NIF Environmental, Safety, and Health Considerations

The proposed NIF has been rated by the DOE as a radiological low-hazard, non-nuclear facility. Our analysis to date of environmental, safety, and health issues related to the NIF, presented in documents that are available to the public, shows that the system will have no significant environmental impact and present no significant safety or health risk to the work force and the general public.

ENVIRONMENTAL, safety, and health (ES&H) considerations are of paramount importance in all phases of the design of the National Ignition Facility (NIF). From the outset, maximizing public and employee safety and minimizing health risk and environmental impact have been integral parts of the design process. In a broader sense, inertial confinement fusion has long-term potential as a source of future energy for the world. Earning the trust of the public and operating in a manner that protects the environment over time are requirements for any future energy source.

This article describes the results of environmental analyses as well as safety and health assessments. The topics fall broadly into three categories presented in the following order: radiation exposure, waste generation, and fusion targets.

The NIF will maintain a small inventory of less than 300 curies (0.03 grams) of tritium fuel and unburned tritium from inertial confinement fusion experiments. The fusion reactions in the 1-mm capsule will release a neutron for every tritium atom consumed, about 10^{17} atoms for an ignition experiment. The NIF target area employs heavy shielding, including 2-meter-thick concrete walls and a shielded vessel against the radiation. We have estimated the routine annual radiation dose at the site boundary, the maximum annual dose and average annual dose to any NIF worker, and the effects of a worst-case accident assuming release of the maximum planned tritium inventory. We have also estimated the quantities of hazardous, mixed, and low-level radioactive wastes. Before turning to these matters, a brief overview of the review process will help to put our efforts to date into perspective.

The Assessment and Review Process

Safety and environmental analysis specific to the NIF began more than two years ago. This work was an outgrowth of continuing environmental impact and safety analyses of general concepts for future inertial confinement fusion (ICF) facilities. More than a year ago, a standing NIF working group was formed at LLNL. The group is made up of environmental and safety experts in radiation protection, safety analysis, environmental evaluation, laser operations, occupational safety, tritium handling, waste handling, quality assurance, and fire protection. The group meets biweekly to ensure consistent and well-documented evaluation of environmental and safety aspects of the NIF design.

The NIF working group has prepared the Preliminary Hazards Analysis for the NIF[1] as well as radiation protection,[2] safety, environmental, quality assurance, and decommissioning evaluations of the NIF design.[3] These analyses are available to the public as published reports.[4]

ES&H issues are extensively analyzed by experts, documented, and reviewed by the public as part of the process established by the DOE for major system acquisitions such as the NIF. Whereas major steps toward safety and environmental analyses have already been done for NIF, additional analyses will include an Environmental Impact Statement, Preliminary and Final Safety Analyses, and Operational Readiness Reviews. The DOE requires all of these studies to ensure that essential aspects of the project are thoroughly analyzed and are completely satisfactory before operations begin.

Radiation Doses

In our radiological assessments, the unit of measure is the rem, which stands for roentgen-equivalent in man and is a unit of biological radiation dose. It is the amount of ionizing radiation that produces the same damage to humans as 1 roentgen of high-energy x rays. Natural background radiation from the environment—that is, from naturally occurring elements, cosmic radiation, and so forth—averages 0.3 to 0.5 rem/yr depending on where an individual lives. This natural background radiation does not include exposure to other potential sources of radiation, such as that from airplane flights and some types of medical diagnoses or treatments.

The routine annual dose from NIF at a site boundary 300 meters from NIF is expected to be 0.00013 rem. Put into perspective, this value represents 0.13% of the DOE and Environmental Protection Agency guideline and is 350 times less than the annual radiation dose arising from emissions from a 1-GW_e coal-fired power plant.

The average annual dose received by flight attendants is 0.5 rem, a dose not monitored by the airline industry. In comparison, the *maximum* annual dose to any NIF worker will be less than 0.5 rem, which is less than 10% of the DOE guidance. The *average* dose to any NIF worker is estimated to be about 0.01 rem.

The maximum tritium inventory for the NIF will be 300 curies (Ci). This amount is the equivalent of 0.03 grams of tritium. The maximum NIF inventory is less than 3% of the routine inventory of the National Tritium Labeling Facility in Berkeley, California, which uses tritium for tagging biomedical samples. One NIF target will contain less that 2 Ci of tritium, one-fifth the amount of tritium in some typical theater exit signs of which more than one million are sold annually.

There are no significant radioactive or hazardous effluent levels for NIF. For example, the projected maximum emission of tritium is less than 10 Ci/yr, the equivalent of the tritium in a single exit sign. The dose to a member of the public expected from all NIF effluents is 600 times less than that from a single cross-country airline flight.

The worst-case accident considered in our safety assessment assumes the release of all the tritium (300 Ci) in its worst biohazardous form (tritiated water) immediately after a maximum-yield experiment (20 megajoules). This postulated, but highly unlikely, accident would result in a calculated dose of 0.056 rem at a site boundary 300 meters from NIF. This dose is 0.2% of the DOE siting guidelines for annual exposure.

Waste Generation

NIF will generate three types of waste: hazardous, low-level radioactive, and mixed (a combination of hazardous and low-level radioactive). To be on the conservative side, we estimated higher waste quanlities than are likely from the NIF's waste streams. Moreover, our assessment has not fully considered waste-minimization techniques, such as frozen carbon dioxide pellet cleaning. Waste minimization will be an important and continuing design activity.

The annual hazardous waste stream associated with NIF will be about 3180 kg (7000 lb) of solid waste and 2270 L (600 gal) of liquid waste.[3] Most of this waste stream, about 2270 kg (5000 lb), will be in the form of 20 boxes of paper soaked with capacitor oil. Such waste is similar to but smaller in quantity than that generated in the same time by an automobile oil-changing facility. The waste will be routinely disposed of by certified contractors.

Mixed waste is both radioactive and chemically hazardous. The annual mixed waste stream associated with NIF will be about 135 kg (300 lb) of solid and about 2000 L

(530 gal) of liquid,[3] which represent a small fraction of the quantities currently generated at LLNL. These mixed waste quantities take into consideration some use of frozen CO_2 pellet cleaning, a dry, high-pressure scouring technique that decontaminates objects and avoids the need for alternate methods that use hazardous liquid solvents, thereby generating large quantities of liquid mixed waste.

The annual solid low-level radioactive waste stream, 400 kg (850 lb), will be a small fraction of the quantity currently generated at LLNL and is less than one-sixth of that produced by a major university's medical center. The annual liquid low-level radioactive waste stream (aqueous waste) will be disposed of in several 55-gallon drums,[3] along with two drums of vacuum pump oil, according to applicable guidelines.

Fusion Targets

ICF targets are used in many facilities throughout the country. Examples of current or future facilities using such targets include the Nova laser; the Particle Beam Fusion Accelerator II (PBFA-II) at Sandia National Laboratory in Albuquerque, NM; the planned upgrade of the Omega laser at the University of Rochester; and the proposed NIF. The manufacture and filling of fusion fuel capsules is a separate and ongoing activity of the national ICF Program that supports present and future facilities. These functions are carried out at several DOE and commercial sites (for example, at General Atomics in La Jolla, CA; the University of Rochester in Rochester, NY; Los Alamos National Laboratory in Los Alamos, NM; and LLNL).

The filling activity for NIF targets requires a total inventory of less than 5 grams of tritium. The target manufacturing and filling facilities have their own *National Environmental Policy Act* (NEPA) documentation and engineered systems to protect workers, the public, and the environment by safely confining any tritium.

Because of the existing national capability, the NIF project will not include a dedicated target manufacturing and tritium filling facility. Instead, it will receive several types of targets from several different sites. Targets for NIF will be transported in certified containers prescribed by the Department of Transportation and in accordance with the *Code of Federal Regulations* (Title 49, section 173).

Summary

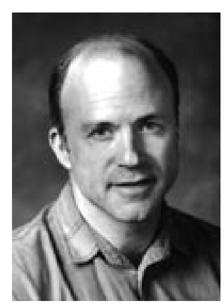
After reviewing the Preliminary Hazards Analysis report, the DOE concurred with the preliminary categorization of the NIF as a radiological low-hazard, non-nuclear facility. This means that operation of the NIF will have minor onsite and negligible offsite consequences. The hazards categorization will be reviewed in each subsequent safety analysis report.

The conservative safety and environmental analyses outlined in this article are the first of a series of studies required to ensure the safety of workers, the public, and the environment. The NEPA process of the DOE ensures joint participation by the public and those states that may be affected by the project. The Environmental Impact Statement process will also allow participation by the public in reviewing the potential environmental impacts of the NIF.

Key Words: environmental safety and health (ES&H); National Ignition Facility (NIF)—radiation dose; tritium inventory; waste stream.

Notes and References

1. S. J. Brereton, *Preliminary Hazards Analysis for the National Ignition Facility*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-ID-116983 (1993).
2. M. S. Singh, *Radiological Analysis of the National Ignition Facility*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-LR-115188 (1993).
3. *National Ignition Facility Conceptual Design Report*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-PROP-117093 (1994) and *National Ignition Facility Seting Proposal–LLNL*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-PROP-119353 (1994).
4. To obtain copies of references 1 and 2, contact the National Technical Information Services (NTIS), U. S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. Reference 3 cites ongoing documents that will not be available to the public through NTIS until complete; copies, however, are available to read at the Livermore Public Library, Livermore, CA, and at the Visitors Center at LLNL.
5. S. Brereton, G. Greiner, M. Singh, and M. Trent also contributed to this article.



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