Heysham-2 station's standpipe liner modification project. The work involves modifying the standpipe liner sleeve by drilling a small vent hole about 1 m down each liner tube, using a robotically operated tool.

Building a modern maintenance service at British Energy

BY DICK KOVAN

Deregulation has forced constant awareness of costs and spending at British Energy, along with a goal to be in the top decile of WANO PIs.

SINCE BEING PRIVATIZED less than a decade ago, British Energy's advanced gas-cooled reactors (AGRs) have doubled their output and halved their staffing levels while significantly improving safety performance. Today, deregulation is the main driver for the company, forcing it to be constantly looking at its costs and spending, a way of life that did not exist in the days of the nationalized Central Electricity Generating Board.

The corporate objective for the whole fleet, including its one and only pressurized water reactor, Sizewell B, is to be in the top decile of the World Association of Nuclear Operators (WANO) performanceindicators (unit capability, unplanned trip rates, safety system performance, fuel reliability, etc.). A large part of the responsibility for achieving this is in the hands of the stations' maintenance departments.

Heysham-2: Leading the way

British Energy owns and operates seven two-unit advanced gas-cooled reactor stations. Heysham-2, whose two 690-MWe reactors are the most powerful in the AGR fleet, is in its 10th year of operation, and has just received clearance for continued operation from the Nuclear Installations Inspectorate (NII), the U.K.'s nuclear regulatory agency.

In today's competitive market, even maintenance departments have to operate as profit centers and meet business plans, notes Mark Gorry, maintenance manager of the Heysham 2 AGR station. "We are much more aware of how our plant is performing, for example, in terms of downtime, refueling cycle times, outage duration, what we are spending on maintaining the plant, what our maintenance-induced losses are, and how it affects the business plan."

At the moment, Gorry is acting plant director and has to deal with all license responsibilities of Heysham-2, which is the lead station for a number of innovative programs initiated by British Energy.

In what is a remarkable turnaround, AGRs are producing about double the output compared with the nationalized days, which were characterized by low load factors and long statutory outages, averaging about 16 weeks. Outages are now typically just over 40 days, with the best being 35 days. The staffing level at Heysham-2 has been reduced from 890 to about 460 people, in line with the company norm.

"The pressure to reduce costs, be more cost-effective, provide safer and more reliable output is no different from anywhere else in the world. But we probably feel the pressure here more than in the United States," claimed

Gorry: Feeling cost-reduction pressures

British Energy's Heysham-2 station

At Heysham-2 station, technicians work down a gas circulator penetration, preparing a gas circulator for removal and subsequent replacement.

Gorry. The reasons, he explained, have to do with the relative complexity and high operational costs of the AGR, coupled with the pressures on prices faced by the company as Britain marches toward total deregulation of the power market.

For new ideas Britain certainly looks to the United States. Gorry pointed to the very professional operation he has seen at the best U.S. plants, in terms of, for example, material conditions, procedural adherence, training, FIN ("fix-it-now") maintenance. "The trick for us is to replicate that performance with fewer people and spending less money. This is not easy, but Heysham-2 is doing it in many areas."

For example, the high trip rates of nationalized times were once considered normal. Now, while trip rates are not down to American levels, they have improved dramatically. Heysham-2 has operated for more than a year without a scram, and the Torness plant, in Scotland, which is the same design as Heysham-2, recently completed 825 days of uninterrupted operation.

Organizational changes

Substantial organizational changes have been made since privatization. In the nationalized days, the structure boasted about 10 levels with the station director at the top. There are now only four layers, which Gorry thinks is the practical minimum.

Possibly the most revolutionary change was to place the engineering and outage management functions under maintenance. Previously, engineering and maintenance were separate roles in the company. The move to this model came out of a business process reengineering exercise that looked at the real processes involved in running a plant.

The reasoning, explained Gorry, is that "these activities are all undertaken in support of maintaining the safety, reliability and availability of the station. . . . [M]aintenance is what they are there for. We considered calling it engineering & maintenance or maintenance & engineering, but the term maintenance prevailed."

Besides delayering, British Energy has moved to a system-based maintenance regime, as is common in the United States. In the old days, maintenance was divided by discipline—for example, mechanical, electrical, and control & instrumentation. For a system such as a pump, which includes mechanical parts, electrical motor, and instrumentation, each element would be maintained by craftsmen from the appropriate discipline. In the system approach, the plant is divided into systems and each is "owned" by an engineer who, supported by maintenance teams, has overall responsibility for its performance. Maintenance work is now handled by multidisciplined teams, which work more flexibly and across a wider range of tasks. Craftsmen are now called maintenance technicians, whose job description includes multi-skilling and increased responsibility.

According to Gorry, it has been a difficult transition and there is a long way to go before it is fully embedded. There was some resis-

tance; some people could not live with it and have taken the opportunity to leave with the benefit of a generous severance scheme. The company has tried to help everyone through it. Workers have been sent to plants in other countries to see what actually can be achieved by doing things differently. This has been a powerful means for selling people on change.

This is only part of a near revolution in how work is being organized at British Energy. In 1998, the company and the unions concluded a maintenance technician agreement for AGR power stations, under which technicians can now take on new responsibilities. They used to work only to written instructions provided by engineers. Within limits, the technicians can now specify their own work and write and amend their own procedures. Furthermore, tagouts—which were traditionally only carried out by operations staff, never by craftsmen—can now be done by maintenance technicians.

The new responsibilities include health physics. Much routine work of monitoring contamination, radiation, and dose control can be done by the maintenance technicians following suitable training. There used to be 40 or 50 health physics technicians working at the station. This is down to about 14.

Planning

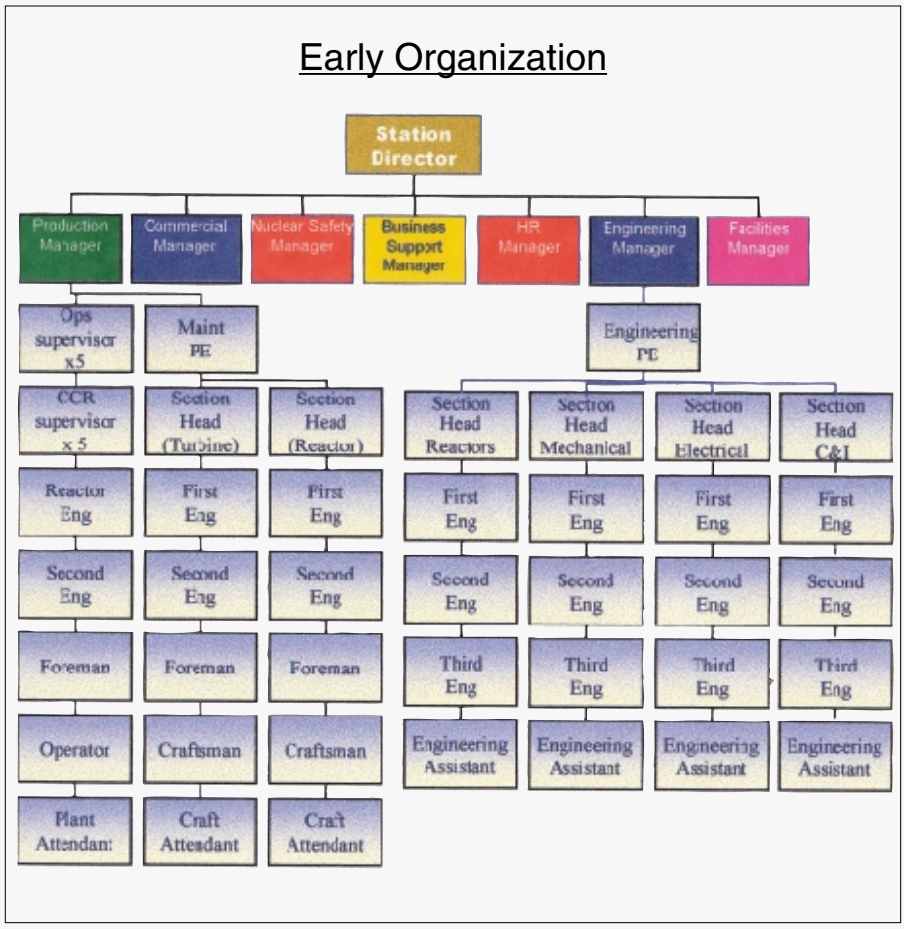
Heysham-2 has introduced the American 13 rolling work week planning procedure with a nominated work week manager. While top American plants will achieve 90–100 percent of their jobs, British Energy plants are well below that. "Being resource-constrained, we have to make lots of value judgments on what to do and what to let slip. Outside of the statutory and safety case work, we are probably only achieving about 60 percent of the work scheduled in any week," said Gorry.

(Gas-cooled reactors are refueled on-load, and to meet licensing requirements, they must be shut down periodically for safety inspections and to undertake work demanded by the NII. These "statutory" outages were initially done on a two-year cycle, but Heysham-2 and some other AGR stations are now authorized to operate on a three-year outage cycle.)

One important development that is improving the situation is to involve operations staff. The operations technicians have also signed an agreement with the company allowing them to do a certain amount of maintenance work, such as first-line fault-finding, minor repairs, and simple maintenance tasks. They would now be expected to change a lamp in a panel and do more testing.

Fix-it-now

Another new development for the United Kingdom was the establishment of fix-it-now (FIN) teams. Before the changes to multidiscipline teams, maintenance teams did a mix of both routine and defect work. Through visits to American plants, maintenance managers learned how useful FIN teams are. By specializing in emerging work, the other teams could concentrate on planned routine work. The first trial of a FIN team was at Heysham-2. To help sell the idea, British Energy



Maintenance department: The old hierarchical structure (top) and the new "flat" structure (bottom)

ON CROSSING THE BRIDGE TO HEYSHAM-2 station's reactor building, staff are reminded to "Take 2." Take 2 was devised as a prompt to raise awareness of key concerns of safety, quality, and the environment. The worker is provided with a simple checklist of things to consider and check before progressing with a task to confirm, among other things, that all the instructions given are correct and that the work will not cause harm to those carrying out the tasks or to others.

Take 2 reinforces the INPO STAR (Stop-Think-Act-Review) process, which the company adopted in 1992. While STAR continues to underpin safety culture, the management at Heysham-2 felt that following some safety-related incidents and near misses at the plant, additional measures were needed. Under Take 2, a worker should answer several questions at three critical steps of a job, including the following:

1. When given a task:
   a. Does the safety document cover the task on the work order cards and are the details correct?
   b. Do you have all the correct paperwork and do you fully understand the information?
   c. Do you have all the relevant tools, equipment, and PPE [personal protective equipment] needed to carry out the task?
2. Before starting work:
   a. Is the plant exactly as specified on the safety document and work order card?
   b. Could the work area for the task harm others? Have you considered other potential hazards?
   c. Can you get in and out of the location safely?
   d. Are all involved in the task briefed on what to do in the event of emergencies?
3. On completion of work:
   a. Is work area left clean and tidy?
   b. Are work order card details complete?
   c. Are defect tags removed?
   d. Is safety document cancelled?

Each step should take about two minutes. Personnel carrying out a Take 2 are expected to record having carried out the process by signing or ticking a label that appears on the Work Order Card, used for verification of the task's being completed. Supervisors, team leaders, managers, and other nominated persons can then randomly carry out independent verification by observing the task and checking whether a Take 2 assessment has been carried out.

brought in maintenance people from PECO, its United States partner in Amergen, who explained how they use the FIN process. "Once set up, we quickly found it very successful. It has been a main element in driving down our defect backlog, from about 5000 five years ago to about 800," explained Gorry. Most of the stations now have FIN teams, although they call them by different names. Heysham-2 calls its FIN team DART, for Defect and Rectification Team.

Ending the overtime culture

Another development was the introduction of the "stable income scheme," which is an innovative way to break the old overtime culture. It is being used in other industries in Europe. Heysham-2 is the pilot for this scheme in British Energy.

Under the stable income scheme, the department and each team have agreed overtime payments at the beginning of the year. The money is paid throughout the year no matter how much overtime is actually done in the month. The important thing is that the work that needs to be done is completed, whether with overtime or without. If the work is not getting done during normal shifts, or the defect catalog is growing, or some plant breakdowns occur, the workers will be called to work until it is completed.

According to Gorry, "the old overtime culture, where workers made money out of delays, was harmful and drove a lot of bad behavior. Before, they were less inclined to flag up an inefficiency, as this hit their own pocket. This scheme has changed attitudes. Today, about half the overtime is done. Now, when something needs doing they get on and do it. Even better, management and workers work together to see how the amount of time at work can be minimized. Workers are much more willing to cooperate with each other, do each others jobs, even work through breaks. The scheme makes the team want what the management wants. It is now in everybody's interest to get things done."

The national unions remain hesitant and have demanded that it not be imposed without a ballot. Furthermore, they want everyone at the plant to be on it and for it to be proved successful over a couple of years before it is rolled out across the company. The plant is only now at a stage where everyone has signed up. The maintenance staff joined two years ago, but some of the operations shift workers rejected it until recently.

Many other cultural changes have been introduced. Team building is given a high priority, with teams given opportunities to develop their relationships away from the plant, where they can talk about what a good team is and how to make it work. Heysham-2 maintenance teams now hold a meeting every morning to discuss the day's jobs. This would have never gone on before.

Team leaders are now selected for their ability to manage people and to deal with people issues and given training and other support, including outside assistance, for this.

Managers have their part to play. Most important, they must keep staff informed on

Inspection of a high-pressure turbine module at Heysham-2 station

what is going on: what the targets are, how the plant and each department are performing (budgets, generation, safety) and what the current and future needs of the business are. Newsletters and weekly team briefings are now standard. The station director gives a quarterly briefing to the whole staff.

The "no-blame culture" has been introduced at Heysham-2 and pushed very hard. According to Gorry, American plants are good at devising open systems for reporting problems, including observed deficiencies or near misses. Reporting even minor events is new to Britain's workers. "We are committed to a culture where workers will not be disciplined for making a mistake. They understand that learning from it is the most important aspect. It is virtually unknown now for people to get disciplined for making mistakes. This is because we want people to feel comfortable with being honest and open, and [to] want to learn."

The only time it departs from this "no-blame culture" is when people are plainly negligent, unreasonably so.

Investment

The plant has invested heavily in providing staff with good facilities, including well-equipped meeting rooms for team use. The contractors are not forgotten. With only about 80 in-house craftsmen, the plant uses year-round contractors who are fully integrated and treated just like the staff. Furthermore, the people there just during statutory outages are provided with facilities equal to those of the staff, including round-the-clock hot-food catering. Investing so much when the statutory outages are only every three years was controversial, but it has proven worthwhile.

Apart from buying new stations, the biggest investment that the company has made is the Work Management Project, costing some tens of millions of dollars, to develop a comprehensive asset management system. The company wanted to have the best system possible for planning, documenting and managing work, assessing risks, controlling access, etc. The system must also support licensing compliance. Working with Indus International, whose Passport system was already widely used at British Energy, a best-of-class asset management package has been developed. Heysham-2 was chosen as the lead station for implementing the new package. It goes live on December 4.

Heysham-2 located the project installation team next to DART, because, said Gorry, "they are the best at what we do—the way they work as a team, plan their own work day to day, write their own procedures on occasions, and do all sorts of other things. They provide useful discussion to the project team for its implementation."

Maintenance manager's role

The role of maintenance manager has changed dramatically over the past few years. The flatter organization means that many people report directly to Gorry. Managers and team leaders all have business plans and budgets, and he has to monitor and appraise their performance, and be responsible for their development as well.

"It is much busier and more challenging," noted Gorry. "I now have much more contact with people and must make sure I am less remote. In having many more direct reports, I have to be prepared to trust people and let them get on with things.

"We never had this in the nationalized company. We had no idea how much things cost at all. Again, looking at other plants around the world, often people do not have an understanding of what they are spending or even have to think about that. Now, we have to plan our spending and live within our means." NN

Reviewing and restructuring maintenance at Sizewell B

COMMISSIONED IN 1995, Sizewell B, Britain's only pressurized water reactor, is a young plant and its maintenance strategy is still evolving. "Our goal," said maintenance manager Matt Sykes, "is to achieve top decile WANO performance. We have a way to go yet, but it's in our sights and we are committed to achieving it."

Compared with other PWRs, Sizewell B is rather complex—Americans call it a "late model Mercedes" in terms of its design. It includes a number of features specially

British Energy's Sizewell B site

added to satisfy the U.K.'s regulatory regime. There are some 285 000 items in the plant's data base that attract some form of maintenance.

One feature of this "Mercedes" is its high level of scheduled maintenance. An important part of Sykes' work is to identify where this can be reduced. While always taking a cautious and prudent approach before diluting the amount of maintenance carried out, he believes it must be right to challenge what you are doing and change it if safety and reliability are not affected.

The maintenance team is now halfway through a review of the station's maintenance strategy reports, looking for areas where it might be possible to reduce the level of routine work required. A strategy report identifies the degradation mechanisms affecting systems and components, the maintenance required and the reasons these are set. The reviews take account of experience from all over the world, and try to set out a revised maintenance strategy. In the early days, the strategies were heavily biased by the original manufacturer's warranty For the nuclear steam supply system, safety case and license compliance considerations meant there was a lot more conservativism in the strategies. But even here, experience can lead to a lessening of measures while retaining the same level of safety and reliability.

"Even after only three outages [the fourth began in September], there are rich cost savings to be made by blending in experience and adjusting the maintenance strategy accordingly. We will be doing this through the life of the plant," explained Sykes.

Sizewell B has also bought into a company initiative called the Work Optimization Process, which looks to minimize the number of routines undertaken. "We try and push out the maintenance frequencies, where you have justification to do so," Sykes said. Since March 1997, the number of annualized routines (e.g., surveillances, preventive maintenance, company-imposed maintenance, statutory requirements) has dropped from about 29 000 to just over 20 000.

One significant area relates to the Equipment Qualification (EQ) requirements, which set a lifetime for components based on their ability to satisfy safety-related functions. The EQ can add highly onerous demands on maintenance schedules. The original EQs were very conservative, which meant high-frequency, high-cost routines. As an example, he noted an actuator seal whose EQ required that after year five the seals be changed, since beyond this time, according to the design-basis accident analysis, the safety function could not be guaranteed. To challenge this, its operation was monitored to see if the system ran as assumed by the EQ and specified in the safety case. In this case, the temperature was much lower than assumed, which changed the EQ case, allowing the operation of the seal for 20 years before replacement. This saved a substantial amount of money. "We are always looking to feed back 'live' information into the safety case to challenge requirements and if possible change them," said Sykes. "This requires plant modification approval throughout our processes, but with a young plant and a long life ahead, it's worth the investment."

Business plan enablers

To meet the demands of the business plan, the maintenance department focuses on three key "enablers"—outages, pence-per-unit, and the INPO 1 rating (of the Institute of Nuclear Power Operations in the United States).

The first two are straightforward. Reducing outage duration is a major target as market competition and deregulation force down prices. The maintenance program aims to optimize outages by identifying and implementing best practices from around the world. The pence-per-unit enabler looks at activities critical to cost that can be reduced or eliminated without compromising safety. Typically this means doing things smarter and more efficiently to eek out more kilowatts.

Although Sizewell B does not have an INPO rating, it wants to achieve "best in class," and INPO 1 units provide many pointers as well as a model. As an example, a World Association of Nuclear Operators (WANO) international peer group review was held in 1998. The review generated Areas For Improvements (AFIs) on the plant that were fed into the maintenance program.

To complement this, the company has signed up to the International Safety Rating System (ISRS), which helps build quality into the work early on through independent audits of management practices and facilitates the development of an effective safety management program. It is based on the idea that proper management control will prevent the basic causes of loss from occurring. Elements of the ISRS that are audited include critical task analysis, leadership, task observations, planned inspections, and maintenance. These have led Sizewell B to strengthen many of its procedures and approach to work across the site. Examples include:

■ A critical task coordinator is now nominated to make sure that critical tasks are properly carried out.

■ The "setting to work" procedures for line supervisors have been reinforced. Supervisors are now trained to develop a structured, systematic approach for implementing work. For example, a team leader must be sure that the maintenance technician is well briefed about the system being worked on, understands its safety significance, its current status, what the job entails, timescale, etc. One gratifying instance noted by Sykes was during a follow-up visit by WANO, when a technician carrying out a maintenance job on an emergency standby diesel was able to demonstrate to a WANO representative that he knew the nuclear safety implications of what he was doing and why he was doing it, and also the safety implications of having that system offline at that time.

■ Supervisors are now required to do spot observations in the field. This is not an adversarial activity. "We see it as a coaching exercise to check out that the instructions given to the worker are being implemented. Workers have taken it very well. They know it is there to improve their performance," explains Sykes.

■ Once every month, a full task observation is undertaken when the leader goes through the task with the maintenance team from start to finish. The plan is to move a stage further, to peer checking, where the team members do it themselves.

Sykes: Rich cost savings to be made

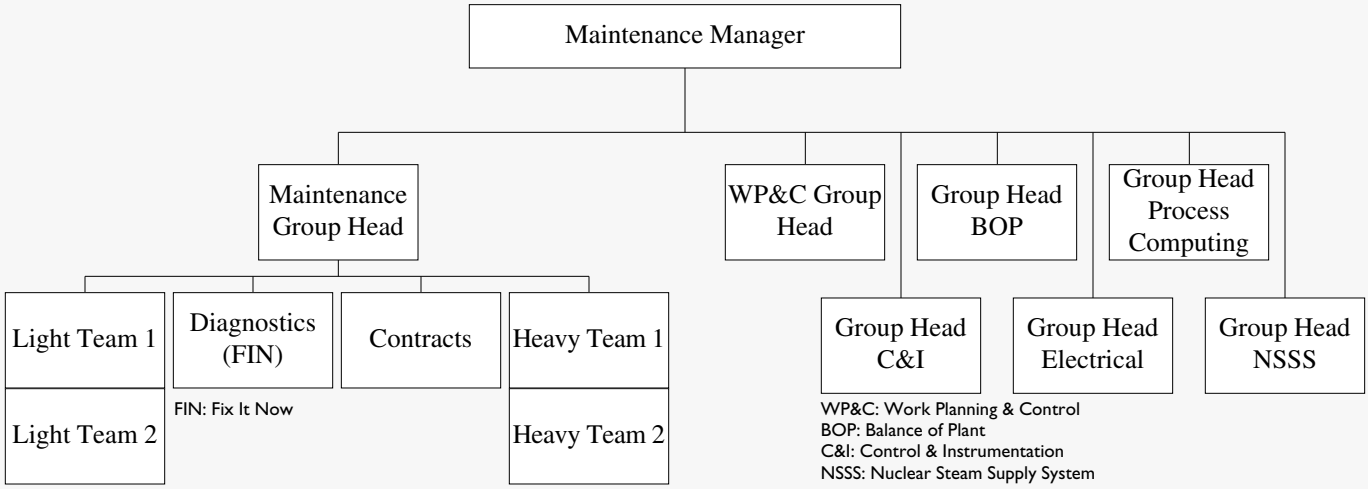
The right structure

Since operation began, the maintenance organization has been under review. A flat structure has evolved to facilitate the different types of work: routine, emerging, and longer-term planning. The maintenance teams are expected to take more ownership of routine maintenance, while the diagnostic team (the plant's FIN team) takes care of the daily "here-and-now" issues. This frees the system engineers from the day-to-day problems, allowing them to look beyond the horizon.

Sizewell B adopted the systems engineering approach, an INPO international practice. There are 170 systems, each with a maintenance strategy and a system engineer responsible and accountable for the health of that system.

All maintenance and operations jobs go through Work Planning & Control. The actual maintenance work is managed by a nominated work week manager who concentrates on the critical tasks. The ownership of the work belongs to the person carrying it out. "The work week manager's life should be easy, but we tend to make it difficult. We are not supporting that process properly yet," explained Sykes. "We have an action plan to improve our approach and we are hitting it hard at present."

The maintenance group is divided into light and heavy maintenance teams, a diagnostic team, and contract managers. Each light and heavy maintenance section is split into two teams of eight to nine people, each with a team leader. Each work week is managed by one of the two team leaders for each section—the light maintenance team leader has both light maintenance teams at his command, and the heavy maintenance team



Sizewell B maintenance department organization

leader has both heavy maintenance teams at his command—while the second team leader is planning the following week's work, which takes considerable strain off him. The change was made this summer. It has had a dramatic effect. "These guys think this is the best thing since sliced bread," said Sykes. "It is working well for them and the plant. However, they are acquiring experience and need mentoring."

Of 500–700 jobs each week, about 12–14 critical tasks are chosen for management focus. The goal is to get 100 percent completion of these in time. "We are not hitting this yet," said Sykes, "but the approach is beginning to work."

Sykes said the structure is working in part because all parties were involved in the discussions as it developed and "own it." It took 18 months to set up the structure, which had to be approved by the regulator.

This setup has also helped the plant reduce by half its defect backlog in 18 months, from 2000 to just under 1000. He would like to get it to the 500 mark, which would be "best in class."

For Sykes, "the ultimate goal is for all defects to occur on event-based items. If the condition monitoring and routine maintenance program are right, unplanned maintenance will be unnecessary—by default, the only defects will be on plant items chosen to operate to failure."

Planning new projects

Sykes chairs a forum called the Station Operation and Coordination Committee, or SOCC, which identifies and evaluates potential new work. Members include the principal managers and group heads, mainly from system engineering. The forum looks at the benefit of doing the work and its impact on safety and on the business plan. Before any decision is made, the customer—operations—must also buy into it.

There are several other aids to planning. A rolling "Ops Top 10" lists the customer's top 10 concerns, which is on a live data base. A risk catalog has been prepared to help manage business risks, which relate to safety, commercial concerns, design, people, and other issues. Once every month, a plant managers peer group from BE's nuclear plant sites get together via a video link to discuss key issues, particularly those concerning change and long-term questions. It is also a forum for others to make presentations to maintenance managers. An every-other-month formal interface with the Engineering Division (British Energy's headquarters engineering staff) is also staged to oversee the progress of technical support to the site.

Inspecting the turbine generator at Sizewell B (Photo by Nick Davies Photography)

The role of the manager

Sykes sees his role as both manager and leader. As manager, he has to make sure the tools are in place for people to do what they have to do, look out for what is around the corner, and undertake strategic planning for the longer term. As leader, he is mindful of his position. He believes it is necessary to get out to know the people, give them time, and develop a rapport with them. Sykes and the station director go on plant tours on a weekly basis, no matter what else is going on.

"At the end of the day," emphasized Sykes, "it is the people that make it work. They have enough to do. From me they need support, clarity, honesty, a listening ear. What I strive to be is to be the best leader I can be. You have to reach out and make a difference.

"I am a great believer in giving people what they need and letting them get on with it. You can go wrong if you are heavy handed, aggressive, and take punitive measures. This is the wrong way. You must respect their integrity and give them room to do the job. There must still be accountability, but you must be clear about it."

Finally, he observed, "these people will turn their lives around, when there is a problem, [to solve it]. You cannot ask for anything more. That is a mark of the people, not me." NN