8B-1

SCALE MODELS: A PROVEN COST-EFFECTIVE TOOL FOR OUTAGE PLANNING

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ABSTRACT

As generation costs for operating nuclear stations have risen, more nuclear utilities have initiated efforts to improve cost effectiveness. Nuclear plant owners are also being challenged with lower radiation exposure limits and new revised radiation protection related regulations (10 CFR 20), which places further stress on their budgets. As source term reduction activities continue to lower radiation fields, reducing the amount of time spent in radiation fields becomes one of the most cost-effective ways of reducing radiation exposure. An effective approach for minimizing time spent in radiation areas is to use a physical scale model for worker orientation planning and monitoring maintenance, modifications, and outage activities. To meet the challenge of continued reduction in the annual cumulative radiation exposures, new cost-effective tools are required. One field-tested and proven tool is the physical scale model.

INTRODUCTION

This article details how three drywell area models for Commonwealth Edison Company (CECo) were deployed to improve outage performance through improved planning and contractor employee plant orientation, resulting in a considerable reduction of both CECo and contractor radiation exposure.

Cost-Effective Tool

The model is a tool. And like a tool, it saves time; specifically, it reduces time that people spend in containment, saving both dose and money. By adding physical models to their operation and maintenance programs, nuclear stations can improve the quality of their maintenance work, lower personnel radiation exposures, reduce design interferences, lower modification costs, and improve the quality of backfit design.

The complexity of a particular model is determined by its intended use. If the model is to be used for equipment lay-down only, a simple block model may be sufficient. If it is to be used to support maintenance, modification, and outage planning, a detailed model including equipment, piping, raceways, ducts, supports, etc., may be required. The benefits of the physical model for design and modification work are well known.

Because a physical model is uniquely capable of presenting total visual information, it can provide at a glance what would otherwise require a thorough examination of many drawings. Models can show a plant system or area in its full three dimensions, easily allowing station personnel to jointly review and evaluate the area.

A detailed model permits rapid comparisons of alternate designs, facilitating the choice of a constructible, operable, and maintainable design. From a standpoint of keeping personnel radiation exposure as low as reasonably achievable (ALARA), using a model can minimize the time needed for design personnel to conduct field verification activities in high-radiation areas.

Before planned outages, station personnel can use a model to collectively view the area and discuss the scope of work. The model can be used to plan manpower allocation and to identify restricting or interfering work assignments, which can save valuable outage time, reduce personnel radiation exposure, and help with future outage planning. As a result, a model can easily pay for itself.

Maintenance-Outage Planning Tool (Part 1)

Our first drywell area application, a 1:16 physical scale model of an operating BWR Mark II for LaSalle Unit 2, was completed and successfully used by the CECo project team as an outage and planning tool. The area model, built with a ribbed containment and bioshield structure, also allows ongoing continuous model development to support design use for the life of the plant.

Station outage personnel used the scale model to collectively view the work areas and plan the scope of work away from the drywell. The model was also used to plan manpower allocation and identify restricting or interfering work assignments. The planning and review of work locations for maintenance activities were easily visualized and demonstrated on the model, creating a significant reduction of personnel radiation exposure, improved lead shielding placement, and improved prejob briefings before entering the drywell.

Economic Justification

In the future, the availability of the area model will greatly improve the long and short range planning capabilities while the drywell area is not accessible. The model was completed in nine weeks at a cost of approximately $80,000. The benefits indicated show that the cost of the model was easily recovered. For the economic justification, CECo used a factor of approximately $5,000 for one person-rem. Since then, the client has increased the value to approximately $10,000 per person-rem.

The following benefits were noted by the utility through a post-outage evaluation on the use of the model.

- An estimated 6 person-rem was saved by using the model to improve ALARA briefings by Inservice Inspection engineers (ISI), modification work locations, temporary lighting planning, prejob crew allocation and prearranging the flow path of equipment to and from work locations. **Estimated Savings: $30,000**

- From the model, improved engineering planning benefitted 9 person-rem in estimated savings by prearranging temporary lead shielding placements and demonstrating to craft personnel the location and method to hang the shielding. **Estimated Savings: $45,000**

- An estimated 5 person-rem were saved through improved utilization of scaffold and platform layout and identification of the locations for valves, snubbers, and welds. **Estimated Savings: $25,000**

- The orientation of new personnel, such as craft and/or station personnel to the general layout of the drywell, was accomplished through the use of the model, reducing the expected orientation exposure accumulation to almost zero, saving an estimated 5 person-rem. **Estimated Savings: $25,000**

  Outages are overwhelmingly the source of exposures in nuclear plants. According to NRC staff calculations, outage dose accounts for 31 times the nonoutage dose on an industry-wide average.

In our most recent drywell areas application for Dresden 2 and 3, two 3/4" = 1'-0" physical scale models were completed and successfully used by the CECo project team as an outage planning and management tool. To explain in detail the purpose of the models, the daily planning activities with ISI engineers and craftsmen, project benefits and economic justification, I would like to introduce Mr. Roy Lee.

Dresden 3 - A Case Study (Part 2)

The scale model that you are viewing has already been used in one outage. It paid for itself by saving 57 person-rem through reduced man-hours and radiation exposure. During the outage, the model was set up in the craft supervisory area where maintenance foremen had their offices to make it accessible. It took about two weeks for people to realize the model's benefits and, after they did, there was so much activity around it that it was nicknamed the "ALARA coffee pot." There were as many as 25 to 30 people at a time around the model planning their daily activity.

As Bob said in Part 1 of this talk, the model is a tool. Well, what does this tool do? It saves time. Specifically, it reduces the time that people spend in containment and that saves dose and money.

Orientation Benefit

One of the major time savings comes from orienting people. One of the common problems during an outage is that new people who are not familiar with the containment layout have a difficult time finding their way to work locations. Well, if a picture is worth a thousand words, a model is worth a thousand pictures. For most of these people, it is easier to orient themselves when they can see the entire drywell in 3D than they do when they are given verbal instructions, marked-up drawings, even photographs. Of course, it helps that the model has colored see through floors, and can be viewed from several different angles. But the fact remains that almost everyone can relate to a scale model and remember what they saw.

The model has all of the major landmarks so it was easy to show a team exactly where to find a snubber, valve, ISI point, or any other work location. ISI points were shown on the model using small white "post-it" labels or "stickeys." It was also easy to show team members the correct "low dose" route to take to work. This meant they could get to work faster. Even more importantly, they did not need to waste time and dose walking around the containment, sometimes in the wrong direction, looking for their work. In summary, the model makes it easy for people to get to the right place quickly the first time. To make this even easier, a book located at the drywell entry had photos of the containment location next to photos of the model. People could see exactly where to go, how to get there, and what to look for when they arrived.

Planning Benefit

A second timesaver is simply keeping people out of the containment. It was easy to plan major equipment moves, staging areas, and work sequences from the model so the need for physical walkdowns was greatly reduced. Every person kept out of containment means a saving of time, money, and dose. In addition, it is easier to discuss something standing around a model in an office than it is standing under a valve with full plastics and a respirator.

Shielding Benefit

The model really helped when it came to installing temporary lead shielding. The shield installers were shown on the model exactly where to put the lead blankets. Since everything is to scale, the correct location and number of blankets could be put on the model. Red plastic blankets were cut to scale to show the exact blanket locations. Shield installers were then given a shielding package that had a photo of the model (with the shielding on it) and a plant photo marked up to show where the shielding was to be placed.

There was a real time saving on shift turnovers. For example, the insulators could indicate exactly where insulation was partially removed so that the next crew knew exactly where to continue removal. The ISI crews benefitted too because they could schedule their work without having to do a walkdown in the containment to check progress.

With all of this information shown on the model, people began to use it to coordinate the flow of equipment and personnel. The real value here is that since work in progress is there for everyone to see, the situation can be avoided where one crew is sitting around waiting for another crew to finish so they can start.

Since the model is always available, it was then used for postoutage reviews and prejob planning.

Economic Justification

To pay for the model during the last outage, any one of the following had to occur

- reducing time spent in the drywell by 1 percent.
- improving lead blanket handling efficiency by 30 percent.
- improving ISI efficiency by 0.5 percent.
- preventing just one overexposure.
- preventing disassembly of one wrong component.

The final result of the outage was an ISI exposure saving of 12 person-rem, a lead installation exposure saving of 25 person-rem and a total saving of 57 person-rem. The model cost was approximately $100,000 and resulted in a financial savings of approximately $540,000 for one outage (one person-rem = $9500).

Since the model paid for itself during the first outage, its use is essentially free from now on. But, is the model sturdy enough to last for more than one outage with all of the use it sees? The answer is a qualified yes. These are plastic creations with a lot of small parts, and some people do have heavy hands. There was some minor damage but it was easily repaired, and the model is ready for another outage. Furthermore, it can be turned into a living model by installing the mods as they occur -- after they have been planned out using the model, of course.

Dresden 2 - Continued Outage Development (Part 3)

Our third drywell area model was used last year as a planning tool for a major outage. The model for Dresden 2 was purchased by Engineering and Construction, buoyed by the success of the Dresden 3 outage application.

The person rem savings attributed to the model was 90 person rem with a savings of 4000 ISI hours. The largest saving, 45 person-rem, and benefits came from the Inservice Inspection Program (ISI). The area model was used daily to identify and describe the ISI team program and locate ID points. Implementation of the program through team meetings and briefings with the ISI team, craft, management, and prejob craft meetings, was a big part of the savings. The model cost was approximately $120,000 and resulted in a financial savings of approximately $900,000 for one outage (one person-rem = $10,000).

Outage Team Survey

Finally, I would like to give you some quotes from surveys that we made following the outages. These quotes are from two stations that used BWR drywell models.

> "It shows techs exactly where to take surveys."

"Instead of hunt and find in the drywell, now you hunt and find on the model and go directly to the area in the drywell."

"I think the model was as useful as any other tool used in the outage." (From drywell coordinator)

"Not as much time was spent discussing the job at the jobsite."

"It saved us from confusion."

"Showed where to put tents."

"It was faster and easier to show men where the work was located rather than having to explain."

"Used model for planning before access to containment was available."

"The model encouraged a lot of conversation about jobs that normally would not have taken place."

Most of the comments were positive but, like everything else, the model setup was not perfect.

"Need someone to keep the model clean and make minor repairs."

"Would like some electrical details shown."

"Put it on a higher table with a guard rail."

"Would like a step stool to see the top."

And one comment from an iron worker that I really like, "It's a good start."

SUMMARY

In the past, when working with the craft, we often felt that they viewed ALARA as being just the opposite of donuts: donuts taste good on the way down but, in the end, they are not very good for you. However, ALARA can taste pretty bad on the way down but be great for you in the end. One of the ALARA pills that is often difficult for the craft and their supervisors to swallow is planning, planning, and more planning. For the craft, the model is the sugar coating on the ALARA planning pill.

To meet the challenge of continued reduction in the annual cumulative radiation exposure for nuclear workers, new cost-effective tools are required for improving the quality of time spent in radiation fields and assisting utilities in operating safe, reliable, and efficient nuclear stations that are competitive on individual and industry basis. Optimization of ALARA practices does not rely on any single ALARA tool, but rather on a combination of tools. One effective tool is the physical scale model.

Authors' Biographies

Roy Lee is an ALARA Engineer for the Corporate Health Physics Support Group of Commonwealth Edison Company. He has 22 years of combined experience in radiation protection and plan operations for both boiling water and pressurized water design nuclear power plants.

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Robert Segroves has 18 years of experience in the nuclear industry. He is responsible for model applications at Sargent & Lundy to support new plant design, maintenance, modifications, ALARA programs, and outage planning. Prior to his appointment to the Model Section, he was a Mechanical Design Project Leader and was responsible for fossil station arrangements and piping design.

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PAPER 8B-1
DISCUSSION

Unknown: Where did you locate the model?

Lee: Actually, it was moved around quite a bit. First, it was in the construction management office. Right now it is in the ALARA review trailer where the contractors go in. We had one similar model at the drywell.

Cybul: Are any of the components removable? If they are, how did you pick out which ones?

Lee: The components in this particular model are not removable, except for the reactor vessel. It is not intended to be what you may call a working model. Other models have been developed where you may do so.