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Design and Implementation of an International Training Program on Repository Development and Management-8076

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ABSTRACT

Korea Hydro & Nuclear Power Co., Ltd. (KHNP) is an electric company in the Republic of Korea with twenty operational nuclear power plants and eight additional units that are either planned or currently under construction. Regulations require that KHNP manage the radioactive waste generated by their nuclear power plants. In the course of planning low, intermediate, and high level waste storage facilities, KHNP sought interaction with an acknowledged expert in the field of radioactive waste management and, consequently, contacted Sandia National Laboratories (SNL). KHNP has contracted with SNL to provide a year long training program on repository science. This paper discusses the design of the curriculum, specific plans for execution of the training program, and recommendations for smooth implementation of international training programs.

INTRODUCTION

Korea Hydro & Nuclear Power Co., Ltd. (KHNP) is an electric company in the Republic of Korea with twenty operational nuclear power plants and eight additional units that are either planned or currently under construction. KHNP has responsibility for permanent disposal of low and intermediate level waste as well as high level waste. Management of nuclear waste is a complex issue, so KHNP has made an effort to educate their staff on the many issues involved. In the course of planning low, intermediate, and high level waste storage facilities, KHNP sought interaction with an acknowledged expert in the field of radioactive waste management and, consequently, contacted Sandia National Laboratories (SNL). SNL has more than thirty years of experience with radioactive waste management. SNL serves as the scientific advisor to the U. S. Department of Energy for the Waste Isolation Pilot Plant (WIPP), the world's only licensed and operational facility for permanent geological disposal of transuranic waste. SNL's advisory responsibilities include site characterization, investigations and monitoring of repository performance, long–term probabilistic performance assessment of the repository with respect to regulatory requirements, impact assessments of modifications to the repository design and waste inventory, and periodic recertification of the WIPP. SNL is also the lead laboratory coordinating scientific work and the license application for the Yucca Mountain Project (YMP). The Department of Energy plans to submit the license application for YMP to the U. S. Nuclear Regulatory Commission in 2008, and SNL is responsible for conducting the post-closure performance assessment. Because of SNL's extensive experience in radioactive waste management KHNP has contracted with Sandia National Laboratories to provide a year long

training program on repository science. This paper discusses the design of the curriculum, specific plans for execution of the training program, and recommendations for smooth implementation of international training programs.

TRAINING OBJECTIVES

The objective of the training program is to provide KHNP with the advanced knowledge, capability, and experience required for the development of low and intermediate level waste and high-level waste repositories in the Republic of Korea. The transfer of knowledge and experience is accomplished through a combination of lecture and work activities. The objectives of the training program are well served by transfer of knowledge (lecture) and application of that knowledge.

The training program consists of two main approaches: formal classroom training and on-the-job training. The training program is designed to last approximately one year (fifty-one weeks), and thirty-one weeks are scheduled for classroom training. The formal classroom training has thirteen main topics: radioactivity and ionizing radiation; regulatory requirements; quality assurance; waste characterization and classification; repository siting and characterization; packaging and transportation of nuclear and hazardous waste; assembly of a safety case; repository operation, design, and closure; environmental monitoring and risk analysis; financial administration; interim storage of spent fuel; transportation of spent fuel and high level waste; and safeguards and nonproliferation. The lecture topics are a combination of relevant background material and issues directly related to repository development and management.

The remaining twenty weeks of the training program are comprised of on-the-job training. On-the-job training activities will include day-to-day job assignments related to the WIPP and YMP, interactions with stakeholders, and attending public meetings. All training activities will take place at SNL or affiliated facilities in Carlsbad, New Mexico, Albuquerque, New Mexico, and Las Vegas, Nevada. The proximity of the training activities to ongoing repository management activities will enhance knowledge transfer.

CURRICULUM DESIGN

Rechard has chronicled the major technical milestones that were achieved during planning, testing, opening, and operating the WIPP [1]. The training curriculum for this project is based upon Rechard's major technical milestones listed below:

- Site Selection;
- Geological Characterization;
- Testing and Modeling of Site Hydrology;
- Conceptual Design of Repository;
- Making the Safety Case;
- Design of Package Transport;
- Shaft Sealing Ideas and Closure Plans;
- Identifying Repository Inventory;

- Testing and Modeling Chemical Reactions in Repository;
- Engineered Barrier Design;
- Features, Events, and Processes (FEPs) Screening;
- Performance Assessment with Scenario and Parameter Uncertainties; and
- Compliance Certification Application.

The curriculum is divided into sixteen training modules. Twelve modules primarily consist of classroom training for a total of 31 weeks (including 5 weeks of university based classroom training), and on-the-job training accounts for the remaining four modules that comprise an additional 20 weeks of training. The following sections discuss the content and motivation of each raining module.

Module 1: Fundamental Principles of Radioactivity and Ionizing Radiation as Applied to Radioactive Waste

The first module of the training program covers background topics in radioactivity and ionizing radiation that are relevant to people working with radioactive waste. The duration of this module is one week. The topics include fundamental processes in radiation physics, applications of radiation physics, radioactivity and decay chain, dose conversion factors, health effects, the nuclear fuel cycle, and management of radioactive waste. These topics are included in the curriculum as a review since the KHNP employees have some previous knowledge of these topics. Additionally, lecture over these topics provide an introduction of technical discussions in the English language.

Module 2: Regulatory Requirements and Quality Assurance Programs

The second module of the training program covers topics in the areas of regulatory requirements and quality assurance (QA) programs. This module is an essential foundation for many of the remaining module since many of the management and modeling approaches for waste management are driven by regulatory requirements. Additionally, a rigorous QA program is essential to providing confidence to stakeholders and regulators that waste is being managed safely and effectively.

One week is devoted to each of the topics. During the first week of this module, lecture topics include the organizational structure of operating and regulator entities for WIPP and YMP, the regulatory framework for WIPP and YMP, regulatory processes for WIPP and YMP, and public acceptance efforts for WIPP and YMP. The regulatory environments for each of the two repositories are analyzed to familiarize the KHNP trainees with a range of possible regulatory rules.

Lecture during the second week of Module 2 features the historical and regulatory basis for the WIPP QA program, customer mandated regulatory requirements, audits, ISO 9000, procurement and vendor interactions, lessons learned, and case studies. The lessons learned and case studies sections include discussion of WIPP and YMP examples as well as international examples. The goal of this week of lecture is to assist KHNP in development of a rigorous QA program.

Module 3: Waste Characterization and Classification

The waste characterization and classification module spans one week. The main topics of this module are discussions of waste types and examples for the U. S. DOE, U. S. commercial entities, and international groups. Additional discussion includes the regulatory framework pertaining to waste characterization and classification and waste characterization case studies. This module is included as a foundation for later discussions of inventory management. Module 3 is the final module in background topics relevant to repository design and assessment.

Module 4: Repository Siting and Characterization

Module 4 is the first module that focuses on core repository issues. Repository siting and characterization are critical activities in the effort to select a repository site that will effectively contain nuclear waste. The topics in Module 4 require four weeks of lecture. The first week contains a discussion of siting criteria. The main topics during this week are siting criteria for low and intermediate level waste versus high level waste, the geologic setting for repositories, and analysis of hydrogeology and geochemical conditions. The second week of Module 4 focuses on site characterization plans. Lecture topics include site characterization plan components, iterative refinement of these components, dealing with uncertainty, and case study discussion of the WIPP, the YMP, and international repository program site characterization plans. The third week of Module 4 focuses on site characterization methods. Discussions on geological, geophysical, hydrological, and geochemical methods are presented in this week. Lecture concluded with case study discussion of the WIPP, the YMP, and international repository program site characterization. The fourth week of Module 4 covers the realm of data integration in repository management. Lecture topics include compendium characterization reports, technical baseline documents, environmental impact statements, the technical basis for decisions making, and case study discussion of WIPP, YMP, and international repository program data integration techniques.

Module 5: Packaging and Transportation of Nuclear and Hazardous Waste

Module 5 is the first of two modules in the curriculum that cover the topics of packaging and transportation of nuclear and hazardous waste. Safe transport of nuclear waste is another essential activity in the successful implantation of a repository. Module 5 is composed of three one-week sections. The first week focuses on general, programmatic, and regulatory overviews of packaging and transportation of nuclear and hazardous waste. Lecture topics include an overview of transportation practices in the United States, the regulatory framework and requirements for transportation of nuclear and hazardous waste, package design and performance, modes of transport, and an overview of the Yucca Mountain Project transportation plan. The second week of Module 5 focuses on package development and risk analysis. Lecture topics include the package development process, Safety Analysis Report preparation, risk analysis, routing, sabotage testing, burn and drop tests of packages, and an overview of RADTRAN, a transportation risk analysis code. The third week of Module 5 focuses on operations and public interaction. Lecture topics include logistics and systems modeling, operational processes, emergency response, physical protection, and public interaction.

Module 6: Assembly of a Safety Case

Module 6 covers the requirements for assembling a safety case. This topic is emphasized in the curriculum because effectively communicating that a repository is safe is a critical step in the licensing process. Module 6 spans four weeks. The first week provides an overview of safety cases and the System Prioritization Method 2 (SPM2). SPM2 is a quantitative methodology used by management to determine how resources should be allocated for development of technical issues. Topics covered during this week include safety strategies, assessment basis, synthesis of safety assessment, primary areas of analysis, development of performance objectives based on regulations, description of performance objectives, and the System Prioritization Method 2. The second week of Module 6 covers FEPs screening, development of performance assessment scenarios, and waste inventory. The waste inventory discussion includes discussion of New Mexico Environment Department and Environmental Protection Agency requirements, waste characterization processes, and inventory characteristics incorporated into performance assessment. The WIPP is used as a case study when discussing the topics of data management for repository inventory and calculation of normalized releases. An analysis of the current baseline inventory is also presented.

The third week of Module 6 is a discussion of performance assessment methodologies. Specific lecture topics include the probabilistic performance assessment framework, statistical regulatory requirements, representing uncertainty in performance assessment models, parameter development, random sampling techniques, sensitivity analysis, and incorporation of deterministic and probabilistic modeling. The final week in Module 6 is an investigation of numerical models in WIPP performance assessment. Lecture covers the interface between site characterization and performance assessment models and modeling methodologies and processes. Discussion of the specific numerical models includes modeling of salt creep, brine and gas flow, chemistry conditions in the repository, actinide mobilization and transport, direct release of radionuclides to the environment, groundwater modeling, and stochastic processes.

Module 7: Tour of Yucca Mountain Facility

Module 7 consists of a one week visit to various sites related to radioactive waste management in Las Vegas, Nevada. Training activities include tours of the Nevada Test Site, the YMP repository site, and a tour of the University of Nevada at Las Vegas. This module is included as on-the-job training activities related to the management of spent nuclear fuel.

Module 8: Repository Design, Operation, and Closure

Module 8 is a two week module covering the topics of repository design, operation, and closure. These topics are included because of their relevance to repository programs. Lecture topics during the first week include repository design with an emphasis on the design processes for the WIPP and YMP repositories, natural and engineered barriers, and performance confirmation and monitoring. The second week of Module 8 includes lecture over shaft seal systems and site closure plans. The module also includes a tour of the above and underground facilities at the WIPP.

Module 9: Environmental Monitoring and Risk Analysis for a Nuclear Waste Repository

Module 9 is a five week module that covers a variety of topics. This module is taught through the Carlsbad Environmental Monitoring and Research Center (CEMRC) in Carlsbad, New Mexico. These topics are included in the curriculum to educate KHNP on the issues inherent in long term management of a repository. The first two weeks of the module consist of lecture and demonstration on the topic of environmental monitoring. Environmental sampling techniques and equipment are covered through lecture and demonstration. Data collection and management are discussed. The third week of Module 9 is a mock exercise in site characterization for a repository containing spent fuel. The trainees analyze mock site data, create and revise site conceptual models, prepare a safety case, and analyze international case studies. The fourth week of Module 9 emphasizes risk assessment and contaminant transport. Lecture topics include exposure and dose, sources of exposure, aerosol dynamics, inhalation, soil dynamics, and foodchain pathways. Module 5 concludes with a week of discussion on mathematical risk assessment tools. Lecture topics include uncertainty and sensitivity analysis, dose and risk, and use of models.

Module 10: On-the-Job Training, WIPP Activities

Module 10 is a five week module of on-the-job training activities. Assignments include day-to-day job assignments with WIPP staff members, discussion of WIPP issues with Department of Energy personnel, development of a features, events, and processes list for a Korean repository, and participation in public stakeholder activities. The trainees had the opportunity to observe a peer review for a set of WIPP performance assessment conceptual models.

Module 11: Fund Administration of Nuclear Waste Disposal

Module 11 focuses on the financial structure of a repository program and lasts for one week. This module is included in the curriculum to inform the trainees about the complexities of financial management of a repository. Lecture topics will include the structure of the United States government and Constitution, annual federal appropriations, continuing resolutions, budget proposals, forecasts, negotiations, work breakdown structures, and scheduling.

Module 12: Interim Storage of Spent Fuel

Module 12 is a two week module that focuses on interim storage of spent fuel, a necessary precursor to permanent disposal. Lecture topics during the first week include an overview of storage practices, regulatory framework and requirements the storage of spent fuel, existing storage systems, technical and economic issues, legal, institutional, and economic issues, and case studies. The second week of lecture focuses on siting, licensing, integration of storage and transportation, operations, systems analysis, facility capabilities, and the Global Nuclear Energy Partnership.

Module 13: Transportation of Spent Fuel and High Level Waste

Module 13 is a two week module that expands upon the topics discussed in Module 5. The first week of lecture concentrates on modeling and testing. Lecture topics include discussion of WIPP transportation packages, transportation computer codes, regulatory testing, extra-regulatory testing, and acquisition and analysis of numerical and test data. The second week focuses on package development and risk analysis. Lecture topics include technology development, regulatory oversight, package development, transportation program plans, and public hearings and communication.

Module 14: Safeguard and Nonproliferation

Module 14 is a four week module that covers the topics of safeguards and nonproliferation. The first week of Module 14 is an overview of nonproliferation topics. Lecturers cover nuclear nonproliferation, the Nuclear Nonproliferation Treaty, International Atomic Energy Agency, the International Safeguards Regime, United Nations Security Council Resolution (UNSCR) 1540, supply-side nonproliferation approaches, and cooperative monitoring. The second week of Module 14 is an overview of physical protection. Lecture topics include introduction to physical protection, roles and responsibilities, regulatory framework, categorization of threats, facility characterization, threat definition, and design, implementation, and evaluation of physical protection systems. Week three focuses on physical protection tools, approaches, applications, and issues. Lecture topics include intrusion detection, alarm assessment, entry control, access delay, risk analysis, material attractiveness, physical protection and transportation of spent nuclear fuel and high level waste, physical protection and storage of spent nuclear fuel and high level waste, and radiation sources and detectors. Week four is a study on approaches to reduce the proliferation risk of spent fuel and high level waste. Lecture topics include repository safeguards, decommissioning spent fuel and high-level waste facilities, transparency and monitoring, application of proliferation risk and resistance assessment to storage facilities and repositories, and fuel cycle service systems.

Module 15: On-the-Job Training, WIPP Activities

Module 15 consists of seven weeks of on-the-job training on topics related to the WIPP. This module will expand on activities completed in Module 10. Activities include participation in WIPP performance assessment activities, meetings with Department of Energy and management and operations personnel, and evaluation of repository conceptual designs and engineered barriers using uncertainty and sensitivity analysis techniques.

Module 16: On-the-Job Training, High Level Waste Activities

Module 16 consists of seven weeks of on-the-job training on topics related to the YMP. Activities include participation in YMP site characterization and performance assessment activities, meetings with Department of Energy and management and operations personnel, and planning and development of packaging and transportation plans.

IMPLEMENTATION PLANS

The implementation of the training program is divided into lecture sessions and on-the-job training sessions. On-the-job training activities are scheduled throughout the term of the training program with the goal of enhancing understanding of critical lecture topics.

The classroom training sections of the curriculum follow several general guidelines. During classroom training sections, instructors provide lecture and discussion on a daily basis. Lecture periods last for an interval of four to eight hours with intermittent breaks. Instructors also assign homework and reading assignments for independent completion. An emphasis is placed on personal study time in order to allow the trainees to learn through reading and application as well as through lecture and discussion. During study time, the trainees are encouraged to work together to enhance each other's understanding of the lecture material and to prepare questions for the next day of lecture. Job activities are scheduled during and between classroom training modules as time and schedules permit.

At the end of each training module, trainees are asked to give feedback and to indicate if further information on any topic is needed. The feedback is used to help plan on-the-job training assignments and to assess the need for supplementary lecture. On-the-job training assignments include technical work activities as well as exposure to the many companies involved in WIPP and YMP repository science activities.

SUCCESSFUL IMPLEMENTATION OF INTERNATIONAL TRAINING PROGRAMS

There are several issues that should be addressed in advance of commencement of an international training program in order to ensure success. International travel is a complex undertaking, particularly for long stays. The start and end dates of the training program should be determined far in advance to allow for approval of visas. Applications should be submitted as early as possible to allow for any delays in processing. Also, the administrators of an international training program should be sensitive to the cultural challenges inherent in a long stay in a foreign country. The trainees will need support and welcome from both the training administrators and the community they will inhabit. If families are accompanying any trainees, there will extra personal issues that need to be addressed. A list of useful information such as housing options, banks, transportation options, schools, grocery stores, and entertainment options will smooth the trainees' entry into a new community. Finally, if the training program will last many months, vacation days should be included for the benefit of instructors and trainees.

There are several adjustments that can be implemented during the execution of the training program in order to provide the best possible training experience. International training programs may involve parties with different native languages. If this is the case, training administrators may choose to provide supplemental training in the native language of the trainees. It can be very challenging to learn new topics in a foreign language, so instructors should plan a slow pace for lecture that allows for many questions. Trainees should be encouraged to ask questions, and topics should be covered until all parties are convinced that effective communication has taken place. Instructors should also be prepared to augment curriculum with topics of particular interest to the individual trainees. Finally, instructors should

include hands-on activities, tours, and demonstrations to the maximum possible extent. Lecture is certainly necessary for a transfer of information, but the inclusion of many hands-on activities will enhance understanding and prevent accumulated boredom from lectures.

CONCLUSIONS

The KHNP training program commenced on May 21, 2007. As of February 24, 2008, 37 of the 51 weeks of training have been completed. The training program has been supported by more than 150 individuals from SNL and other companies. The curriculum has been implemented as it was designed, with the addition of many lecture topics and activities that are of particular interest to the six KHNP trainees. The experience with an international training program has enriched both SNL and KHNP and allowed the possibility of future collaborative opportunities.

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REFERENCES

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