APPLYING INTERNATIONAL SAFEGUARDS TO IRRADIATED FUEL AT THE HFIR

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Applying International Safeguards to Irradiated Fuel
at the High Flux Isotope Reactor (HFIR)

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Abstract

The International Atomic Energy Agency (IAEA) is considering the application of international safeguards to a limited quantity of irradiated high-enriched uranium fuel residing at the High Flux Isotope Reactor (HFIR). Although the IAEA has not yet selected the HFIR for safeguards, a series of technical exchanges between the United States (U.S.) and the IAEA have focused on a proposed safeguards approach that would minimize HFIR operational impacts while satisfying both the IAEA and U.S. mutual goals of nonproliferation.

Introduction

The International Atomic Energy Agency (IAEA) is considering the application of international safeguards to a limited quantity of irradiated high-enriched uranium (HEU) fuel residing at the High Flux Isotope Reactor (HFIR). This fuel is planned as a substitute for safeguarded Chilean irradiated fuel being returned to a United States (U.S.) facility currently not eligible for IAEA safeguards to satisfy requirements of the safeguards agreement between Chile and the IAEA.

The HFIR irradiated HEU fuel was considered by the IAEA to be an acceptable substitute because of its similarity in form and composition to Chilean irradiated fuel. Moreover, the relatively large on-site inventory of irradiated HEU fuel at the HFIR could also serve as additional substitute material, as required. HFIR fuel consists of two types of cylindrically annular items — inner fuel elements and outer fuel elements. Each HFIR core (known as a fuel assembly) consists of one inner fuel element and one outer fuel element. Each fuel assembly has an outer diameter of about 1.4 ft, a height of about 2.6 ft, and initially contains approximately 9.4 kg of $^{235}\text{U}$.

As shown in Figure 1, the HFIR vessel is located in a large water-filled rectangular pool, which is approximately 60-ft long (east/west), 18-ft wide (north/south), and 20-ft deep. The pool may be subdivided into approximately three equal sections using movable separation gates. The western third, which contains the reactor vessel, is designated as the reactor pool. The center third is designated as the center (or west) pool, and the eastern third is designated as the east pool. The east and center pools collectively represent the clean pool.

Two movable (east/west) bridges (rolling and motorized) allow personnel access over both the reactor pool and the clean pool. The clean pool (combined center and east pools) holds both auxiliary reactor components and irradiated HEU fuel in fuel-storage arrays (FSAs). The current FSA configuration is shown in Figure 2, which provides capacity information at three distinct
elevations (approximately 3, 6, and 9 ft) above the pool floor. These three elevations define which multitier FSA locations can accommodate stacked (as high as three) fuel. Each stacked fuel assembly is locked into a movable jacket assembly, which is positioned within a stationary silo. Stacking fuel more than three high (more than 10 ft above the pool floor) is restricted because of both fuel-handling and reactor-operations issues.

**HFIR Experience with IAEA Safeguards**

To prepare for international safeguards at the HFIR, the U.S. Department of Energy (DOE) International Safeguards Division (ISD) – in coordination with the DOE Office of Nuclear Energy, Science and Technology – conducted a tutorial on IAEA safeguards at the HFIR in September 1996. At the tutorial, representatives from the Y-12 Plant National Security Program Office (NSPO) and other safeguarded U.S. facilities gave presentations that focused on the function and operation of the IAEA, a description of safeguards methodologies, and lessons learned in implementing safeguards at other US facilities. A tour of the HFIR by the participants was followed by a discussion of the initial effort required to generate the Design Information Questionnaire (DIQ) for HFIR.

The first IAEA technical meeting at HFIR was held in October 1996 and was sponsored by the facility with substantial support provided by the ISD through the NSPO in preparing the presentation materials. The meeting focused on providing sufficient technical information on the HFIR to the IAEA to facilitate the determination a cost-effective safeguards approach that would minimize operational impacts. Additionally, the IAEA toured the reactor building, including the reactor bay, and detailed information was presented on the path fuel follows at HFIR (e.g., handling of fresh, operation in the reactor, handling of irradiated, and shipment).

The second IAEA technical meeting at the HFIR, which was also sponsored by the facility, focused on the progress the IAEA had made on the development of a safeguards approach for irradiated HEU fuel residing at the HFIR. During the meeting, the IAEA tested an improved Cerenkov viewing device (ICVD) on irradiated HEU fuel located in the HFIR FSAs. This material had decayed for as long as 12 yr since its last critical operation. The test results indicated that the ICVD could be used in the IAEA safeguards approach. The IAEA also discussed preliminary containment and surveillance methods to employ at the HFIR. These methods focused on the multitier silo located in the southwest corner of the east pool (see Figure 2). This silo, which is designated as MS-101 and could hold up to three safeguarded stacked HFIR fuel assemblies. An IAEA support area located in the center pool could allow for the inspection (external to their jacket assembly) of safeguarded irradiated HEU fuel elements.

Because the continued movement of objects (i.e., auxiliary reactor components, irradiated HEU fuel, the rolling and motorized bridges, etc.) over MS-101 is required to support on-going HFIR operations, continuous camera surveillance of it from above the pool is difficult. As a result, the IAEA described a containment device that could be attached to the wall of the pool and extended vertically downward to a depth of about 9 ft. Such a containment device, which could be sealed at the location at which it is attached to the pool wall (above the water surface), could prevent the
unauthorized movement of safeguarded irradiated HEU fuel within MS-101. In order to minimize interference with other on-going pool operations, it was discussed that the containment device could be designed to vertically follow the pool wall until the depth at which it extends over the silo.

Also, as part of the second technical meeting, the IAEA outlined inspection activities that would be potentially used for initial inventory verification at the HFIR include item counting, identification of items by serial number, and gross-defect tests of items using the ICVD. Interim inventory verifications would consist of seal checks only and would occur on a quarterly basis. As a result of the second technical meeting, follow-on actions were developed to allow the IAEA to further investigate the feasibility of different options for a potential safeguards approach at the HFIR.

Conclusions

Although a methodology has been discussed for the application of international safeguards on irradiated HEU fuel residing at the HFIR, the implementation details remain undefined. As a result, a number of issues are currently open concerning the safeguards approach. These include:

- the quantity of irradiated fuel to be safeguarded (both initially and ultimately),
- the substitution methodology (i.e., distinct item for distinct receipts, running balance, ultimate quantity in advance, plutonium conservation, implementation delay, etc.), and
- the facility design information (initially encompassing one silo).

Even though the HFIR has not yet been selected by the IAEA for the application of international safeguards, the technical information exchange process has been beneficial and is continuing. This process has been significantly eased through domestic support provided by the ISD, NSPO, and interactions with representatives from other safeguarded U.S. facilities. Both the ISD tutorial and an IAEA-sponsored accounting workshop in Atlanta provided excellent opportunities to understand the philosophy and operation of the IAEA as related to U.S. facilities.

It is anticipated that future technical information exchanges between the U.S. and the IAEA on the HFIR facility will result in the development and implementation of a cost effective safeguards approach which will minimize operational impacts while satisfying both the IAEA and U.S. mutual goals of nonproliferation.
Figure 1. High Flux Isotope Reactor Pool Isometric.
Figure 2. High Flux Isotope Reactor Fuel Storage Arrays (circa 1997).