Engineered Radiological Controls Training at Chornobyl NPP

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ABSTRACT

The accident at the Chornobyl Nuclear Power Plant (ChNPP) left over 190 tons of lava-like fuel containing mass scattered throughout the facility's reactor building. These masses will be characterized using core drilling. Given the potential for high dose from inhalation of dust containing fission products and transuranics, a method had to be developed to protect the workers. The selected method was a custom-built, positive pressure tent, through which the core drill could be operated, while protecting the workers within.

In September 1999, a team from the U.S. went to Chornobyl to provide instruction on the operation of the tent and ventilation equipment. The U.S. team provided classroom instruction to a multi-disciplined group of engineers, and practical instruction to both the classroom attendees and other workers. The instruction included the engineering principles, operation and maintenance of the ventilation, and techniques for rapid assembly and disassembly of the tent.

BACKGROUND

Lava-like Fuel Containing Masses (LFCM) were first discovered in autumn of 1986 in the Shelter surrounding the destroyed reactor of Chornobyl Unit Four. The first LFCM discovery was the famous "elephant's foot." Three flows of LFCM were discovered as the investigation progressed: a large and small vertical flow and a large horizontal flow. In essence, several areas on several different levels of the Shelter contain these masses.

While the molten fuel has been very useful in reconstructing the events during the accident, questions remain concerning the physical stability and criticality safety of the masses themselves. The surface of the material tends to degrade quickly, a process that generates a significant amount of fuel dust. The process by which this degradation occurs is not completely understood, but appears to be the result of moisture intrusion into the very high radiation environment (Tacis 1998). Ukrainian nuclear safety regulations also require accountability for all fissile material. Core sampling is necessary to address each of these technical issues.

Because so many LFCM pockets were discovered, core sampling must be performed in several locations. This sampling will generate a significant amount of dust. In order to protect workers from possible uptakes of airborne radioactive fuel fragments, an engineered control was sought.

Pacific Northwest National Laboratory (PNNL) has played a leading role in the International Nuclear Safety Program and specifically in health physics technology-transfer initiatives in the Unit Four Shelter. Other PNNL projects completed at the Chornobyl Shelter include the development of a nuclear safety monitoring system, transfer of dust suppression equipment and technology, and equipment for improving industrial safety and structural integrity investigation and analysis.

EQUIPMENT

A positive pressure containment tent was used as the solution to the LFCM core sampling problem. The work group could stand inside the tent, at the back wall, and operate the drilling equipment through a custom-installed port. Equipment provided to the Chornobyl Shelter was commercially available and field-proven to the extent practical according to project requirements. The tent was designed and constructed by Lancs Industries of Kirkland, Washington[1], and consisted of a large work area, about 51 m^3 (1800 ft^3), and two optional-use anterooms.

Ventilation was provided by use of an NFS – Radiation Protection Systems, Inc., SP-700 high-efficiency particulate air (HEPA) filtration unit operating at 22.65 m^3/sec (800 ft^3/min). This system was designed for high mobility, ease of operation, and sufficient air movement to satisfy the needs of the containment.

CLASSROOM TRAINING

A U.S. health physicist, reflecting on the use of such a containment design, might consider positive pressure somewhat out of the ordinary. Beyond that, nothing would seem unusual because such containments are common in U.S. nuclear facilities. Everyone in this field can probably think back to the first time he or she ever saw a tent and remember what a good idea it seemed at the time.

However, consider a place where no one has ever seen such a system. The Chornobyl staff had little or no experience with engineered controls for keeping radiological contamination as low as reasonably achievable (ALARA). The tent would improve matters dramatically during the core drilling, but only if the entire system was properly used. Therefore, it fell to three PNNL staff members to develop, organize, and conduct the training as part of a larger effort to improve radiological protection practices at Chornobyl.

Dr. George Vargo is responsible for leading the overall health physics technology transfer program with the ChNPP Shelter and was the project manager. He was responsible for the equipment specification and final approval of the course material.

Mr. Kelly Neal, a radiological engineer, has extensive experience with dose-reduction issues at Chornobyl, and his background includes radiological protection in military and commercial nuclear power, as well as experience in the research-type programs at PNNL. He developed the positive pressure containment design that was used.

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[1] The mention of specific manufacturers or brand names does not constitute an endorsement by the U.S. Department of Energy, Battelle, or the Pacific Northwest National Laboratory.

Mr. Larry Page, a training instructor, has commercial, environmental, and research-type radiological protection experience. He developed and delivered the training course.

The level and type of training was determined by Mr. Neal and Mr. Page after thorough discussion in the U.S. They reached the decision to provide classroom training for one-third of the time and hands-on equipment training for two-thirds of the time.

The target audience for the training could not be determined until the training actually began. This matter was potentially more critical than determining the level and type of training. The Shelter maintains its own permanent staff which numbers in the hundreds. The team faced the following question, “Should the training be developed to train an engineering audience or to a worker audience?”

Tent equipment was delayed at Ukrainian Customs, postponing the training course for nearly 18 months. Finally, in July 1999, a date was established and Mr. Neal and Mr. Page departed in September for the Shelter at Chornobyl Unit Four. They were joined enroute by Mr. Graham Hollingsworth and Mr. Kevin Bylin of Lancs Industries, who participated in the classroom training and led the hands-on training.

Training began in a classroom where Mr. Page presented the lecture to three members of the Shelter engineering staff. Mr. Page used a notebook computer and a PowerPoint presentation, which had been translated into Russian. An interpreter translated the lecture and students’ questions. The training objectives were for the students to:

- Understand the concept of radiological containments as an engineered control
- Understand how a containment with a ventilation system can reduce exposure
- Know the components of a containment and ventilation system
- Know the considerations that go into containment design and proper use of ventilation systems
- Know how ventilation system losses can occur, and steps to prevent or correct these losses
- Understand the purpose of effectiveness testing and discharge monitoring
- Demonstrate competence in the setup and dismantling of tents and ventilation systems.

Engineered controls were defined, and examples were given, including a detailed description of the ALARA philosophy of internal dose reduction. The proper use of filtered vacuum cleaners and the associated hazards were discussed. The components of a ventilation system, the proper ways to use both positive and negative pressure, and similarities between air and water movement were also described. Critical measurements used to monitor system performance were discussed.

Since the students attending the classroom training were all part of the engineering staff, subjects such as the mathematics used to calculate proper airflow and air exchange rates were mentioned, but not thoroughly discussed. The appropriate formulae and instructions were included in the operating manual for the HEPA system, which had been translated before shipping.

The classroom training included instruction on hazard awareness, prevention, and mitigation for fire, excessive water use, dust loading, and chemical use. Considerations in the design and operation of the containment system were presented. Proper job analysis was discussed, along with considerations for decontamination and reuse of the tent. Proper ventilation flow paths within the tent and layout for access and egress were demonstrated. The last item in the lecture was effectiveness evaluations of the system through chemical testing and dose monitoring of the filters. Following the lecture, a video, prepared by Lancs, was shown that demonstrated the assembly of the tent. This concluded the classroom component.

HANDS-ON TRAINING

During the presentation, the students said that they had already used the tent in some exercises. So, the hands-on training began with an attempt to find all of the tent parts. Other workers joined the engineers on the search for the missing parts. Once the parts were collected, Mr. Bylin taught the engineers and the workers who joined the search party how to assemble the tent. Mr. Page assisted Mr. Bylin, while Mr. Hollingsworth videotaped the session. The initial assembly took well over an hour. While this was to be expected for the first-time, the duration would be unacceptable in the high-dose environment.

During the tent assembly, the Chornobyl staff made a great discovery: slightly over pressurizing the tent using the HEPA system made some of the finishing tasks (i.e., tie-wrapping the tent grommets to the frame) easier.

With this in mind, Mr. Neal took notes and developed a plan to assemble the tent much more rapidly. A joint consultation between the team members fine-tuned Mr. Neal's plan. The team developed an additional plan for a partial disassembly of the tent to allow timely transfer and reassembly at another location. It was determined that complete disassembly is not always necessary and taking the partially assembled tent to the next work site could actually allow work to start sooner.

Disassembling the tent went much faster than assembly. The group applied the over-pressurizing technique to disassembly after loosening the vertical sections of the frame. As the rising tent lifted the frame, all but four of the vertical sections could be removed. At this point, the tent collapsed because the flow of the ventilation was reversed. The remaining four pipes could be released from the bottom frame, held by workers to control the top frame, and guided down safely to the ground. Opposing sections of the top and bottom frames were removed. This disassembly process took 15 minutes. At this point, the tent and frame could be folded in on itself and easily transported to the next LFCM site by the six people in training.

Reassembly simply reversed the procedure. The tent was unfolded and the missing sections of the top and bottom frames were attached. Immediately, the HEPA unit was attached and the tent inflated. When all vertical sections were in place, some of the air was released and the tent was allowed to operate at the appropriate pressure. The second assembly went much faster and was completed in 25 minutes.

As the team left, the Chornobyl staff said they would practice more.

CONCLUSION

Designing a tent to contain radiological contamination at the Shelter surrounding the destroyed reactor of Chornobyl Unit Four, then training the engineers and workers was very rewarding for the PNNL staff. The effort was considered a success

REFERENCES

Tacis Services DG IA. 1998. *The Shelter's Current Safety Analysis and Situation Development Forecasts.* PC World Ukraine Ltd.