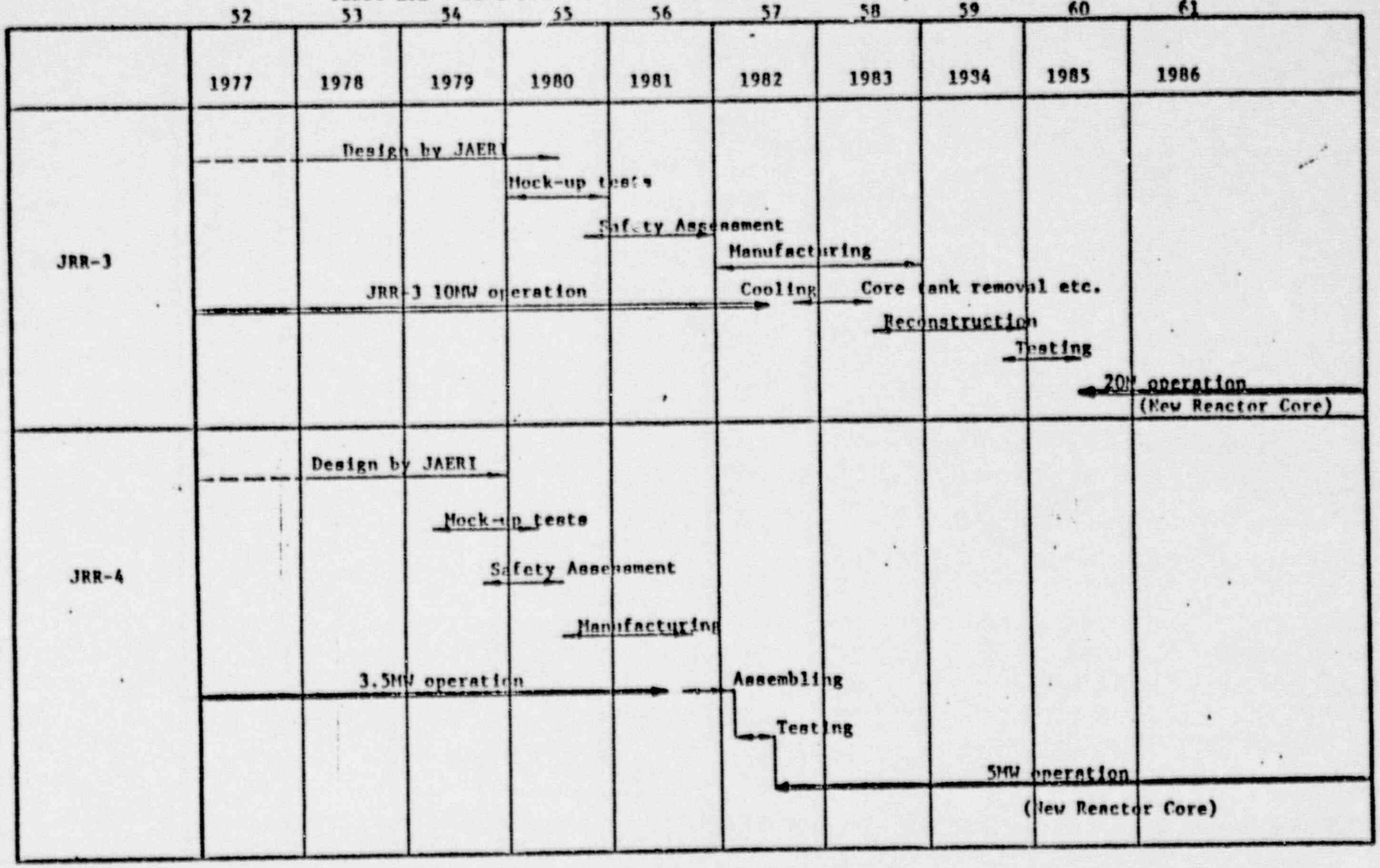
Fuel Assembly Design Description

Type	MTR, Flat Plates
Uranium Enrichment	93%
Fuel Meat	U-Al Alloy (19 wt% U)
Meat Dimensions	0.51 x 6.8 x 600 mm
Clad	Al, 0.38 mm Thick
^{235}U Density in Fuel Meat	0.532 g/cm^3
Plates/Standard Fuel Assembly	15
^{235}U/Standard Fuel Assembly	166 g
Average ^{235}U Discharge Burnup	14%

Attachment 5

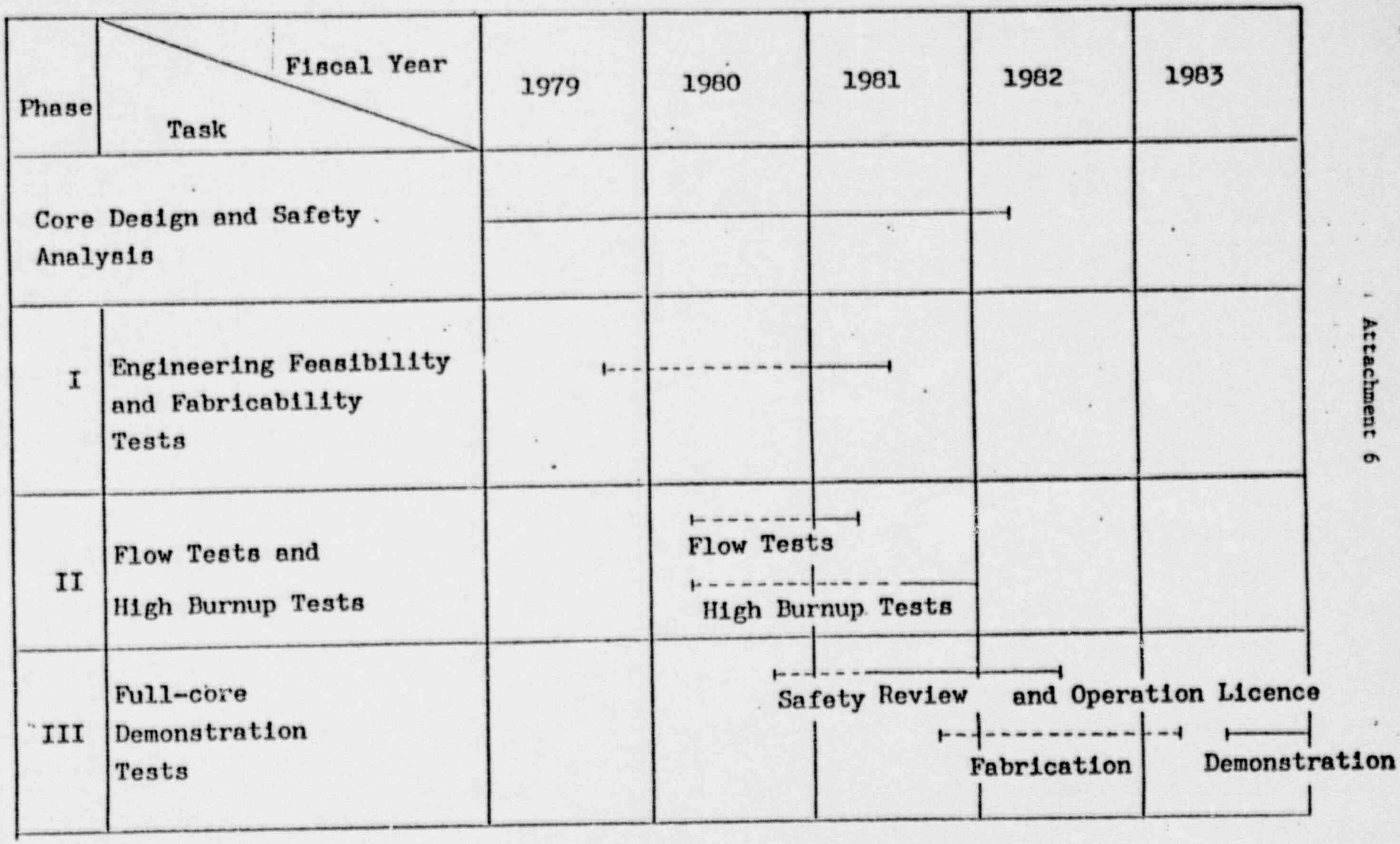
(Reproduced from Ref. 10, May 1978)

Table 1.1 Time Schedule of JRR-3 and JRR-4 Grade-up Plan



(Reproduced from Ref. 7)

Fig. 1 Schedule of JAERI's Intermediate-Enriched Fuel Development Program



Budgetary arrangement is to be required for each year later than FY 1980.

Attachment 6

Attachment 7

(Reproduced from Ref. 7)

Table 4 Modified Fuel Specifications

Reactor	JMTR, JMTRC		JRR-2		JRR-4
	Standard	Follower			
Fuel type	ETR	ETR	MTR	Cylindrical	ETR
Enrichment (wt.%)	45	45	45	45	45
^{235}U/element (gr)	320	210	220	220	285
Plates/element	19	16	17	3 × 5	19
Meat dimension (mm)	0.51×61.6 ×750	0.51×49.7 ×750	0.51×58.5 ×600	0.51 × 600	0.51×6[illegible] ×600
Cladding thickness(mm)	0.38	0.38	0.38	0.38	0.38
Plate thickness(mm)	1.27	1.27	1.27	1.27	1.27
Water gap (mm)	12×2.67 2×2.92 4×3.02	2.59	3.0	3.0	3.0
Uranium loading density in fuel meat (wt.%)	40	40	40	40	40
Dimension of element (mm)	76.2×76.2 ×1200	63.6×63.6 ×890	76.2×76.2 ×950	103^{Φ}×950	80×80 ×1000

Attachment 8

(Provided by JAERI delegation to ANL personnel, July 11-12, 1979; Ref. 8)

HEU FUEL SCHEDULE FOR JAERI'S REACTOR (AS of June 1, 1978)