COMMONALITY OF IAEA SAFEGUARDS AND OPERATIONAL MONITORING AT GEOLOGICAL REPOSITORIES

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ABSTRACT

In September 2002, the International Atomic Energy Agency's (IAEA's) Geological Repository Safeguards Experts Group evaluated the overlap between the monitoring requirements for IAEA safeguards, national physical protection and material control and accounting, repository performance confirmation and quality assurance, and operational safety. Experts representing all four disciplines met in Oskarshamn, Sweden, to identify and discuss each function's monitoring needs. The monitoring requirements were compared for the pre-operational, operational, and post-closure phases of a geological repository. During the pre-operational period, the IAEA's design information verification requirements closely overlap the state and operator's design and performance confirmation monitoring activities. During the operational period, the IAEA's safeguards verification requirements will significantly overlap with monitoring activities performed to meet domestic nuclear material accounting, operational safety, and quality assurance requirements. During the post-closure period, IAEA safeguards will have the only required monitoring activities; however, some States are considering monitoring, for a limited time, to provide assurance that the repository remains undisturbed. Using the results of the Experts Meeting, the Waste Technology Section of the IAEA's Department of Nuclear Energy held Consultants' Meetings to determine what repository design considerations could facilitate the effective implementation of IAEA safeguards at geological repositories.

BACKGROUND

The International Atomic Energy Agency (IAEA) safeguards approach for the final disposal of spent fuel in geological repositories is nearing the implementation phase. During the past year, the IAEA Departments of Safeguards, Safety, and Nuclear Energy conducted evaluations on how the proposed geological repository safeguards approach can be effectively and safely implemented. The Department of Safeguards organized a meeting of experts in safety, geological repository operations, and safeguards from six States (i.e., Canada, Finland, Germany, Sweden, U.K., and U.S.), the European Commission, and IAEA. This meeting was held in Oskarshamn, Sweden, during September 16-20, 2002, to address "Interface Issues and Interactions between Safeguards and Radioactive Waste Management in the Context of Geological Repositories." The Department of Nuclear Energy organized Consultants' Meetings in Vienna, Austria, on December 11-13, 2002, and May 12-16, 2003, to address "Technological Implications of Safeguards Requirements for Geological Disposal of Radioactive Waste." The Department of Safety organized a panel discussion on "How to Accommodate Nuclear Safeguards Requirements for Spent Fuel in a Final Disposal Facility" during the December 9-13, 2002, International Conference on Issues and Trends in Radioactive Waste Management.

Facilities for the final disposal of spent fuel, though still in the planning stages, are being designed and submitted for licensing approval. Site characterization activities are being

conducted and some exploratory facilities have been excavated. Belgium, Switzerland, France, Germany, Canada, and Sweden have excavated underground laboratories to confirm their repository concepts. The United States (U.S.) exploratory facility at Yucca Mountain is complete and will become part of the U.S. repository. Finland's underground laboratory, whose construction will begin in 2004, will become part of its repository. Finland designated the Olkiluoto site for its national geological repository in May 2001 and the United States designated the Yucca Mountain site as its repository in July 2002. Sweden is expected to designate its repository location in early 2008. The U.S. repository is scheduled to begin operation in 2010, Sweden in 2015, and Finland in 2020. IAEA, Euratom, and Finland have met to discuss the implementation of safeguards for Finland's repository, beginning with design information verification.

This report mainly addresses the results of the September 2002 Experts Meeting. The Experts Meeting participants primarily assessed where monitoring activities can serve multiple functions and how safeguards can use these synergies to make safeguards more effective and efficient. The participants identified and compared potential monitoring activities to be conducted for IAEA safeguards, operational safety, physical protection and material control and accounting (PPC&A), and performance confirmation and quality assurance (PC/QA), during the pre-operational, operational, and post-closure phases. The results of the other meetings built on the Experts Meeting results and will be addressed at the end of the paper.

GEOLOGICAL REPOSITORY OPERATIONS

Final disposal of spent fuel and other nuclear materials may occur in geological repositories at depths of 250-1000 meters below ground level. Depending on the host rock and disposal concept, emplacement may occur in crystalline rock (e.g., granite), salt, tuff, or clay. The operational life of a repository is expected to be 20-100 years before it is closed, backfilled, and sealed. The spent fuel in a filled repository is expected to contain 2,000-200,000 metric tonnes of uranium and 10-2,000 metric tonnes of plutonium, as well as other potentially attractive materials.

Pre-operational phase: The pre-operational phase is defined to be the period from designation, by a State, of a site for construction of a geological repository for spent fuel disposal up through receipt of the first disposal container. The pre-operational phase may include site characterization, underground exploration, and construction of the repository. In some States, site characterization (including access construction and underground exploration) may occur before national designation of the geological repository site.

Operational Phase: The operational phase starts when the first disposal container arrives and continues through final closure of the repository. The operational phase may include receipt of disposal containers, tunnel and vault excavation, emplacement of containers, deployment of engineered barriers, tunnel and vault backfilling, and repository backfilling and sealing. The various barriers and seals may be put in place at different times depending on waste and rock characteristics. National requirements for waste package retrievability may have a significant influence on the disposal options chosen.

Post-closure Phase: The post-closure phase starts when the geological repository has been backfilled and closed and the surface facilities have been decommissioned. Closure is defined as a permanent condition with respect to the status of the geological repository at the end of its operating life. Monitoring and surveillance could be maintained for as long as society considers it beneficial, although it is a principle of geological disposal that assurance of safety should not require post-closure monitoring.

MONITORING

The geological repository and its operations will be monitored by the national (and regional) authorities, repository operator, and/or IAEA, during the pre-operational, operational, and post-closure phases, to confirm that:

(1) The repository is operated safely and provides long-term isolation of the spent fuel from the biosphere, and
(2) The contained nuclear materials are not diverted to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown.

Certain monitoring activities will begin at the earliest possible stage of the site investigation and repository development program, before changes to the environment, caused by the mining activities and repository operation, begin to accumulate. This early information creates an understanding of the nature and properties of the natural, undisturbed environment of the disposal system (baseline) against which the repository monitoring data can be compared.

The following four monitoring activities were evaluated by the experts:

Performance Confirmation and Quality Assurance: PC/QA is the responsibility of the facility operator and is subject to oversight by national authorities. PC/QA assesses the performance of the repository during operations to ensure that the final disposal of radioactive waste does not adversely affect human health and the environment now or in the future and does not impose an undue burden on future generations. PC/QA will gather and analyze data to confirm whether conditions within the repository are within the expected ranges and to support predictions that post-closure performance will achieve the stated goals defined in References 1-4.

Operational Safety: Operational safety is also the responsibility of the facility operator and is subject to oversight by national authorities. Operational safety refers to occupational safety and health, radiation protection, environmental safety, and other related safety activities and includes considerations for reducing hazards to workers and to members of the public under normal and abnormal situations. These activities are similar to those conducted for other mine construction and nuclear-related activities and must meet the general safety objectives and criteria, as specified in Reference 5, the IAEA's Basic Safety Standards. Operational safety monitoring ensures a safe working environment during the construction, operation, and pre-closure periods.

Physical Protection and Material Control and Accounting: PPC&A is implemented by the facility operator and is subject to oversight by national and regional authorities. Physical protection protects the facility and the contained nuclear materials against adversary actions that

could result in a loss of control of the facility or nuclear materials, radiological sabotage, nuclear material theft, or other unacceptable risk to the public health and safety. Physical protection will be provided by an integrated system of administrative procedures, access control, physical barriers, monitoring, and guard force response in accordance with the guidance of Reference 6. Material control and accounting controls access to nuclear materials to only authorized persons; maintains knowledge of the location, composition, and quantities of nuclear materials at the facility; and detects and responds to potential losses of these nuclear materials. Geological repositories will be item accounting facilities for which the repository operators will keep records showing the receipt, inventory, location, disposal, and transfer of each item. For containers of spent fuel, which have not been emplaced, the operator will conduct a periodic physical inventory of the items. Monitoring will be performed to maintain current knowledge of the spent fuel items and of the security of the facility.

IAEA Safeguards: The objective of IAEA safeguards, under Comprehensive Safeguards Agreements (INFCIRC/153)[7] and Additional Protocols to the Agreements (INFCIRC/540),[8] is the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown, deterrence of such diversion by the risk of early detection, and providing credible assurance of the absence of undeclared nuclear materials and activities in a State. The IAEA is responsible for conducting independent verification activities to provide assurance of the nondiversion of nuclear materials from declared activities and of the absence of undeclared nuclear materials and activities.

IAEA safeguards policy states "Spent fuel disposed in geological repositories is subject to safeguards in accordance with the applicable safeguards agreements. Safeguards on such material are maintained after the repository has been back-filled and sealed and for as long as the safeguards agreement remains in force."[9]

The IAEA Programme for the Development of Safeguards for the Final Disposal of Spent Fuel in Geological Repositories (SAGOR) (comprised of eight IAEA Member States, the European Commission, and IAEA) developed generic safeguards approaches for operating and closed deep geological repositories.[10] The safeguards objective for an operating repository is to provide a high level of assurance that the declared quantity of nuclear material contained in the spent fuel is transferred into the repository and that undeclared removal of nuclear material would be detected. The safeguards approach is expected to use item accounting supported by a reliable and comprehensive containment and surveillance (C/S) system above ground to verify the transfer and flow of spent fuel containers. Design information verification (DIV) is the recommended primary safeguards measure in the underground areas of the facility. DIV in this instance could include geophysical techniques in so far as they would be feasible, effective, and efficient.

RESULTS

The experts' evaluation identified that most of the parameters that the IAEA desired to monitor for safeguards purposes would probably also be monitored by the operator or the state (or regional) authority for PC/QA, operational safety, or PPC&A. Monitoring needs were identified for different purposes in the pre-operational, operational, and post-closure phases of the

repository. However, for the post-closure phase, the monitoring needs are primarily those of IAEA safeguards. There is general agreement within the international nuclear safety community that geological repositories should not need active institutional control (monitoring) for safety reasons in the post-closure phase.

The following parameters are expected to be monitored at geological repositories for IAEA safeguards, and also for regulatory, and operational purposes:

1) differences from declared repository surface facility design, documentation, equipment, construction materials, testing materials, and activities (pre-operational and operational phases);
2) differences from declared repository underground facility design, documentation, equipment, construction materials, testing materials, and activities (pre-operational, operational, and post-closure phases);
3) undeclared neighboring underground constructions or caves and undesirable features in the surrounding geological media (pre-operational phase);
4) subsurface engineering activities (e.g., undeclared tunneling) (pre-operational, operational, and post-closure phases);
5) subsurface radiological events (e.g., opening of casks) (operational phase);
6) cask management (e.g., receiving, movement, and disposal) (operational phase);
7) undeclared removal of nuclear material (e.g., spent fuel) (operational and post-closure phases);
8) changes in instrument effectiveness (pre-operational, operational, and post-closure phases).

In addition to the above monitoring needs, the regulatory authority and operator may also monitor the following parameters during the pre-operational and operational phases:

1) changes in the host rock;
2) changes in groundwater levels and chemistry;
3) smoke;
4) changes in subsurface air quality, including radon, from baseline;
5) changes in ventilation;
6) changes in effluents released to environment from underground activities;
7) changes in personnel capabilities;
8) unauthorized intrusion by people;
9) loss of property by theft.

Equipment used to monitor some of these parameters may also provide information useful to IAEA safeguards.

CONCLUSIONS

The experts evaluating "Interface Issues and Interactions between Safeguards and Radioactive Waste Management"[11] concluded that, during the pre-operational period, the IAEA's design information verification requirements closely overlap the state and operator's design and performance confirmation monitoring activities. During the operational period, the IAEA's safeguards verification requirements will significantly overlap with monitoring activities performed to meet PC/QA, operational safety, and PPC&A requirements. During the post-closure period, IAEA safeguards may have the only required monitoring activities; however, some States are evaluating whether monitoring should be continued, for a limited time, to provide assurance that the repository remains undisturbed.

The IAEA Consultants evaluating "Technological Implications of Safeguards Requirements for Geological Disposal of Radioactive Waste" concluded that the implications of IAEA safeguards on a geological repository are not conceptually different from those at other fuel cycle facilities. They believed that safeguards-related impacts can be handled satisfactorily through advance planning and cooperation between the IAEA, state, and facility operator. Early cooperation for the review of design considerations was recommended to facilitate installation of IAEA equipment to maximize its effectiveness and to minimize its impacts on facility operations.[12]

The Chairman's summary of the panel discussion on "How to Accommodate Nuclear Safeguards Requirements for Spent Fuel in a Final Disposal Facility" held during the December 2002 International Conference on Issues and Trends in Radioactive Waste Management identified that the potential impact of safeguards on repository design and post-closure management were consistent with envisaged operational controls but would require unprecedented institutional commitments over long time periods if a repository is left unsealed and not backfilled for an extended period.

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