THE *NUCLEAR NEWS* INTERVIEW

Joe Tocco on Dresden's CRD guide tube flushing tool

Employees at the Dresden plant collaborated with General Electric to develop a tool that removes crud from control rod drive guide tubes.

Joe Tocco is the control rod drive (CRD) system manager at the Dresden nuclear power plant in Morris, Ill., where Exelon Generation operates two 867-MWe General Electric boiling water reactors. Unit 2 started commercial operation in June 1970, and Unit 3 in November 1971. A third unit, Dresden-1, was shut down in October 1978.

In 2006, Tocco came across a GE PowerPoint presentation about a prototype device for flushing crud from CRD guide tubes. "We historically had big problems with guide-tube crud at Dresden," he said, "and it's been time-consuming to remediate. You have to disassemble the cell, take out all the fuel and the control blade, and vacuum it out from above from the refuel bridge. This can take anywhere from one-and-a-half hours to three hours per location."

Tocco said that the plant's CRD team asked management for five days of critical path time during one outage to clean out the crud, but the response was, "No way. Find a quicker process." So Tocco contacted GE and got the ball rolling on developing the prototype device to Dresden's specifications. "Throughout the next year or so, I was constantly in touch with GE by phone or e-mail or flying to GE's San Jose office to refine the tool and get it to the point where we would be willing to put it in our core," he said.

The prototype was refined enough to be used successfully in late 2009 during Dresden-2's 21st outage. Improvements to the tool are ongoing, according to Tocco.

For helping to develop the tool in collaboration with GE, Dresden employees received the GE Hitachi Nuclear Energy Vendor Award, part of the Nuclear Energy Institute's Top Industry Practice awards program. The award was presented during NEI's 2010 Nuclear Energy Assembly, held May 17–19 in San Francisco.

Tocco talked about the tool and its use and development with Rick Michal, *NN* senior editor.

Tocco: "The Vortex tool can be used at any boiling water reactor."

Could you describe the tool that you developed?

Dresden collaborated with GE to develop and employ the device, which is called the CRD Guide Tube Flushing tool, or the Vortex tool. We needed a tool that would remove crud from the CRD guide tubes when a CRD mechanism (CRDM) is replaced during an outage. Crud in CRD guide tubes (consisting primarily of iron oxide) has been shown to challenge reactivity management because it has a negative impact on the notching performance and overall reliability of the CRDMs.

Historically, the iron concentration in Dresden's feedwater has been excessively high. The iron adheres tightly to the fuel during operation and then becomes loose in the oxidizing environment experienced during refueling outages. Some of the crud then sloughs off the fuel, ultimately settling

The head of the Vortex tool with the flush head deployed at left and the video camera lens on the right (the tool is usually deployed vertically, but is shown horizontally for display purposes). (Photos: Exelon Generation)

at the bottom of the CRD guide tubes, where it is ingested into the CRDM during scram operation.

The Vortex tool is innovative because it takes a whole new approach to guide tube crud removal. The old method was a time-consuming process that involved emptying a fuel cell and trying to accurately guide a hose from the fuel bridge into a cylinder 40 feet below in the refuel cavity, whereas with the Vortex tool, a small nozzle is deployed precisely where the crud resides. The tool is actually a very simple device. It works by using water pressure from the flooded-up reactor vessel to force the crud into the removal tube, with no pump or vacuum assist needed.

What does the Vortex tool look like, and how does it actually work?

The tool is a long cylinder, and it looks similar to a CRDM. There is a nozzle attached to an articulating arm that goes into the guide tube. The refuel cavity is flooded up in the outage, so there is about 70 feet of water above the guide tube. A flexible tube that runs from the tool to the sump allows for the treatment of the crud-entrained water by the radwaste system. Between the tube and the sump is a motor-operated valve (MOV) that stops the flow until the valve is opened. Essentially, the tool is installed, the nozzle, which can be rotated 360 degrees, goes into the CRD tube, and a visual sweep is done. Then the MOV can be opened remotely, and as soon as that happens, there is a flow path from the head of water above the tool, down through the nozzle, through the tube, and into the sump. The mode of force, then, is that head of water above the tool.

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How does the crud negatively affect operations?

Once ingested, the crud wedges in the internal CRDM drive and the collet piston seals, and it causes unreliable speed control and notching performance. We have installed condensate prefilters that have significantly reduced feedwater iron concentration, but the prefilters do not address the historical crud.

Could you explain more about the method used before the implementation of the Vortex tool?

We used in-vessel guide tube vacuuming, done from the refuel bridge using a submersible pump and filter. We've traditionally done the vacuuming at locations only where a control blade was being replaced. Trending indicated that those locations—where the CRDM was replaced and the guide tube was vacuumed in the same outage—started with better performance than those that were not vacuumed, and that this advantage persisted for at least six years. Most new CRDMs were being installed in locations with guide tubes that had a lot of crud, which entered the mechanism when scram timing was being performed at the end of the refueling outage. (Every control rod is scram timed at the end of every refueling outage, per technical specifications.) In-vessel guide tube vacuuming is very time consuming, because the cell must be emptied of the control blade and all of the fuel. During a typical refueling outage, vacuuming all of the CRDM replacement locations would extend the outage's critical path by a day or more.

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A mock-up of a control rod drive guide tube shows (from left) the Vortex tool partially inserted, the tool inserted with the flush head deploying, and the flush head fully deployed.

How does use of the Vortex tool differ from in-vessel vacuuming?

The Vortex tool is designed to perform the same function as vacuuming, but it is used from under the vessel and can be used with the fuel and control blade in place. The tool is installed after the old CRDM is removed, and the effluent is routed to the plant's normal radwaste stream, such as the drywell equipment sump. Once the tool is installed, a remote operator performs a visual sweep for foreign materials using the camera that is attached to the tool head. After the foreign materials extrusion inspection, a valve on the effluent tube is opened and a water stream that comes from a tube on the head provides the force to flush the crud out of the guide tube. The tool sweeps around the guide tube twice, and in about two minutes the flush is complete.

What are the advantages of using the Vortex tool?

Some of the advantages are that all CRDM replacement locations can be flushed of crud without affecting outage critical path; the use of a camera provides real-time information that can be used to gauge the effectiveness of the flush; and the highly radioactive crud is processed by the plant's normal radwaste stream, eliminating the need for expensive and difficult-to-dispose-of filters.

When was the tool first deployed?

The Vortex tool was used for the first time during Dresden-2's 21st refueling outage, in November 2009. It flushed out 26 CRDM replacement locations, and the initial results have exceeded expectations. Visually, the amount of crud removed was staggering. The effluent started out black and cleared up during the flush, eventually returning to clear water before the tool was disengaged. This was good evidence that the tool was effective in removing nearly all loose crud that could be ingested into a CRDM during a scram. An estimated 1.5 curies of activity were removed per flushed location, and surveys indicated a lower undervessel dose rate than before flushing.

> **"It flushed out 26 CRDM replacement locations, and the initial results have exceeded expectations."**

Is there a cost savings from using the new tool?

Yes. For Dresden-2's 2009 outage, vacuuming the 26 CRDM replacement locations from above would have taken 32 to 40 hours of critical path time. The incremental cost of using the Vortex tool is dwarfed by the savings—at least $1 million based on critical path savings. Similar savings are expected in future outages.

There are also cost savings when viewed from a source-term removal perspective. Chemical cleaning is more expensive than guide tube flushing by about an order of magnitude per curie removed.

What about transferability to other sites?

The Vortex tool can be used at any boiling water reactor, although some modifications may be required for plants with different undervessel configurations. The plants that would see the most benefit are those with high historical feedwater iron and resultant crud accumulation. Not coincidentally, the plants with high feedwater iron tend to be the ones with the worst CRD equipment reliability. Several plants have already expressed interest in using the tool for future refueling outages. The only other time it's been used so far was at the Kernkraftwerk Leibstadt plant in Switzerland, but we haven't heard about the results yet.

Are there any concerns about the tool?

It is pretty dose-intensive to use. We did take some personnel dose. On the other hand, when the job is finished, the dose rate undervessel has gone down because of the reduction in source term.

Anecdotally, it looks like it's removing all of the crud. It didn't look like there was any crud left down there when we were done. I can't be as confident when we're talking about vacuuming from above.

Does Dresden own the tool?

No, GE owns it, and GE technicians came in and installed it and controlled it during our outage.

Could the tool be improved?

There was talk about doubling the speed of the pneumatic winch used to hoist the tool in and out of the water. Also, when we used it, an engineer had to stand in the keyway undervessel to help guide the tool around any obstructions. He was not completely undervessel, but he was still soaking up dose. Three engineers were needed to operate the tool, but there is talk of eliminating the need for the engineer in the keyway. NN