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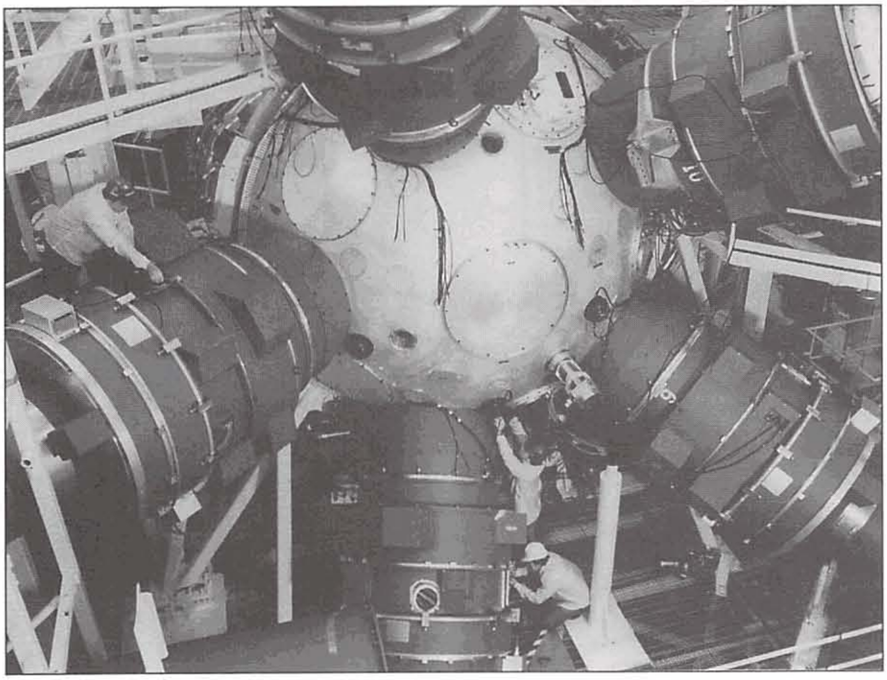

High-tech DOE lasers attempt to melt gigantic snowball. (Just kidding! Actual caption on page 16.)

The Nuclear Safety Smokescreen[1]

By Hisham Zerriffi

U.S. advocacy of a "Comprehensive Test Ban" (CTB) treaty to end all nuclear explosions is tied to the start-up of a major new initiative called the Science Based Stockpile Stewardship (SBSS) program. The SBSS program will allow the U.S. to retain a large number of nuclear warhead designers for an indefinite period. It is also tied to maintaining the Nevada Test Site in a state of permanent readiness to resume testing should the United States decide to withdraw from the CTB under a "supreme national interest" clause that it wants built into the treaty.

The Department of Energy's SBSS program would replace underground nuclear testing with a combination of above-ground experimental facilities and advanced computational abilities. These new facilities are justified by the Department of Energy (DOE) on the basis of ensuring the continued "safety and reliability" of the nuclear weapons arsenal as it ages. However, as IEER discusses in its new report, "The Nuclear Safety Smokescreen," there are two fundamental technical problems with the DOE's justification of the Science Based Stockpile Stewardship program.

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[1] This article is based on the IEER report *The Nuclear Safety Smokescreen: Warhead Safety and Reliability and the Science Based Stockpile Stewardship Program*, by Hisham Zerriffi and Arjun Makhijani, published in May 1996.

Editorial

A Durable, Stable Nuclear Test Ban

By Arjun Makhijani

A Comprehensive Test Ban (CTB) treaty to end all nuclear explosions is being negotiated in Geneva. A "zero yield" treaty would be a great step forward toward reducing proliferation problems. The five nuclear weapons states favor such a CTB for the future, but have attached conditions to it. China wants a review in ten years to allow for the possibility of "peaceful nuclear explosions." The other nuclear weapons powers also want conditions that will perpetuate weapons design capabilities. However, the conditions could undermine the stability of the CTB in times of crisis, and create serious new global tensions and dangers in the long term.

The United States, Russia, France, Britain, and China each possess nuclear weapons design laboratories and apparently plan to continue their use after a CTB is in place. In the U.S., the Science Based Stockpile Stewardship (SBSS) program would

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First, the DOE often does not distinguish between safety and reliability. Second, the DOE implies that aging will have a significant effect on the safety of nuclear weapons. For instance, the DOE has stated that "The effects of aging on weapons components can affect their long-term safety and reliability. Safety may be affected by chemical or structural changes in the HE [high explosives] or detonators, which may lead to altered response to impact or fire."

To examine the DOE's claims for the SBSS program, we decided to go back to basics, starting with definitions of safety and reliability. Quite simply, safety is making sure warheads don't blow up when you don't want them to, while reliability is making sure warheads do blow up when you want them to. Moreover, while safety is purely a technical issue, reliability also has political and military (strategic) aspects. For example, the type and level of reliability required for retaliation to a nuclear attack (a deterrence strategy) differs substantially from the reliability required for a first nuclear strike against a heavily armed nuclear adversary.

Using DOE documents specially compiled through a Freedom of Information Act request, IEER analyzed data relating to the types of safety and reliability problems that have been experienced with warheads in the past, what types of problems the DOE expects for the future, and how these relate to the types of facilities the DOE plans to construct as part of its Science Based Stockpile Stewardship Program.

Safety Problems

Two key parts to a nuclear warhead are the "primary" and the "secondary." The primary is the first stage of the nuclear explosive which contains high explosives, plutonium-239 and/or highly enriched uranium, and a small fusion ("booster") component. The secondary contains both thermonuclear (fusion) and fission components. Though both are important to warhead safety, by far the most crucial component to the nuclear safety of a warhead is the primary.

DOE data show very clearly that there have never been aging-related safety problems associated with either the primary or the secondary of a warhead. Defects with these nuclear components, collectively called the "physics package," were design-related—they were not problems due to aging. (See box below.)

While primaries do deteriorate with age, this deterioration affects the *reliability* of the warhead, not its safety. According to DOE data, aging only affected the safety of *non-nuclear components* of warheads, such as the parachute system, gas transfer system and radar. (See table on page 7 of the Centerfold.)

These findings suggest that the SBSS facilities, which are designed mainly to investigate parts of the physics package, would have little or

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CAUSES OF WARHEAD SAFETY PROBLEMS

	Caused by Aging	Cause other than Aging
Nuclear Component Problems:		
Affecting Primaries	0	38
Affecting Secondaries	0	2
Non-Nuclear Component Problems:	8	18

SCIENCE FOR DEMOCRATIC ACTION

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6935 Laurel Avenue
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Phone: (301) 270-5500
FAX: (301) 270-3029
Internet address: ieer@ieer.org
Web address: http://www.ieer.org

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Managing Editor: Pat Ortmeyer

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no relevance to maintaining the safety of the nuclear arsenal. The non-nuclear components of the warheads that had aging-related safety problems are ones that can be functionally tested apart from the warhead, even when redesigned. This capability is the responsibility of Sandia National Laboratories and would not involve SBSS facilities.

Additionally, the National Ignition Facility (NIF), a laser fusion facility to be constructed at Lawrence Livermore National Laboratory in California, is not designed to study non-nuclear components or primaries (except during late stages in the explosion, at which point safety is a moot point). Furthermore, this facility operates at volumes which are much smaller than a nuclear explosion. As a result, all information obtained from this facility must be scaled up, a difficult process when applied to existing warheads.

In New Mexico, the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility is being constructed at the Los Alamos National Laboratory. This facility is intended to study the implosion of primaries. However, this may not be necessary, considering the historical data on safety problems with primaries. All warheads in the arsenal are certified to be "one-point safe"[2]—an important measure of safety. Therefore, further testing seems unnecessary as long as the primary undergoes no modifications. Because modification could introduce uncertainty in warhead safety and reliability, a number of experienced analysts have specifically recommended against modifying nuclear components. By focusing on the nuclear components of warheads, the DOE seems to be ignoring this advice.

SBSS facilities would have little or no relevance to maintaining the safety of the nuclear arsenal.

While the utility of these facilities in maintaining the safety of existing nuclear warheads is highly questionable, they could add significantly to the weapons design capabilities of the United States. Facilities similar to the National Ignition Facility and the Dual Axis Radiographic Hydrodynamic Test facility have been used in the past as part of the weapons design program. The tables on page 10 in the Centerfold describe SBSS facilities and their potential for designing nuclear warheads.

A variety of official documents discuss weapons design capabilities for the period following the signing of the CTB. Perhaps the most striking example is testimony by C. Paul Robinson, director of Sandia National Laboratories, before a Senate committee in March of this year. Robinson refers to the CTB and the halt in new weapons production only as a "hiatus" that could be several decades long, noting that children "entering kindergarten this year" will be the future engineers and scientists designing the next generation of weapons systems.[3] In this view, new warheads will eventually be designed and built.

Reliability Problems

DOE has defined "reliability" very narrowly, so that even a small chance of a slight decrease in performance, either with respect to yield or target accuracy, is considered a reliability defect. This strict definition only seems relevant if the purpose of the nuclear arsenal is to issue a first strike to destroy an adversary's nuclear arsenal. In such a strategy, high accuracy and yield at or above the rated value may be necessary to destroy strategic missiles stored in "hardened" silos.

But such a strict definition of reliability is not relevant to a deterrence strategy based on retaliation in response to a nuclear attack. Nuclear weapons are so devastating that the possibility of a small decrease in yield or accuracy below design values would not affect the decision of an aggressor to launch a nuclear attack.

So far as IEER has been able to discern, only 12 of 186 problem types identified in the data may be relevant to a strategy based on retaliation to a nuclear strike. The vast majority of reliability concerns seem to connect to a first strike strategy. Yet neither the DOE nor the Pentagon have put their decision regarding the SBSS program in this context. *However, this conclusion is very tentative and is only indicated by the data on reliability defects.* We cannot arrive at a definitive conclusion because the requisite data have not yet been made public.

DOE Omits Other Options

The inherent technical design capability of the SBSS program is only one of the many indications that the DOE intends to go beyond the maintenance of the current weapons stockpile. In its Draft Programmatic Environmental Impact Statement (PEIS)[4] on Stockpile Stewardship and Management, the DOE explicitly ruled out re-manufacturing or maintenance as alternatives to the costly SBSS program, though it had not given these options due consideration. We briefly describe these options here:

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[2] "One-point safety" means that if detonation occurs at one point on the high explosive that surrounds the primary, then the probability should be less than one in a million that the explosive yield will be greater than 4 pounds of TNT.

[3] Robinson, C. Paul, Prepared Statement of C. Paul Robinson, Director, Sandia National Laboratories, to the Strategic Forces Subcommittee of the Senate Armed Service Committee, March 13, 1996.

[4] The National Environmental Policy Act requires that before developing a plan of action, a federal agency must evaluate the potential impacts of the course of action it plans to take. This study is called an Environmental Impact Statement (EIS), or in the case of the Science Based Stockpile Stewardship program, a *Programmatic* Environmental Impact Statement (PEIS), as it affects various sites nationwide.

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Re-manufacturing: The DOE states that precise replication is not always possible and therefore re-manufacturing is not a reasonable alternative. Additionally, the PEIS states that the emphasis of the SBSS program is on "nuclear components which can no longer be functionally evaluated by nuclear tests." The elimination of this option fails to take into account several key points:

- A number of experts, including former nuclear weapons designers, such as Ray Kidder, J. Carson Mark, and Richard Garwin, have stated that re-manufacture is a reasonable method to maintain the nuclear arsenal after a Comprehensive Test Ban.[5]
- The PEIS does not consider the implications of a recommendation that "fixes" to the primary should be avoided, even if meant as "improvements." Kidder, Mark, and Garwin, among others, have stated that re-manufacturing is preferable to changes in the "physics package" of warheads.
- The failure to consider systematic ways to deal with safety and reliability issues arising from non-nuclear components is an egregious omission because such problems could be solved by re-manufacturing.

Maintenance: This approach is the most similar to the proposed SBSS program. The major difference seems to be that new experimental facilities would not be constructed, while surveillance of weapons would be enhanced. Existing experimental facilities would continue to be used. Eliminating this option makes it clear that this PEIS is biased towards one outcome: the construction of new facilities that would expand design capability.

DOE has also not considered an intensification of the Stockpile Evaluation Program, even though it has relied mainly on this program to discover warhead safety and reliability problems. This program is distinct from DOE laboratory capabilities and has been in place since 1958. It was designed to monitor warheads during production and after deployment and to fix any problems that were found.

The program withdraws new components and complete warheads from the production line and from deployment. The samples varied over the years both in number and also according to whether the warhead was in production or was deployed. Currently, the program consists of withdrawing approximately eleven warheads of each type from the stockpile every year. Ten of them are system tested, reassembled, and returned to the stockpile. The nuclear explosive package in the eleventh is destructively tested.

Over the decades, the DOE has created a database of problems found with the nuclear arsenal. A majority of these problems (75 percent) were discovered during the Stockpile Evaluation Program, while the rest were discovered during research and development, through underground testing, and through a variety of other methods.

DOE could intensify this program by withdrawing a larger number of warheads for inspection. If new safety-related problems arise in the future due to the aging of warheads beyond their design lives, as postulated by the DOE, then an intensified Stockpile Evaluation Program would seem to be more appropriate than the SBSS program. Yet DOE has not considered this alternative, much less done an analysis showing that the SBSS program would better serve to maintain the safety and reliability of the existing arsenal.

Conclusion

By eliminating reasonable alternatives from its programmatic environmental assessment, such as the ones discussed above, the DOE has indicated its determination to build new facilities regardless of their relevance to safety and reliability. At the most basic level, the DOE has simply failed

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PRINCIPAL FINDINGS OF "THE NUCLEAR SAFETY SMOKESCREEN"

- The Department of Energy's analysis of the need for an SBSS program confuses safety and reliability—issues which are technically distinct. Consequently, DOE has not justified the need for SBSS facilities as they relate to safety issues, separately from their relevance to reliability issues.
- The DOE has not related the types and levels of reliability required of the arsenal to overall U.S. military strategy.
- DOE data show that the nuclear detonators in nuclear warheads (the primaries) have never had safety problems linked to aging. The data clearly indicate that SBSS facilities are not needed for safety of the nuclear package.
- The SBSS program will give the U.S. powerful capabilities for designing new warheads (as mandated by present nuclear weapons policy).

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[5] Kidder, R.E., *Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban*, UCRL-53820, Lawrence Livermore National Laboratory, Livermore, CA, October 1987, pp. 6–9, 27–29; and Garwin, Richard L., "Atoms do not age," *The Bulletin of the Atomic Scientists*, Vol. 49, No. 8, October 1993, pp. 10–11. (Mark, J. Carson, cited in Kidder, pp 27–29.)

Going Global: IEER's Nuclear Material Dangers Project

By Pat Ortmeyer

On April 15, 1996, IEER released the Russian translation of its report, *Fissile Materials in a Glass, Darkly*, marking the beginning of its new global outreach project, "Nuclear Material Dangers." The project will provide information and analysis regarding security and environmental aspects of nuclear weapons-usable materials and technologies to journalists and activists in key nuclear countries. It will also bring the views of experts in these countries to audiences in the U.S.—particularly to journalists, non-governmental organizations, and decision-makers in Washington—thus broadening the scope of discussions on critical issues such as plutonium disposition, reprocessing, nonproliferation and disarmament. The project aims to connect the resolution of these issues to the development of sustainable energy strategies.

Central to the project is reaching activists and journalists in their own languages. Through translated publications and a new multi-lingual newsletter similar to *Science for Democratic Action,* activists will gain the tools they need to effectively address problems related to nuclear materials and technologies. The English version of this newsletter, to be distributed in the U.S. and other English-speaking countries, will include guest articles from scientists and activists in Russia, India, Japan, and other key countries. This 16-page publication will be supplemented by inserts covering issues unique to the region or country of distribution.

During the first year of the project, the newsletter will be published in Russian and English. Other selected IEER materials will be translated into French, Chinese, and Japanese. In 1997 we will expand the newsletter translation to include French, Chinese, and possibly other languages. IEER will also post translated articles and summaries of reports to international e-mail lists beginning in late 1996, and will enhance its World Wide Web page to include links in other languages.

> *The successful pursuit of nuclear nonproliferation and disarmament is possible at the end of the Cold War.*

IEER's newest staff member, Anita Seth, will be coordinating the project as managing editor of the global newsletter. With Anita's Russian and French language skills and her familiarity with Spanish and Hindi, IEER will be able to reach our international colleagues as never before. In addition to editing the global newsletter, Anita will coordinate Washington press briefings with international press correspondents, as well as press teleconferences with journalists based in their home countries.

The "Nuclear Material Dangers" project is being launched in a time of unprecedented global security threats and unparalleled opportunity to achieve nonproliferation and disarmament goals. Nuclear proliferation dangers today stem from unwise policies such as the resumption of reprocessing in the U.S., the building of a new commercial reprocessing plant at Krasnoyarsk in Russia, continued nuclear testing by China, research in various countries into inertial confinement fusion, lack of progress globally on disposal of high-level waste, and reprocessing of commercial spent fuel in Japan, Russia, France, India and Great Britain.

These trends not only threaten global security in the short term, but also erode support for the Non-Proliferation Treaty (NPT), threatening in particular the fulfillment of Article VI on nuclear disarmament. But the successful pursuit of nuclear nonproliferation and disarmament is possible at the end of the Cold War, especially if key governments also adopt sound non-nuclear energy strategies. Sustained progress on these issues depends on informed activists, journalists and members of the public who have reliable and understandable technical information to help them influence the debate. By providing a common technical information base in many languages, IEER will help these individuals to more effectively promote sustainable energy technologies, work for cessation of the production of nuclear weapons-usable materials, and halt development of technologies which exacerbate proliferation problems.

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to show why it needs to operate its existing design facilities or to construct new experimental facilities for maintenance of the existing arsenal. The DOE already operates a number of facilities of a similar nature, albeit not necessarily as advanced as the new facilities. If the DOE wishes to pursue the SBSS program it has to show a need for these facilities based on specific problems it expects.

Copies of the full 49-page report, *The Nuclear Safety Smokescreen,* are available from IEER for $10.00, including postage. Special arrangements can be made for low-income groups or individuals.

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maintain both nuclear warheads and weapons designers indefinitely, as the accompanying article shows. Like the U.S., France is building a large laser fusion device for laboratory testing of thermonuclear components. Russia has announced a stockpile stewardship program similar to that of the U.S. China could continue design work under a provision which, if incorporated into the CTB, would allow for a review of the "peaceful nuclear explosions" issue ten years hence. This could be China's way of maintaining the design capability that the SBSS program would give to the U.S., Britain, and France.

A Comprehensive Test Ban treaty that does not restrict nuclear weapons programs and is not accompanied by a closing of all test sites leaves the treaty and other nonproliferation agreements vulnerable. The United States intends to keep the Nevada Test Site open indefinitely as a condition for acceding to the zero yield CTB. Though the U.S. Department of Energy (DOE) has stated that the lack of full-scale underground testing will be a major impediment to any new warhead design,[1] it could nevertheless design new weapons using the SBSS facilities and keep the test site ready to explode them for final testing before certification and production. Keeping the test site in a state of readiness to undertake full-scale nuclear tests on short notice would allow the U.S. to introduce new weapons into the arsenal very quickly and easily once these designs have been mostly completed on computers and in lab facilities. The capabilities of modern facilities to accomplish complex design tasks were demonstrated by the success of the Boeing 777, a large commercial aircraft designed mainly by computer and wind tunnel experiments.

Weapons programs in the U.S. and other countries will employ thousands of people to build, run, and maintain laboratory and testing facilities. It is widely recognized that the SBSS program was the price paid to the nuclear weapons laboratories to support or at least not actively oppose a zero yield CTB. But the same large weapons bureaucracy created by the program will constitute a strong lobby which could exert pressure to withdraw from the CTB in times of crisis.

A CTB that does not restrict nuclear weapons programs and is not accompanied by a closing of all test sites leaves the treaty and other nonproliferation agreements vulnerable.

The maintenance and expansion of nuclear weapons programs also has implications for disarmament efforts. Russia and probably China lack the funds to greatly expand their nuclear design infrastructure. Moreover, the U.S. has a long-standing and extensive program to share nuclear weapons data with Britain. The U.S. and France recently signed a secret agreement to share the data that would come out of their nuclear weapons laboratory and computer simulation efforts. The immense financial and technical advantages of the three western powers combined with this secret agreement may provide incentives to China and Russia to test in order to make up for their lack of advanced facilities, and could cause them to hold up progress on disarmament on other fronts.

These vulnerabilities of the CTB are similar to the current crisis affecting two existing treaties, the Anti-Ballistic Missile (ABM) treaty and the Second Strategic Arms Reduction Treaty, START II. In the U.S., many powerful voices advocate a partial or total abandonment of the ABM treaty and the deployment of a ballistic missile defense system, popularly called "Star Wars." But Russia lacks the money to develop such a system, much less to deploy it. Many in Russia view the Star Wars program as a strategic threat because they fear that such a system, were it to become fully operational, could allow the United States to both launch a first strike against Russia and to defend itself against a retaliatory attack. It was precisely on this point that President Gorbachev rejected President Reagan's proposal for nuclear disarmament during their Reykjavik summit in 1985.

Therefore, Russia has linked its ratification of START II to U.S. adherence to the ABM Treaty. In such a situation, the potential technical capability of the Star Wars system overrides the stated motives of the United States—namely, to counter putative missile threats from countries such as North Korea and Iran.

It is worth noting that the pressures for the U.S. to withdraw from the ABM treaty have increased since the 1980s, when the Star Wars program began receiving large sums of money. Similarly, a Comprehensive Test Ban which includes a built-in weapons design lobby with a vested interest in justifying its long-term existence invites danger in the years ahead.

Another possible reaction to the SBSS program by Russia, and possibly even by China, would be to participate in a form of "cooperative stewardship." A recent official workshop held at Los Alamos on cooperative stewardship discussed the advantages of the five nuclear weapons states

See **Test Ban**, *page 16*

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1 Department of Energy, *The National Ignition Facility and the Issue of Nonproliferation: Final Study*, U.S. Department of Energy, Office of Arms Control and Nonproliferation (NN-40), Washington, D.C., December 19, 1995, p. 4.

A CENTERFOLD FOR TECHNO-WEENIES

The fundamental rationale the DOE gives the public for the SBSS program is to assure the safety and reliability of the nuclear arsenal as it ages. However, as our main article points out, there has not been a single aging-related safety problem in the U.S. nuclear arsenal that affected the nuclear components of a warhead (the "physics package"). (See table p. 2 and below.) Moreover, the SBSS facilities being maintained and constructed by the DOE appear to contribute more to weapons design or modification than they do to assuring the safety of the arsenal.

This centerfold discusses the facilities proposed for the SBSS program, focusing primarily on two key facilities: the **Dual Axis Radiographic Hydrodynamic Test (DARHT) facility** at Los Alamos National Laboratory in New Mexico, and the **National Ignition Facility (NIF)** at Lawrence Livermore National Laboratory in California. While the DOE asserts these facilities are necessary to assure warhead safety, they are the same types of facilities used by the DOE in the past for weapons design.

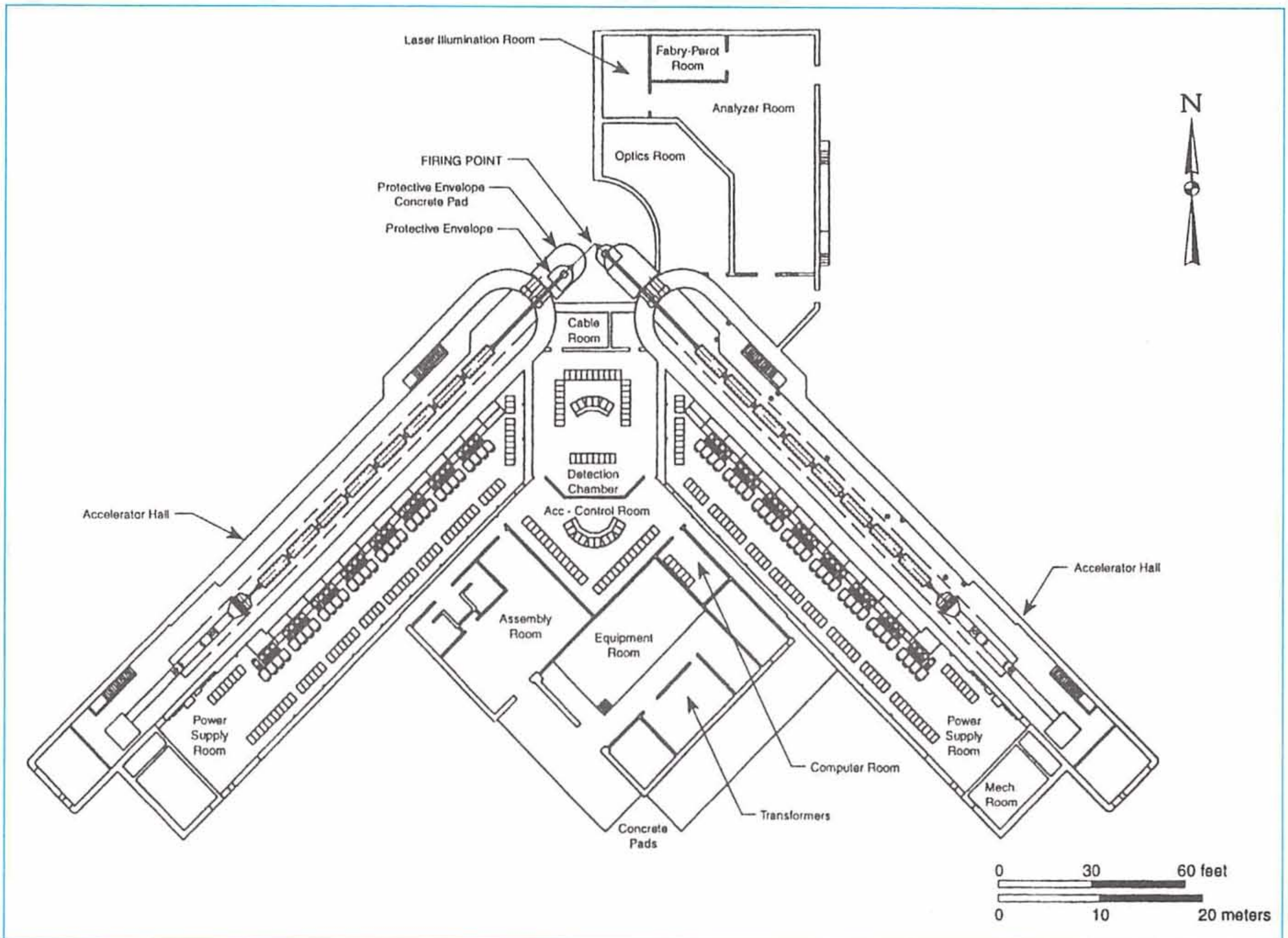
DARHT is a *hydrodynamic facility*, which helps weapons designers determine the physical behavior of uranium and plutonium under the extreme temperature and pressure conditions that prevail during detonation. The term "hydrodynamic" is used to describe such testing because materials tend to behave like liquids under these conditions. Hydrodynamic tests are among the most realistic of non-nuclear tests, because they can be used to study a warhead up to the point that it would achieve criticality (a self-sustaining nuclear chain reaction).

NIF is a *high energy density facility*, which can be used to study thermonuclear (fusion) reactions that take place in the secondaries of nuclear warheads, and during the boosting phase of a detonation.[1] "Ignition" refers to the burning of a pellet of deuterium and tritium after exposure to high energy lasers. High energy density facilities must conduct these experiments at much lower total volumes than would take place in a detonation, requiring that the results be scaled to the volume of actual warheads in order to apply them to improve safety or reliability.

STOCKPILE SAFETY PROBLEMS DUE TO AGING

Warhead Number	Affected Component	Year Warhead Entered Production	Years after First Production Unit When Problem was Found	Comments
B28	Parachute System	1958	4	Retired
W40	Arm/Safe/Fire	1959	3	Retired. Problem affected both safety and reliability
B43	Parachute System	1961	5	Retired
B43	Structure/Assembly	1961	3	Retired
W58	Structure/Assembly	1964	1	Retired
B61 (CHE)[2]	Radar	1968	18	Retired. Problem affected both safety and reliability
B61 (IHE)[3]	Parachute System	1979?	5	Active. The eleventh modification of this warhead is due to be completed in 1997
W87	Gas Transfer System	1987	3	Active. Problem affected both safety and reliability and was the result of both aging and a design problem

[1] Boosting involves injecting the pit of a warhead with tritium and deuterium to increase the efficiency of use of fissile materials.
[2] CHE stands for Conventional High Explosives
[3] IHE stands for Insensitive High Explosives



Aerial view of the B-2 Stealth bomber? Despite the similar shape, this is actually the DARHT facility, at Los Alamos National Laboratory in New Mexico.

The Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT)

The Dual-Axis Radiographic Hydrodynamic Test facility would be used by the DOE to study the behavior of warhead primaries during detonation. "Dual-Axis" refers to two very large X-ray machines which are used to take "radiographs" (X-ray photographs) of the implosion of a mock-up nuclear warhead pit. The materials tested can be depleted uranium or plutonium-242, a non-fissile isotope of plutonium. As discussed above, "hydrodynamic" refers to the fact that under the extreme pressure and temperature conditions of implosion, these materials take on the qualities of liquids, and therefore their physical behavior can be modeled by equations which apply to liquids. Like all hydrodynamic facilities, DARHT can be used for new weapons design.

According to its proponents, the two main improvements of DARHT over other hydrodynamic testing facilities (see page 10 for a table of other facilities) are the increased resolution of radiographic images, and the use of two axes instead of one. The second axis allows for three-dimensional observation of the compressed materials simulating the pit of a warhead. However, Seymour Sack, a Laboratory Associate at Livermore, argues that the information that DARHT is designed to provide can be gleaned through small-scale experiments at existing or upgraded facilities.

The DOE plans to use the information gained from hydrodynamic and dynamic experiments to validate or refine the computer codes used to model warheads. According to the DOE, the computer models would be used to predict possible problems with primaries, or as one test of whether a corrective action would work. (However, new codes based on data from SBSS facilities will be less accurate when applied to existing warheads and could adversely affect safety and reliability.) Hydrodynamic testing could also be used to certify certain weapons components after re-manufacture or design. The total estimated cost of the new DARHT facility is $123.8 million.

The National Ignition Facility (NIF)

Considered one of the cornerstones of the SBSS program, the National Ignition Facility would use lasers to produce X-rays to study fusion at low volumes. The process involves Inertial Confinement Fusion experiments in which powerful lasers are used to superheat a minute capsule of deuterium and tritium to the point of ignition, resulting in a self-sustaining thermonuclear burn—a tiny thermonuclear explosion.

Since NIF is expected to be able to operate at energy densities similar to the level of a nuclear explosion, it can be used to study the thermonuclear phenomena that occur in nuclear warheads during detonation. This would allow weapons designers to gain information on new weapons design concepts without nuclear weapons testing, though it would not contribute significantly to understanding the types of problems that have historically affected the secondaries of warheads.

Even at the high densities possible through NIF, the total energy released in the experiments is from 10,000 to a billion times less than that of a nuclear weapons test and must be appropriately scaled to be useful in accurately assessing the operation of existing warheads. NIF can only examine isolated fusion phenomena and is incapable of exactly simulating the complex interplay of a variety of fission, fusion, and non-nuclear physical processes that occur in a nuclear explosion. It would therefore be irrelevant to studying or assuring the nuclear safety of existing warheads, but would enable advances in the design of new ones. Proponents claim that NIF would be relevant to studying reliability. However, IEER has tentatively concluded that DOE's definition of reliability seems to relate mainly to first strike capability rather than maintaining retaliatory deterrence. The National Ignition Facility is estimated to cost about $1 billion.

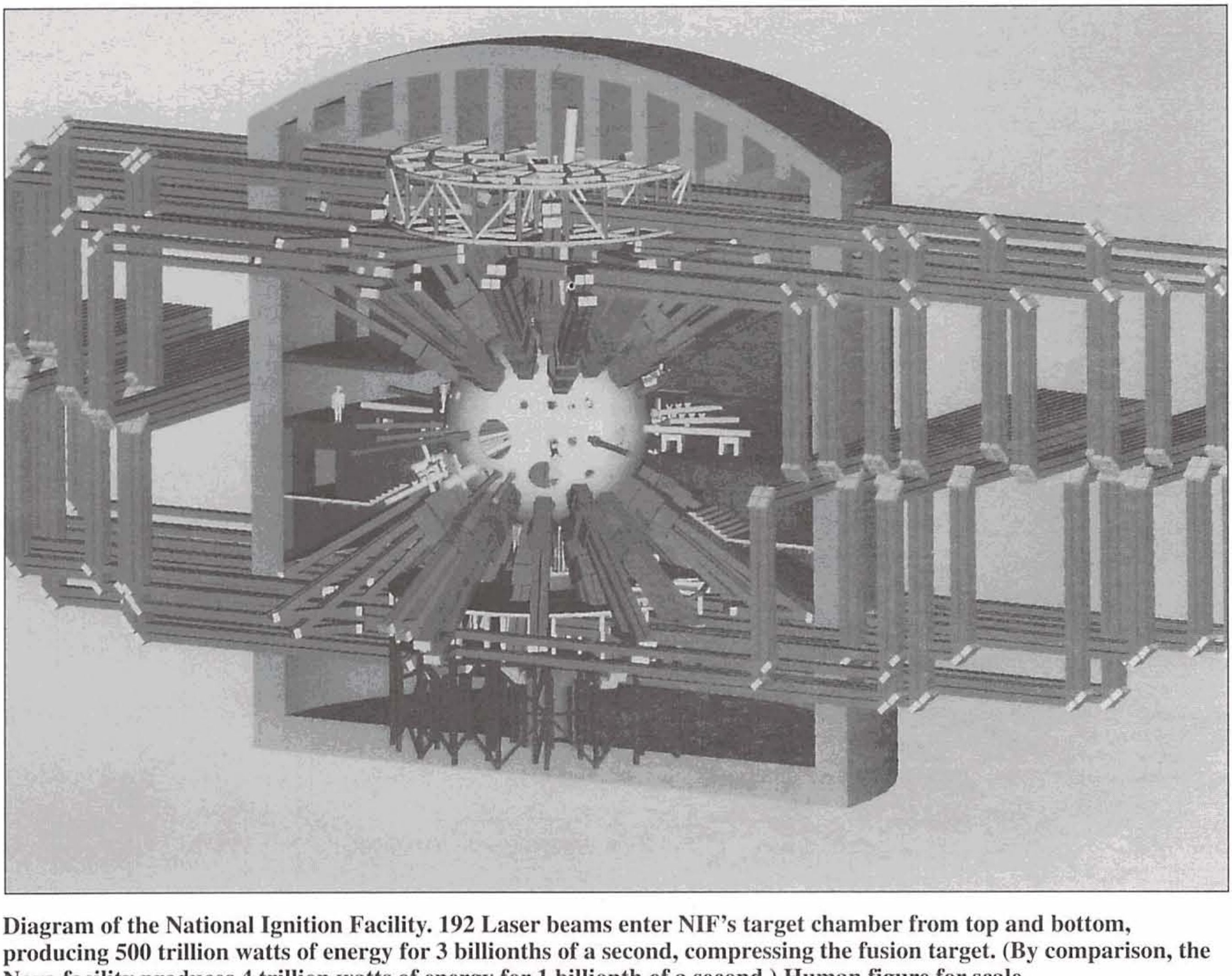


Diagram of the National Ignition Facility. 192 Laser beams enter NIF's target chamber from top and bottom, producing 500 trillion watts of energy for 3 billionths of a second, compressing the fusion target. (By comparison, the Nova facility produces 4 trillion watts of energy for 1 billionth of a second.) Human figure for scale.

HYDRODYNAMIC TESTING FACILITIES

Facility Name	Type	Location	Status[4]	Design Capability
Advanced Hydrotest Facility (AHF)	4-6 Axes	Unknown	Proposed Next Generation Facility ($422 million)	Yes
Big Explosives Experimental Facility (BEEF)	Large-scale experiments	Nevada Test Site	Existing	Yes
Contained Firing Facility (CFF), an FXR Upgrade	Single Axis, Dual Pulse	Livermore	Proposed in SSM Programmatic EIS. ($48.5 million)	Yes
Dual Axis Radiographic Hydrodynamic Test Facility (DARHT)	Dual Axis	Los Alamos	Court Injunction lifted, construction resumed ($48 million)	Yes
Explosive Components Facility	Component Development	Sandia	Completed ($27.8 million)	Yes
Flash X-Ray (FXR)	Single Axis	Livermore	Existing	Yes
High Explosives Applications Facility (HEAF)	New High Explosives Testing	Livermore	Existing	Yes
LYNER	Hydrodynamic and Hydronuclear	Nevada Test Site	Existing	Yes
PHERMEX	Single Axis	Los Alamos	Existing	Yes
PHERMEX Upgrade	Single Axis, Dual Pulse	Los Alamos	Not Completed	Yes

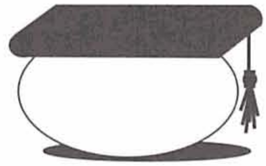
HIGH ENERGY DENSITY TESTING FACILITIES AND ACCELERATORS

Facility Name	Type	Location	Status[4]	Design Capability
Atlas	Capacitor Bank Pulsed Power	Los Alamos	Proposed in SSM Programmatic EIS ($48.4 million)	Yes
Bright Source II	Laser	Los Alamos	Existing	Yes
LANSCE II program to convert LAMPF[5]	Accelerator	Los Alamos	Proposed ($650 million)	Yes
Los Alamos Meson Physics Facility (LAMPF)[5]	Accelerator	Los Alamos	Existing	Yes
National Ignition Facility	ICF Laser	Livermore is the preferred location	Proposed in SSM Programmatic EIS (~$1 billion)	Yes
Nova	Inertial Confinement Fusion (ICF) Laser	Livermore	Existing	Yes
Pegasus II	Capacitor-Bank Pulsed Power	Los Alamos	Existing	Yes
Procyon	High Explosive Pulsed Power	Los Alamos	Existing	Yes
Trident	Laser	Los Alamos	Existing	Yes
Ultra-Short Pulse	Laser	Livermore	Existing	Yes

[4] For proposed facilities, estimated construction costs are provided. These costs do not include operation or decommissioning of the facility.

[5] This facility does not reach the energy densities of the other facilities on this list, but is included in order to show the range of facilities at DOE's disposal.

It Pays to Increase Your Jargon Power



by Dr. Egghead

Physics package

a) A plastic surgeon package deal which includes: a face lift, breast implants, liposuction, and belly reduction.

b) What universities offer outstanding science students to encourage their attendance in physics programs.

c) Another spelling for the foil pouch surrounding Alka Seltzer tablets (usually: "fizzics package").

d) The primary and secondary stages of a nuclear warhead. The primary stage consists of the fissile material(s), and high-explosives and a deuterium-tritium "booster." The secondary stage contains both thermonuclear (fusion) and fission components.

One-point safety

a) The blinking red light at the top of the Washington Monument that keeps planes form crashing into the tip.

b) An accident prevention course for speakers who like to use pointers.

c) A needlepoint stitch designed to ensure that one's pants will stay up.

d) A system to ensure that, in case of accidental detonation at one point on the high explosive that surrounds the primary of a nuclear weapon, there will be less than one chance in a million that the nuclear explosive yield will be greater than 4 pounds of TNT.

DARHT

a) The short form for d'Artagnan, one of the three musketeers.

b) The acronym for Don't Access Radioactive High-level Trash. The DOE is considering putting a sign with this acronym around Yucca Mountain.

c) A small missile with a sharp point at one end and feathers at the other that some nuclear weapons designers would love to develop if funding were approved.

d) The acronym for Dual Axis Radiographic Hydrodynamic Test Facility. Using non-fissile analogs like plutonium-242 and depleted uranium, DARHT would study the physical behavior of plutonim-239 and highly enriched uranium in the primary of a warhead under conditions of extreme pressure and temperature which prevail during detonation.

NIF

a) To smell, as in the expression: "get up and nif the coffee."

b) The sign standing for: "No Irons in the Fire," which is hung at the door of nuclear weapons labs during the weekend.

c) The term of endearment by which Nephertiti's husband called her in the privacy of their home.

d) The acronym for National Ignition Facility, a laser fusion facility, which can be used to study thermonuclear reactions in the deuterium-tritium primary booster and in the secondary of a nuclear weapon.

Kindergarten

a) Where children learn to get along.

b) Where children take naps and learn to play in an orderly way.

c) Where nuclear weapons designers look for new talent.

d) All of the above.

Zero yield

a) A bad harvest year.

b) A bank robbery where the robbers leave with nothing.

c) A common cause of accidents occuring on highway entrance ramps.

d) The term describing a type of comprehensive test ban treaty under which no nuclear explosions, however small, would be allowed.

Correct Answers: 1. d; 2. d; 3. d; 4. d; 5. d; 6. d.

Dear Arjun

Dear Arjun,

What is DUF_6? Is it dangerous and what should we do with it?

—Flummoxed in Florida

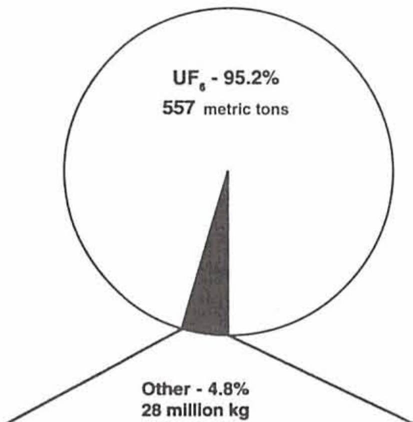
Dear Flummoxed,

In 15th century Scotland, DUF_6 was not dangerous and was known as "duff," another way of saying dough, the paste made from flour. Back then women were making the dough. Unfortunately men, who always tended to meddle in women's affairs, took over the making of the bread dough and turned it into green dough. As they attempted to make greater amounts of green dough, the men added more and more flour, changing the spelling of the name from "duff" to "dufff" and eventually to "duffffff" to reflect the immense flour content. This was eventually shortened to "DUF_6."

The nuclear establishment has given an entirely new meaning to DUF_6. Today it stands for Depleted Uranium Hexafluoride, the by-product of uranium enrichment, and the chemical form of most depleted uranium. Depleted uranium (DU) is also stored in other chemical forms, such as metal and oxide. (See diagram.)

How DUF_6 is Made

Natural uranium is composed of three isotopes: uranium-238 (99.284 percent); uranium-235 (0.711 percent); and, uranium-234 (0.005 percent), all of which are radioactive. The purpose of uranium enrichment is to concentrate uranium-235, the fissile isotope, in one stream. The other stream which is low in uranium-235, is called depleted uranium (DU), which typically contains only 0.2 to 0.3 percent uranium-235.

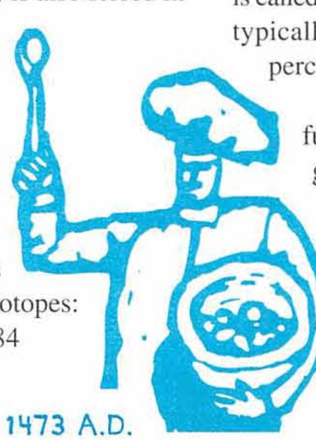


Form	Quantity (kg)	Percent of Total DU	Percent of Other Forms
UO_3	19,564,000	3.3	69.8
Metal	5,270,000	0.9	18.8
UF_4	2,982,000	0.5	10.7
Other Oxides	145,000	0.0	0.5
Misc and Scrap	35,000	0.0	0.1

SOURCE: DOE

Depleted Uranium Stocks, by Chemical Form

The enriched uranium is then further processed to varying degrees of enrichment. Uranium with between 3 and 5 percent uranium-235 (Low Enriched Uranium, or LEU) is used as nuclear fuel for commercial nuclear power plants. Uranium with over 90 percent uranium-235 (Highly Enriched Uranium, or HEU) can be used to make used nuclear weapons. In the U.S. HEU is also used in naval reactors. About 180 kilograms (kg) of depleted uranium result from the production of 1 kg of HEU with 93.5 percent uranium-235. Five to 10 kilograms of depleted uranium result from the production of 1 kg of LEU, depending on the degree of enrichment. Enrichment plants generally require uranium to be converted into the hexafluoride chemical form for processing reasons.



DUF_6, circa 1473 A.D.

Storage of DUF_6 and Environmental, Health and Safety Hazards

Currently there are almost 560,000 metric tons of DUF_6 stored primarily in 14-ton cylinders located near Portsmouth, Ohio; Oak Ridge, Tennessee; and Paducah, Kentucky. The long-term storage of DUF_6 presents environmental, health and safety hazards due to the chemical instability of UF_6. When UF_6 is exposed to moist air, it reacts with the water in the air to produce UO_2F_2 (uranyl fluoride) and HF (hydrogen fluoride), both of which are toxic. Storage cylinders must be regularly inspected for evidence of corrosion and leakage. Continuing to store depleted uranium in cylinders would require constant maintenance and monitoring of the stockpile because the estimated life-time of the cylinders is measured in decades, while the half-life of the main constituent of DU, uranium-238 is about 4.5 billion years.

See **Dear Arjun**, *page 13*

Dear Arjun, *from page 12*

Classification of Depleted Uranium

Currently, depleted uranium is still classified as a source material although its possible uses are few and the quantities involved are small. The major uses of depleted uranium—to produce armor-piercing shells and armor plating for tanks—are likely to be phased out due to concerns about its radioactivity and heavy metal toxicity. Hence, DU is essentially a radioactive waste, though it has not been declared as such. The Department of Energy (DOE) has begun a process for considering how DU ought to be managed and how it should be disposed of if it is declared a waste.

In its consideration of a license application for a new uranium enrichment plant in Louisiana, the Nuclear Regulatory Commission (NRC), declared that DU from the plant would be considered "Class A" "low-level" radioactive waste. "Class A" is the category for the least dangerous "low-level" radioactive waste. The NRC made this declaration under the default provision for unclassified wastes in the Code of Federal Regulations 10 CFR 61.55. This classification is fundamentally flawed and potentially dangerous.

The NRC's own research demonstrates why this default classification is wrong. In a 1994 report, it determined that shallow-land burial, the usual means for disposing of Class A low-level radioactive waste, would be inappropriate for DU because it could result in unacceptably high doses in the future.[1]

TABLE 1
Specific Activities of Various Chemical Forms of Depleted Uranium Compared to Transuranic Waste and Uranium Ore

Chemical form	Specific activity (nanocuries[3] per gram)
Depleted uranium oxide (DU_3O_8)	340
Depleted uranium hexafluoride (DUF_6)*	270
Transuranic activity in TRU waste[2]	>100
0.2 % uranium ore (including decay products)	4

* By comparison, the specific activity of uranium-238 is 340 nanocuries per gram.

A sound disposal program for managing DU as waste needs to be based on the properties of depleted uranium, not a flawed and arbitrary classification system.

Properties of Depleted Uranium

Health and environmental effects of radioactive materials are influenced by several factors: the specific activity of the radioactive material (the radioactivity per unit weight); the nature of the radiation being emitted during the radioactive decay (alpha or beta, and whether the decay is accompanied by gamma radiation); the energy per radioactive decay; the half-life; and the behavior of the specific radionuclide and its various chemical forms in the body. As illustrated in Tables 1 and 2, depleted uranium is the same as transuranic waste (TRU waste) in the essential respects that matter to health and the environment.[2] The difference is terminological, not substantive.

Table 1 illustrates that the specific activity (here, radioactivity per gram) of depleted uranium in any form is 2.7 to 4 times more than the minimum specific activity of transuranic waste.

Table 2 compares isotopes of uranium and selected transuranic

See **Dear Arjun**, *page 14*

TABLE 2
Properties of Uranium Isotopes and Selected Long-Lived Transuranic Elements

Isotope	Main decay mode	Alpha particle energy, MeV	Half-life in years	Comments
Uranium Isotopes:				
uranium-238	alpha	4.1	4.46 billion	
uranium-235	alpha	4.7	704 million	
uranium-234	alpha	4.8	245,000	
Transuranics:				
neptunium-237	alpha	4.8	2.14 million	
plutonium-238	alpha	5.5	87.7	
plutonium-239	alpha	5.1	24,110	
plutonium-240	alpha	5.1	6,537	
americium-241	alpha	5.5	432	strong gamma emitter*

* With the exception of americium-241, all of these radionuclides are weak gamma emitters.

1 Final Environmental Impact Statement for the Construction and Operation of the Claiborne Enrichment Center, Homer Louisiana, NUREG-1484, Vol. 1, August 1994.

2 Transuranic wastes are those which contain elements with atomic numbers (number of protons) greater than 92 (the atomic number of uranium), half-lives greater than 20 years, and concentrations greater than 100 nanocuries per gram.

3 A nanocurie is a billionth of a curie.

Dear Arjun, *from page 13*

elements. It is clear that in all cases, the predominant mode of decay is the same (alpha decay) and that the decay energies are about the same (ranging from 4.1 to 5.5 mega-electron volts). Thus, the amount of radiation dose per radioactive decay of DU is approximately the same as that of a radioactive decay of a transuranic radionuclide of TRU waste.

As Table 2 shows, the half-lives of the uranium isotopes and transuranic elements vary greatly. The fact that the half-lives of the uranium isotopes are all longer than the half-life of plutonium-239, and the fact that over hundreds of thousands of years the decay products of uranium-238 will continue to build up resulting in an increase in radioactivity, pose a challenge for long-term management of depleted uranium that has not been addressed adequately by the regulatory agencies.

DOE's Proposed Action for the Disposition of DU as Waste

On January 25, 1996 the DOE issued a Notice of Intent (NOI) to prepare a Programmatic Environmental Impact Statement (PEIS). In the NOI, the DOE presented six "reasonable alternatives" for addressing the long-term management and use of depleted uranium hexafluoride. The alternatives are:

1) "no-action"—a continuation of the current management program of on-site storage of DUF_6 in cylinders;
2) retrievable storage in the UF_6 form;
3) retrievable storage in the oxide form;
4) use as radiation shielding after conversion to metal;
5) use as radiation shielding after conversion to oxide;

and, if DU is declared a waste,

6) disposal in oxide form in drums placed in either engineered trenches, below-ground concrete vaults, or mines.

In its alternative relating to depleted uranium as waste, the DOE does not specify under which low-level waste category DU would be classified. Disposal in engineered trenches corresponds to an erroneous classification of DU as Class A low-level radioactive waste. The other two disposal options fail to take into account that DU is essentially similar to transuranic waste in all aspects but its name. For example, putting depleted uranium in mines in no way replicates replacing the original material that was removed from the ground. As Table

See **Dear Arjun**, *page 16*

SELECTED PUBLICATIONS

Prices include shipping and handling.

IEER Books

***Nuclear Wastelands**: A Global Guide to Nuclear Weapons Production and Its Health and Environmental Effects*
MIT Press, 1995 • Hardbound, 666 pages • List price: $55 • SDA readers price: $40

***Fissile Materials in a Glass Darkly** (now available in Russian!)*
IEER Press, 1995 • Paperback, 126 pages • Price: $12

***Mending the Ozone Hole**: Science, Technology, and Policy*
MIT Press, 1995 • Hardbound, 355 pages • List price: $35 • SDA readers price: $27.50

High-Level Dollars, Low-Level Sense
Apex Press, 1992 • Paperback, 138 pages • Price: $15

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Books/Reports: Indicate titles and quantities and make checks payable to IEER.
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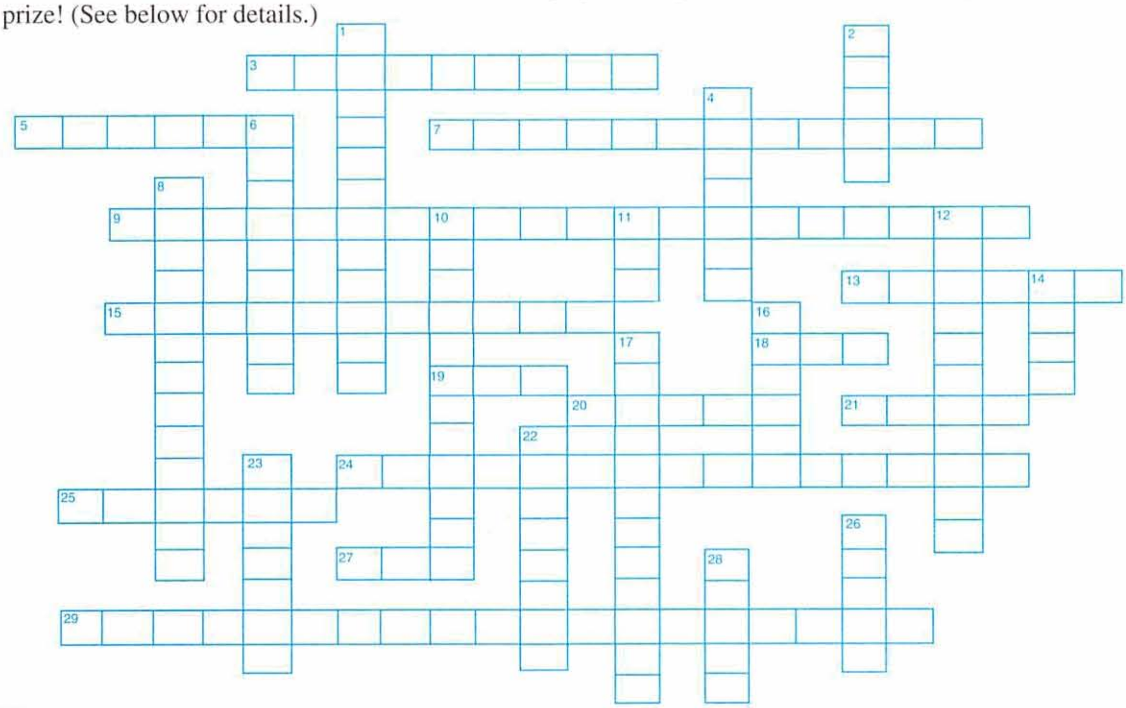
ATOMIC PUZZLER

OK, SDA readers, sharpen those pencils and review that newsletter! All terms used in this crossword are found somewhere in the newsletter. So have some fun, learn some jargon, and give the Atomic Puzzler a try! Don't forget about the $25 prize! (See below for details.)



ACROSS

3. Location of Reagan/Gorbachev summit in 1985.
5. UO_2F_2 is also known as ___ fluoride.
7. Adjective to describe X-ray photographs.
9. The program referred to in 14 Down is described as necessary to assure the ______ of the nuclear arsenal as it ages. (Three words.)
13. Category for the least dangerous "low-level" radioactive waste.
15. IEER obtained DOE research documents through the Freedom of ______ Act.
18. Acronym for the $1 billion facility proposed for the study of thermonuclear phenomena in warhead secondaries.
19. Location of facility in 2 Down: ___ Mexico.
20. One of the chemical forms for depleted uranium in addition to metal and DUF_6.
21. With 28 Down, type of comprehensive test ban treaty under which no nuclear explosions, however small, would be allowed.
24. Several former weapons designers propose this method for maintaining the nuclear arsenal after a CTB.
25. One of the former nuclear weapons designers referred to in 24 Across. (Last name only.)
27. Large commercial aircraft designed mainly by computer and wind tunnel experiments: Boeing ___.
29. Type of fusion research being conducted by some countries at present.

DOWN

1. Term to describe the behavior of liquids.
2. Acronym for the facility which uses 2 large X-ray machines to study implosions of compressed materials simulating the pit of a warhead.
4. The first stage of a nuclear warhead which contains high explosives and fissile materials.
6. Weapons laboratory in California where the facility referred to in 18 Across is located. (Second word of name only.)
8. In addition to Russia, France, and Great Britain, the countries that are currently reprocessing commercial spent fuel are _______.
10. The transuranic element with a half-life of 2.14 million years.
11. Adjective describing the enriched uranium in the term "LEU."
12. Term for radioactive isotopes with atomic numbers greater than 92.
14. Acronym describing the program proposed by DOE for the study of aging nuclear weapons.
16. In January, 1996, the DOE filed a Notice of _____ presenting alternatives for the management of DUF_6.
17. DUF_6 stands for Depleted Uranium ______.
22. Term for the safety standard relating to the high explosive which surrounds the primary in a warhead.
23. The facility in 18 Across is a "High Energy _____ Facility."
26. DOE data show that this has never been the cause of safety problems with the nuclear components of warheads in the U.S. arsenal.
28. See 21 Across.

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. (Fax #: 301-270-3029) 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 **August 15, 1996.**

Answers to the Last Atomic Puzzler (Vol. 5, No. 1) **Across:** 3. Triple Play; 5. Reprocessing; 7. Purex; 10. Electrometallurgical; 12. Interim Storage; 14. Nitric; 15. High Burnup. **Down:** 1. Accelerator; 2. Helium 3; 4. Nine Percent; 6. Objectives; 8. Strategic; 9. Decladding; 11. Hydrogen; 13. HTO.

Test Ban, *from page 6*

working together whenever possible. Such cooperation could have its advantages in the context of implementation of Article VI of the Non-Proliferation Treaty (NPT), under which the weapons states are obliged to end the arms race and pursue nuclear disarmament in "good faith." But cooperation to indefinitely maintain their nuclear arsenals, as the weapons states seem inclined to do, will not likely be viewed in a positive light by many non-nuclear states or by non-signatories to the NPT, notably Israel, India, and Pakistan. These last three countries are unlikely to accede to the NPT or abandon their own nuclear weapons programs under such circumstances.

A breakdown of the CTB in a time of crisis due to internal lobbying pressures may even cause the NPT regime to unravel. While that risk may appear small at the present time, U.S. pressures on the ABM treaty and the concomitant failure thus far of Russia to ratify START II are stark reminders of the possibility. Few could have predicted the current impasse at the time the ABM or START II treaties were signed.

The dangers of an unstable nuclear test ban can be avoided with a few simple commitments that should be incorporated into the implementation of a zero yield CTB. The nuclear weapons powers should:

- permanently renounce all nuclear testing, including "peaceful nuclear explosions," and close down their test sites;
- unequivocally renounce design of nuclear warheads;
- stop construction of new laboratory testing facilities;
- refuse to allow any escape clauses such as "subcritical" underground testing or modification of the CTB to allow "peaceful" nuclear explosions in the future.

A zero yield CTB with these minimal provisions would avoid future unpredictable conflicts and instabilities. As the remaining superpower both militarily and economically, the U.S. should show the way by being first to announce support for these steps.

The real caption for the photograph on page 1: **Outside view of the NOVA target chamber, an Inertial Confinement Fusion Laser at Lawrence Livermore National Laboratory in California.**

Dear Arjun, *from page 14*

1 shows, DU in the oxide form is 85 times more radioactive than typical 0.2 percent uranium ore. Disposing of DU in this manner is analogous to putting transuranic waste in the ground, and TRU waste qualifies for deep geologic disposal.

IEER's Recommendations

IEER makes the following recommendations for the long-term management of depleted uranium:

- DU should be declared a waste and reclassified to reflect the fact that, for all practical purposes, the properties of DU are the same as the properties of TRU waste.
- Like TRU waste, classification of DU should require deep geologic disposal under the rules specified in 40 CFR 191.
- In the interim, DUF_6, which makes up most of the stockpile, should be converted to an oxide form in order to greatly reduce the hazards of storage. Conversion should be done with care-ful attention to health and environmental protection.

The Institute for Energy and Environmental Research
6935 Laurel Avenue
Takoma Park, MD 20912

Address correction requested.

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