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STATEMENT OF DR. DAVID W. HAFEMEISTER

Subcommittee on Energy Development and Applications, and
Subcommittee on Energy Research and Production,
Committee on Science and Technology
House of Representatives

REGUARDING THE NEED TO CONVERT DOMESTIC RESEARCH REACTORS FROM HIGHLY ENRICHED TO LOW-ENRICHED URNAIUM FUELS

BIOGRAPHY BRIEF

I am a Professor of Physics at the California Polytechnic University. My curriculum vitae is attached. From 1962 to 1966, I used research reactors at the University of Illinois and at the Los Alamos Scientific Laboratory to carry out experiments in nuclear and solid state physics. From 1975 to 1977, I was Science Advisor to Senator John Glenn, who was the Ad-Hoc Chairman of the Governmental Affairs Committee on Nonproliferation matters. From 1977-79 I was Special Assistant and Expert Consultant to Under Secretary of State Lucy Benson and Deputy Under Secretary Joseph Nye, working primarily on nonproliferation matters. Among other responsibilities, I was the lead State Department delegate to Working Group 8 (Advanced Fuel Cycle and Reactor Concepts) of the International Fuel Cycle Evaluation (INFCE) which was held at the Internaional Atomic Energy Agency (IAEA) in Vienna. Subgroup C of this Working Group had as its sole task the assessment of methods of reducing proliferation risks associated with research reactors. I also was a member of the interagency Subgroup on Nuclear Exports (SNEC).

CONCLUSION

It is my opinion that research reactors in the U.S. should be required to convert from high-enriched uranium fuels (HEU) to low-enriched uranium fuels (LEU). The lower flux reactors can convert to the presently available uranium-aluminum fuels, and the higher flux reactors can convert to the uranium-silicon fuels which will be available in a few years. Exceptions to this conversion should be allowed only upon a finding that the new fuels would not be feasible. This conclusion is based on (1) requirements for adequate physical security, (2) consistency with the national policy on nonproliferation, and (3) technical availability of the new LEU fuels. If the NRC's proposed rule requiring conversion to non-weapons grade fuel does not go forward as planned, which I think would be a mistake, and HEU remained at these reactors, security would have to be strictly increased. The strictly increased security would be far more expensive than conversion, it would be academically intrusive, and it would be far less effective in reducing risks of theft of weapons-usable material. Failure to go forward with domestic conversion would throw a major obstical in the way of our long standing foreign policy goal of conversion of foreign reactors and reduction in the international commerce of HEU.

WEAPONS IMPLICATIONS

There is general agreement that highly-enriched uranium is

dangerous in that nuclear weapons can be fabricated from this material. The proliferation risk associated with HEU is that it can be used directly to make nuclear weapons, unlike the low-enriched uranium used, for example, in power reactors. No further enrichment, generally very costly and difficult, would be necessary in order utilize the material in a clandestine fission explosive, thus making it a potentially attractive target for theft or diversion. For this and related reasons, it has been the policy, both nationally and internationlly, to attempt to minimze the amount of HEU in use.

The American Nuclear Society acknowledges this problem. In a recent study (C. Starr, Science 224, 952 (1984)), the American Nuclear Society stated that:

> "There are now about 350 research reactors in about 50 countries, of which 25 are developing countries. Many of these reactors are too small to produce signficant amounts of plutonium. However, most of them have been supplied with highly enriched uranium fuel, which, in principle, might be accumulated to make a single nuclear device. This possiblity is now being precluded by conversion to lower enrichment (less than 20 percent) designs."

HEU WEAPONS

Since HEU can be used directly to fashion a clandestine fission explosive by either a state or a terrorist group, the use of HEU should be minimized, and when HEU is used it must be under adequate physical security. LEU is considerably less effective as a nuclear explosion since (1) it requires about 15 times more LEU uranium than HEU uranium (with reflectors), (2) about 3 times more U-235, and (3) it is much more difficult to develop and deliver a nuclear weapon that consists of hundreds of kilograms of uranium.

HISTORICAL PERSPECTIVE

The Indian device of 1974 hightened concerns in the U.S., the Congress, and the Executive Branch. Shortly after this event, about one-half dozen contracts were signed to export enrichment and reprocessing plants to smaller nations, many of which did not have an economic need for such facilities. In response to these events, the Congress commissioned a study by the Office of Technology Assessment. The OTA report (1977) acknowledged that solutions to nuclear nonproliferation are not simple by stating that:

> "It is not too late to contain proliferation at a level which can be assimilated by the international political system. However, there are no single or all-purpose solutions; no short-cuts. A viable nonproliferation policy will require the coordinated, planned use of a wide variety of measures."

THE RESPONSE OF THE CONGRESS

The U.S. Congress (essentially unanimously) responded to this situation by passing the Nuclear Nonproliferation Act of 1978 (NNPA) and the Glenn-Symington Amendment. As a result of these and other

actions, the U.S. policy is to minimize the use of HEU in the world. The U.S. government has not exported HEU for lower-flux reactors, and it has asked for conversion to higher density fuels in the future for higher-flux reactors. This program, known as the Reduced-Enrichment Research and Test Reactor Program (RERTR), represents the official policy of the United States aimed at attempting to reduce enrichments of research reactor fuels and thus the amount of HEU in use.

INTERNATIONAL RESPONSE

The summary report of the International Nuclear Fuel Cycle Evaluation (1980) has stated that it is feasible to markedly reduce the uranium enrichment of a great majority of research reactors: INFCE endorsed the conversion of HEU fueled research reactors to lower enrichment.

HEU EXPORT LICENSES

The U.S. no longer will accept new commitments to export HEU for foreign research reactors. New research reactors are being sold only with LEU fuels. A few commitments for HEU for high-flux research reactors are being carried out on an interim basis to Belgium, France, Holland and Japan, but, we have asked them to convert to LEU, and, as I understand it, they have agreed to do so. Recently, the U.S. did export 0.9 kg of HEU to the Canadian-built SLOW POKE reactor in Jamaica, but the Canadians have stated they will not request any more HEU for their research reactors.

HEU AND THE APPLICATION OF THE GLENN-SYMINGTON AMENDMENT

This amendment denies military and economic aid to those non-nuclear weapons states that (a) explode a nuclear device, or (b) build enrichment and reprocessing facilities outside of an international framework. On April 6, 1979, this sanction was applied to Pakistan since it was concluded that Pakistan was building an enrichment plant to produce weapons-grade uranium. This sanction was later removed because of the Soviet invasion of Afganistan. I was intimately involved with this amendment while working with Senator Glenn (joining him in the House-Senate Conference where the House accepted the Senate language), and while working in the State Department (debating its merits before the Deputy Secretary of State, at OMB meetings, writing testimony, etc.) This amendment was adopted without dissent in the Congress. The Congress was, and is, concerned about HEU.

HEU IN THE IRAQI REACTOR

This HEU-fueled research reactor was destroyed by Israel in 1981. France no longer will export HEU to Iraq, but they will export LEU to Iraq.

CONSISTENCY IN FOREIGN POLICY

The professional staffs concerned with nonproliferation matters are convinced that it would be helpful to convert U.S. research reactors in order to be consistent with the French, Canadian, and American positions. Interagency meetings at OMB might try to soften

this position, but I know of no serious nonproliferation staff member who would disagree with the conversion requirement. As we have seen from the examples of Pakistan and Iraq, nonproliferation can be compromised by other foreign policy concerns. It is true that the carrying out of a sanction against one nation, may well cost us in our diplomatic standing with that nation, and that larger events (such as the Soviet invasion of Afganistan) can push nonproliferation policy the other way, towards ignoring the problem. The beauty of the HEU conversion proposal is that, for at most $15 million, the U.S. can achieve consistency between what we demand of others and what we demand of ourselves. I have found out from personal experience when dealing with nuclear officials of other nations that "moral leadership" quite often does not work in foreign policy, but most of us would agree that being inconsistent by favoring our university reactors with HEU will certainly make the political climate abroad for the HEU to LEU conversions all the more difficult. In the area of nonproliferation policy, the $15 million figure is relatively minor, as compared to other costs in this area.

INTERNATIONAL RAMIFICATIONS IF THE DOMESTIC RULE IS REVERSED

Domestic HEU conversion would be consistent with U.S. policy of protecting against the very worrisome prospect of large quantities of HEU without adequate safeguards. Failure to take this precaution in the U.S. would damage U.S. foreign policy interests by undercutting our government's attempts to reduce international commerce in HEU and convince other nations of the need to reduce their HEU holdings. I know from personal experience in representing the State Department in interactions with nuclear officials from other countries that it will be much more difficult for the U.S. to succeed in its policy of reduced enrichments and HEU holdings abroad if the policy is not vigoriously pursed at home. This inconsistency would not be lost on the nations we are trying to influence.

PHYSICAL SECURITY

It should be stated that it is both national and international policy that kilogram quantities of HEU must be safeguarded. While timely warning, after the fact, of theft or diversion is a key element in such safeguards, post-loss reporting is not sufficient protection and fails to minimize the possibliites for unauthorized removal os such material. The removal of kilogram quanities of 93% enriched U-235 would have extraordinarily serious potential consequences.

Section 10 CFR 73.67(a)(1) states that

"Each licensee ... shall establish and maintain a physical proctection system that will achieve the following objectives:

(i) Minimize the possibilites for unauthorized removal of special nuclear material consistent with the potential consequences of such actions: and

(ii) Facilitate the location and recovery of missing special nuclear material."

First of all, I would like to address the word "consequences" in (i). The consequences of obtaining HEU could be the development of a nuclear device which could destabilize our international framework of nations. This extremely serious event might kill thousands of people and could be a precursor to an international conflict. Next I would like to address the word "consistent" in (i). To minimize the possibiliites of unauthorized removal in a way which is consistent with the seriousness of the potential consequences of such a removal means that very stringent physical security and recovery techniques must be available. The (hypothetical) intrusion must be site-specific. Is the facility really secure? The time line of possible recovery must be considered. How long would it take for a recovery team to arrive? Would the signal be triggered by the penetration into the building, and would there be time delays before the penetration of the secondary barriers? From where would recovery team come? Would the detection devices be applicable for fuel that was not very radioactive? How far can a vehicle travel during this time to get away with the fuel? What is scan rate of the aircraft? If it is 70 square kilometers per hour, then this would imply a radius of 4.7 km (3 miles). The minimum velocity of the escape vehicle would have to be

$$V\ (MPH) = 3/T$$

where T is the arrival time in hours of the monitoring aircraft after the first signal. If it took one hour after detecting the first signal of the violation to obtain a scanning aircraft above the reactor, the minimum velocity of the vehicle would be 3 MPH. It is difficult to imagine any vehicle being slow enough to get caught under this circumstances. In other words, one cannot contain HEU with post-theft detection since the fuel would be gone.

RADIATION BARRIER

As I understand it, the radiation level of a bundle of fuel from a typical 100 kW reactor would drop to only about 10 REM/hour (unshielded at 3 feet) in about 7 days after shutdown. Since this level would not deter theft, it would be necessary to protect the HEU with strict physical security measures.

CONCLUSIONS

Research reactors in the U.S. should be required to convert from HEU to LEU. The lower-flux reactors should do this within the near term, and the higher-flux reactors should convert to LEU when the U-Si fuels are available. Exceptions should be permitted only for the very rare case where it can be shown that this conversion is infeasible. If the reactors are not converted to LEU, then the reactors should be operated so that the fuel bundles will have strict physical security to protect them. Our long standing efforts to reduce HEU would be severely damaged if the proposed rule did not go into effect.

David W. Hafemeister

Professional Qualifications

1. Education:

   a. Bachelor of Science degree in Mechanical Engineering from Northwestern University, 1957
   b. MS. and Ph.D. in Physics, University of Illinois, 1959, 1964
   c. Post-Doctoral Fellowships:
      Los Alamos Scientific Laboratory (1964-66)
      American Association for the Advancement of Science
      Congressional Fellowship (1975-1976)

2. Employment

   a. Mechanical Engineer, Argonne National Lab (1957-58)
   b. Physicist, Los Alamos Scientific Laboratory (1964-66)
   c. Assistant Professor of Physics, Carnegie-Mellow University (1966-69)
   d. Associate Professor of Physics (1969-72)
      Professor of Physics (1972-)
      California Polytechnic University, San Luis Obispo, CA
   e. Visiting Professor of Physics
      University of Groningen, The Netherlands (1972, 1980)
   f. Legislative Assistant and Science Advisor to Senator John Glenn
      U.S. Senate (1975-77)
   g. Special Assistant to Under Secretary of State Lucy Benson and Deputy-Under Secretary Joseph Nye, U.S. Department of State (1977-1979)
   h. Visiting Scientist, Mass. Instit. of Technology (1983-4)

3. Experience with Nuclear Non-Proliferation Matters

   a. U.S. Senate: After the detonation by India of a nuclear device in 1974, the Committee on Governmental Affairs of the U.S. Senate held extensive hearings on the "Export Reorganization Act of 1975" which dealt with nuclear nonproliferation. It was my job to be the full-time staffperson to the Ad-hoc Chairman of the Committee, Senator Glenn, on hearings and mark-up of the act. I was Senator Glenn's main advisor on nuclear non-proliferation matters.

   b. Department of State: In 1977, I was appointed as one of two Special Assistant on the issue of nuclear nonproliferation to Under-Secretary Benson and Deputy-Under Secretary Nye. Dr. Nye had the lead role for nuclear non-proliferation in the Executive Branch and at the London Nuclear Supplier Negotiations.

      During this time, I was intimately involved with the drafting and passage of the Nuclear Non-Proliferation Act of 1978, participating in the Department of Energy's Non-proliferation Alternative Systems Assessment Program (NASAP), and dealing as a representative of the Under Secretary with officials of other nations' nuclear programs.

In addition, I was the lead State Department delegate to Working Group 8 (Advanced Fuel Cycle and Reactor Concepts) of the International Fuel Cycle Evaluation (INFCE) which was held at the International Atomic Energy Agency (IAEA) in Vienna Subgroup C of this Working Group had as its sole task the assessment of methods of reducing proliferation risks associated with research reactors. DOS member of interagency Subgroup on Nuclear Exports (SNEC).

4. Publications

a. Nuclear Non-Proliferation:

i. "Nonproliferation and Alternative Nuclear Technologies", Technology Review 81, 58 (December 1978).

ii. "Science and Society Test V: Nuclear Nonproliferation", American Journal of Physics 48, 112 (1980)

iii. prime author/editor of the Presidential Report to the Congress on the environmental impacts associated with nuclear exports abroad (1980)

iv. co-author/editor of the Supplement Nuclear Research and Development Export Activities to ERDA 1542 (U.S. Nuclear Export Activities), September 1979.

b. Solid State and Nuclear Physics:

20 articles; four book chapters; one book

c. Energy Technology and Policy:

15 articles, co-edited 2 books