NUMEX 2004: Room to innovate

BY DICK KOVAN

Innovation, cost savings, teamwork—all were displayed in the finalists' submissions to the NUMEX 2004 nuclear plant maintenance competition.

THE WINNER OF the NUMEX 2004 Trophy was a maintenance team at the Leibstadt plant, in Switzerland. The team took on a difficult fabrication job requiring a high level of performance from its systems engineers and workshop. The successful replacement of all the pins and rollers on a full reactor set of control rod blades (CRB) was a considerable achievement that impressed the judges.

The NUMEX Trophy is a prize for excellence in nuclear maintenance awarded by the Nuclear Maintenance Experience Exchange (NUMEX), an organization of plant maintenance managers and engineers, sponsored by utilities. NUMEX holds the competition every other year to promote innovation and excellence in the maintenance of nuclear power plants. The group is sponsored by utilities, most of them European, and administered by Brennus SA, a group of consulting engineers based in France. The NUMEX Web site is at <www.numex.org>.

The contest involves the competitors' presenting their work to a jury of maintenance managers that assesses the presentations according to four main criteria: (1) shows effective teamwork; (2) challenges old and established methods, solutions, or behavior; (3) can be used by many plants now and in the future; and (4) shows a good safety culture in the plant.

The Leibstadt team won the 2004 trophy for developing and implementing a special process (tools and workflow) to modify spare control rods acquired from another station so that they could be used at the plant. This project—which brought important savings—demonstrated what innovation, teamwork, and self-reliance can achieve.

The runners-up were from BNFL's Bradwell Magnox plant, which ceased electricity production in 2002, somewhat earlier than expected. Improving maintenance had a high profile at Bradwell, and this attitude has carried on in the current defueling and decommissioning phase. As demonstrated in the team's presentation, innovative measures for managing maintenance and other services can provide serious benefits in performance and cost at a shutdown plant.

Another finalist team, from the Ringhals Group, in Sweden, described the selection and testing of a method for optimizing maintenance known as Streamlined Reliability Centered Maintenance. The demonstration that the method would achieve the desired goals convinced management to implement this tool at all of the Group's reactors.

Following are accounts of these three finalists in the 2004 NUMEX competition.

Old blades renewed: Replacing pins and rollers at Leibstadt

Leibstadt NUMEX Trophy winner presentation team: Otto Frommherz, project lead and QA; G. Ledergerber, KKL project promoter; O. Roje, system engineer; P. Tischler, welding engineer; H.-J. Mueller and H. Rohrer, maintenance workshop–machinery; and S. W. Baettig and K.-H. Wolf, maintenance workshop–welding.

IN 2003, THE Leibstadt nuclear plant, in Switzerland, undertook a difficult and unusual operation in its workshops: the replacement of the pins and rollers on 96 control rod blades (CRB). The plant, operated by Kernkraftwerk Leibstadt AG (KKL), is an 1165-MWe (net) General Electric boiling water reactor that began commercial operation in 1984.

The discovery of an increased concentration of boron in the reactor water was the first indication of boron carbide erosion of some CRBs. It soon became apparent that the problem was severe and that it would be necessary to change all of the plant's CRBs. Before deciding on the best approach, KKL devised and undertook a step-by-step strategic plan.

The two main options available were either to order new (original design) CRBs from GE or purchase unused blades if they were available. In fact, KKL located a large quantity of CRBs originally intended for the unfinished Valdecaballeros power plant project in Spain; the blades had been stored by the plant's owner, Iberdrola.

Velocity limiter, showing four new pin/rollers

Drill alignment fixture for velocity limiter roller

Drill above alignment fixture over velocity limiter roller

Purchasing CRBs

The main advantage of purchasing new CRBs was that they would be complete and functional. They also would have been improved so as not to be subject to the problem of the early CRBs, which included components with high cobalt levels. On the other hand, the CRBs from Valdecaballeros were significantly cheaper. Having been manufactured more than 25 years earlier, however, these CRBs had some high-cobalt parts that would have to be replaced. These were the pins and rollers, whose purpose is to guide CRB movement and positioning to ensure they avoid making contact with fuel elements.

In the end, KKL decided that its maintenance department could replace the high-cobalt components itself at a reasonable cost and took this option.

Replacing the pins and rollers

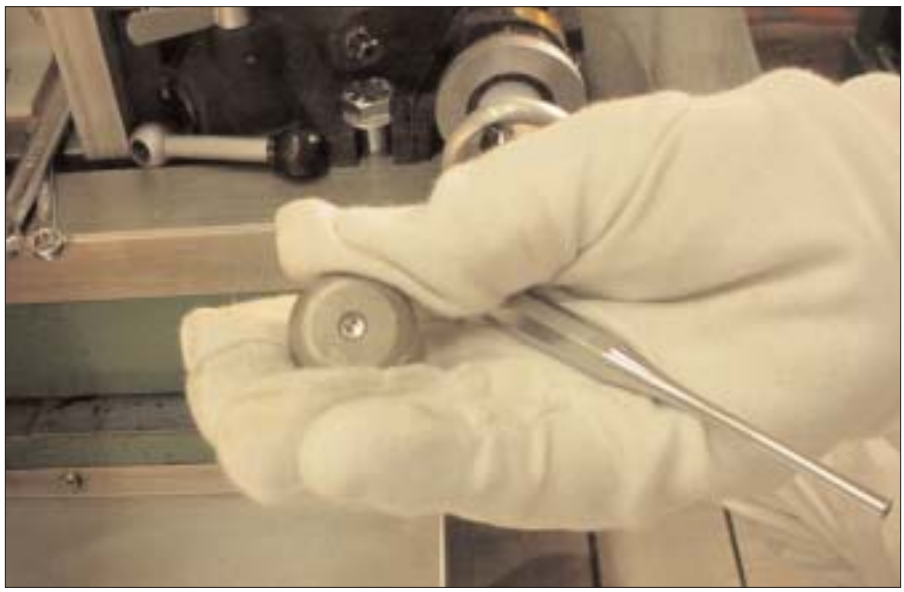
KKL undertook extensive preparations for the replacement of the CRB pins and rollers. This included:

- A comparison of KKL technical specifications with those of the Spanish CRBs, including the drawings.
- A comparison of quality assurance records of the original KKL CRBs and those of the Valdecaballeros blades.
- A visual inspection of random samples of the CRBs by KKL's quality assurance people in Spain according to GE design specification and drawings.
- The preparation of a KKL-Fabrication Inspection Plan and Welding Procedure Specification, including the Welding Procedure Qualification Record.

New quality assurance (QA) documents were also developed to meet the requirements of the KKL-Total Quality Management System, GE specifications, ASME codes, and the requirements of the Swiss nuclear regulator (HSK).

KKL also devised a detailed program to determine the fabrication procedures for the replacement of the pins and rollers that

Pin being removed from CRB



Roller removed from CRB

Pin being removed from top handle

Drilled handle weld following pin/roller replacement

would meet the requirements of HSK. This included the determination of cleanliness requirements, the training of KKL maintenance personnel to conduct the machining and welding operations, the preparation of necessary gauges for the top handles and velocity limiters (a part on the bottom of the CRB to prevent it from damaging fuel rods when traveling at full speed), and the preparation of special tooling (e.g., twist drill, reamer, rose bit, etc.).

Project implementation

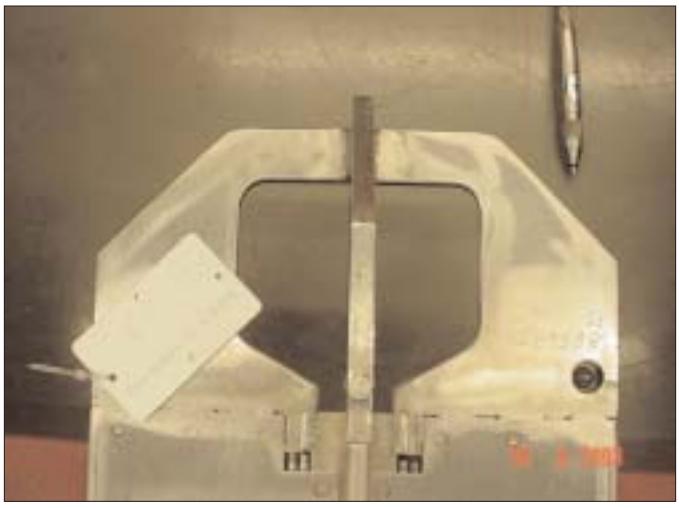
The replacement pins and rollers, as well as the welding filler material, were purchased from GE. The replacement was carried out in two campaigns. The first replacement procedure, involving 21 CRBs, took place May 26–June 20, 2003, and was supervised by GE. The second, involving 75 blades, was completed between October 20 and December 12, 2003; this operation was supervised by KKL's own QA and welding departments.

Project achievements

The project recorded a number of achievements:

- All CRB modification work was performed under the responsibility of KKL, which developed the special technology needed to undertake the machining and welding processes.
- Know-how for the operation, which was based on GE requirements, was successfully transferred to KKL staff under GE

CRB being inspected for scratches and dents



New identification tag and change part number on renovated CRB

supervision.
- The plant's workshops demonstrated the capability to work in accordance with the GE requirements for reactor internals.
- KKL found that its own standard working procedures and processes could be applied to this job without modification.
- The standard of European workmanship was proven to meet U.S. requirements.
- The plant gained useful knowledge and experience in reconditioning of reactor internals.
- The purchase of the spare CRBs provided KKL savings of more than 55 percent compared with the price of new, original-design CRBs.

Finally, after two inspections, the nuclear safety authority expressed its view that the work done was excellent. The replacement of the pins and rollers was a considerable success for KKL and demonstrated the kind of best practice that NUMEX is trying hard to spread throughout the maintenance community.

Contract initiatives bring improved maintenance at Bradwell

The Bradwell presentation team included Neil Minter, the contract management team leader, and Russ Rainger, head of day production.

MAINTENANCE AT THE Bradwell nuclear power station, in England, differs significantly from most NUMEX member plants because the station ended electricity generation in March 2002, after 40 years of production. The current staffing level at this BNFL Magnox station is approximately 280 personnel supporting defueling and decommissioning operations.

The Bradwell team presented two recent initiatives that have provided benefits beyond expectations. The first is the development of a "Site Services Contract"; the second is the establishment of a Contract Management Team, a specialist group to manage contract processes at the plant.

Russ Rainger, Bradwell's head of day production (equivalent to maintenance manager), said he was surprised at the extent to which these initiatives have improved maintenance arrangements at the plant. On their own, Rainger explained, each change benefited team-working, maintenance efficiency, and safety. When combined, there were even greater improvements. Through simple solutions and effective team-working, he said, "we have improved maintenance performance."

Rainger

These initiatives, Rainger said, are being reviewed for introduction at other Magnox locations.

Site Services Contract Scope

Crane hire	Maintenance welding
Laundry services	Fork lift truck maintenance
Air compressors	Waste management
Thermal insulation	Cleaning services
Scaffolding	Pest control
Air conditioning	Vehicle hire
Building maintenance	Site vehicle maintenance
Fire systems maintenance	Technical and office support
Electrical maintenance	Oil and chemical spill kits
Portable appliance testing	Grounds maintenance
Fabrication works	

Contracting innovations

Before the latest initiatives were introduced, maintenance was managed by the plant's Maintenance Facilities Team, which consisted of team leader Neil Minter, five

coordinators, and 10 team members. Each of the team coordinators was responsible for different work areas; in some of these areas the work was performed by the area's own team members, and in others the work was provided via a combination of different contracts. Together they were accountable for delivering approximately 30 maintenance-related services. There was a considerable amount of "juggling" of the delivery of the services and the selection of resources; there was also a duplication of effort in contract administration and management.


Minter

The aim of the new Site Services Contract was to combine most, if not all, required maintenance-related services (with a few critical exceptions) that were being delivered by the Maintenance Facilities Team and the Engineering Department into a single contract—a process commonly referred to as contract "bundling"—and via a competitive tender process to let this work to a single contractor. To develop the new contract, the Maintenance Facilities Team worked closely with Engineering to develop specifications and scope for each of the service areas to be covered. The services that are not included are fuel cask transportation, servicing and maintenance of breathing apparatus, and rigging/slinging services.

This mixture of services in a single contract was a key factor during contract negotiations, as one of the goals was for the contractor to directly undertake as many of the services as possible. A single contract manager would be responsible for ensuring that services were delivered on time, schedule, quality, and cost. Not only would this be more cost-effective, with the elimination of a number of subcontractors, it would also enable better management, accountability, and improved control and supervision, and would increase site awareness of the contractor's personnel, improvements that will also enhance site safety.

This process also means that only a single monthly invoice would be issued for a large package of services, which initially numbered just over 20 (see list). The new single contract was awarded to Promanex Ltd.

The second innovation began in April 2003, when a new specialist Contract Management Team was formed, comprising a contract manager from the previous facilities maintenance team, a commercial specialist from the Business and Procurement office, and a section head. The main purposes of forming such a dedicated team were to enhance contract delivery and compliance to company standards and procedures and to improve productivity and efficiency. There was also to be a specific focus on contractor safety, along with commercial and risk management to lessen the company's exposure to business loss.

The objectives for the new Contract Management Team were to improve the following:

- Control and supervision of contract maintenance work.
- Safety and environmental culture and compliance.
- Contract administration to company procedures.
- Budget and finance control, with accurate reporting of costs and expenditures.
- Quality assurance, particularly ensuring that service level agreements were met.
- Contractor performance through setting and monitoring of key performance indicators (KPI).
- Communication with key stakeholders and customers.

New arrangements

With the combination of the two initiatives—the awarding of a single Site Services Contract and setting up the new Contract Management Team—Engineering was relieved of the management of a number of

contracts, freeing engineers to concentrate on their core skill—system engineering. At the same time, their experience and expertise are retained to provide technical advice, direction, and specifications for contract work when needed.

Including the Site Services Contract, the new team now manages approximately 50 contracts that provide for more than 80 services across the site, many of these directly related to support of maintenance activities. These contracts vary considerably, from providing the site restaurant food to maintenance welding.

The new team has made improvements in many aspects of contract management. Before the start of each new contract, a group of key staff is formally appointed to provide direct support to the contract and the contract manager. This group is normally made up of a commercial specialist, a technical specialist or engineer, a safety and environmental specialist, and a financial advisor. The team also carries out a consultation process with workshop union representatives before a contract is let, or on specific contract work that may relate to tasks normally performed by Bradwell's own maintenance staff.

This communication and consultation process significantly reduces the potential for conflict, not only between management and employees, but also between employees and contractors. This has proved essential in effective team-working between all concerned.

The Bradwell nuclear power plant

An evolving partnership

The Promanex contract, which is the largest single contract that the Contract Management Team manages, has developed quickly and now covers some 35 services. At the start, it was essential that the knowledge and experience of the facilities team were passed on to the contractor to enable a smooth transition without disrupting services and without breaches in safety or statutory compliance. According to Minter, the professional attitude and team-working of station and contract staff quickly established an effective working relationship and began to break down some of the barriers that commonly exist between the two groups. The new team also works closely with the Promanex management team to create a culture of mutual trust and partnership, which has greatly facilitated the resolution of any problems. This relationship, combined with the contractor's having a permanent core of staff on site, has significantly improved the flexibility and performance of contract personnel, compared with past experiences.

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The partnership continues to evolve. Given the significant scope of the contract, particularly in maintenance-related areas, the Contract Management Team concluded that both organizations could benefit from Promanex's integrating further into Bradwell's systems, procedures, and culture. For example, the plant has undertaken a program of training and formal authorization of all maintenance team leaders and contract managers to satisfy nuclear regulators that it can manage and deliver safety compliance by "control and supervision" of maintenance activities on site. The Promanex site-management team has been included to improve their knowledge and understanding of company and regulator expectations of compliance to health, safety, and environmental regulations. They are now authorized to the same standards as Bradwell staff.

Promanex has also been encouraged to integrate into the Bradwell safety culture through active participation in its safety processes, such as the Health and Safety Committee (membership is made up of staff safety representatives, safety and environmental specialists, contractors, and senior site managers). Promanex also participates in a "safety advisor" role to promote health and safety around the work place as a team-related subject. Its people have also been trained as Behavioral Safety Observers in order to be able to give constructive feedback to personnel on their safety behavior as they undertake their tasks. This includes encouraging individuals to recognize hazards and giving praise where good examples of safety behavior are being practiced.

There are already good results, said Rainger. In the first 18 months, there were no reported accidents, due to a combination of an excellent safety culture and good

A simple color-coded label enables staff to quickly identify whether equipment is within its test date. In the first year, this service innovation delivered an 80 percent savings. . . .

management from the contractor and the Bradwell team.

Adding value

With regard to the services themselves, a number of significant improvements have been achieved through innovation and change, as follows:

■ *Cleaning:* The cleaning service had previously been based on a number of scheduled routines on weekly, fortnightly, and monthly frequencies. The service was focused on the delivery of these routines, not necessarily on maintaining a clean site. For example, a waste bin would be emptied daily, regardless of how much—or how little—material was in it. The service was converted to performance- or condition-based, and is now done when required, not scheduled. The changes have resulted in significant cost savings and a more motivated team.

■ *Transportation services:* Hire cars have been traditionally used for staff to attend training or business meetings away from the plant site. A detailed survey of car hire usage showed that it would be more economical to use a small fleet of four permanent cars, retained and managed from the site. The administration, basic maintenance, and cleaning of the car fleet are also managed and completed by Promanex's own staff. This change of service has resulted in savings of approximately 20 percent.

■ *Appliance testing:* The statutory safety checks and testing of electrical appliances had previously been undertaken by two contract personnel. A detailed review of this service revealed that, on average, they were testing only about 20 units a day and their records were not accurate. A new service structure was developed to make the process more efficient and cost-effective. Promanex arranged for a specialist contractor to test all the portable electrical appliances on site in a single visit, bringing all the appliances on site to common test dates, either yearly or four times yearly. In just two weeks, 4000 electrical items were tested, tagged, and recorded in a database. A simple color-coded label enables staff to quickly identify whether equipment is within its test date. In the first year, this service innovation delivered an 80 percent savings on previous annual expenditures.

Achievements

The two initiatives have—at least in the first period of operation—led to a number of achievements, including the following:

■ Improved environment and culture of contractors and staff, through involvement of contractors in Bradwell's safety processes, such as Behavioral Safety.

■ Successful change management, through excellent team-working and ensuring knowledge and skills are not lost.

■ Improved management and delivery of contract maintenance services, focused on safety, time, quality, and cost.

■ Ensured proper application of safety, business, and commercial procedures, through use of a specialist contract team.

■ Improved use of station and contract resources, with engineers released from contract management.

■ Savings of nearly €210 000 (about $255 000), in the first year.

Streamlined Reliability Centered Maintenance at Ringhals, Barsebäck

The project's core team: Hans Göransson, project manager; and Göran Eriksson, Kenth Persson, Peter Sandholm, and Hans Palmqvist, analysis managers.

IN THE FALL of 2003, the Ringhals Nuclear Group, in Sweden, began a new maintenance optimization project, which involves implementing a systematic analytical method and tool—called Streamlined Reliability Centered Maintenance (SRCM)—at the company's five nuclear plants, Ringhals-1 through 4 and Barsebäck-2. Peter Sandholm, an SRCM analyst and instrumentation and control engineer in the Ringhals maintenance engineering department, said the goal was "to perform world-class maintenance."

SRCM was chosen from among several other methods being used elsewhere to optimize maintenance—including a very effective risk-centered maintenance approach undertaken at the Koeberg plant in South Africa—as the most suitable candidate. The method, which was developed by ERIN Engineering and Research, Inc., was then tested in a pilot project in 1999 and 2000 on five different systems at Ringhals-1. The results led to the decision to implement SRCM at all five plants.

What is SRCM?

The systems chosen for analysis are those that are safety-related or maintenance-intensive. The selection is made by the technical department for each unit. Although there is no limit on the number, the intention is that there should be no more than about 50 systems per unit involved. Even at this number, the project will take several years to complete. This is, however, a "living program" that will be continually updated to ensure that maintenance is always being optimized.

The goals of the SRCM program are:

- To satisfy the SKIFS 98 (the Swedish nuclear power inspectorate's regulatory code).
- To achieve higher availability.
- To gather experience.
- To reduce DUAM (the added cost of plant operation, maintenance, administration, and marketing).
- To achieve higher earnings.

Although SRCM should lead to many economic benefits, it is focused on safety and, in particular, the need to satisfy the SKIFS 98 by providing a well-documented maintenance program for all safety-related systems/components, explained Sandholm.

The technique involves pinpointing and analyzing systems that are safety-critical and those that have a history of failures. These are the systems that need intensive maintenance. The components that are non-critical or in the "run-to-failure" category are left with a minimum level of maintenance or no maintenance at all.

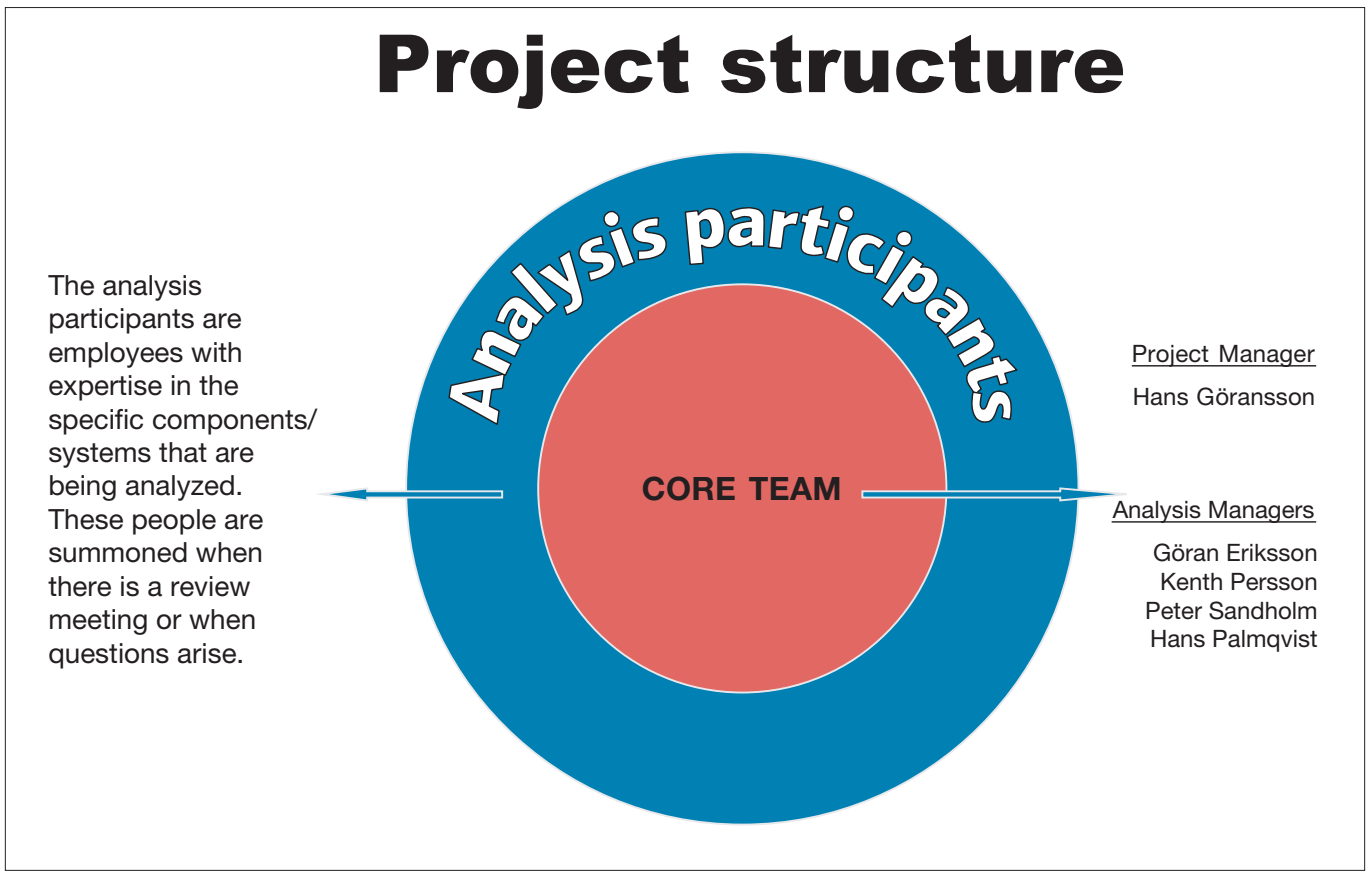
Another aim of the Ringhals project is to collect staff experience, particularly as more and more come to retirement. The analysis will draw on their experience, which will be documented and held in the SRCM database.

The team also sees this approach as strengthening the work culture by gathering people around a shared problem. This makes them more interested in the maintenance program and fosters better communication and understanding, particularly between operations and maintenance staff. This is essential to achieving the maintenance program goals.

In the end, it is hoped that there will be positive synergy effects that produce cost savings and higher earnings.

The SRCM program

The program involves two groups of staff: the core team, and system special-



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ists, called "analysis participants." The analysis participants are made up of staff members with expertise in the specific components and systems that are being analyzed. These people are called on when there is a review meeting or when questions arise.

It is considered essential to gain the full support of the analysis participants, which is one of the jobs of the core team. This requires convincing them that it is important to be as near to 100 percent accurate as possible and is achieved through various means, notably by keeping staff fully informed and explaining the reasons for the analysis. Therefore, it is essential that a well-developed dialog is fostered. In fact, said Sandholm, this presentation is one of the tools used to reach out to the analysis participants.

Criticality criteria

The pilot project identified eight critical failure effects. This makes it possible to categorize components as critical or not critical. A component is critical if it results in one or more of the following: reactor trip; reduced power or efficiency; exceeding technical specification limits; personnel safety hazards; significant damage; violation of environmental release limits; radiation release to the public; or fire.

[SRCM] provides a more structured way to systematize, document, and coordinate the tasks that are performed, and to keep maintenance data up-to-date.

The analysis process

The analysis participants provide the analysis manager with information about the systems and their functions. In every analysis, there is at least one person from each technical discipline (primarily electrical, mechanical, and instrumentation). The final results of the process will be maintenance procedures that will be implemented by the maintenance organization.

As mentioned, the technical department for each unit selects the systems to be analyzed. The next steps are to carefully define the system's boundaries and determine the functions—e.g., pumping, cooling, etc. Then the "functional failures"—when the system can't fulfill its function—are determined. The "criticality analysis" is organized by functional failure and involves analyzing each individual component in a system in terms of the effects of its failure on the system. This is very important for defining the best maintenance regime. For this step, the system experts and operations people participate. A review forum is held following this analysis to verify whether or not the analysis is correct.

Once this is completed, the analysis manager continues with a selection of the appropriate maintenance procedure, which includes a comparison with the existing maintenance program. This is also subject to a review meeting. The new maintenance program is performed by the maintenance organization but supervised by the SRCM project group.

Timeframes

The SRCM analyses began in fall 2003. Those undertaken for Ringhals-1, -3, and -4 and Barsebäck-2 are planned to be finished by the end of December 2006 and the analysis for Ringhals-2 by the end of November 2007. The delay of the analysis of Ringhals-2 is due to work at the plant involving the replacement of instrumentation and control equipment.

Achievements and conclusions

SRCM is not just another assignment for the maintenance and operations personnel. The project has benefited the plants in many ways besides analyzing systems and components. For example, it contributes to the education of those involved, particularly the analysis managers, in the specific systems and components being analyzed. It provides a more structured way to systematize, document, and coordinate the tasks that are performed, and to keep maintenance data up-to-date. It also strengthens the relationships and understanding between operations and maintenance staff.

As mentioned, the communication between the different parties is crucial to the exercise. The approach taken is to keep everyone informed about the project and how it is progressing, noting the importance of teamwork and that this is something everyone is doing together. There is now a greater appreciation that "what we do at Ringhals, we do together," said Sandholm. This, he added, is the key to success.

At the beginning of the project, some negative opinions of the new maintenance project were voiced. Now, however, most in the organization seem to understand that it is important to have a document that sets out what maintenance will be done and why. NN