OFFICE OF THE
COMMISSIONER

March 2, 1984

The Honorable Tom Bevill, Chairman
Subcommittee on Energy and Water Development
Committee on Appropriations
United States House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

I am writing in a personal capacity to bring to your attention the Nuclear Regulatory Commission's efforts to restrict the use of highly-enriched uranium fuel in university research reactors and the need for funds to help the effort succeed. There are 25 university reactors in 18 states which use highly-enriched uranium.

The difficulty is that highly-enriched uranium is a nuclear explosive. Although some protective measures have been prescribed by the NRC to protect this material, there are limits to the protection available on a campus. The most effective protection would be to use low-enriched uranium fuel, which is not an explosive.

The NRC has directed its staff to prepare a rule that would require universities to convert to a lower enriched fuel if it is technically feasible. The Department of Energy, which provides the fuel for university research reactors, is sponsoring a program for developing lower enriched fuel, and conversion is feasible for almost all reactors today. However, no funds have been provided for covering the cost to the universities of converting their reactors.

These costs include the engineering calculations and measurements needed before conversion, as well as a testing program after conversion. I think these can reasonably be considered as research activities falling within NRC's charter. The results would be useful in provding information for our efforts to gain support for similar conversions abroad. The total non-fuel costs for those universities subject to our proposed rule is estimated at $6 million over a several year period. These costs are a major obstacle to conversion of university reactors, and in many cases cannot be met by the universities themselves.

Therefore, I propose that $1.5 million be set aside next year from our research budget as the initial allocation for funding those university programs which are essential to the successful conversion of research reactors away from fuels that use explosive forms of uranium. It would be an exceptionally good investment in domestic and international security.

Sincerely,

Victor Gilinsky
Commissioner

Attachment:
List of University Reactors

cc: Rep. John Myers

1.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
COMMISSIONER

March 2, 1984

cc Senator J. Bennett Johnston

The Honorable Mark Hatfield, Chairman
Subcommittee on Energy and Water Development
Committee on Appropriations
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

I am writing in a personal capacity to bring to your attention the Nuclear Regulatory Commission's efforts to restrict the use of highly-enriched uranium fuel in university research reactors and the need for funds to help the effort succeed. There are 25 university reactors in 18 states which use highly-enriched uranium.

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UNIVERSITY [illegible]

| | | Type of Reactor | Power Level | Authorized Amount $U_{235}$ (kg.) | Estimated Available Date for LEU Fuel | License Exp. |
|---|---|---|---|---|---|---|
| 1. | Oregon State University | TRIGA | 1 MW | 16.3 | 1985 | 2006 |
| 2. | Washington State University | TRIGA | 1 MW | 19.9 | 1985 | 2002 |
| 3. | Texas A. & M. University | TRIGA | 1 MW | 17.2 | 1985 | 2003 |
| 4. | University of Wisconsin | TRIGA | 1 MW | 13.65 | 1985 | 2000 |
| 5. | Virginia Polytechnic Institute | Argonaut | 100 kW | 8 | 1985 | Under review |
| 6. | University of California (L.A.) | Argonaut | 100 kW | 5 | 1984 | Exp. 1980 hearings |
| 7. | University of Michigan | MTR | 2 MW | 16.11 | Being converted | 1985 |
| 8. | University of Lowell | MTR | 1 MW | 4.8 | Now | 1985 |
| 9. | University of California (S.B.) | Homo-geneous | 10 W | 1.35 | Now | 1994 |
| 10. | University of Missouri (Rolla) | MTR | 200 kW | 4.3 | 1986 | Pending to 2003 |
| 11. | Ohio State University | MTR | 10 kW | 4.6 | Now | |
| 12. | Renssalaer Polytechnic Institute | Critical facility | 100 W | 4.99 | May require redesign | 2003 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. | Iowa State University | Argonaut | 10 kW | 4.6 | 1985 | Pending to 2003 |
| 14. | University of Washington | Argonaut | 100 kW | 7.5 | 1984 | 1989 |
| 15. | University of Florida | Argonaut | 100 kW | 4.82 | 1984 | 2002 |
| 16. | Worcester Polytechnic University | MTR | 10 kW | 4 | Now | 2002 |
| 17. | University of Virginia (UVAR) | MTR | 2 MW | 17.6 | 1986 | 2002 |
| 18. | Purdue University | MTR | 1 kW | 3 | Now | 1986 |
| 19. | Georgia Institute of Technology | MTR | 5 MW | 13.5 | 1986 | 1994 |
| 20. | Manhattan College | Critical facility | .1 W | 3.2 | May require redesign | Renewal to 2003 |
| 21. | University of Kansas | MTR | 1 kW | 4 | 1989 | Renewal to 2003 |
| 22. | University of Missouri (Columbia) | ATR | 10 MW | 45 | Technology not yet available | 2001 |
| 23. | M.I.T. | MTR | 5 MW | 29 | Technology not yet available | 1996 |
| 24. | University of Virginia (Cavalier) | Cavalier | 100 W | 17.6 | 1986 | ? |
| 25. | Rhode Island | - | 2 MW | 10.4 | Now | |

* Material taken from LEU Study Group Report of November 15, 1983

Briefing material for Lloyd hearing

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Table 1.1

University Research and Training Reactors with HEU Fuel

| | University/Laboratory | Location | Reactor Acronym | NRC Docket | License Exp. Date |
|---|---|---|---|---|---|
| | **Plate Type Fuel, 93% Enriched Uranium** | | | | |
| | **High Power** | | | | |
| 1. | University of Missouri-Columbia | Columbia, MO | MURR | 50-186 | 2001 |
| 2. | Massachusetts Inst. of Technology | Cambridge, MA | MITR | 50-20 | 1996 |
| 3. | Georgia Inst. of Technology | Atlanta, GA | GTRR | 50-276 | 1994 |
| | **Medium Power** | | | | |
| 4. | Rhode Island Nuclear Science Center | Narragansett, RI | RINSC | 50-193 | 2002 |
| 5. | University of Michigan | Ann Arbor, MI | FNR | 50-2 | 1985 |
| 6. | University of Virginia-UVAR | Charlottesville, VA | UVAR | 50-62 | 2002 |
| 7. | University of Lowell | Lowell, MA | ULR | 50-223 | 1985 |
| | **Low Power** | | | | |
| 8. | University of Missouri-Rolla | Rolla, MO | UMRR | 50-123 | 2004* |
| 9. | Ohio State University | Columbus, OH | OSURR | 50-150 | 2000 |
| 10. | University of Kansas | Lawrence, KA | BRTR | 50-148 | 2004* |
| 11. | Worcester Polytechnic Institute | Worcester, MA | WPI | 50-134 | 2002 |
| 12. | Purdue University | West Lafayette, IN | PUR-1 | 50-182 | 1986 |
| 13. | Rensselaer Polytechnic Institute | Troy, NY | RPI | 50-225 | 2003* |
| 14. | University of Virginia-Cavalier | Charlottesville, VA | Cavalier | 50-396 | 2002 |
| 15. | Manhattan College | Riverdale, NY | MCZPR | 50-199 | 1984 |
| | **TRIGA, UZrH Rod Fuel 70% Enriched Uranium** | | | | |
| 16. | Oregon State University | Corvallis, OR | OSTR | 50-243 | 2002 |
| 17. | Texas A&M University | College Station, TX | NSCR | 50-59 | 2002 |
| 18. | University of Wisconsin | Madison, WI | UWNR | 50-156 | 2000 |
| 19. | Washington State University | Pullman, WA | WSUR | 50-27 | 2002 |
| | **ARGONAUT, Plate Fuel 93% Enriched Uranium** | | | | |
| 20. | University of California-Los Angeles | Los Angeles, CA | UCLA-R1 | 50-142 | 1980** |
| 21. | University of Florida | Gainesville, FL | UFTR | 50-83 | 2002 |
| 22. | University of Washington | Seattle, WA | UWNR | 50-139 | 1989 |
| 23. | Virginia Polytechnic Institute and State University | Blacksburg, VA | VTAR | 50-124 | 2002 |
| 24. | Iowa State University | Ames, IA | UTR-10 | 50-116 | 2003* |
| | **Atomics International L-77, Aqueous Homogeneous, 90% Enriched Uranium** | | | | |
| 25. | University of California-Santa Barbara | Santa Barbara, CA | UCSB | 50-433 | 1994*** |

*License renewal pending. Projected expiration date assuming license is renewed in 1983 or 1984.
**In hearing. License renewal date is not specified.
***Fuel possession only license.

## 2.4 University Reactor Characteristics Related to Feasibility

There is a great range in the characteristics of university research reactors presently using HEU fuels. Certain features of the 25 NRC-licensed university reactors are given in Table 2.1. It is seen that power levels range from 0.1 watts to 10,000,000 watts, that uranium densities in the core "meat" of fuel plates vary from 0.25 g U/cc to 1.6 g U/cc, and that there are several types of materials used for fuel and for control purposes.

There are technical limitations on converting from HEU to LEU if the latter is to be accommodated in the fuel plates or rods without any change in fuel plate geometry. If there is no change in fuel plate outer dimensions, the operating and transient thermal-hydraulic characteristics are changed little, if at all, and so no major modifications should be required, other than in the fuel. It would be necessary to revise the Safety Analysis Report, showing that control worths are adequate, etc., but the revisions would be minor (See Section 4). In order to convert from HEU to LEU fuel and maintain the same fuel plate outer dimensions, the uranium density can be increased in the fuel meat.

An alternative to increasing uranium density is to change fuel plate geometry, for example to increase fuel meat thickness. This could result in significant changes in core fluid flow and heat transfer characteristics if the plates must also be made thicker. Alternatives that produce core thermal-hydraulic modification are undesirable because they increase the scope of the facility's license change from a minor amendment to a major revision and because of potential expenses associated with engineering modifications to the facility.

Uranium density limits on current fuel meat technology that have been proven and operationally tested in research reactor fuels are given in Table 2.2.

Test programs sponsored by the Department of Energy through Argonne National Laboratory are designed to demonstrate by the dates indicated that uranium densities can be increased to the values also listed in Table 2.2 for the various types of fuels. The values are taken from information provided by the RERTR Program.

Table 2.1

Reactor Parameters

| Reactor | Power (MW) | No. of Elements Norm/Max | Element U-235 (grams) | No. of Plates | Plate Thick. (mils) | Clad/Core /clad (mils) | Control Poison |
|---|---|---|---|---|---|---|---|
| **Plate-Type Fuel - 93% Enriched** | | | | | | | |
| **High Power** | | | | | | | |
| 1. Missouri-Columbia | 10 | 8/8 | 780 | 24 | 50 | 15/20/15 | Boral |
| 2. MIT | 5 | 24/27 | 510 | 15 | 70 av. | 20/30/20 av | B-SS |
| 3. Georgia Tech | 5 | 17/19 | 190 | 16 | 50 | 15/20/15 | Cd |
| **Medium Power** | | | | | | | |
| 4. Rhode Island | 2 | 30/35 | 120 | 18 | 60 | 24/12/24 | Boral |
| 5. Michigan | 2 | 35/45 | 167 | 18 | 50 | 15/20/15 | B-SS |
| 6. Virginia-UVAR | 2 | 20/64 | 190 | 18 | 50 | 15/20/15 | B-SS |
| 7. Lowell | 1 | 26/30 | 140 | 18 | 60 | 24/12/24 | Boral |
| **Low Power** | | | | | | | |
| 8. Missouri-Rolla | 0.2 | 27/51 | 170 | 10 | 60 | 20/20/20 | B-SS |
| 9. Ohio State | 0.01 | 24/30 | 140 | 10 | 108 | 36/36/36 | B-SS |
| 10. Kansas | 0.01 | 16/20 | 170 | 10 | 60 | 20/20/20 | Boral |
| 11. WPI | 0.01 | 25/51 | 140 | 10 | 99 | 30/40/30 | Boral |
| 12. Purdue | 0.001 | - | 170 | 10 | 100 | 20/60/20 | - |
| 13. RPI | 0.0001 | 25/49 | - | - | 30 | 5/20/5 | - |
| 14. Va.-Cavalier | 0.0001 | 0 | 165 | 12 | 50 | 15/20/15 | - |
| 15. Manhattan | $10^{-7}$ | 18/31 | - | - | - | 15/--/15 | Cd, SS |
| **TRIGA $UZ_rH$ Fuel 70% w/o Enriched** | | | | | | | |
| 16. Oregon State | 1 | 89/126 | 126 | n.a. | 1.47 D | 1.43/.020 | B-graphite |
| 17. Texas A&M | 1 | 90/202 | 122 | n.a. | 1.41 D | 1.37/.020 | B-graphite |
| 18. Wisconsin | 1 | 91/236 | 122 | n.a. | 1.41 D | 1.37/.020 | Boral |
| 19. Wash. State | 1 | 110/196 | 122 | n.a. | 1.41 D | 1.37/.020 | Boral |
| **Argonaut $H_2O$ & Graphite 93 w/o enriched** | | | | | | | |
| 20. U. Cal. - LA | 0.1 | 24/24 | 140 | 11 | 70 | 15/40/15 | Cd |
| 21. Florida | 0.1 | 24/24 | 140 | 11 | 70 | 15/40/15 | Cd |
| 22. U. Washington | 0.1 | 24/24 | 143 | 11 | 70 | 15/40/15 | Cd |
| 23. VPI | 0.1 | 12/12 | 266 | 12 | 80 | 20/40/20 | Boral |
| 24. Iowa State | 0.1 | 12/12 | 266 | 12 | 80 | 20/40/20 | Boral |
| **Aqueous Homogeneous** | | | | | | | |
| 25. U. Cal. - SB | $10^{-5}$ | Aqueous solution, 1.3 ft. diameter sphere | | | | | Cd |

Table 2.2 Current and Planned Fuel Technology

| Fuel Meat | Clad | Uranium Density in Fuel Meat (g/cc) | | Planned Qualification Dates |
|---|---|---|---|---|
| | | Current | Planned | |
| $UAl_x$-Al | Al | 1.60 | 2.3 | January 1984 |
| $U_3O_8$-Al | Al | 1.30 | 3.2 | June 1985 |
| $UZrH_x$ | Stainless Steel | 0.35 | 3.7 | January 1985 |
| $U_3Si_2$-Al | Al | | 4.8 | January 1986 |
| $U_3Si$-Al | AL | | 7.0 | June 1989 |

The increase in uranium density necessitated by conversion from 93% HEU to LEU fuel can be fairly accurately calculated as follows:

$$\text{Uranium Density}\Big|_{LEU} = \text{Uranium Density}\Big|_{HEU} \text{ (g/cc)}$$

$$\times\ 0.93 \text{ (g U235/g U in HEU)}$$

$$\times\ 5 \text{ (g U/g U235 in LEU)}$$

$$\times\ 1.15$$

$$= 5.35\ \text{Uranium Density}\Big|_{HEU} \qquad (2.1)$$

The factor, 1.15, accounts for extra uranium 235 necessary in LEU fuel to overcome increased uranium 238 resonance absorption and produces approximately the same end-of-cycle core reactivity as existed with HEU fuel.

For TRIGA reactors with 70% rather than 93% enriched fuel, the uranium density is approximately:

$$\text{Uranium Density}\Big|_{LEU} = 4.03\ \text{Uranium Density}\Big|_{HEU}. \qquad (2.2)$$

Using equations (2.1) and (2.2), LEU uranium densities have been calculated for the 25 universities being considered. The values are listed in Table 2.3 along with the fuel type proposed for use by each reactor assuming direct LEU substitution for HEU with no plate or element dimension changes.

## 2.5 Reactors for which LEU Conversion is Technically Feasible

It is instructive to consider reactors using the extremes in uranium loading (refer to Table 2.3). Purdue at 0.25 g U/cc, WPI at 0.35 g U/cc, Ohio State at 0.41 gU/cc, and Michigan at 0.33 g U/cc have the lowest HEU loadings. The last reactor has been converted to LEU fuel with no technical problems, because it was possible to utilize a current state-of-the-art fuel technology, $UAl_x$ with a density of 1.6 g U/cc, plus a thicker plate to accommodate the necessary extra uranium (0.060 in., a thickness previously used for Michigan fuel and, hence, easily licensed).

Table 2.3 Estimate of Core Changes Required to Use LEU

| Reactor | Power (MW) | Present Density (g U/cc) | If No Dimensional Changes: Required Density (g U/cc) | Fuel Tech Req'd | Date Qualified | If Present Fuel Technology[1,2,3] Must Change Parameter, From/To: Fuel Meat (mils) | Plate (mils) | No of Plates | No of Elmnts |
|---|---|---|---|---|---|---|---|---|---|
| **Plate-Type Fuel - 93% Enriched** | | | | | | | | | |
| **High Power** | | | | | | | | | |
| 1. Missouri-Columbia | 10 | 1.6 | 8.6 | - | 1989+ | | Not Feasible | | |
| 2. MIT | 5 | 1.6 | 8.6 | - | 1989+ | | Not Feasible | | |
| 3. Georgia Tech | 5 | 0.66 | 3.5 | $U_3Si_2$ | 1986 | 20/39[4] | 50/69 | n.c. | 17/19 |
| **Medium Power** | | | | | | | | | |
| 4. Rhode Island | 2 | 0.72 | 3.9 | $U_3Si_2$ | 1986 | 12/30 | n.c. | n.c. | n.c. |
| 5. Michigan | 2 | 0.33 | 1.8 | $UAl_x$ | 1984 | 20/30 | 50/60 | n.c. | n.c. |
| 6. Virginia-UVAR | 2 | 0.61 | 3.3 | $U_3Si_2$ | 1986 | 20/30 | 50/60 | n.c. | 20/28 |
| 7. Lowell | 1 | 0.78 | 4.2 | $U_3Si_2$ | 1986 | 12/30 | n.c. | n.c. | 26/27 |
| **Low Power** | | | | | | | | | |
| 8. Missouri-Rolla | 0.2 | 0.94 | 5.0 | $U_3Si_2$ | 1986 | 20/33[4] | n.c. | n.c. | 27/51 |
| 9. Ohio State | 0.01 | 0.41 | 2.2 | $U\ Al_x$ | 1984 | 35/50 | n.c. | n.c. | n.c. |
| 10. Kansas | 0.01 | 1.03 | 5.5 | $U_3Si$ | 1989 | 20/30 | n.c. | 10/18 | 16/20 |
| 11. WPI | 0.01 | 0.35 | 1.9 | $U\ Al_x$ | 1984 | 40/47 | n.c. | n.c. | n.c. |
| 12. Purdue | 0.001 | 0.25 | 1.3 | $U\ Al_x$ | now | n.c. | n.c. | n.c. | n.c. |
| 13. RPI | 0.0001 | | Redesign | | | | | | |
| 14. Va.-Cavalier | 0.0001 | 0.61 | 3.3 | $U_3Si_2$ | 1986 | 20/30 | 50/60 | n.c. | - |
| 15. Manhattan | $10^{-7}$ | - | - | - | - | - | - | - | - |
| **TRIGA UZrH Fuel - 70% w/o Enriched** | | | | | | | | | |
| 16. Oregon State | 1 | 0.47 | 1.9 | UZrH | 1985 | No changes, but short core life | | | |
| 17. Texas A&M | 1 | 0.49 | 2.0 | UZrH | 1985 | No changes, but short core life | | | |
| 18. Wisconsin | 1 | 0.46 | 1.9 | UZrH | 1985 | No changes, but short core life | | | |
| 19. Wash. State | 1 | 0.50 | 2.0 | UZrH | 1985 | No changes, but short core life | | | |

?

Table 2.3 Estimate of Core Changes Required to Use LEU (Continued)

| Reactor | Power (MW) | Present Density (g U/cc) | If No Dimensional Changes: Required Density (g U/cc) | Fuel Tech Req'd | Date Qualified | If Present Fuel Technology[1,2,3] Must Change Parameter, From/To: Fuel Meat (mils) | Plate (mils) | No of Plates | No of Elmnts |
|---|---|---|---|---|---|---|---|---|---|
| **Plate-Type Fuel - 93% Enriched** | | | | | | | | | |
| **Argonant - $H_2O$ & Graphite - 93 w/o Enriched** | | | | | | | | | |
| 20. U. Cal. - LA | 0.1 | 0.44 | 2.4 | $UAl_x$ | 1984 | 40/60 | 70/90 | | |
| 21. Florida | 0.1 | 0.38 | 2.0 | $UAl_x$ | 1984 | 40/51 | 70/81 | n.c. | n.c. |
| 22. U. Washington | 0.1 | 0.45 | 2.4 | $UAl_x$ | 1984 | 40/60 | 70/90 | n.c. | n.c. |
| 23. VPI | 0.1 | 0.58 | 3.1 | $U_3O_8$ | 1985 | 40/70 | 80/100 | n.c. | n.c. |
| 24. Iowa State | 0.01 | 0.58 | 3.1 | $U_3O_8$ | 1985 | 40/70 | 80/100 | 12/14 | n.c.* |
| | | | | | | | | 12/14 | n.c.* |
| **Aqueous Homogenous** | | | | | | | | | |
| 25. U. Cal. - SB | $10^{-5}$ | 0.044 | 0.24 | Now Higher Concentration | | - | - | - | - |

Notes:

(1) Present technology means 1.6 g U/cc for $UAl_x$; 0.35 for UZrH.

(2) Increasing plate thickness or number of plates may cause significant change in hydraulics.

(3) Increasing number of elements means larger core, hence lower fluxes, which may fail to meet criterion of no penalty in performance.

(4) Plates with cores thicker than 30 mils may not be considered qualified for use in these reactors.

* n.c. means no change

It appears that Purdue's 0.25 g U/cc for HEU could be converted to about 1.34 g U/cc for LEU without any geometry change. WPI's 0.35 g U/cc for HEU would require 1.87 g U/cc for LEU (expected to be demonstrated by 1984) or the existing 1.6 g U/cc if the clad-meat-clad in mils dimensions are changed from 30/40/30 to 26.5/47/26.5. Ohio State's 0.41 gU/cc for HEU would require 2.2 gU/cc for LEU or the existing 1.6 gU/cc if the clad-meat-clad dimensions are changed from 36/36/36 to 29/50/29. Presumably there will be no licensing problems for 1 KW and 10 KW reactors changing to LEU in 0.100 in. thick plates having fuel meat cores of these projected thicknesses.

The University of California-Santa Barbara has a uranyl sulfate solution reactor. The potential for increasing density in this aqueous homogeneous core is presumed to be possible since a similar reactor at Brigham Young University is now operating with 20% enriched uranium.

## 2.6 Reactors for which LEU Conversions Is Not Technically Feasible

At the other extreme are Missouri-Columbia and MIT. Both of these reactors have been designed to operate with HEU at a density of 1.6 g U/cc, the highest loading that has been demonstrated for plate-type fuel to date, although it is expected that somewhat higher loadings will be proven by the RERTR Program within the next year or so. Information furnished by the program, indicates that densities of 2.3 g U/cc should be qualified in FY 1984 ($UAl_x$), and 3.2 g U/cc in FY 1985 ($U_3O_8$). The highest loading that RERTR currently is planning to investigate is 7.0 g U/cc, using the new, still unproven $U_3Si$ technology, the qualification date for which RERTR estimates to be about 1989. This loading is still less than the 8.6 g U/cc density that it is estimated will be necessary for Missouri-Columbia and MIT if these reactors are to convert to LEU with no change in the fuel geometry.

The Missouri and MIT core designs provide practically no flexibility for changing the core geometry, e.g. increasing the core size, to accommodate more uranium. Both cores are contained in structures that cannot be expanded without major modifications, a requirement that IAEA did not contemplate as being technically feasible. The fuel meat in the MIT design is already 0.030 in. thick, and the fuel plate surfaces are finned to increase the heat transfer by a factor of almost two. Missouri already uses a high primary coolant velocity, 23 ft/sec, so that thicker plates and narrower channels would quickly lead to excessive pressure drops across the core. Only minimal increases in element loadings could be achieved by geometry changes in the fuel itself, and even for these increases detailed thermal-hydraulic studies would be required to determine what higher loadings, if any, are possible.

## 2.7 Reactors for Which LEU Conversion May Be Technically Feasible After Further Study

In between the above extremes are 18 reactors with varying characteristics. The Rhode Island (2 MW) and Lowell (1 MW) reactors have characteristics that may minimize the impact of conversion relative to other reactors. Specifically, the clad-core-clad dimensions are 24-12-24 mils, respectively, suggesting that a 1.6 g U/cc density in a 15-30-15 mil plate might permit LEU fuel to be fabricated with current technology and no overall plate or element dimensional changes. In these, as in other reactors, it will

be necessary to demonstrate that safety is not compromised, (e.g. control blade worths are adequate, power excursions will be limited prior to core damage, etc).

The University of Virginia-UVAR Reactor (2 MW) uses 20 mil meat in its fuel, and hence cannot gain as much by going to 30 mils. It appears that a larger core (more elements) is possible; one-third larger would appear to be required, but this would decrease the flux in inverse proportion, in addition to the decrease that would result directly from the LEU conversion. This does not meet the criterion of no penalty in performance, and so it would be necessary to await the development of $U_3Si_2$ fuel, estimated by RERTR for FY 1986, or to investigate the effects on other parameters of approximately doubling the core fuel meat thickness. In all of these cases it is understood that the estimates are only approximate and that detailed analyses are necessary to predict the expected change.

Georgia Institute of Technology, the only other reactor in the megawatt range, appears to be more restricted in that the core size can be only slightly increased, from 17 to 19 elements.

At the University of Missouri-Rolla (0.2 MW), the situation is similar to that at Virginia, with the added option of increasing the number of plates above 10 per element.

All of the last three reactors above probably can convert to LEU without any geometry change when the $U_3Si_2$ fuel is demonstrated at 4.8 g U/cc, estimated by the RERTR program for FY 1986.

There are seven reactors in the "Low Power" category, with power levels up to 10 KW. These are among the facilities with life-time cores. There is only limited information available in Reference 4, but it appears technically feasible for Purdue, Ohio State, and WPI to convert, as mentioned earlier. On the other hand, the University of Kansas reactor uses HEU at 1.03 g U/cc and will have to await the demonstration of $U_3Si$ (about FY 1989) unless the core meat thickness, the number of plates and the number of elements are all increased.

The class of reactors known as ARGONAUTS, four reactors at 100 KW and one at 10 KW, have relatively low density HEU fuel, 0.38 - 0.58 g U/cc, and probably can be converted to LEU when the 2.3 g U/cc $UAl_x$ is qualified, estimated to be in FY 1984. Conversion with today's technology may be feasible if increasing the number of plates per element above 11 and decreasing the water gap is possible. This, presumably, would increase the depth of analysis required in the SAR.

TRIGA reactor groups have found from experience that 70% enriched fuel provides a longer fuel life in the core than 20% enriched fuel and, hence, reversion to the lower enrichment will increase fuel cycle costs. However, it appears that conversion to LEU without economic penalty may be possible following the demonstration of higher $UZrH_x$ fuels, expected by RERTR for FY 1985.

## 2.8 Conclusion

Based on our assessment, conversions can be divided into three categories: those that appear to be technically feasible with today's fuel technology, those that are not feasible even with advanced technologies now under development or projected, and those that require further study before a prediction of technical feasibility can be made with confidence. The reactors at Michigan (already demonstrated), Purdue, WPI, and Ohio State University pool reactors which now have fuels with the lowest uranium densities, fall in the first category, along with the liquid fueled reactor at UCSB. Missouri-Columbia and MIT, with the highest uranium densities, fall in the second, and all other reactors are in the third category pending further evaluation.

FEDERAL REGISTER (EXPORT/IMPORT)—Continued

| Name of applicant, date of application, date received, and application number | Material type | Material in kilograms | | End-use | Country of destination |
|---|---|---|---|---|---|
| | | Total element | Total isotope | | |
| Mitsubishi Int'l Corp., July 21, 1982, Aug. 9, 1982, XSNM01980. | 3.25 pct enriched uranium | 19,769 | 643 | Reload fuel for Ohi-2 | Japan. |
| General Electric Co., Aug. 5, 1982, Aug. 9, 1982, XSNM00463(06). | 3.85 pct enriched uranium | [1]3,734 | [1]82 | Increase quantity of material for Caorso reactor, extend date, add intermediate consignee-fuel for Caorso. | Italy. |
| Total | | 126,585 | 3,055 | | |

[1] Additional.

[FR Doc. 82-23045 Filed 8-23-82; 8:45 am]

BILLING CODE 7590-01-M

## Use of High-Enriched Uranium (HEU) in Research Reactors; Policy Statement

**AGENCY:** U.S. Nuclear Regulatory Commission.

**ACTION:** Statement of policy.

**SUMMARY:** The Nuclear Regulatory Commission (NRC) has licensing responsibility for domestic use and for export abroad of Special Nuclear Material, including High-Enriched Uranium (HEU), and is interested in reducing, to the maximum extent possible, the use of HEU in domestic and foreign research reactors. The NRC is pleased to note that the current U.S. Administration continues to support the Reduced Enrichment for Research and Test Reactors program and that to date the U.S. Congress has approved adequate funding for this program. In this connection, the NRC has prepared the following policy statement.

**FOR FURTHER INFORMATION CONTACT:** James V. Zimmerman, Assistant Director, Office of International Programs, U.S. Nuclear Regulatory Commission, Washington, DC 20555, (301) 492-7866.

**SUPPLEMENTARY INFORMATION:**

In the 1950's the U.S. entered into several short-term agreements for cooperation (5–10 years) allowing for the export of research reactors and fuel under the "Atoms for Peace" program. In subsequent years the U.S. has been a major supplier of high-enriched uranium (HEU) for use abroad, primarily in research and test reactors. Such reactors produce radioisotopes for use in such areas as medicine, agriculture, desalination, research in biological effects of radiation, etc. Materials test reactors are also used to train future operators of commercial power reactors and to test new materials and fuels.

In the mid 1970's, particularly following India's detonation of a nuclear explosive device in 1974, nuclear proliferation concerns began to increase. Expanded efforts were undertaken to prevent nuclear power programs from being exploited to produce nuclear weapons. Particular concerns were expressed with respect to the proliferation risks associated with inventories of HEU for research and test reactors abroad. The widespread use of HEU fuel, which involved a large number of domestic and international fuel shipments, increases the risks of proliferation through theft or diversion of this material. In contrast to HEU, the use of fuel with lower enrichments reduces proliferation risks.

In an effort to allay concerns of proliferation risks, efforts were made to reduce HEU inventories, on the assumption that any reduction in the potential for access to these inventories would constitute a reduction in the proliferation risk. These concerns eventually led to the establishment of the reduced enrichment for research and test reactors (RERTR) program. This program was established to develop and demonstrate the technology that will facilitate the use of reduced-enrichment uranium fuels in research and test reactors. If successful, this could lead to a significant reduction of HEU inventories abroad, and thereby increase the proliferation resistance of related fuel cycles.

The objective of the RERTR program is to develop research and test reactor fuels which will allow substitution of uranium of low enrichment (LEU, less than 20%) for HEU and which will not significantly affect reactor performance characteristics or fuel cycle costs. On an interim basis, some reactors may utilize intermediate enrichment fuels (45%), while the LEU fuel development program is in progress. It should be noted, however, that no U.S. effort will be made to develop fuels with enrichments significantly below 20%, because of the increasing magnitude of plutonium production in fuels with very low or no enrichment.

To date, DOE has initiated a development and test program managed by the Argonne National Laboratory (ANL) to prove the feasibility of the new lower enrichment fuels. Many foreign countries are cooperating with the U.S. in this effort, and, within the past year, NRC has issued several export licenses for reduced-enrichment uranium to be fabricated into test elements for foreign and domestic research reactors.

Assuming RERTR program success, most of the performance testing of LEU aluminide and oxide fuels with high uranium densities for use in plate-type reactors will be completed by the end of 1984. The irradiation of pin-type zirconium hydride fuel with high uranium density for use in Triga-type, and possibly plate-type, reactors will be completed in 1983. Assuming licensing approvals, these fuels could then enter into full scale use in appropriate reactors. Silicide fuels with very high uranium densities are also being developed and tested by the RERTR program. These fuels may be needed for conversion of high power reactors.

As part of the overall RERTR program, Argonne conducts for DOE a technical and economic evaluation of each significant HEU export license application including the potential of the reactor for conversion to reduced-enrichment fuel within the planned availabilities of appropriate reduced-enrichment fuels. Nearly all potential conversion candidates have been evaluated. Technical conversion schedules are being planned by reactor operators based on demonstration and licensability of the fuel. Based on the technical and economic evaluation by ANL, a coordinated Executive Branch recommendation on the license application is developed by the Department of State and is submitted to the NRC.

The objectives of the RERTR program have been fully supported by NRC since its inception. The Commission has also utilized Argonne's analyses in support of its reviews of proposed interim exports of HEU, particularly with respect to determining the dates when conversion to lower-enriched fuels can be anticipated. The Commission is pleased to note that the current Administration continues to support the RERTR program and that Congress has approved adequate funding for the program.

The Commission also notes that ... l types of LEU fuel are currently ... ested in DOE's RERTR program. As soon as all the necessary tests are completed, the Commission is prepared to act expeditiously to review the use of the new fuel in domestic research and test reactors licensed by NRC.

With respect to future export license applications for HEU, bearing in mind the Commission's responsibility to make an overall finding that each export would not be inimical to the common defense and security of the U.S., the Commission intends to continue its current practice of careful scrutiny to verify that additional interim HEU exports are justified. The Commission plans to continue to monitor the progress of the RERTR program so that it can understand what would be appropriate conversion schedules, and to encourage that actions be taken to eliminate U.S.-supplied inventories of HEU to the maximum degree possible.

The Commission notes that U.S. research reactor operators have shown little interest in converting to lower enrichment fuel. As part of a policy to strongly encourage conversion by foreign operators, the Commission will take steps [1] to encourage similar action ... S. research reactor operators.

... at Washington, D.C. this 17th day of ... 1982.

For the Commission.

Samuel J. Chilk,

*Secretary of the Commission.*

[FR Doc. 82-23051 Filed 8-23-82; 8:45 am]

BILLING CODE 7590-01-M

## Abnormal Occurrence Report; Section 208 Report Submitted To the Congress

Notice is hereby given that pursuant to the requirements of Section 208 of the Energy Reorganization Act of 1974, as amended, the Nuclear Regulatory Commission (NRC) has published and issued the periodic report to Congress on abnormal occurrences (NUREG-0090, Vol. 5, No. 1).

Under the Energy Reorganization Act of 1974, which created the NRC, an abnormal occurrence is defined as "an unscheduled incident or event which the Commission (NRC) determines is significant from the standpoint of public health or safety." The NRC has made a determination, based on criteria published in the Federal Register (42 FR 10950) on February 24, 1977, that events involving an actual loss or significant reduction in the degree of protection against radioactive properties of source, special nuclear, and byproduct materials are abnormal occurrences.

This report to Congress is for the first calendar quarter of 1982. The report identifies the occurrences or events that the Commission determined to be significant and reportable; the remedial actions that were undertaken are also described. The report states that there were four abnormal occurrences at the nuclear power plants licensed to operate. The first involved diesel generator engine cooling system failures. The second involved pressure transients during shutdown. The third involved major deficiencies in management controls. The fourth involved a steam generator tube rupture. There were no abnormal occurrences for the other NRC licensees during the report period. The Agreement States reported no abnormal occurrences to the NRC.

The report to Congress also contains information updating some previously reported abnormal occurrences.

Interested persons may review the report at the NRC's Public Document Room, 1717 H Street, NW, Washington D.C. or at any of the nuclear power plant Local Public Document Rooms throughout the country. Single copies of the report, designated NUREG-0090, Vol. 5, No. 1, may be purchased from the National Technical Information Service, Springfield, Virginia 22161.

A year's subscription to the NUREG-0090 series publication, which consists of four issues, is available from the NRC-GPO Sales Program, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Microfiche of single copies of the publication are also available from this source.

Dated at Washington, D.C. this 16th day of August 1982.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,

*Secretary of the Commission.*

[FR Doc. 82-23053 Filed 8-23-82; 8:45 am]

BILLING CODE 7590-01-M

[Docket No. 50-373]

## Commonwealth Edison Co.; Issuance of Amendment to Facility Operating License

On April 17, 1982, the U.S. Nuclear Regulatory Commission (the Commission) issued Facility Operating License No. NPF-11, to Commonwealth Edison Company (licensee) authorizing operation of the La Salle County Station, Unit 1 (the facility), at reactor core power levels not in excess of 166 megawatts thermal (5 percent power) in accordance with the provisions of the license, the Technical Specifications and the Environmental Protection Plan.

The Commission has now issued Amendment No. 4 to Facility Operating License No. NPF-11, which authorizes operation of the La Salle County Station, Unit 1, at reactor core power levels not in excess of 3323 megawatts thermal (100 percent power) in accordance with the provisions of the amended license. In addition, the Amendment makes administrative modifications dealing with omissions, an addition and changes in the areas of exemption, reporting to the Commission, and completion date of equipment qualification; requires confirmation of vacuum breakers to withstand pool swell forces; and a license condition regarding HVAC systems with respect to operation above 5% and 50% power.

La Salle County Station, Unit 1 is a boiling water nuclear reactor located in Brookfield Township, La Salle County, Illinois. The amendment is effective as of the date of issuance.

The application for the amendment complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations. The Commission has made appropriate findings as required by the Act and the Commission's regulations in 10 CFR Chapter I, which are set forth in the amended license. Prior public notice of the overall action involving the proposed issuance of an operating license was published in the Federal Register on June 9, 1977 (42 FR 29576-29577). The increase in power level authorized by this Amendment is encompassed by that prior public notice. Prior public notice of the administrative changes authorized by this Amendment was not required since these changes do not involve a significant hazards consideration.

The Commission has determined that the issuance of this amendment will not result in any significant environmental impacts other than those evaluated in the Final Environmental Statement, its Addendum, and assessment of the effect 40 year license from issuance of this amendment since the activity authorized by the license is encompassed by the overall action evaluated in the Final Environmental Statement, its Addendum, and assessment of license duration. Further, with respect to the administrative changes in the Amendment, the Commission has determined that the issuance of this Amendment will not result in any

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... use the "steps" referred to in the above ... r have not been detailed or discussed. ... ...issioner Roberts does not agree to the sentence since it implies that a specific course of action will be followed by the NRC.

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

# Limiting the Use of Highly Enriched Uranium in Domestic Research and Test Reactors

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The Commission is considering amending its regulations to limit the use of highly enriched uranium (HEU) fuel in domestic research and test reactors (non-power nuclear reactors). The proposed amendment generally would require that new non-power nuclear reactors use low enriched uranium (LEU) fuel and that existing reactors replace HEU fuel with LEU fuel when available.

The Commission considers that currently licensed non-power reactors using HEU fuel are operated without undue risk to the health and safety of the public. The proposed rule is intended to reduce the risk of theft or diversion of HEU fuel used in non-power reactors and the consequences to public health, safety and the environment from such theft or diversion. The reduction in domestic use of HEU fuel may encourage similar action by foreign research reactor operators, and thereby reduce the amount of HEU fuel in international use.

DATES: Comment period expires SEP 4 1984. Comments received after this date will be considered if practical to do so, but only those comments received on or before this date can be assured of consideration.

ADDRESSEES: Comments should be submitted in writing to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Docketing and Service Branch. All comments received will be available for public inspection in the Commission's Public Document Room at 1717 H Street, NW, Washington, DC.

FOR FURTHER INFORMATION CONTACT: William R. Lahs, Jr., Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Telephone (301) 443-7874.

SUPPLEMENTARY INFORMATION:

## Background

On August 17, 1982, The Commission issued a Policy Statement on the use of HEU in research reactors. The Policy Statement indicated that NRC has licensing responsibility for domestic use and for export abroad of Special Nuclear Material, including HEU, and is interested in reducing, to the maximum extent possible, the use of HEU in domestic and foreign research reactors. The Policy Statement also noted that as part of a policy to encourage conversion by foreign operators, the Commission would take steps to encourage similar action by U.S. research reactors operators.

Public Commission meetings on this subject were held December 19, 1983, January 27 and February 6, 1984. As discussed at the meetings, the Commission believes that the 31 non-power reactors (25 owned by universities, five by private businesses and one by the Government) presently licensed to use HEU fuel are operated without undue risk to the public health and safety. The proceeding is intended only to cause replacement of HEU fuel. (Target material, special instrumentation or experimental devices using HEU, are not included.) This reduction is desirable because HEU, in appropriate form and quantity, can be used to make an explosive device which can have severe adverse consequences on public health, safety and the environment. LEU has relatively little value for this purpose. The Commission believes that a new rule could reduce the risk of theft or diversion of HEU, could encourage similar actions by foreign operators of non-power reactors, and thereby, could reduce the amount of HEU in international use.

The Policy Statement also describes a continuing program to develop and demonstrate the technology that will facilitate the use of reduced enrichment fuels. The Reduced Enrichment for Research and Test Reactors (RERTR) program

was initiated by the Department of Energy (DOE) and is managed by the Argonne National Laboratory (ANL). Its objective is to prove the ability of new low-enriched uranium (LEU) fuels to replace existing HEU fuel without significant changes to existing reactor cores or facilities, or significant decrease in performance characteristics of the reactors. The RERTR program's progress and anticipated continued success over the next five years have encouraged NRC to undertake a rulemaking proceeding which would cause reduction in the use of HEU fuel in domestic research and test reactors.

Detailed information on the RERTR program was presented by Dr. A. Travelli, ANL, at the International Symposium on the Use and Development of Low and Medium Flux Research Reactors, held October 17-19, 1983, at the Massachusetts Institute of Technology. A copy of Dr. Travelli's paper, "RERTR Program Activities Related to the Development and Applications of New LEU Fuels", is available for public inspection in NRC's Public Document Room at 1717 H Street, NW., Washington, DC.

One source of information which identifies and classifies the affected university reactors and addresses the range of impacts of converting from HEU to LEU is a contractor's report, "Assessment of the Implications of Conversion of University Research and Training Reactors to Low Enrichment Uranium Fuel," NUREG/CR-3666. The report is available for public inspection and copying for a fee in NRC's Public Document Room at 1717 H Street, NW., Washington, DC. As part of the development of the proposed amendment, Commission briefings, open to the public, were held December 19, 1983, and January 27, 1984. At the briefings, information was presented by the DOE, Department of State, Nuclear Engineering Department Heads Organization (NEDHO), NRC staff and other interested persons.

Information considered to date indicates that conversion of several non-power reactors from HEU fuel to LEU fuel is technically feasible and, if the goals of the RERTR program are successfully achieved over the next five years, will be technically feasible for almost all the remaining reactors. The information also shows that a major consideration to operators is the cost of conversion which hinges on the availability of vendor supplied fuel. NRC shares the licensees' expressed view that conversion costs should largely or

entirely be financed by the Federal Government. Historically, the DOE and its predecessor agencies have provided significant support to research and test reactor programs. The availability of Federal support will be a key factor considered in determining the availability of LEU fuel and schedules for conversion.

Under the proposed rule, non-power reactors would be required to use LEU fuel unless there is a demonstration that the facility's unique purpose cannot be accomplished without the use of HEU. Licensees now authorized to use HEU fuel would be required to develop and submit to the NRC's Director of the Office of Nuclear Reactor Regulation a proposed schedule for conversion to LEU fuel. In preparing the proposed schedule, account will be taken of factors such as the availability of shipping casks, financial support, and reactor usage. Determination that the conversion fuel is available is dependent upon the successful accomplishment of the tasks set out in DOE's RERTR program and the development of commercially available replacement fuel. A final schedule will then be determined by the Director. This schedule will depend upon the availability of LEU fuel readily adapted to use in the licensee's reactor with minimum modifications or adverse impacts on the licensee's program.

A matter of interest to the Commission in requiring conversion and establishing the schedule will be financial considerations. Interested persons are invited to comment on the extent that they believe the economics of conversion should influence Commission actions. Any economic analysis should include estimates of the aversion of risk to the public health, safety and the environment.

Technically, in its simplest form, conversion from HEU fuel to LEU fuel consists of replacing relatively low density HEU by relatively high density LEU. By using a higher density of uranium in the fuel matrix, it is expected that the same amount of U-235 can be present in a fuel element without changing the external dimensions of the element or significantly changing the thermal-hydraulic characteristics of the reactor. Under these conditions it is possible that existing technical specifications will remain unchanged and no unreviewed safety question will be involved. NRC is evaluating the reactor

performance and safety aspects of conversion and expects to publish a report prior to reaching a determination on issuance of a final rule.

To facilitate conversion safety reviews, the NRC is considering the development of generic envelopes of safety limits for the several types of non-power reactors. An affected licensee would then submit an analysis showing that both the normal operating and postulated accident conditions of the reactor fall within the limits. These safety limits would be used in establishing limiting conditions of operation (such as coolant flow, coolant pressure, reactivity conditions). Current developments by the RERTR program indicate that these limiting conditions of operation with LEU fuel may not differ significantly from limiting conditions of operation now used with HEU fuel; however, a definitive conclusion on this matter, applicable to all the conversion candidates will depend on the continued success of the RERTR program over the next several years. Comments are invited on this approach of using generic envelopes of safety limits and limiting conditions of operation.

In cases where conversion from HEU fuel to LEU fuel would neither conflict with the technical specification incorporated in the license nor involve an unreviewed safety question, the conversion could proceed without amendment of the license. In other cases, a license amendment would be required. In view of the significance of this proposed rule to the national interest, the Commission, when implementing the rule, intends to waive any licensing fees that would normally be assessed for amending licenses issued to production and utilization facilities. Interested persons are invited to comment on the possibility that a license amendment will not be required or that an amendment would not present an unreviewed safety question or a conflict with technical specifications.

In summary, the Commission recognizes that successful implementation of the proposed rule, while maintaining the nuclear research and training capability which these reactors provide, depends on (1) the continued success of the DOE funded RERTR program (2) the development of acceptable, and available, replacement fuel, and (3) the extent of financial and operational support provided to affected licensees by the Federal Government through DOE. The Commission also recognizes that the degree of RERTR program success directly impacts the

costs attributed to attendant NRC safety reviews. The Commission therefore, is especially interested in public comments on these aspects of the proposed rule.

National Environmental Policy Act Consideration

The Commission has determined, under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in 10 CFR Part 51, that promulgation of this proposed rule will not have a significant effect on the quality of the human environment and that, therefore, an environmental impact statement is not required. (The environmental assessment and finding of no significant impact on which this determination is based are available for public inspection at the NRC Public Document Document Room, 1717 H Street, NW., Washington, DC.)

Paperwork Reduction Act Statement

The proposed rule amends information collection requirements that are subject to the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). This rule has been submitted to the Office of Management and Budget for review and approval of the paperwork requirements.

Regulatory Analysis

The Commission has prepared a regulatory analysis for the proposed amendment. The analysis examines the costs and benefits of the amendment and the decision criteria considered by the Commission. A copy of the regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 1717 H Street, NW., Washington, DC.

Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980, 5. U.S.C. 605(b), the Commission hereby certifies that this proposed rule will not, if

promulgated, have a significant economic impact on a substantial number of small entities. The proposed regulation affects non-power reactor licensees that own and operate nuclear utilization facilities licensed under section 103 and 104 of the Atomic Energy Act of 1954, as amended. These licensees do not fall within the definition of small businesses set forth in section 3 of the Small Business Act, 15 U.S.C. 632, or within the Small Business Size Standards set forth in 13 CFR Part 121.

## List of Subjects in 10 CFR Part 50

Antitrust, Classified information, Fire prevention, Incorporation by reference, Intergovernmental relations, Nuclear power plants and reactors, Penalty, Radiation protection, Reactor siting criteria, Reporting and record keeping requirements.

Under the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and 5 U.S.C. 553, notice is hereby given that adoption of the following amendment to 10 CFR Part 50 is contemplated.

PART 50 - DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The Authority citation for Part 50 continues to read as follows:

Authority: Secs. 103, 104, 161, 182, 183, 186, 189, 68 Stat. 936, 937, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 1244, as amended (42 U.S.C. 2133, 2134, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, 202, 206, 88 Stat. 1242, 1244, 1246, as amended (42 U.S.C. 5841, 5842, 5846), unless otherwise noted.

Section 50.7 also issued under Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851). Sections 50.57(d), 50.58, 50.9 and 50.92 also issued under Pub. L. 97-415, 96 Stat. 2071, 2073 (42 U.S.C. 2133, 2239). Section 50.78

also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections 50.80-50.81 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Sections 50.100-50.102 also issued under sec. 186, 68 Stat. 955 (42 U.S.C. 2236).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§50.10(a), (b), and (c) 50.44, 50.46, 50.48, 50.54 and 50.80(a) are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)) ;§§50.10(b) and (c) and 50.54 are issued under sec. 161i, 68 Stat. 949, as amended (42 U.S.C. 2201(i)); and §§50.55(e), 50.59(b), 50.70, 50.71, 50.72, 50.73, and 50.78 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

2. A new §50.64 is added to read as follows:

§50.64 Limitations on the Use of High Enriched Uranium in Non-Power Reactors.

(a) Applicability. The requirements of this section apply to all nuclear non-power reactors licensed under §§50.21(a), 50.21(c), or 50.22 of this part.

(b) Definitions. For purposes of this section:

(1) "High enriched uranium" (HEU) fuel means fuel in which the weight percent of U-235 in the uranium is 20% or greater. Target material, special instrumentation or experimental devices using HEU are not included.

(2) "Low enriched Uranium" (LEU) fuel means fuel in which the weight percent of U-235 in the uranium is less that 20%.

(3) "Unique purpose" means that the project or program cannot reasonably be accomplished without the use of HEU fuel, and may include:

(i) A specific experiment or program,

(ii) Reactor physics or reactor development based explicitly on use of HEU fuel,

(iii) Research projects based on the neutron flux levels or spectra only attainable with HEU fuel, or

(iv) A reactor core of special design that could not perform its intended function without using HEU fuel.

(c) Requirements.

(1) The Commission will not issue a construction permit for a new non-power reactor that would use HEU fuel unless the applicant demonstrates that the proposed reactor will have a unique purpose as defined in (b)(3).

(2) Unless the Director of the Office of Nuclear Reactor Regulation has determined, based on a request submitted in accordance with paragraph (d)(1) of this section, that the reactor has a unique purpose, each licensee currently authorized to possess and use HEU fuel in connection with the operation of a non-power reactor shall:

(i) Acquire no additional HEU fuel if LEU fuel acceptable to the Commission for that reactor is available at the time of the proposed acquisition of the HEU fuel by the licensee; and

(ii) Replace all HEU fuel in the licensee's possession with available LEU fuel acceptable to the Commission in accordance with a schedule determined pursuant to paragraph (d)(2) of this section.

(3) If not required by paragraphs (c)(1) and (2) of this section to use LEU fuel, the applicant or licensee must use HEU fuel of enrichment as close to 20% as is available and acceptable to the Commission.

(d) Implementation.

(1) Any request by a licensee for a determination that a reactor has a unique purpose as defined in paragraph (b)(3), should be submitted with supporting documentation to the Director of the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555, by (insert a date 6 months after the effective date).

(2) By (insert a date 12 months after the effective date) each non-power reactor licensee authorized to possess and use HEU fuel shall develop and submit to the Director of the Office of Nuclear Reactor Regulation a proposed schedule for meeting the requirements of paragraphs (c)(2) or (3) of this section. The proposed schedule shall be based upon availability of replacement fuel acceptable to the Commission and consideration of other factors such as the availability of shipping casks, financial support, and reactor usage. A final schedule will then be determined by the Director of the Office of Nuclear Reactor Regulation.

(3) If the replacement of HEU fuel with LEU fuel does not change the technical specifications incorporated in the license or involve an unreviewed safety question as defined in §50.59(a)(2), the holder of a non-power reactor license may replace HEU fuel with LEU fuel without amendment to the license and shall maintain records and furnish reports as defined in §50.59(b). If replacement of HEU fuel with LEU fuel changes the technical specifications incorporated in the license or involves an unreviewed safety question, the licensee shall file an application for an amendment in accordance with §50.59(c).

Dated at Washington, DC this day of June 29, 1984.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,
Secretary of the Commission.

Table 1

Summary

Foreign Research and Test Reactors
Using HEU (>70%) of Western Origin

| Origin of HEU | Fuel Type | No. of Reactors | Power, MW | Annual $^{235}U$ Reqt., kg |
|---|---|---|---|---|
| **Foreign Reactors > 1 MW** | | | | |
| US | Plate | 44 | 684.5 | 429.7 |
| | TRIGA | 3 | 17 | 11.6 |
| | Other | 2 | 150 | 87.9 |
| | | 49 | 851.5 | 529.2 |
| UK | Plate | 2 | 30.5 | 14.3 |
| France | Plate | 1 | 20 | ? |
| | | 3 | 50.5 | ~14.3 |
| TOTAL FOREIGN > 1 MW | | 52 | 902 | 543.5 |
| **Foreign Reactors < 1 MW** | | | | |
| US | Plate | 27 | 0.64 | |
| | TRIGA | 2 | 0.50 | |
| | Other | 8 | 0.12 | |
| | | 37 | 1.26 | 1.0-1.5 |
| UK | Plate | 6 | 1.0 | ~1.0 |
| TOTAL FOREIGN < 1 MW | | 43 | 2.26 | 2.0-2.5 |
| GRAND TOTAL FOREIGN | | 95 | 904 | 546 |

Table 3

Foreign Research and Test Reactors > 1 MW
Using HEU (> 70%) of U.S. Origin

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | Min. LEU Density, g/cm³: No. Geom. Change | Min. LEU Density, g/cm³: Geom. Change | Is or Plans to Test MEU and/or LEU Prototypes (U Density, g/cm³) |
|---|---|---|---|---|---|---|---|
| | | | | | | | **Plate-Type Reactors > 1 MW** |
| 1. | RA-3[a] | Argentina | 3.5 | ~4.0 | 3.1 | – | LEU(?) |
| 2. | HIFAR[b] | Australia | 10 | 9.2 | 2.3 | – | |
| 3. | ASTRA | Austria | 8 | 1.8 | – | 2.9 | MEU(1.6),LEU(2.9) |
| 4. | BR-2 | Belgium | 100 | 55.0 | 7.0 | ? | |
| 5. | IEA-R1 | Brazil | 2 | ~1.0 | – | 1.8 | LEU(1.8) |
| 6. | MNR[c] | Canada | 2(5) | 1.9 | 3.7 | 3.1 | |
| 7. | La Reina[d] | Chile | 5 | 1.0 | 3.7 | 2.8 | MEU(1.6) |
| 8. | DR-3 | Denmark | 10 | 8.6 | 2.8 | 2.4 | MEU(1.0),LEU(2.6) |
| 9. | RHF | France | 57 | 55.8 | 6.1 | ? | |
| 10. | SILOE | France | 35 | 22.5 | 4.5 | ? | MEU(2.2),LEU(~4.5) |
| 11. | SCARABEE | France | 20 | ? | ? | ? | |
| 12. | ORPHEE | France | 14 | 14.7 | 6.4 | ? | |
| 13. | MELUSINE | France | 8 | 5.5 | ? | ? | |
| | FRJ-1[e] | FRG | 10 | 8.6 | 3.6 | ? | MEU(1.4) |
| 15. | FRJ-2 | FRG | 23 | 17.9 | 2.6 | – | MEU(1.1),LEU(3.0) |
| 16. | FRG-1 | FRG | 5 | 2.3 | 2.4 | – | |
| 17. | FRG-2 | FRG | 15 | 10.7 | 2.4 | – | MEU(1.4),LEU(?) |
| 18. | BER-2 | FRG | 10 | 4.8 | – | 2.0 | LEU(2.0) |
| 19. | FRM | FRG | 4 | 2.6 | 3.0 | – | MEU(1.4) |
| 20. | FMRB | FRG | 1 | 1.0 | ~2.3 | – | |
| 21. | GRR-1 | Greece | 5 | 2.7 | 2.2 | – | LEU(2.2) |
| 22. | UTRR | Iran | 5 | ? | ? | ? | |
| 23. | IRR-1 | Israel | 10 | ? | ? | ? | |
| 24. | ESSOR | Italy | 40 | ~4.0 | 3.6 | ? | |
| ~~25.~~ | ~~ARS-1~~ | ~~Italy~~ | ~~7~~ | ~~~0.8~~ | ~~2.6~~ | ~~–~~ | Shut down pre-'82 |
| 26. | ~~RTS-1~~ | ~~Italy~~ | ~~5~~ | ~~~0.6~~ | ~~2.5~~ | ~~–~~ | |
| 27. | JMTR | Japan | 50 | 34.5 | 4.0 | ? | MEU(1.6) |
| 28. | KUHFR[f] | Japan | 30 | 39.2 | 3.7 | ? | MEU(1.6) |
| 29. | JRR-2 | Japan | 10 | <9.9 | 3.5 | ? | MEU(1.6) |
| 30. | KUR[g] | Japan | 5 | ~2.5 | – | 1.3 | TRIGA LEU(1.3) |
| 31. | JRR-4 | Japan | 3.5 | 0.9 | – | 1.8 | LEU(~1.8) |
| 32. | HFR | Neth. | 45 | 35.6 | 5.2 | ? | LEU(2.1),LEU(?) |
| 33. | HOR | Neth. | 2 | 1.7 | 3.1 | – | |
| | PARR | Pakistan | 5 | ~0.6 | ? | ? | |
| 35. | PRR-1[h] | Philip. | 1 | 0.4 | – | 1.3 | TRIGA LEU(1.3) |
| 36. | RPI | Portugal | 1 | ~0.6 | ? | ? | |

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | Min. LEU Density, g/cm³ No. Geom. Change | Min. LEU Density, g/cm³ Geom. Change | Is or Plans to Test MEU and/or LEU Prototypes (U Density, g/cm³) |
|---|---|---|---|---|---|---|---|
| 37. | JEN-1[i] | Spain | 3 | ~1.0 | <3.0 | - | LEU(?) |
| 38. | SAFARI[j] | S. Africa | 20 | 11.7 | 3.1 | - | MEU(1.3),LEU(?) |
| 39. | R2 | Sweden | 50 | 32.7 | 3.7 | <3.2 | LEU(?) |
| 40. | R2-0 | Sweden | 1 | ~0.3 | 3.7 | <3.2 | |
| 41. | SAPHIR | Switz. | 10 | 5.6 | 3.7 | ? | MEU(1.6) |
| 42. | TR-1 | Turkey | 3 | ~1.6 | 3.7 | 3.0 | |
| 43. | TR-2 | Turkey | 5 | ~2.6 | 3.7 | 3.0 | |
| 44. | PLUTO[b] | UK | 25.5 | 11.3 | 2.7 | - | MEU(1.1),LEU(~2.7) |
| | | | 684.5 | 429.7 | | | |

TRIGA-Type Reactors > 1 MW

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | No. Geom. Change | Geom. Change | Prototypes |
|---|---|---|---|---|---|---|---|
| 45. | TRIGA | Korea | 2 | ~1.0 | 1.3 | - | |
| 46. | TRIGA | Mexico | 1 | ~0.7 | 1.3 | - | |
| 47. | TRIGA | Romania | 14 | ~9.9 | 3.7 | - | LEU(3.7) |
| | | | 17 | 11.6 | | | |

Other-Type Reactors > 1 MW

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | No. Geom. Change | Geom. Change | Prototypes |
|---|---|---|---|---|---|---|---|
| 48. | NRU | Canada | 125 | 62.8 | 3.2 | - | LEU(3.2) |
| 49. | NRX | Canada | 25 | 25.1 | 4.5 | - | LEU(4.5) |
| | | | 150 | 87.9 | | | |

TOTAL U.S. ORIGIN 851.5 529.2

Foreign Research and Test Reactors > 1 MW
Using HEU (> 70%) of Other Western Origin
(All Plate-Type Reactors)

U.K. Origin

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | No. Geom. Change | Geom. Change | Prototypes |
|---|---|---|---|---|---|---|---|
| 1. | DIDO | UK | 25.5 | 11.3 | 2.7 | - | |
| 2. | HERALD | UK | 5 | ~3.0 | ? | ? | |
| | | | 30.5 | 14.3 | | | |

French Origin

| | Reactor | Country | Power, MW | Annual $^{235}U$ Reqt., kg | No. Geom. Change | Geom. Change | Prototypes |
|---|---|---|---|---|---|---|---|
| 3. | Lo Aguirre[k] | Chile | 20 | ? | 1.7 | - | |

TOTAL OTHER WESTERN ORIGIN 50.5 14.3

GRAND TOTAL 902 ~543.5

[a]Recently received 100 kg LEU (~20 kg $^{235}U$) from Soviet Union.

[b]Has utilized fuel of both U.S. and U.K. origin.

[c]Normal power is 2 MW. Operates at 5 MW from time to time.

[d]Attempting to obtain ~7.5 kg 45% enriched U from U.K.

[e]Scheduled to be shutdown in 1984.

[f]Construction of KUHFR has not yet begun.

[g]Scheduled for conversion to TRIGA LEU fuel after KUHFR begins operation.

[h]Scheduled for conversion to TRIGA LEU fuel.

[i]Has procured 51.2 kg LEU in 1980 for conversion as new fuel is needed.

[j]As of February 1982, SAFARI was operated intermittently at 5 MW with about 13 HEU (93%) elements (2.6 kg $^{235}U$) with U of U.S. origin and about 13 MEU (45%) elements (2.9 kg $^{235}U$) with U of South African origin. Desires core conversion to LEU fuel produced indigenously.

[k]Under construction. Cooling system not yet complete. Has about 4.6 kg French HEU (90%) contained in 31 fuel elements fabricated by JEN, Spain. Critical experiments with natural convection cooling were completed in February 1977.

# Table 4

## Foreign Research and Test Reactors < 1 MW Using HEU (> 70%) of U.S. Origin

### Plate-Type < 1 MW

| | Reactor | Country | Power, MW |
|---|---|---|---|
| 1. | RA-2 | Argentina | $10^{-7}$ |
| 2. | MOATA | Australia | 0.01 |
| 3. | SAR-GRAZ | Austria | 0.01 |
| 4. | BR-02 | Belgium | 0.0005 |
| 5. | PTR | Canada | 0.01 |
| 6. | IAN-R1 | Columbia | 0.03 |
| 7. | ULYSEE-Strasbourg | France | 0.1 |
| 8. | ULYSEE-Saclay | France | 0.1 |
| 9. | SILOETTE | France | 0.1 |
| 10. | EOLE | France | 0.01 |
| 11. | MINERVE | France | $10^{-4}$ |
| 12. | RANA | Italy | 0.008 |
| 13. | RB-3 | Italy | $10^{-4}$ |
| 14. | RIMTO | Italy | $10^{-4}$ |
| 15. | ROSPO | Italy | Negl. |
| 16. | KUCA | Japan | $10^{-4}$ |
| 17. | JMTRC | Japan | $10^{-5}$ |
| 18. | UTR-10 KINKI | Japan | $10^{-7}$ |
| 19. | LFR | Neth. | 0.01 |
| 20. | RP-0 | Peru | Negl. |
| 21. | AGN211P | Switz. | 0.02 |
| 22. | LIDO | UK | 0.2 |
| 23. | NESTOR | UK | 0.03 |
| 24. | DAPHNE | UK | $10^{-4}$ |
| 25. | HECTOR | UK | $10^{-4}$ |
| 26. | HORACE | UK | $10^{-5}$ |
| 27. | RUDI | Uraguay | Negl. |
| | | | 0.64 |

### TRIGA-Type < 1 MW

| | Reactor | Country | Power, MW |
|---|---|---|---|
| 28. | TRIGA | Yugo. | 0.25 |
| 29. | TRIGA | Austria | 0.25 |
| | | | 0.50 |

### Other Type < 1 MW

| | Reactor | Country | Power, MW |
|---|---|---|---|
| 30. | Slowpoke Ottawa | Canada | 0.02 |
| 31. | Slowpoke Toronto | Canada | 0.02 |
| 32. | Slowpoke Montreal | Canada | 0.02 |
| 33. | Slowpoke Halifax | Canada | 0.02 |
| 34. | Slowpoke Edmonton | Canada | 0.02 |
| 35. | Slowpoke Koeln | Canada | 0.02 |
| 36. | RB-1 | Italy | $10^{-5}$ |
| 37. | DCA | Japan | $10^{-3}$ |
| | | | 0.12 |
| | Total | | 1.26 |

## Foreign Research and Test Reactors < 1 MW Using HEU (> 70%) of UK Origin (All Plate-Type)

| | Reactor | Country | Power, MW |
|---|---|---|---|
| 1. | ASPARA | India | 0.4 |
| 2. | SSRC-UTR | U.K. | 0.3 |
| 3. | CONSORT | U.K. | 0.1 |
| 4. | QMC-UTR-B | U.K. | 0.1 |
| 5. | URR | U.K. | 0.1 |
| 6. | JASON | U.K. | 0.01 |
| | Total | | 1.0 |

These 43 reactors with power < 1 MW have a total power of about 2.3 MW and an annual $^{235}U$ requirement of about 2-2.5 kg.

Department of Energy Resea[illegible]nd Test Reactors
Using HEU Greater Th[illegible] [illegible] Percent

| Reactor | Location | Power (MW) | Comment |
|---|---|---|---|
| **Plate-type DOE Reactors Greater Than 1 MW:** | | | |
| 1. Advanced Test Reactor | Idaho | 250 | Primarily used by naval reactors |
| 2. High Flux Isotope Reactor | ORNL | 100 | Will require silicide fuel if development is successful. |
| 3. High Flux Beam Reactor | Brookhaven | 60 | Will require silicide fuel if development is successful. |
| 4. Oak Ridge Reactor | ORNL | 30 | Presently used to test fuels for RERTR Program. |
| 5. Omega West Reactor | Los Alamos | 8 | |
| 6. Brookhaven Medical Research Reactor | Brookhaven | 3 | Low utilization. Will probably not need to be refueled during lifetime. |
| 7. Bulk Shielding Reactor | ORNL | 2 | Using fuel elements intended for Safari reactor. Will probably never need additional fuel. |
| 8. Tower Shielding Reactor #2 | ORNL | 1 | |
| SUBTOTAL | | 454 | |
| **Plate-type Reactors Less Than 1 MW:** | | | |
| 1. JANUS | Argonne | 0.2 | |
| 2. CFRMF | Idaho | 0.1 | |
| 3. Standard Pile | Savannah R. | 0.01 | |
| 4. ARMF | Idaho | 0.01 | |
| 5. ATSR | Argonne | 0.01 | Low usage (100 hrs/yr) |
| 6. Pool Critical Assembly | ORNL | 0.01 | |
| 7. ATRC | Idaho | 0.005 | |
| SUBTOTAL | | 0.35 | |
| **TRIGA-Type:** | | | |
| 1. NRAD | Idaho | 0.25 | |

TOTAL EXPORTS[1] OF HEU[2] AND PLUTONIUM

FOR THE PERIOD

JANUARY 1, 1954 THROUGH DECEMBER 31, 1982

| Country | HEU (grams) | % U-235 (average) | Plutonium (grams) | %Pu-239 (average) |
|---|---|---|---|---|
| Argentina | 94,106 | 63% | 9 | 100% |
| Austria | 9,751 | 75% | 162 | 93% |
| Australia | 10,191 | 90% | 6,577 | 92% |
| Belgium | 186,548 | 85% | 57,644 | 81% |
| Bolivia | 1 | 100% | - | - |
| Brazil | 7,701 | 93% | 84 | 93% |
| Canada | 1,861,491 | 93% | 5,017 | 87% |
| Columbia | 3,113 | 91% | 80 | 93% |
| Czechoslavakia | 8 | 50% | 29 | 86% |
| Denmark | 26,213 | 90% | 81 | 93% |
| Finland | 3,863 | 20% | 3 | 67% |
| France | 6,268,415 | 74% | 41,507 | 92% |
| Germany (West) | 9,990,460 | 66% | 754,072 | 89% |
| Greece | 6,608 | 93% | 192 | 93% |
| IAEA | 308 | 81% | 387 | 91% |
| Ireland | 2 | 100% | 16 | 94% |
| Indonesia | 18 | 72% | - | - |
| India | 98 | 83% | 82 | 91% |
| Israel | 18,730 | 91% | 606 | 93% |
| Iran | 5,546 | 93% | 112 | 92% |
| Iraq | - | - | 16 | 94% |
| Italy | 382,068 | 80% | 129,103 | 79% |

[1] Figures represent shipments by U.S. to foreign countries. Returns to U.S. and retransfers to other foreign countries are not reflected in the data.

[2] Highly enriched uranium (HEU). Uranium enriched to 20% or more in the Isotope U-235

| Country | HEU (grams) | % U-235 (average) | Plutonium (grams) | %Pu-239 (average) |
|---|---|---|---|---|
| Japan | 1,995,306 | 47% | 159,145 | 88% |
| Rep. of Korea | 29,610 | 62% | 8 | 88% |
| Malaysia | 7 | 86% | - | - |
| Mexico | 29,629 | 42% | 164 | 91% |
| Netherlands | 63,220 | 89% | 835 | 90% |
| Norway | 10 | 80% | 1,083 | 86% |
| New Zealand | - | - | 80 | 93% |
| Pakistan | 5,764 | 90% | 117 | 93% |
| Philippines | 3,294 | 93% | 32 | 94% |
| Portugal | 7,661 | 93% | 1 | 100% |
| Romania | 39,245 | 93% | - | - |
| South Africa | 32,700 | 92% | 159 | 93% |
| Spain | 9,412 | 88% | 6 | 83% |
| Sweden | 148,070 | 90% | 9,702 | 91% |
| Switzerland | 8,787 | 93% | 1,502 | 93% |
| Taiwan | 9,912 | 93% | 708 | 87% |
| Thailand | 5,302 | 90% | 80 | 80% |
| Turkey | 5,324 | 90% | 368 | 92% |
| United Kingdom | 2,301,016 | 93% | 54,378 | 84% |
| Uruguay | 5 | 100% | 80 | 93% |
| Venezuela | 11 | 82% | 10 | 90% |
| Rep. of Vietnam | 386 | 21% | 80 | 93% |
| Yugoslavia | 17,051 | 35% | - | - |
| Zaire | 1,354 | 20% | - | - |
| Total | 23,588,000 | 72% | 1,224,000 | 87% |

Source: Department of Energy, Nuclear Materials Management and Safeguards System

COSTS ASSOCIATED WITH CONVERSION OF RESEARCH REACTORS

| COST CATEGORY | Thousands of $ | COMMENTS |
| --- | --- | --- |
| 1. FUEL REPLACEMENT COSTS | | ASSUMES REPLACEMENT OF ALL CORES IS REQUIRED |
| Lost fabrication costs | | This is the cost associated with replacement of cores which have not been fully utilized. |
| a)routine refueling | | |
| university | $500.0 | |
| private | $700.0 | |
| b)lifetime cores | | |
| university | $5,000.0 | |
| TOTAL | $6,200.0 | |
| LEU/HEU Fab. Cost Difference | $0.0 | This is the cost differential between LEU and HEU cores |
| 2. TRANSPORTATION COSTS | $2,500.0 | This is the cost associated with the return of the replaced HEU elements to DOE. This could be as low as $1.5 million. |
| 3. FACILITY MODIFICATIONS COSTS | $250.0 | This assumes a $25,000 cost at half of the 20 university reactors. |
| 4. ADMIN. & LICENSING COSTS | $3,000.0 | This could range from $1.5 to $3.0 million depending on whether licensing is generic or not. |

12 m TOTAL

STATEMENT OF
DR. JAMES S. KANE
DEPUTY DIRECTOR
OFFICE OF ENERGY RESEARCH
U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE
AND
ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE

U.S. HOUSE OF REPRESENTATIVES

SEPTEMBER 25, 1984

Mr. Chairman and Members of the Subcommittees:

It is a pleasure to appear before you today to review the Department's goals for the University Reactor Fuel Assistance Program and present our position on the proposed NRC rule for the conversion of university research reactors to the use of low-enriched uranium. I will cover in my testimony the origin of the university reactor program, the role these reactors play in science and engineering education, and our response to the proposed refueling of these reactors with low-enriched uranium (LEU).

By way of background, the University Reactor Fuel Assistance Program was initiated by the Atomic Energy Commission under authority of the Atomic Energy Act of 1954, Section 31. Following World War II, the science and technological base for nuclear research essentially resided at a few contractor and national laboratory facilities. It was clear, however, that the university community had to be involved if progress were to be made in developing the many potential applications of nuclear energy. During the next decade, the Atomic Energy Commission encouraged and supported the establishment of a wide range of university-based nuclear and radiation safety training programs in reactor and radioisotope technology, and in biology and medicine. Graduate research fellowships were established in nuclear science and engineering, health physics and industrial medicine. Grants were provided to universities to build or purchase training and research reactors. Research equipment and instrumentation were also provided to universities for nuclear research and teaching the fundamentals of radioactive materials.

The goal in establishing and supporting these university facilities was not only to train future nuclear scientists and engineers in the design and

operation of nuclear reactors but also to provide the research tools essential for the application of nuclear and radiation technology to medicine, agriculture, materials and the geosciences. These same needs continue today.

At the present time there are 46 university research and training reactors, ranging in power levels from zero to 10 megawatts. The three general classes are: 1) those that use the Materials Test Reactor (MTR), plate-type fuel; 2) those that use the TRIGA cylindrical fuel rod and 3) the seven small facilities that use a homogeneous type uranium oxide fuel either in polyethylene discs or solution form. (See Table I for selected characteristics of these facilities.)

Currently, there are 25 university nuclear engineering departments offering BS, MS or PhD programs and 37 other nuclear engineering programs combined with other departments. In 1983 these programs produced 674 BS degrees, about 1% of the total BS engineering degrees that year. There were more than 1500 graduate students enrolled in nuclear engineering programs in the fall of 1983, including some 250 who were working in industry or government jobs and taking graduate degree programs part-time. Recent manpower studies forecast continuing increased demand by industry for nuclear engineering graduates, particularly for operational and quality assurance positions. We believe that continued direct access by students to university-based nuclear research reactors is very important in their preparation for future professional careers in nuclear R&D and operations.

Many university scientists and engineers use university research and training reactors and their associated analytical facilities. As a source of thermal neutrons for a wide variety of research, a reactor is still one of the more effective research tools available. The range of research conducted on university reactors was illustrated in the results of a recent International Symposium hosted by the MIT Nuclear Reactor Laboratory. This Symposium on the Use and Development of Low and Medium Flux Research Reactors, brought together over 200 participants from research reactor centers in twenty-one different countries. The discussions in this Symposium clearly underlined the broad range of applications of research reactors on a worldwide basis and the continuing interest in the use of these research tools.

The main use of the smaller reactors is for instruction, usually for classes in nuclear engineering and radiation protection, at both the graduate and undergraduate levels to demonstrate various principles of nuclear reactor physics. Many demonstrations and experiments are also carried out for undergraduate students in physics, chemistry and biology classes. A number of universities also use their facility to provide basic training for reactor operators and operations managers for utilities installing power reactors. This is possible because basic neutron behavior is the same in small reactors as it is in large power reactors. These services would not be as easily and economically provided if university reactors were not available.

Regarding the fuel used in university reactors, currently, there are only two fabricators of research reactor fuel in the United States. G. A. Technologies in San Diego, Ca. produces a rod-type uranium-zirconium/hydride fuel for the TRIGA reactors. Babcock and Wilcox in Lynchburg, Va. produces the MTR plate type fuels for reactors using MTR-type assemblies. Of the seventeen university TRIGA reactors, thirteen use a 20% enriched uranium fuel and four use a 70% enriched fuel developed in the late sixties by General Atomics in the fuel-life-improvement program (FLIP) to reduce the costs of fuel procurement and shipment. Each of these four facilities has an estimated fuel supply of about twenty years.

This fuel is loaned by DOE to the universities with title remaining with the government. Our support covers the fabrication costs of the fuel elements and shipment to the universities. Spent fuel is returned to DOE for reprocessing or storage. The MTR plate fuel is sent to Savannah River and the TRIGA fuel to the Idaho processing facility. It should be noted that due to its chemical composition and cladding material, the TRIGA fuel must be reprocessed separately from the plate type fuel.

We also support a small activity called "Reactor Sharing", which assists universities with the additional costs incurred when they make their reactor and laboratory facilities available to scientists and students from other colleges and universities for research and training. Seventeen sharing grants averaging $15,735 were made in FY-1984. For the last complete grant year 173 schools, involving 1900 students and 198 faculty, participated in

the program. Such a program makes more efficient use of the existing reactor facilities, reduces the need for new reactors and allows faculty at colleges and universities without reactors to both offer courses of study in the nuclear sciences and to conduct research.

Let me now turn to the Department's position on the proposed NRC rule calling for all licensed research and training reactors using high enriched fuel to convert to low enriched fuel. We understand that the primary reason for NRC's proposed action is to discourage nuclear weapons proliferation by encouraging foreign research reactors to change to the use of LEU. Since our objective is primarily to set an example for other countries, then careful consideration must be given to the cost-benefit aspects and the overall effect such a requirement will have upon the universities.

Last December, in testimony before the Nuclear Regulatory Commission, the Department supported the conversion to LEU for university reactors refueled on an annual basis, provided that acceptable LEU fuel was available. We also volunteered to store unirradiated HEU fuel at secure DOE sites, if needed, to further reduce on-campus inventory. Our support of these conversion activities assumed that the LEU fuel will be phased in as existing fuels are used up and that conversion would not result in any significant economic or technical penalty to the individual university.

Our position was based in part on the fact that if the small amount of unirradiated fuel a reactor might have is adequately stored, either on campus or at a DOE facility, the diversion or theft of unirradiated fuel ceases to be an issue. We have never considered the diversion or theft of irradiated fuel to be a credible issue. The difficulties in surreptitiously handling highly radioactive elements plus the technical and financial resources needed to separate the uranium in sufficient amount for a nuclear device make such a threat, if any, extremely remote.

Our main disagreement with the proposed NRC rule centers on its treatment of reactors that have essentially a life time supply of fuel. It is worth noting that the U.S. government is not seeking the conversion to LEU of foreign reactors with lifetime cores. With the exception of the four, one-megawatt TRIGA reactors which use a different type of fuel, these are small, low powered reactors with in-core inventories of less than five kilograms of U-235. We believe that theft or diversion of fuel from these small facilities is unattractive, and therefore extremely improbable. In fact, the total amount of HEU currently in storage at all of these low power reactors is less than 15 kg's.

If conversion of all U.S. university reactors is mandated, some are almost certain to cease operation. For negligible benefit, we will have lost a valuable nuclear training and research capability.

We are further concerned with the effect relicensing may have on a university. It should be pointed out that the NRC's licensing criteria

contained in (Part 50, Title 10 Code of Federal Regulations) are primarily for large power reactors operated by utilities and are used in various modified forms for the low power research and training reactors that differ widely in design, operation and use. We suggest that NRC look closely at their licensing procedures for these low power reactors to see what revisions are possible to lessen the risk to universities faced with relicensing.

In summary, we recommend that the small research reactors with a life-time fuel supply, and the four TRIGA reactors with FLIP type fuel, be exempted from the proposed NRC rule and that conversion of other HEU fueled reactors proceed only after existing stocks of HEU fuel elements are used, and when conversion can be done without a serious technical or economic penalty.

The Department of Energy strongly supports U.S. initiatives to prevent nuclear weapons proliferation, but seriously questions whether broadly imposing LEU conversion on domestic university reactors would have any positive and measurable impact on the proliferation issue.

Mr. Chairman, this concludes my prepared testimony and I will be happy to answer any questions you might have.

## UNIVERSITY RESEARCH AND TRAINING 'R

| UNIVERSITY | REACTOR TYPE | KW POWER | ENRICH-MENT | KG IN-CORE | KG STORED* UNIRRAD | KG STORED* IRRAD |
|---|---|---|---|---|---|---|
| **Plate Fueled Reactors** | | | | | | |
| University of Missouri-Col | PWR, Open pool, LW Mod & Cooled | 10000.00 | 93 | 5.40 | 1.55 | 35.00 |
| Georgia Institute of Technology | Tank, HW Moderated & Cooled | 5000.00 | 93 | 3.01 | 4.90 | .12 |
| Massachusetts Institute of Technology | Tank, LW Mod. HW Reflector | 4900.00 | 93 | 8.80 | 0.96 | 18.00 |
| University of Virginia | Pool, LW Moderated | 2000.00 | 93 | 3.23 | 4.38 | 4.7 |
| Rhode Island Nuclear Science Center | Pool, LW Moderated | 2000.00 | 93 | 3.60 | 0.25 | 4.2 |
| University of Lowell | Pool, LW Mod. Graphite Refl. | 1000.00 | 93 | 3.30 | 0.00 | .75 |
| University of Michigan | Pool, LW Moderated | 2000.00 | 20 | 6.35 | 0.00 | 0 |
| University of Missouri-Rol | Pool, LW Moderated | 200.00 | 89 | 2.87 | 0.00 | 1.4 |
| Virginia Polytechnic Institute | Argonaut, LW Mod. Graphite Refl. | 100.00 | 90 | 3.11 | 1.20 | 3.4 |
| University of California, L.A.1/ | Argonaut, LW Mod. closed 8/84 | 100.00 | 93 | 3.56 | 0.00 | 0 |
| University of Washington | Argonaut, LW Mod. Graphite Refl. | 100.00 | 93 | 3.43 | 0.61 | .21 |
| University of Florida | Argonaut, LW Mod. Graphite Refl. | 100.00 | 93 | 3.34 | 0.81 | .17 |
| Iowa State University | Argonaut, LW Mod. | 100.00 | 93 | 3.02 | 0.00 | 0 |
| Ohio State University | Pool, LW Moderated | 10.00 | 93 | 3.18 | 3.95 | .15 |
| Purdue University | Pool, LW Mod. Plate fuel | 1.00 | 93 | 2.05 | 0.00 | 0 |
| Worcester Polytechnic Institute | Pool, LW Moderated | 10.00 | 93 | 3.27 | 0.50 | 0 |
| University of Kansas | Open pool, tank, LW Mod. | 10.00 | 90 | 2.40 | 0.17 | .24 |
| University of Virginia | Pool, LW Cooled & Moderated | 0.10 | 93 | 2.30 | 0.00 | 0 |
| University of California, SB | L-77, LW Moderated | 0.01 | 89 | 1.23 | 0.00 | 0 |
| Rensselaer Polytechnic Institute | Critical Facility, LW Mod. | 0.00 | 93 | 4.99 | 0.03 | 0 |
| Manhattan College | ZPR, Pool, LW Moderated | 0.00 | 92 | 3.02 | 0.08 | 0 |
| **Triga/Rod Type Fueled Reactors** | | | | | | |
| University of Illinois | Triga, Open tank, LW Moderated | 1500.00 | 20 | 3.80 | 0.30 | 0 |
| Pennsylvania State University | Triga, MK III Pool, LW Mod. | 1000.00 | 20 | 4.37 | 0.00 | 0 |
| Texas A&M University | Triga, LW Mod. FLIP fuel | 1000.00 | 70 | 10.20 | 0.00 | 1.1 |
| Washington State University | Triga, Pool, LW Moderated | 1000.00 | 70 | 13.50 | 0.25 | 0 |
| University of California | Triga, Pool, LW Moderated | 1000.00 | 20 | 3.50 | 0.00 | 0 |
| Oregon State University | Triga, LW Mod. FLIP fuel | 1000.00 | 70 | 11.49 | 0.38 | .82 |
| University of Wisconsin | Triga, Pool, LW Mod. FLIP fuel | 1000.00 | 70 | 11.10 | 2.02 | .13 |
| Kansas State University | Triga, Pool, LW Moderated | 250.00 | 20 | 2.70 | 0.00 | 0 |
| University of Maryland | Triga, Tank | 250.00 | 20 | 3.40 | 0.00 | 0 |
| Reed College | Triga, MK 1, Pool LW Mod. | 250.00 | 20 | 2.30 | 0.00 | 0 |
| Columbia University | Triga, Pool, Not fueled | 250.00 | 20 | 0.00 | 0.00 | 0 |
| Michigan State University | Triga, MK 1, Pool type | 250.00 | 20 | 2.50 | 0.00 | 0 |
| University of California, IR | Triga, MK-1, Pool, LW Moderated | 250.00 | 20 | 2.29 | 0.00 | 0 |
| University of Texas | Triga, MK-1 Pool. LW Mod. | 250.00 | 20 | 2.55 | 0.00 | .71 |
| University of Utah | Triga, Pool, LW Moderated | 100.00 | 20 | 2.90 | 0.00 | 0 |
| Cornell University | Triga, MK II, Pool type | 100.00 | 19 | 3.00 | 0.00 | 0 |
| University of Arizona | Triga, Pool LW Moderated | 100.00 | 20 | 3.31 | 0.00 | 0 |
| Brigham Young University | L-77, LW Mod. Liquid Fuel | 0.01 | 20 | 1.38 | 0.00 | 0 |
| Idaho State University | AGN-201 | 0.00 | 20 | 0.67 | 0.00 | 0 |
| University of New Mexico | AGN-201 | 0.00 | 20 | 0.66 | 0.00 | 0 |
| University of Oklahoma | AGN-211 | 0.01 | 20 | 0.81 | 0.00 | 0 |
| Georgia Institute of Technology | AGN-201 | 0.00 | 20 | 0.66 | 0.00 | 0 |
| Memphis State University | AGN-201 | 0.00 | 20 | 0.66 | 0.00 | 0 |
| State University of New York | Pulstar, LW Mod. Open tank | 2000.00 | 6 | 18.00 | 0.00 | 0 |
| North Carolina State University | Pulstar, Pool type | 1000.00 | 4 | 14.36 | 0.00 | 0 |

*KG Stored shown only for reactors with HEU Fuel.

1/ UCLA announced plans for closing the reactor in August.