Nuclear plant availability: Real achievements

by James Daglish

A symposium on advances in nuclear power plant availability, maintainability and operation – held in Munich in May – demonstrated clearly the maturity of the nuclear industry. Nearly 140 operators and representatives of utilities and regulatory bodies from 29 countries and six international organizations had what might be termed "a valuable exchange of views" on the 32 papers, principally from Europe, which were presented.*

It is worth recalling that the 345 nuclear power reactors in operation in 26 countries at the end of 1984 have now accumulated more than 3500 reactor-years of operating experience. Admittedly, not all of this experience has been good. The industry is still recovering from the bad press which followed the Three Mile Island incident. But that should not be allowed to overshadow the very real achievements of the nuclear industry worldwide.

Papers presented at the symposium showed that improvements in plant performance have resulted from:

- *Raising the quality of equipment, by modifying design or manufacturing practices.* Feedback and evaluation of information on equipment performance during operation have contributed to the selection of optimal design changes.
- *Advances in planning and scheduling of operation and maintenance.* Papers presented at the symposium demonstrated that computer-aided scheduling of all operations, and the execution of activities in strict accordance with schedules, can reduce plant downtime for maintenance and refuelling to about 5% of the available time.
- *Development of new tools and other equipment for maintenance, repair, in-service inspection and operational testing.* This has contributed significantly to the reduction of maintenance and repair time, and toward raising the quality of work performed.
- *Implementation of strict quality assurance (QA) requirements in operation, maintenance and repair work.*
- *Qualification training and re-training of operation and maintenance staff.* Some utilities are introducing five or six shifts of operations personnel so that one shift can be continuously retrained on a rotating schedule.

The French experience

French dependence on nuclear plants for electricity generation is currently nearly 60%. Its tranche of pressurized-water reactors (PWRs) must obviously operate in a load-following mode, in other words responsive to fluctuating electricity demands. This is something not only the French, but operators in other European countries with a high nuclear component in electricity generation, are learning to live with. In such countries, availability has become a more important performance yardstick than load factor. Plants in France and Sweden are in fact routinely demonstrating availabilities of about 80%.

Bernard Meclot, from the "Département Exploitation Sûreté Nucléaire" of Eléctricité de France (EdF), noted in a particularly interesting presentation that EdF plans its maintenance schedule for anything up to a couple of years ahead, and takes unplanned outages into account at regular review sessions at which the planned schedule for plant non-availability is adjusted. To cope with short-term demand fluctuations, much of the tranche of nuclear plant is run in load-following mode at less than its design output, with results claimed to be "perfectly satisfactory". Even under such conditions, nuclear retains a clear cost advantage over equivalent generation from coal-fired plants.

During 1984, French nuclear plants recorded a "production factor" of around 75% (the amount of electricity produced compared with the theoretical maximum) which must be set against the recorded availability of 81.3%. The 6% difference corresponds to loss of production attributable principally to the need to run plants at less than optimal output not only to follow load but for purposes such as maintenance of frequency stability on the grid.

During January 1985, including a period when all available capacity was required, EdF's tranche of 900-megawatt PWRs recorded an availability of 90%; the two 1300-megawatt PWRs at Paluel had an availability of 85.4%. (Meclot underlined, incidentally, the importance of comparing like with like: Operators in different countries have different ways of measuring

Mr Daglish of the Agency's Division of Public Information served as the symposium's press officer.

* The symposium was organized by the IAEA in co-operation with the Government of the Federal Republic of Germany and the Gesellschaft für Reaktorsicherheit, at Garching.

such things as availability. Should the production statistics reflect planned shutdowns for refuelling? Some operators exclude such planned downtime from their performance indicators.)

Design improvements

The growing importance of nuclear energy in Europe as a whole was underlined on the first day by Dr K.E. Schroeter, from the Federal German Ministry for Research and Technology. He noted that although nuclear accounts for only 13% of electricity production worldwide, in Europe as a whole the figure is closer to 30%. In the Federal Republic of Germany, nuclear accounts for about a third; in Bavaria, the proportion is at least 50%.

Dr Schroeter acknowledged that nuclear construction costs everywhere are high, and rising, because of increasingly sophisticated engineering, special single-part manufacture, prolonged construction periods, and complicated licensing procedures. Standardization has been promoted in France for years in an attempt to limit costs without detriment to safety in operation; in the Federal Republic the so-called "convoy" approach of applying for licenses for reactors of almost identical design has also proved successful. However, investment costs continue to be high, and to a large extent the future of the industry depends on its ability to further optimize plant utilization by achieving increased availability and capacity utilization, so as to make the power supplied as inexpensive as possible.

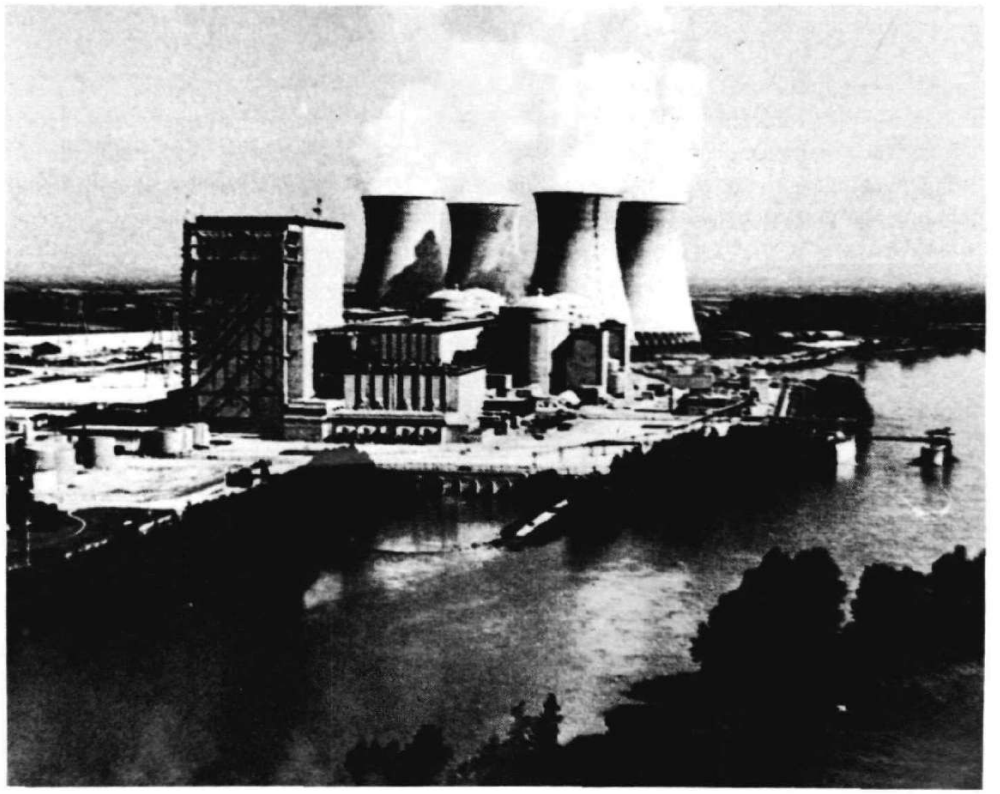
Prof. Leonard Konstantinov, IAEA Deputy Director General in charge of the Department of Nuclear Energy and Safety, noted in closing remarks that nuclear plant designers and manufacturers attending the symposium had reported no major changes in plant design.

"Major changes, backfitting and modifications are even not desired," he said. However, new designs of equipment and instruments for use in plant maintenance, testing, and in-service inspection were described in detail. Using such equipment, considerable improvements have been achieved in length and effectiveness of maintenance, reduction of exposure of plant personnel to radiation, reliability and effectiveness of inspections and tests, and reduction of plant unavailability due to maintenance and testing requirements.

Analysis of plant outages

From the IAEA, David White presented a paper authored jointly with Robert Skjoeldebrand analysing 15 300 nuclear power plant outages which had occurred at operating nuclear plants up to the end of 1983. Full data on these outages is contained in the Agency's Power Reactor Information System (PRIS). The main conclusions to be drawn from the analysis were that the main factors influencing performance are:

- Degree of standardization achieved in plant design and construction
- Quality assurance standards used
- Regulatory climate
- Competence of the operating organization.



Bugey nuclear power station, France. (Credit: CEA)

White and Skjoeldebrand noted that "in cases where plants really have been standardized, there is often an improved performance both with the age of each plant and particularly for subsequent plants". French experience was a case in point; note should also be taken of the good performance of Soviet-supplied 440-megawatt PWRs in several countries (an average cumulative load factor of 77.4% from 43 reactor-years' experience in Czechoslovakia, Finland, and Hungary). A high degree of improvement had also been achieved by several utilities in the Federal Republic. The most remarkable improvement had been achieved, however, in Japan, where there are many suppliers and utilities.

The data reported to PRIS is not sufficiently detailed to permit analysis of component reliability – something which is more appropriately carried out by utilities and their organizations. White and Skjoeldebrand pointed out, however, that equipment failure accounts for about 20% of nuclear power plant unavailability. Many of these failures occur in "conventional" plant systems, with the turbo-generator, feedwater, and condenser systems contributing 31% to outage time. They urged that this should be seen as cause for action – for example, by improving QA requirements for such systems.

Incident reporting

The IAEA Incident Reporting System (IAEA-IRS) was described in a paper by Stanislav Novák. Nuclear power plants are now in operation in 26 countries, 12 of which take part in the IAEA-IRS directly and six through the similar system operated by the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD). The IAEA-IRS now contains incident reports from 22 countries. Such reports are analysed and conclusions of general interest are disseminated to all participants, and further reviewed at technical committee meetings once a year.

The objective is to allow all safety-related events, including component and system failures, human errors, and incidents to be analysed, in order to prevent repetitions in other units, at other sites, and under other circumstances by implementing "lessons learned" from operational experience, and improving personnel and plant performance.

The IAEA-IRS is still in its infancy: it was launched by a letter from the Director General to Member States only in April 1983. However, its potential is clear. Novák noted that most of the incident reports received so far have been from developed countries, but "some of the lessons learned from events that have been analysed in developing countries represent significant contributions to the safe operation of nuclear power plants worldwide".

Safety reviews

Yet another IAEA initiative is the offer of Operational Safety Review Teams (OSARTs) to support operating organizations and regulatory authorities in an attempt to enhance the safe and reliable operation of nuclear power plants. The way the scheme works was described in a paper by IAEA staff members P.A. Bliselius and F.L. Franzen. In brief, an OSART usually consists of six to ten experts who review the operating history of a plant, check how routine operation, surveillance testing, and maintenance are performed, explore the planning and preparation of future work, and verify the approach taken to ensure the feedback of operating experience and to cope with potential emergencies.

Presenting the paper, Bliselius noted that recurrent findings from the OSARTs which have taken place so far are that improvements are often required in the managerial approach to safety, and that more attention needs to be paid to the implementation of effective QA programmes. He also pointed out that OSARTs are only one of the services offered by the IAEA in the field of operational safety. The IAEA-IRS has already been mentioned; others include publications in the Nuclear Safety Standards (NUSS) series and the periodic review of current operational issues by small working groups. All these together form a package which the Agency offers to its Member States as part of its continuing efforts to enhance operational safety worldwide.