# SCIENCE FOR DEMOCRATIC ACTION

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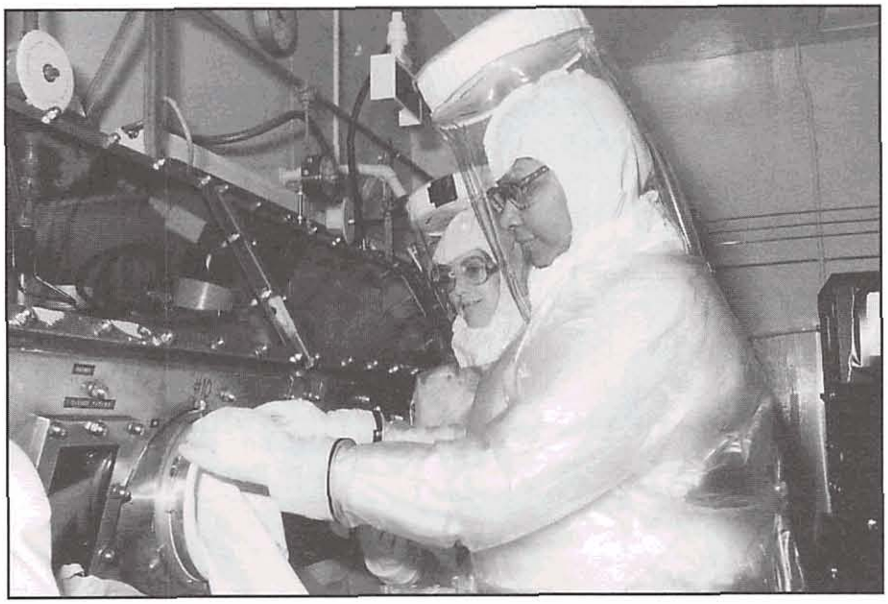

**Workers inspect gloveboxes in the F Area at the Savannah River Site.**

## DOE's Reprocessing Relapse

by Noah Sachs

Propelled by pork-barrel politics and flawed assumptions, reprocessing[1] is making a come-back in the United States. In recent press releases and statements to the media, the U.S. Department of Energy (DOE) has outlined a program of "limited" reprocessing for "environmental management" purposes to extract plutonium and/or uranium from some of its inventory of approximately 2,700 metric tons of spent nuclear fuel. According to DOE, reprocessing will reduce accident risks from continued spent fuel storage and will make it easier to dispose of nuclear materials in a geologic repository. However, DOE's program raises serious environmental and nonproliferation concerns.

The fine print on reprocessing is contained in dozens of DOE documents and environmental impact statements (EIS's) released in 1994 and 1995. They show that DOE is considering a hodgepodge of programs and policies that could resurrect reprocessing in the United States over the long-term. The documents demonstrate that DOE has not fully considered the environmental and non-proliferation liabilities of its reprocessing proposals. In fact, DOE's own data show that reprocessing carries greater environmental and health risks than other alternatives for spent fuel stabilization. But with an undiminished Cold War attachment to

*See* **Reprocessing** *page 2*

[1] Reprocessing is the separation of spent nuclear fuel (material that has been irradiated inside a nuclear reactor) into its constituent parts, mainly plutonium and/or uranium and lighter elements, called fission products, that are the product of nuclear fission in reactors.

## Tritium Production: DOE Moves Ahead Where Non-Proliferationists Fear to Tread

by Hisham Zerriffi

A recent U.S. Department of Energy (DOE) decision to resume production of tritium, a radioactive gas contained in nuclear weapons, could have profound effects on non-proliferation efforts as well as serious environmental and health consequences. The DOE and the Pentagon claim the move is needed to ensure adequate quantities of tritium to support a 5,000 warhead arsenal after the year 2011.

But woefully little public debate has preceded the assumption that the U.S. needs to maintain thousands of warheads for decades to come. Moreover, the DOE's decision does not seem to demonstrate good faith efforts toward nuclear disarmament, as required by the Non-Proliferation

*See* **Tritium** *page 12*

**Reprocessing,** *from page 1*

reprocessing among powerful members of Congress and in some parts of DOE, current proposals could be the first step down a decades-long reprocessing road in the United States.

## A Dangerous Backslide

DOE's decision is a dramatic reversal of previous policy. The Department of Energy and its predecessor agencies operated reprocessing plants for almost five decades to obtain bomb materials for the U.S. nuclear arsenal. But because of safety concerns and because the U.S. no longer needed fissile materials, reprocessing was suspended around 1990. Reprocessing ended at the Hanford Reservation in Washington in 1990. In 1992 DOE committed to phase-out reprocessing at the Savannah River Site (SRS) in South Carolina and at the Idaho National Engineering Laboratory. In the same year, President Bush officially halted military reprocessing and said his decision was part of a "set of principles to guide our non-proliferation efforts in the years ahead." The White House added that this decision was "intended to encourage countries in regions of tension such as the Middle East and South Asia to take similar actions."[2]

*DOE is backsliding on its 1992 phase-out commitment and is undermining the important non-proliferation groundwork that was laid in 1992.*

Now DOE is backsliding on its 1992 phase-out commitment and is undermining the important non-proliferation groundwork that was laid in 1992. The Department's proposals carry serious non-proliferation consequences because other countries will not be able to verify the purpose of the reprocessing or the destination of the fissile materials that may be extracted. They may perceive only that the United States is adding to its stockpile of weapons-usable materials. This comes at a time when the United States is working to end reprocessing programs in other countries such as North Korea, India, and Russia.

The United States is currently in a strong position to work to stem the proliferation dangers of reprocessing in other countries because it is the only major power not currently reprocessing for military or civilian purposes. DOE reprocessing proposals, though not military in nature, will nevertheless undermine U.S. credibility by creating the perception of a reprocessing double standard, especially since at least one of the two formerly military reprocessing plants at SRS will be in operation. (DOE reopened its F-Canyon reprocessing plant at SRS in February 1996.) Resuming reprocessing in the United States may undermine negotiation and implementation of the U.S.-supported international treaty barring fissile material production for military purposes. Despite these risks, non-proliferation issues are addressed only briefly or not at all in the DOE documents.

## Long-Term Reprocessing Relapse

While DOE characterizes its reprocessing proposals as a short-term environmental stabilization program, reprocessing remains very much an open-ended project. DOE has not put any end-point on the amount of material that may be reprocessed or on the time in which reprocessing plants may operate. Indeed, DOE is investigating several new types of reprocessing techniques, notably

*See* **Reprocessing** *page 3*

2 *Statement by the President and Fact Sheet on Nonproliferation Initiative*. White House Office of the Press Secretary, July 13, 1992.

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Managing Editor: Pat Ortmeyer

**Reprocessing,** *from page 2*

"electrometallurgical processing" at the Idaho National Engineering Laboratory. It has considered constructing new reprocessing plants at the Savannah River Site and at Hanford, as well as utilizing the existing Sellafield and Dounreay reprocessing plants in the United Kingdom.

In February 1996, DOE decided it would accept and manage 20 metric tons of spent fuel from research reactors in foreign countries, 95% of which will be sent to the Savannah River Site. Despite a rhetorical nod in the direction of studying alternatives, DOE appears to be on a course to reprocess this material. These proposals are a far cry from DOE's 1992 commitment to phase out reprocessing.

The Defense Nuclear Facilities Safety Board, which is charged with overseeing DOE facilities, said in a November 15, 1995 letter that "the Department of Energy will always need to have available a capability for chemical processing of spent nuclear fuel..." Though the two reprocessing plants at SRS are already over forty years old and are "not in the best of shape," the Safety Board advocated keeping both in operable condition. "Then in event of an unfortunate incident, such as an accident that incapacitated a Canyon (e.g., a fire, a massive contamination, a seismic event), there should still be the other to carry on." Surprisingly the Safety board did not consider the environmental, health, or safety consequences of keeping reprocessing plants open compared to continued storage of spent fuel. Its recommendation appears to be oriented toward maintaining the reprocessing capacity of the facilities rather than minimizing safety, health and environmental risks.

DOE appears to be preparing for long-term reprocessing in other ways. In 1995, it decided to consolidate spent fuel according to cladding type.[3] Since removal of the cladding is the first step in reprocessing, and different types of cladding involve different removal techniques, fuel consolidation by cladding-type makes it easier for DOE to reprocess its spent fuel inventories.

**DOE SPENT FUEL INVENTORY IN METRIC TONS, 1995**

| Location | Amount | Percent |
|---|---|---|
| Hanford | 2133 | 80.6 |
| ID Natn'l Engineering Lab. | 261 | 9.8 |
| Savannah River Site | 206 | 7.8 |
| Oak Ridge Reservation | 1 | .03 |
| Other DOE Facilities | 27 | 1.0 |
| Universities | 2 | .08 |
| Other | 16 | .6 |
| **TOTAL** | **2646** | **100** |

NOTES: According to DOE, approximately 95 metric tons of spent fuel will be added to the inventory by 2035 from foreign research reactors, naval reactors, domestic research reactors, and other sources.

Data on global military and commercial plutonium production can be found in *Science for Democratic Action*, Vol. 4 No. 3, pg. 12: "Rough Estimates of Cumulative Global Plutonium Production."

*Source:* DOE, *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*, April 1995, Summary, p.8.

## A Return of Civilian Reprocessing?

One of the most troubling aspects of DOE's policy is that it seems to reopen the door for a possible resumption of reprocessing of spent fuel from civilian nuclear power reactors. The United States has not reprocessed civilian spent fuel since 1972 because of cost, regulatory, and non-proliferation concerns. As a result, it is the only leading power with the credibility to work to stem the proliferation dangers from civilian reprocessing in countries such as Britain, France, Japan, Russia, and India. President Clinton has stated that the United States does not encourage civil reprocessing programs in other countries and that the U.S. abstention from reprocessing is important to achieve this goal.

Despite the Clinton administration policy, the Department has already tested electrometallurgical processing, a new kind reprocessing technology being developed in Idaho, with spent fuel from a civilian pressurized water reactor.[4] A DOE Environmental Impact Statement stated that future research and development efforts will include "electrometallurgical processing using limited quantities of commercial SNF [spent nuclear fuel]."[5]

Also very significant is a 1995 report by Westinghouse, DOE's Savannah River Site contractor, advocating that all 30,000 metric tons of civilian spent fuel in the United States, as well as naval spent fuel and all aluminum-clad DOE spent fuel, be reprocessed at the Savannah River Site. The prospect of long-term civilian reprocessing and the abandonment of close to two decades of U.S. leadership on the proliferation impacts of civilian reprocessing makes current proposals especially dangerous.

The Westinghouse proposal for reprocessing civilian spent fuel coin-

*See* **Reprocessing** *page 4*

[3] Cladding refers to the type of material out of which the tube that contains the fuel pellets is made. Cladding materials include aluminum, zircaloy (an alloy made with zirconium), stainless steel, and others.

[4] DOE, *DOE Spent Nuclear Fuel Technology Integration Plan*, DOE Office of Environmental Management, Office of Spent Fuel Management and Special Projects, December, 1994, p. B-4.

[5] DOE, *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*, Volume 1, DOE Office of Environmental Management and DOE Idaho Operations Office, April 1995, pp 3-9.

**Reprocessing,** *from page 3*
cides with increased support on Capitol Hill for reprocessing DOE and civilian spent fuel. In June 1995, Senate Armed Services Committee Chair, Strom Thurmond (R-SC) wrote that "a rational program for dealing with nuclear waste..." should include, "at minimum:"

> construction and funding of storage and reprocessing facilities at SRS specifically for commercial, research (foreign and domestic) and other DOE spent fuel, along with legislative mandates that reprocessing, once begun, not be interrupted.[6]

Senator Frank Murkowski, chairman of the Energy and Natural Resources Committee, visited French reprocessing facilities in 1995 and commented that the French policy of civilian reprocessing was "very responsible."[7]

The favorable climate on Capitol Hill and the desire of the state of South Carolina to continue reprocessing in order to maintain jobs have been important factors in advancing reprocessing proposals.

### UNDERSTANDING DOEese

No matter what you call it, it's still reprocessing. DOE, however, has its own vocabulary to describe the procedure. To help SDA readers stay on their toes, we offer this handy reference guide.

*DOE Reprocessing Dictionary*

| DOE Term | Definition |
|---|---|
| Aqueous Processing | Reprocessing |
| Chemical Processing | Reprocessing |
| Chemical Separation | Reprocessing |
| Chemical Stabilization | Reprocessing |
| Conditioning | Reprocessing |
| Electrometallurgical Processing | Reprocessing |
| Electrorefining | Reprocessing |
| Processing | Reprocessing |
| Process Q | Reprocessing |
| Pyroprocessing | Reprocessing |
| Stabilization | Reprocessing |
| Treatment | Reprocessing |

## Environmental Consequences of Reprocessing

While it is true that much of DOE's inventory of spent fuel is not stored under adequately safe conditions today, reprocessing is a cure that is worse than the disease. U.S. military reprocessing plants were never intended for environmental management. In fact, reprocessing was a leading cause of waste generation and environmental contamination among all stages in the nuclear weapons production process. DOE itself projects that stabilization and management of reprocessing wastes will be responsible for over half the costs of cleaning up the nuclear weapons complex.[8]

*One of the most troubling aspects of DOE's policy is that it seems to reopen the door for a possible resumption of reprocessing of spent fuel from civilian nuclear power reactors.*

DOE's reprocessing proposals will generate a significant amount of highly radioactive liquid waste that will be added to waste tanks already at risk of fire or explosion. Reprocessing proposals for the Savannah River Site, for example, will add about three million gallons of high-level liquid waste to the tanks there, a nine percent increase above current levels of high-level waste at the site.

The impact of reprocessing on the safety of the waste tanks is the most serious environmental liability of reprocessing, yet DOE has failed to consider this issue in any of its environmental impact statements. DOE made a similar mistake five years ago when it proposed reprocessing spent fuel from Hanford's N-Reactor. The plan was terminated after a study conducted by IEER pointed to serious unanswered environmental and cost considerations in DOE's analysis.

DOE's haphazard methodology is exemplified by the fact that some of its waste generation figures came from a Westinghouse report stating, "it is likely that careful scrutiny [of this report] will reveal numerous discrepancies, inconsistencies, and omissions," and that "there is little documented basis or calculations to support the data presented."[9] DOE has also relied on flawed assumptions, optimistic cost projections for reprocessing, and misleading terminology. DOE no longer uses the term "reprocessing" in its documents, preferring instead such terms as "processing," "conditioning," or "treatment of spent fuel" to refer to the separation of weapons-usable material from spent fuel. (See sidebar.) This misleading terminology may be a purposeful effort to hide reprocessing proposals behind unfamiliar names.

## An Alternative to Reprocessing

Interim storage of DOE spent fuel is the most sound alternative to reprocessing. DOE has already decided to store Hanford N-reactor spent fuel, which comprises about 75% of its spent fuel inventory, and it could build a similar storage facility at the Savan-

*See* **Reprocessing** *page 7*

6 Letter to Senator Frank Murkowski, June 29, 1995.
7 As quoted in *The Energy Daily*, April 28, 1995, "Murkowski Looks Overseas for Nuclear Waste Solution."
8 DOE, *Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report*, Volume 1, DOE Office of Environmental Management, March 1995, p. 4.21, figure 4.11.
9 Westinghouse Savannah River Company, *Technical Data Summary Supporting the Spent Nuclear Fuel Environmental Impact Statement*, Revision 2, Westinghouse Savannah River Co., March 1994, pp 2 and 8.

# LETTERS

*We received the following e-mail in response to our feature article in the last issue of SDA (Vol. 4 No. 4), "Calculating Doses from Disposal of High-Level Radioactive Waste." As the letter raises issues central to the debate about Yucca Mountain, SDA invited responses form Virginia Sanchez of the Western Shoshone Nation, where Yucca Mountain is located, and Professor Thomas Pigford, dissenting member of the National Academy of Sciences committee, which produced the report on standards for Yucca Mountain.*

Dear Arjun:

Thanks for tackling the NAS [National Academy of Sciences] analysis of Yucca Mountain exposure scenarios. I have the full report but haven't dared to open it.

You asked for comment. I think you fail to point out that, in other areas than radioactive waste disposal, the EPA [Environmental Protection Agency] has begun to back away from the concept of the maximally exposed individual. See for instance the NAS report "Science and Judgment in Risk Assessment," (1994), pp. 46-7. In its guidelines for conducting risk assessments, EPA now prefers "high end" exposure scenarios, which are looser approaches, rather than the maximally exposed individual, MEI, which has become a lightning rod for criticism of the regulators' unwarranted conservatism.

You point out that the "subsistence farmer" and the "small critical group" populations around Yucca Mountain are extensions of the MEI concept. [NAS committee member Professor Thomas] Pigford wants to keep them around, but the committee majority favors a looser standard for determining an exposed population (subarea averaging). To my mind the committee majority is in step with current approaches to risk assessment, and Pigford is a lonely throwback. Maybe the ICRP [International Commission on Radiation Protection] is too.

By clinging to outmoded constructs such as the MEI, risk assessors become all the more vulnerable to attack from their GOP critics. I don't see how a strategic retreat here is going to open the floodgates of environmental pollution.

On the other hand, having reported on Yucca Mountain (Smithsonian, 5-95) and having interviewed a Native American opponent of the project, I can appreciate how a 19th-century Shoshone band fits the description of the 24th-century subsistence farmer. If the Shoshones should by some miracle gain control of their ancestral lands, including Yucca Mountain, they may choose to adopt MEI thinking in their regulation of the white man's high-level repository. Otherwise, let's scrap the concept. This whole business is almost ludicrously hypothetical anyway, angels dancing on the head of a radioactive pin.

Regards — Jeff Wheelwright

*(Jeff Wheelwright is a science writer in Morro Bay, CA)*

## Response from Professor Thomas Pigford

Mr. Jeff Wheelwright states that EPA prefers "high end" performance scenarios rather than the maximally exposed individual (MEI) for calculating radiation doses from environmental releases of radioactivity. Indeed, EPA has adopted language that is more clearly defined, whereas the MEI has had many disparate interpretations in the field of health protection. However, Mr. Wheelwright is incorrect in alleging that the MEI exposure calculation as used in the TYMS[1,2] report is inconsistent with EPA's current practice.

The term "maximally exposed individual" (MEI) alarms some people who mistakenly think that it is the upper value of all possible dose calculations, obtained by assuming the most conservative limits of all vari-

*See* **Pigford** *page 6*

## Response from Virginia Sanchez

Mr. Wheelwright, in his fervor to support bad science and unethical risk assessment, misses the point made by Dr. Makhijani entirely.

The issue of whether we Western Shoshone regain "control" of our homelands was not the point. The point was that the National Academy of Sciences (NAS) committee chose to entirely ignore our land rights issue. The fact is that Yucca Mountain lies in the heart of Western Shoshone homelands, and that was not stated in the [NAS] report.

The second part to this is Western Shoshone ideology and the indigenous perception of the environment. A critically important principle for us to be able to continue as a people is [that] we must pay attention to

*See* **Sanchez** *page 7*

## LETTERS, continued

**Pigford,** *from page 5*

ables and parameters used to calculate exposure and dose. The MEI exposures referred to in the National Research Council's TYMS report on the Yucca Mountain Standard, and as addressed by the Yucca Mountain Project,[3] are calculated by establishing probability distributions that represent uncertainties in parameters and variables. The exposure of the MEI is calculated as the expected (mean) value of the resulting probabilistic distribution of exposures, not the value that would result from assuming limits of all parameters and variables.

The MEI calculated in this way should not be confused with a new term introduced by EPA, the theoretical upper-bound estimate (TUBE), which is an upper bound of all exposure calculations and is far greater that the reasonable maximum exposure. EPA states that the TUBE is inappropriate for determining exposures in an actual exposure assessment for compliance; it is strictly limited to screening out scenarios. I agree. EPA's stated policy is to make "exposure assumptions that result in an overall exposure estimate that is conservative, but within a realistic range of exposure."[4] Under this policy, EPA defines "'reasonable maximum' such that only potential exposures that are likely to occur will be included in the assessment of exposures."

For a geologic disposal dump, exposure frequency and duration are in large part a result of the calculable space-time-dependent concentrations of contaminants in the biosphere. Various human activities can also enter the calculation of exposures for near-term operations, but there is no scientific basis for predicting human habits for the far future, when the highest contaminant concentrations are predicted for geologic disposal systems.

However, we can identify the subsistence farmer as the conservative choice of the individual who will receive the maximum exposure in a given field of contaminant concentration. The choice is not unreasonable; there are subsistence farmers who use ground water in the Amorgosa Valley down gradient from Yucca Mountain. Therefore, the U.S. projects for geologic disposal of radioactive waste have adopted the subsistence farmer as the basis for calculating doses for the reasonable maximum exposure scenario, as have all other countries with similar projects. Thus, the MEI exposure referred to in the TYMS report appears to be synonymous with EPA's reasonable maximum exposure when applied to geologic disposal at Yucca Mountain.

The TYMS committee's belief that the subsistence farmer exposure scenario is too extreme is not justified by EPA guidelines, by the current practice of the Nuclear Regulatory Commission, by the International Commission on Radiation Protection, or by practice in the U.S. and in other countries.

The probabilistic analysis of future human activities, as proposed by the TYMS committee, is not scientifically based. It would rely on unjustified guesses of probabilities of exposure by future people. It would result in an enormously lenient relaxation of standards for health protection. The traditional, conservative, scientifically-based subsistence farmer approach, based on the reasonable maximum exposure of future farmers, is the only prudent and defendable alternative for long-term waste disposal. It is most likely to lead to early success in geological disposal.

If any standard is to be relaxed, then we should require that scientific fact and logic support the change, rather than what Mr. Wheelwright asserts to be political pressure. At the present time, no scientific bases exist to support a policy less stringent than the traditional subsistence farmer approach in effect today. Policy makers must reject pressures for short-term expediency and economy lest, by enacting policy that compromises scientific validity and credibility, they undermine public confidence and put an end to all further nuclear research and application. Other countries, including Sweden, Finland, the United Kingdom, France, Germany, Switzerland, Canada, and Japan, are designing geologic disposal systems using such conservative safety criteria, either as official criteria or as interim goals. It would be folly for us to do otherwise.

For further information, I suggest that Mr. Wheelwright actually read the report as well as my Dissent in Appendix E, which he has not done, by his own admission.

Thomas H. Pigford, Professor
University of California, Berkeley

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[1] Fri, R. W., *et al*, "Technical Bases for Yucca Mountain Standards," National Academy Press, Washington, D.C. 1995.

[2] Pigford, T.H., "Personal Supplementary Statement," Appendix E in "Tecnical Bases for Yucca Mountain Standards."

[3] Andrews, R.W., T.F. Dale, and J.A. McNeish, "Total System Performance Assessment — An Evaluation of the Potential Yucca Mountain Repository," Yucca Mountain Site Characterization Project, INTERA, Inc., Las Vegas, NV 1994.

[4] U.S. Environmental Protection Agency, in Federal Register, 55, 46, 8710, March, 1990

## LETTERS, continued

**Sanchez,** *from page 5*

our relationship/kinship to everything around us, animate and inanimate. Our history tells us how we were first created, placed within our particular bioregions, and provided with instructions on how best to live, allowing for those yet unborn. Soon after the Western Shoshone were created, Water, Air, Wind, and many others told us in unequivocal terms: "Take care of us, and we will take care of you."

From the perspective of being kin to water, the Western Shoshone believe the abandonment of explicit groundwater protection is completely unconscionable. The potential for dangerous precedent-setting, if EPA were to adopt such deplorable standards, would open floodgates of environmental pollution. Just look around you. There are no existing solutions to the radioactive contamination and radioactive waste problems — problems created and perpetuated by shortsighted, greedy interests. I also know that a piece of the solution exists within the indigenous view of the world.

> "We must all see ourselves as part of the Earth, not as an enemy from the outside who tries to impose his will on it...
>
> We, who know the path of the Great Spirit, also know that, being a living part of the earth, we cannot harm any part of her without hurting ourselves."
>
> (Lame Deer, Seeker of Visions, Lakota Nation)

Respectfully, Virginia Sanchez
Western Shoshone Nation

**Reprocessing,** *from page 4*

nah River Site within five years. Under this option, spent fuel at SRS would have to remain underwater in storage pools for a few years while the new storage facility is constructed. The safety of interim storage can and should be improved, as this approach does pose some degree of safety risks, but DOE's own data show these risks to be far lower than those from reprocessing.

*The impact of reprocessing on the safety of the waste tanks is the most serious environmental liability of reprocessing*

Interim storage generates far less liquid high-level radioactive waste than reprocessing, and, according to DOE, the incremental radiation dose to the offsite population near the Savannah River Site is four to five million times less from interim storage than from reprocessing. DOE has estimated that one worker will die from cancer over a forty year period as a result of a DOE decision to reprocess at SRS, but that there is negligible worker cancer risk from the storage option.[10]

An additional benefit of interim storage is that it does not exacerbate proliferation risks. On the contrary, it would allow DOE to more rapidly decommission and dismantle its existing reprocessing plants — a move likely to aid non-proliferation efforts.

Finally, interim storage would allow DOE to gain more information about repository options for its spent fuel before making irreversible near-term decisions. DOE's investigation of a repository site at Yucca Mountain, Nevada has a troubled history of delays and cost overruns, and repository emplacement of DOE nuclear materials may be two or more decades away.[11] DOE is putting the cart before the horse in letting long-term repository issues drive its near-term decisions on reprocessing.

### Conclusion

The United States is at a critical juncture. It could reverse the sound decisions that were made in 1992 and reprocess for a decade or more, jeopardizing important U.S. non-proliferation efforts. Or it could implement a spent-fuel management program based on interim storage and dismantle its existing reprocessing plants. In the documents and environmental impact statements released over the past two years, DOE has rushed to judgment in favor of the reprocessing option without sufficient analysis. By starting up its reprocessing plant at SRS, it has embarked on an environmental management program by relying on the most hazardous option. Though there are no ideal options for addressing the Cold War legacy of spent nuclear fuel, reprocessing is one option that should be abandoned.

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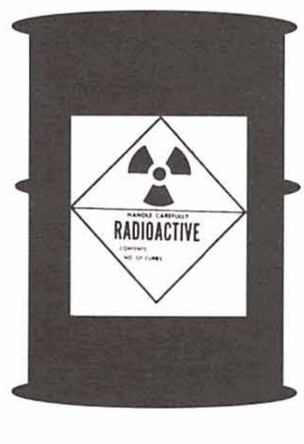
[10] DOE, *Programmatic Spent Nuclear Fuel Management*, Appendix C, pp 5-42 and 5-43.

[11] For more information on the proposed Yucca Mountain waste repository see *SDA* Vol. 4 No. 4.

Copies of the full, 99-page report *Risky Relapse Into Reprocessing* are available from IEER for $10.00, including postage. Special arrangements can be made for low-income groups or individuals.



# A CENTERFOLD FOR TECHNO-WEENIES

In this Centerfold we discuss reprocessing, the chemical separation of irradiated fuel (also called "spent fuel") into its component parts: fission products, plutonium and uranium. It is generally regarded as a key link between civilian nuclear power and nuclear weapons production, since plutonium must be separated from irradiated fuel to be usable in nuclear weapons. In fact, the presence of reprocessing plants is a prime indicator of the ability to make nuclear weapons, whether or not the country in question has a declared program or even the current intention of making them.

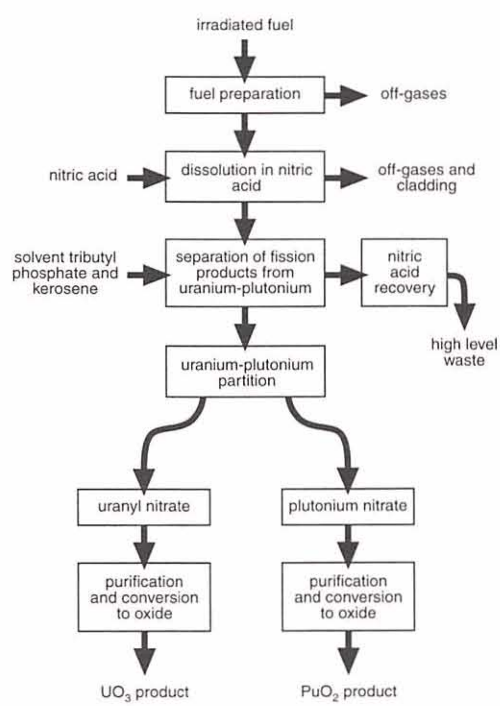
While reprocessing is essential to the production of weapons-usable plutonium, plutonium is not created by reprocessing. Plutonium is first produced in a nuclear reactor from uranium-238 in fuel rods during the course of a controlled nuclear chain reaction in the reactor core. In uranium-fueled reactors, uranium-238 in the fuel rods is converted into fissile plutonium-239 as a result of neutron absorption. Gradually, some of the plutonium-239 is converted into non-fissile plutonium-240 upon absorption of another neutron. As the reactor continues to operate, more uranium-238 is converted into plutonium-239, leading to more plutonium-240 build-up as well. Higher plutonium isotopes, notably plutonium-241 and plutonium-242, also build up with longer irradiation time.

Plutonium is produced in both civilian and military reactors. Spent fuel in civilian plants is typically "high burn-up" spent fuel — that is, it has been irradiated for extended periods at high power output in the reactors so as to generate a large amount of energy. Uranium irradiated for the extraction of plutonium for weapons is "low burn-up" fuel, which has been irradiated to minimize production of plutonium-240 and other undesirable higher plutonium isotopes. Plutonium

*See* **Centerfold,** *page 9*

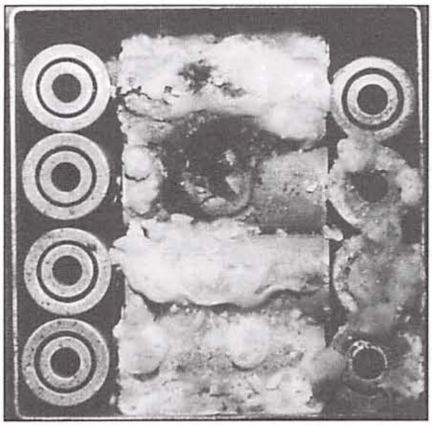
## The Purex Process

1. *Decladding:* One of several processes is used to either open or dissolve the cladding to expose the contents of the irradiated uranium fuel and/or targets.[1]
2. *Dissolution of irradiated fuel.* The fuel rod contents are then dissolved in nitric acid and are now in solution as nitrates. Cladding which has been opened is left unreacted. Cladding which has been dissolved is separated and processed to be stored or discarded as nuclear waste. Both processes (decladding and dissolution) release radioactive gases.
3. *Separation of plutonium and uranium.* The solution is exposed to a solvent called tributyl phosphate (TBP) mixed with kerosene. The TBP selectively separates out the plutonium and uranium from the fission products.
4. *Separation of plutonium and uranium from each other.* The plutonium and uranium are then separated by solvent extraction, producing plutonium nitrate and uranium nitrate, both in solution. Each may be further processed before shipping to reduce risks from accidents. Plutonium in particular is generally converted to solid oxide or metal form before shipping or storage. Uranium is converted to uranium trioxide.




[1] In some military production reactors, as at the Savannah River Site in South Carolina, the special uranium-238 "target rods" are bombarded with neutrons to convert the uranium-238 into plutonium. The irradiated target rods as well as the fuel rods that create and maintain the chain reacton often go under the common rubric "spent fuel."

*Diagram:* Simplified diagram for the Purex process. Adapted from Benedict, M., T.H. Pigford, and H.W. Levi, *Nuclear Chemical Engineering*, 2nd ed., 1981, p. 467.



Corroded reactor target slugs, Reactor Disassembly Basin, Savannah River Site.


Aerial view of the Savannah River Site F Canyon, which was reopened for reprocessing in February 1996. (Note: A-line labeled, but not visible in photo.)

**Centerfold,** *from page 8*

from spent fuel with less than 7% plutonium-240 content is considered "weapons grade" by the Department of Energy, but it is possible to make a nuclear bomb with less pure grades, including plutonium from high burn-up commercial reactor fuel. This is why any consideration of the separation and transportation of plutonium raises significant security concerns, regardless of the stated purpose of the reprocessing.

Plutonium in irradiated fuel cannot be used until it is recovered from the spent fuel through reprocessing. The most common kind of reprocessing is called the "Purex" process, which stands for *P*lutonium-*UR*anium *EX*traction. (See diagram, page 8.)

Other reprocessing techniques that have been used in the past, notably at Hanford, are the Butex (for diBUTyl carbitol EXtraction) process, the Redox (for *RED*uction *OX*idation) process, and the original bismuth phosphate process used to build the first U.S. atom bomb. DOE is also developing new reprocessing methods. The farthest along is electrometallurgical processing, which uses electrolysis to separate spent fuel components. (See main article.)

## DOE Radioactive Waste Inventories as of December 31, 1994

| WASTE CATEGORY | | VOLUME ($m^3$)* | RADIOACTIVITY** (millions of curies) |
|---|---|---|---|
| **High Level Waste** | Savannah River (DOE) | 126,300 | 534.5 |
| | Idaho (DOE) | 11,000 | 51.6 |
| | Hanford (DOE) | 238,900 | 348.0 |
| | West Valley (Commercial & DOE) | 2,180 | 24.7 |
| **Transuranic Waste** | Buried TRUW (transuranic waste) | 141,100 | >0.75 |
| | Potentially Contaminated Soil | >32,000 | >0.08 |
| | Stored TRUW | 74,200 | 1.84 |
| **Low-Level Waste** | (DOE sites) | | |
| | Generated | 37,990 | 0.9 |
| | Cumulative Stored | 125,890 | 3.9 |
| | Cumulative Disposed | 2,963,350 | 12.9 |

* Nuclear waste material is commonly expressed in terms of its volume (i.e., cubic meters), while spent fuel is expressed in terms of its mass (i.e., metric tons). See table, p. 3.
**Except for transuranic wastes, radioactivity data are calculated decayed values as of 12/31/94.

Source: Office of Scientific and Technical Information, Integrated Data Base Report–1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics. DOE/RW-0006, Rev. 11, (Oak Ridge National Laboratory, Oak Ridge, TN, September, 1995), p. 15.

**TECHNOWEENIES TAKE NOTE:** This table is an addendum to the centerfold table of *SDA* Vol. 4 No. 1 page 9. See comments below for further explanation.

### Typical Current Levels of Radionuclides in Soil Due to Fallout from Atmospheric Testing

| RADIONUCLIDE | | SURFACE DEPOSITION (picocuries/cm$^2$) | DECAY-CORRECTED CONCENTRATION (picocuries/gram) |
|---|---|---|---|
| Strontium-90 | Northern hemisphere | 5.8 | 0.10 |
| | Northern hemisphere 40-50 | 8.7 | 0.15 |
| Cesium-137 | Northern hemisphere | 9.3 | 0.15 |
| | Northern hemisphere 40-50 | 14.0 | 0.24 |
| Plutonium-239 | Northern hemisphere | 0.06 | .003 |
| | Northern hemisphere 40-50 | 0.10 | .004 |
| Plutonium-240 | Northern hemisphere | 0.04 | .002 |
| | Northern hemisphere | 0.06 | .003 |
| Plutonium-241 | Northern hemisphere | 1.33 | 0.015 |
| | Northern hemisphere 40-50 | 2.00 | 0.020 |

## Comments:

1. The first release of this table (SDA Vol. 4 No. 1) gave values of concentrations of radionuclides from atmospheric testing on an as-deposited basis. That is, it assumed that only a thin surface layer was contaminated and did not correct for decay. The values in this table assume diffusion into a six-inch thick layer of soil and are corrected for decay as follows: strontium-90 and cesium-137: 40% left; plutonium-241: 25% left (decayed to americium-241); other plutonium isotopes not significantly decayed.

2. Deposition is generally measured in curies per square kilometer. The figures in units of picocuries/cm$^2$ are also aerial values. (1 picocurie/cm$^2$ = 0.01 curie/km$^2$). We assume a soil density of 1.6 grams/cc for computing concentrations of radioactivity per gram of soil, which is useful for comparing fallout values with natural radioactive materials present in the soil. See SDA Vol. 4 No. 1 for natural radioactivity values.

TECHNOWEENIE REFERENCE GUIDE

# A Guide to Past SDA Centerfolds

**(arranged by topic)**

Past SDA Centerfolds, an invaluable source of technical data, can be ordered from IEER at no charge. Simply call, write, or e-mail us for a copy of the Centerfold you need.

### Radioactive Materials and Their Properties:

- Table of Radioactive Materials (Vol. 2, No. 1)
- Dose Conversion Factors (Vol. 2, No. 3)
- Properties of Plutonium Metal (Vol. 3, No. 2)
- A Tool Kit on Natural and Man-Made Radiation (Vol. 4, No. 1)
- Units of Radioactivity–Bequerels and Curies (Vol.1, No.1)

### Legal Limits and Standards for Radioactive Materials

- Selected Derived Air Concentration Limits (Vol. 2, No.2)
- Radiation Clean-Up Standards (Vol. 3, No. 1)

### Nuclear Reactors

- Types of Nuclear Reactors (Vol. 3, No. 3)

### Nuclear Testing

- Estimated Doses and Fatal Cancers from Nuclear Testing (Vol. 4, No.2)

### Other

- Retrospective on the Nuclear Age (Vol. 4, No. 3)
- Yucca Mountain Exposure Scenarios (Vol. 4, No. 4)
- Calculating Specific Activities (Vol. 1, No. 2)
- Table of Units (Vol. 1, No. 3)

# It Pays to Increase Your Jargon Power

by Dr. Egghead

**1. Tritium:**

a. A form of government in ancient Rome headed by triplet brothers.
b. What the French think was a market in ancient Rome where the children would buy their candies ("trits").
c. A German word for a greenhouse in which only trees are planted.
d. A radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons.

**2. Plutonium:**

a. The rock out of which the planet Pluto is made.
b. A toy factory in which only stuffed Pluto dogs are manufactured.
c. The 94th element in the periodic table. Plutonium-239 is an element with 94 protons and 145 neutrons in its nucleus and a half-life of about 24,000 years. It is a radioactive weapons-useable material which is highly carcinogenic when inhaled. It emits mainly alpha radiation.

**3. Reprocessing:**

a. The digestive process of ruminants which involves the regurgitation and mastication of swallowed food.
b. In psychology, a client's repeated telling of his or her troubles.
c. In law, the renewed summons for an individual to appear in court when he/she has failed to do so following the first summons.
d. The chemical separation of irradiated nuclear fuel into uranium, plutonium, and fission products.

**4. Electrometallurgical processing:**

a. A new kind of electric stimulation treatment to help people with allergies to metal.
b. The dangerous practice of using a fork to retrieve a bagel from a still-plugged-in toaster.
c. A method used to produce electricity from metals.
d. A new reprocessing technology which uses electrolysis to separate fission products from uranium and transuranics. One feature of this process is that uranium and transuranics are collected at different electrodes. The end product is in metal form.

**5. PEIS:**

a. A green leguminous plant hated by children but believed to be beneficial healthwise, hence the order by mothers to their children at mealtime: "Eat your peis!"
b. The acronym of the Potato Eaters of Ireland Society.
c. Acronym for Programmatic Environmental Impact Statement, which is an evaluation of the effects of a particular program on the environment.

**6. Triple play reactor:**

a. In baseball, the member of the crowd who responds most vociferously when 3 outs are made on a single at-bat.

**Triple play reactor:** A person who gets angry after gambling three times and losing.

b. A person who gets angry after gambling three times and losing.
c. An actor who re-enacts the same play three times.
d. A reactor which would achieve these three results: produce tritium, use military surplus plutonium, and produce electricity for civilian consumption.

**7. NPT:**

a. Acronym for the Non-Proliferation Treatment which was used in Australia to check the overpopulation of rabbits.
b. A short way of saying "No Please, Thank you" becoming increasingly popular among teenagers due to Nancy Reagan's "Just Say No" campaign.
c. Acronym for the Non-Proliferation Treaty which came into effect in 1970 and was indefinitely extended in 1995.[1]

[1] See SDA article in Volume 3, Number 3.

Correct answers: 1. d.; 2. c.; 3. d.; 4. d.; 5. c.; 6. d.; 7. c.

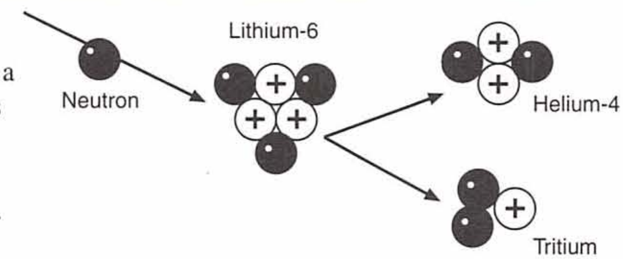
**Tritium,** *from page 1*

Treaty. It does not even take into account the minimum steps needed to reduce the danger of a black market in Russian tactical nuclear weapons.

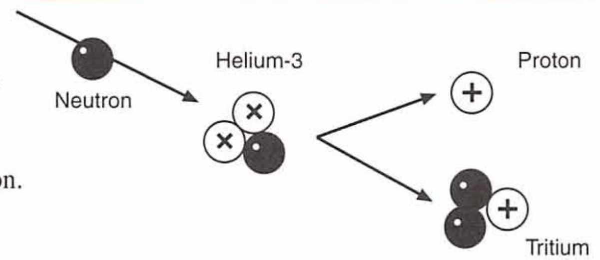
The Department of Energy has not had an operating tritium production facility since 1988 due to safety and health concerns at its aging facilities. Recently it has explored new production technologies and will investigate a commercial reactor option while funding accelerator research. The DOE is under pressure to consider a third option, the new so-called "triple play" reactor. In addition to producing tritium, such a reactor would use surplus military plutonium as fuel and would generate power for civilian consumption. The final decision is expected to be made in three years following the assessment of each approach.

**THE TWO BASIC NUCLEAR PROCESSES FOR PRODUCTION OF TRITIUM**

A neutron strikes a Lithium-6 nucleus making a Tritium nucleus and a Helium-4 nucleus.




A neutron strikes a Helium-3 nucleus making a Tritium nucleus and a proton.




## What is Tritium?

Tritium is a radioactive isotope of hydrogen which has both commercial and military applications. Tritium's commercial uses include medical diagnostics and sign illumination, especially EXIT signs. However, commercial tritium use accounts for only a small fraction of the tritium used worldwide. Tritium's primary function is to boost the yield of both fission and thermonuclear weapons. Contained in removable and refillable reservoirs, tritium increases the efficiency of the use of nuclear materials in warheads.

Tritium's relatively short half-life of 12.3 years and its low concentration in nature necessitate artificial production for use in warheads. Total U.S. tritium production since 1955 is estimated to be 225 kilograms, approximately 150 kilograms of which have decayed into helium-3, leaving a current inventory of approximately 75 kilograms.[1] (Actual data are still classified.) In the United States, tritium has been produced in reactors operated for tritium and plutonium production.

## Health and Environmental Effects of Tritium Production

Tritium contamination exists in the groundwater, surface water, and soil at the Savannah River Site in South Carolina, among other sites, from both operational releases and accidents. Even in low concentrations, tritium has been linked to developmental problems, reproductive problems, genetic abnormalities, and other health problems in laboratory animals.[2] Additionally, tritium may be linked to adverse health effects on populations near facilities which utilize tritium. (For example, an increased incidence of Down's Syndrome has been reported near the Darlington tritium extraction facility in Ontario, Canada.)

Tritium most commonly enters the environment in gaseous form ($T_2$) or as a replacement for one of the hydrogen atoms in water. This "tritiated water" (or HTO, instead of ordinary, non-radioactive $H_2O$) can replace ordinary water in the soft tissue in the human body, approximately 70% of which is water. It can also enter fetuses through the placenta due to its similarities to ordinary water. Once in living cells, tritium can replace hydrogen in the organic molecules in the body. Thus, despite its low radiotoxicity in gaseous form[3] and its tendency to pass out of the body rather rapidly as water, the health effects of tritium are made more severe by its property of being chemically identical to hydrogen.

In addition to the health and environmental threats posed by tritium, normal operation of reactors generates a host of other toxic wastes, including spent fuel and other categories of radioactive and hazardous waste. Should the DOE decide to pursue the reactor option to produce tritium, it would generate from 68 to 105 metric tons of heavy metal in spent fuel

*See* **Tritium** *page 13*

[1] D. Albright et. al., *World Inventory of Plutonium and Highly Enriched Uranium 1992*, Oxford University Press, 1993, p. 34; and Christopher Paine, prepared testimony, *Awash in Tritium: Maintaining the Nuclear Weapons Stockpile in an Era of Deep Reductions*, Natural Resources Defense Council, April 6, 1992, p.14.

[2] For a list of studies that have been conducted on the health effects of tritium, see bibliography in T. Straume, *Health Risks From Exposure to Tritium*, UCRL-LR-105088, Lawrence Livermore National Laboratory, Feb. 1991.

[3] Tritium is considered to have low radiotoxicity, compared, for example, with cesium-137, because it emits relatively low energy beta particles which cannot penetrate the skin, and because it does not emit gamma radiation.

**Tritium,** *from page 12*

per year. This would be added to about 2,700 metric tons of heavy metal in spent fuel that is in DOE's inventory.

If DOE pursues an accelerator option, the facility would not produce spent fuel, but would still produce other waste products, including low-level radioactive waste. The coal or natural gas facility needed to power the accelerator would also create environmental problems, including emissions of sulfur dioxide, carbon monoxide, carbon dioxide, and nitrogen oxides. These pollutants contribute to the problems of acid rain and global warming and have adverse health effects.[4] Still, according to the DOE, the environmental effects of accelerator production of tritium would be less than those from a reactor. This factor contributed to DOE's decision to designate the accelerator as one of its preferred options for tritium production.

*DOE's decision does not even take into account the minimum steps needed to reduce the danger of a black market in Russian tactical nuclear weapons.*

## How Much Tritium Do We Need?

The amount of tritium required by the DOE and the Department of Defense for the nuclear weapons stockpile is determined by several factors, including the amount of tritium needed per warhead, the tritium tied up in the "tritium pipeline,"[5] and the size of the nuclear arsenal.

Of these, the size of the nuclear arsenal has the most direct effect on the amount of tritium required. Over the years, the arsenal size that the Pentagon considers adequate to fulfill its requirements has varied widely. For example, in 1954 the Strategic Air Command estimated that after an attack of just 600-750 warheads, "virtually all of Russia would be nothing but a smoking, radiating ruin at the end of two hours."[6] Later in the Cold War, the number of targets proliferated, especially with the addition of Soviet warheads, missiles, and leadership and command structures as targets. The number of strategic targets in the National Strategic Targeting Database doubled from 25,000 to 50,000 between 1980 and 1985.

The end of the Cold War brought changes in the Pentagon's requirements. Between 1990 and 1992 the Pentagon's "minimum" requirement fell from over 10,000 to 3,500 strategic warheads. Currently, no role has been established for nuclear weapons in post-Cold War military and foreign policy, so there is no generally agreed upon "minimum" for strategic warheads. DOE's estimate of 5,000 warheads necessitates a new tritium production facility by 2011. But by decreasing the stockpile to 1,000 warheads a new tritium facility would not be needed until approximately 2024. If the stockpile were reduced further and the tritium pipeline upgraded, a new facility may not be needed until the middle of the next century or beyond.

## Reducing the Minimum Requirement

*Reduction of Tactical Nuclear Weapons.* Tactical nuclear weapons (such as nuclear landmines and neutron bombs) formed a large portion of the nuclear arsenal during the Cold War. But due to their portability, these weapons pose high security risks, particularly in Russia, where the danger of a black market in tactical warheads is fueled by a poor economic situation and concerns over nuclear safeguards at Russian facilities. This has already led the U.S. and Russia to withdraw most tactical weapons from deployment pursuant to a 1991 initiative by President Bush taken explicitly to reduce black market threats. In order to persuade Russia to eliminate its tactical stockpile, the United States must take the initiative by dismantling the rest of its tactical stockpile. Eliminating the approximately 1,000 tactical warheads (950 active plus spares) scheduled to remain in the U.S. arsenal would delay a tritium decision by three or four years.

*Minimum Deterrence.* Many analysts, some with extensive military planning experience, advocate a theory known as "minimum deterrence." This theory assumes that a country will not risk an attack on the United States if the U.S. arsenal is powerful enough to inflict unacceptable damage and fatalities in a retaliatory attack. Proponents of minimum deterrence postulate that the U.S. could pose a credible second strike threat with anywhere from one to 1,000 invulnerable warheads, thus allowing significant reductions in its nuclear arsenal. Since a single warhead would devastate the capital of any country, there is no credible argument for hundreds, much less thousands, of warheads for such a purpose. Advocates of minimum deterrence include former Secretary of Defense Robert McNamara; Jonathon Dean, Ambassador to the Mutual Balanced Forces Reduction Talks; and Herbert York, first director of Lawrence Livermore National Laboratory.

*Adherence to the NPT.* Tritium production would be an entirely aca-

*See* **Tritium** *back cover*

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4 DOE, *Programmatic Environmental Impact Statement for Tritium Supply and Recycling,* DOE/EIS-0161, U.S. Department of Energy, Office of Reconfiguration, October 1995, pp. 40-478 and 40-480.

5 The "tritium pipeline" includes the tritium needed to operate purification and loading facilities and the tritium tied up in the reservoir exchange process.

6 From the notes of Navy Captain William Brigham Moore at a Strategic Air Command briefing on March 15, 1954. Reprinted in Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb,* Simon & Schuster, 1995, p.563-564.

## SELECTED PUBLICATIONS

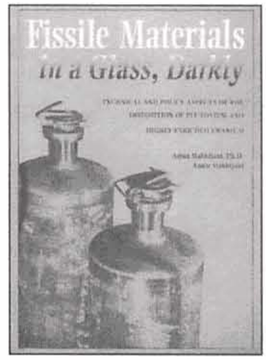

### Nuclear Wastelands
### *A Global Guide to Nuclear Weapons Production and Its Health and Environmental Effects*

MIT Press, 1995
(produced with IPPNW)
edited by Arjun Makhijani, Howard Hu, and Katherine Yih

A handbook for scholars, students, policy makers, journalists, and peace and environmental activists, providing concise histories of the development of nuclear weapons programs of every declared and de-facto nuclear weapons power. The thorough documentation and analyses of *Nuclear Wastelands* bring to light governmental secrecy and outright deception that have camouflaged the damage done to the very people and lands the weapons were meant to safeguard.

No future research into nuclear weapons will be credible unless it refers to this study.
—Jonathan Steel, *The Guardian* (UK), August 9, 1995

Hardbound, 666 pages. List price: $55.00. SDA readers discount price: $40.00 (postage included)




### Fissile Materials in a Glass, Darkly

IEER Press, 1995
by Arjun Makhijani and Annie Makhijani

**Now available in RUSSIAN**

IEER's report analyzes the options for disposition of plutonium and highly enriched urânium and recommends policies designed to put these materials into non-weapons-usable forms as rapidly as possible. It urges that the U.S. adopt vitrification of plutonium as its disposition option (rather than using it in reactors) in order that it may persuade countries still separating plutonium from civilian spent fuel to stop doing so.

Paperback, 126 pages. Price: $12 including postage and handling.

### ORDERING INFORMATION

**Books/Reports:** Indicate titles and quantities and make checks payable to IEER.
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## IEER RESOURCES BY TOPIC

(All resources free unless otherwise indicated.)

**Radioactive Materials and Their Properties**

- NEW Tritium: The environmental, health, budgetary, and strategic effects of the Department of Energy's decision to produce tritium (13 pp.)
- Fissile Material Basics (Produced with Physicians for Social Responsibility (PSR) – 2 pp.)
- Fissile Material Health & Environmental Dangers (Produced with PSR – 2 pp.)
- Physical, Nuclear, and Chemical Properties of Plutonium (4 pages)
- Uranium: Its Uses and Hazards (4 pp.)

**Radioactive Waste**

- NEW Risky Relapse into Reprocessing (99 pp., $10.00)
- Incineration of Radioactive and Mixed Waste (4 pp.)

**Technical Information**

- IEER's Yellow Pages - The technical reference guide for activists, citizens and policy makers on nuclear waste and cleanup issues. (22 pp.)
- *Science for Democratic Action.* (See page 10 for topics in past issues.)

# News From the IEER Library

IEER's library recently acquired a collection of the works of Joseph Needham, a great scholar of Chinese science and technology. This collection was a gift to IEER president, Arjun Makhijani, from the late W.H. Ferry, a friend, visionary, and mentor, who passed away last year.

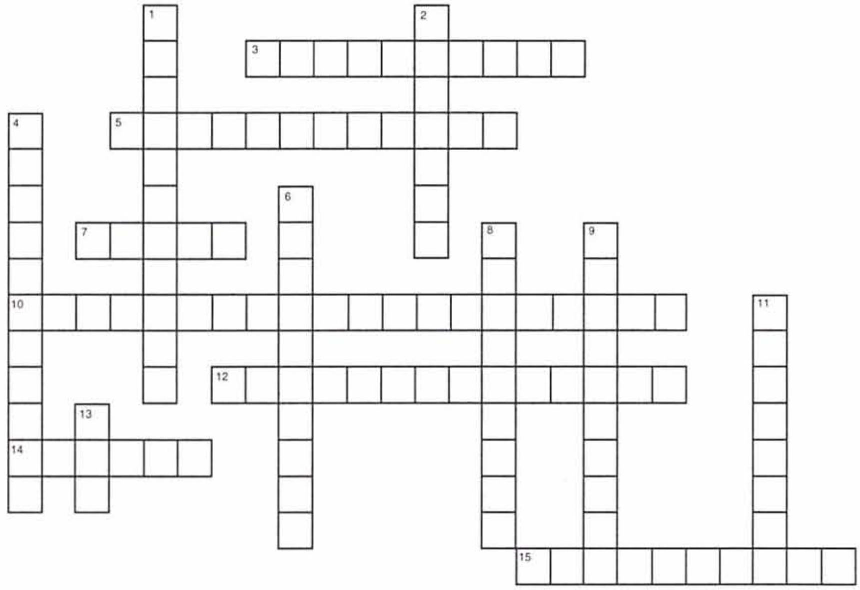
A list of titles in the collection is available from IEER librarian, Lois Chalmers. Serious researchers are welcome to use these materials in IEER's office (by appointment only). Please contact Lois Chalmers for arrangements. References may be required.

## Errata

In the table "Natural Radionuclide Concentrations in Continental Waters" on page 8 of SDA Volume 4 Number 1, the note for Radium-226 should read: "EPA standard for combined radium-226 and radium-228 is 5 pCi/l."

# ATOMIC PUZZLER

Time once again for the popular *SDA* Atomic Puzzler! Yes, this is the familiar **Crossword Edition**, but just so your math skills don't get rusty, we've tossed in a little "Arithmetic for Activists" too. *All words are described somewhere in this issue of SDA.* So read closely, sharpen those pencils, and good luck! And remember, **you could win $25!!**




## ACROSS

3. A multi-purpose reactor, one of whose uses would be tritium production.
5. A generic term for the process of separating spent nuclear fuel into plutonium, uranium, and fission products.
7. This method for the process described in 5 Across uses tributyl phosphate as a solvent.
10. Adjective describing a new technique for the process described in 5 Across to collect uranium and transuranics on different electrodes.
12. IEER recommends this short-term option for the management of spent nuclear fuel.
14. _______ acid is used to remove cladding from spent nuclear fuel rods in the process described in 7 Across.
15. Fuel which has been irradiated for an extended period of time to generate large amounts of energy.

## DOWN

1. DOE will fund research into this type of tritium production technology while pursuing a commercial reactor option.
2. Decay product of tritium.
4. SEE SPECIAL EGGHEAD PUZZLER QUESTION
6. In addition to principles for nuclear non-proliferation and disarmament, the final document of the 1995 Review and Extension Conference of the Non-Proliferation Treaty also outlined _______.
8. Adjective referring to the long-range weapons being reduced in START II.
9. The process through which irradiated uranium fuel and/or targets are exposed.
11. Tritium is a radioactive isotope of this element.
13. Technical shorthand for tritiated water which has one atom of tritium in it.


**PART 1:** The Department of Energy is considering reprocessing a variety of materials at the Savannah River Site. One material is Mark-31 targets used to produce plutonium. The DOE currently has approximately 16,000 Mark-31 targets at the Savannah River Site. Reprocessing would generate approximately 131.25 liters of liquid high-level waste (HLW) for every target processed. How many liters of liquid HLW would be generated from reprocessing all the Mark-31 targets?

**PART 2:** The DOE had 127 million liters of liquid HLW at the Savannah River Site at the end of 1993. What would be the percentage increase in liquid HLW at the site with the waste generated by reprocessing the Mark-31 targets, and an additional 9.5 million liters of liquid HLW from other proposed reprocessing plans? (Express answer as a percent, rounded to the nearest whole number.)

**NOTE:** This is a two-part question. Enter only the second answer.

The **Atomic Puzzler** is a regular *Science for Democratic Action* feature. We offer 25 prizes of $10 to people who send in solutions to all parts of the puzzle, right or wrong. There is one $25 prize for a correct entry. Fill in the puzzle and submit the answer (either a photocopy of the solved puzzle or the answers written out) to Pat Ortmeyer, IEER, 6935 Laurel Avenue, Takoma Park, MD 20912. If more than 25 people enter and there is more than one correct entry, the winners will be chosen at random. The deadline for submission of entries is **May 15, 1996.**

**Answers to the Last Atomic Puzzler** (Vol. 4, No. 4) **Across:** 1. 40 CFR 191; 5. geologic; 9. subsistence farmer; 11. Pigford; 12. realization; 13. Shoshone; 14. CERCLA. **Down:** 2. 100 millirems; 3. decommissioning; 4. critical group; 6. confirmatory; 7. Yucca Mountain; 8. Fri; 10. Nevada.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**Tritium,** *from page 13*

demic discussion in the event that the U.S. and other weapons powers decide to honor their commitments under Article VI of the Non-Proliferation Treaty (NPT), which states:

> Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.

The "Principles and Objectives For Nuclear Non-Proliferation and Disarmament," a final document of the 1995 Review and Extension Conference of the NPT, reaffirmed this commitment.

However, the sole purpose of a new tritium facility would be to maintain a nuclear weapons stockpile well into the next century. Current Department of Defense and DOE planning ignores stockpile reductions below the 3,500 warheads allowed by the second Strategic Arms Reduction Treaty (START II). Establishing the infrastructure to maintain a large U.S. arsenal would most likely be seen as a violation of the spirit of the NPT and would raise objections by non-nuclear NPT signatories.

The Non-Aligned Movement, consisting of over 100 member-states of the United Nations, has taken a strong stand for disarmament, asserting during the NPT Review and Extension Conference that nuclear weapons states "... should reaffirm their commitment to the complete elimination of nuclear weapons."[7] Delaying plans for new tritium production would demonstrate good faith efforts on the part of the U.S. towards nuclear disarmament. Negotiations toward START III would be widely seen as further good faith efforts by the nuclear powers.

## Recommendations

The future role of nuclear weapons should not be driven by a narrow technocratic decision on tritium. Rather, a broad national debate is needed on this crucial subject. We recommend that:

- **The plans for a new tritium source should be put on hold** and an informed public debate over the size and function of the nuclear stockpile should precede any decision on tritium production.
- **The U.S. should persuade Russia to eliminate its remaining tactical nuclear warheads** by unilaterally eliminating its own remaining tactical warheads.
- **Nuclear weapons states should take concrete steps towards nuclear disarmament, as required by the NPT**. A first step would be for the United States and Russia to reduce their nuclear arsenals to around 1,000, roughly the same number as that of the other three powers combined.
- **The U.S. Department of Energy should declassify tritium inventory and use numbers.**

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[7] *1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, Final Document, Part II, Documents issued at the Conference, NPT/CONF.1995/32 (Part II), p. 63, NPT/CONF.1995/14.

For a free copy of the complete 13-page report, *Tritium: The environmental, health, budgetary, and strategic effects of the Department of Energy's decision to produce tritium,* contact IEER.

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