76

REPORT ON THE STATUS OF INSTRUMENTATION AND CONTROL IN SWEDISH NUCLEAR POWER PLANTS

P.E. BLOMBERG
Studsvik Energiteknik AB,
Nyköping, Sweden

Abstract

During 1988 the twelve nuclear power units in Sweden generated 69 TWh, which was 45% of the total electric power produced in Sweden. The production capacity of the nuclear power plants increased successively by upgrading the units to higher nominal power levels.

The paper presents an overview of activities on control and instrumentation in the following:

- maintenance,
- renewal of the I&C systems,
- training.

The operational data of Swedish reactor units are presented.

Some major events

During 1988 the twelve nuclear power units in Sweden generated 69 TWh, which was 45 % of the total electric power produced in Sweden. Operational data, such as output, capacity factors and availabilities of these twelve units are shown in Table 1.

The production capacity of the nuclear power plants increased successively by upgrading the units to higher nominal power levels. Recently the power output of both the Forsmark 3 and the Oskarshamn 3 reactors was increased by 80 MWe. The Ringhals 1 unit has received authorisation to increase its power level by 10 %, and the Ringhals 2 unit from 80 % to 107 %, after the steam generators have been changed in 1989.

As a result of the Swedish nuclear referendum in 1980 the Swedish Riksdag has decided that nuclear power should be phased out by 2010. In March 1988 another bill was passed, according to which two of the 12 units should be phased out during 1995 and 1996, but with the provision that the demand can be met by the national production capacity, and that the Swedish contribution to carbon dioxide pollution is not increased.

Maintenance

The maintenance of the nuclear plants plays an essential role in the operation. The 12 units were installed over a period of 13 years, between 1972 and 1985, and have thus been in operation for 4 - 17 years. The experience of their availability is very good, as illustrated by the data in Table 1. The ageing problems so far are minor, but there are signs that these are now beginning to increase.

Typically many electric components have a life time of 10 to 15 years. It has been observed in the older units that the frequency of replacement of certain components (a o swelling relay-coils, drying condensors, etc) is increasing. When possible, redesigned components are used for the replacements, often because spare parts are difficult to get for the older components, but also because the modernised components are less prone to causing disturbances in the operation of the plant, when maintenance work is carried out on them.

TABLE 1. OPERATIONAL DATA ON REACTOR UNITS

Unit and start comm. production	Output MW net	Production GWh gross 1987	Production GWh gross Jan–Oct 1988	Capacity factor % 1987	Capacity factor % Jan–Oct 1988	Capacity factor % accum. Oct 1988	Operating factor % 1987	Operating factor % Jan–Oct 1988	Availability % accum. Oct 1988
01 BWR 1972	440	3 376	2 502	83.8	74.1	69.1	89.1	78.3	73.6
02 BWR 1975	595	4 416	3 706	82.0	80.9	77.2	88.9	87.8	83.0
03 BWR 1985	1 050	7 356	6 352	75.6	78.4	81.3	91.2	85.7	90.4
R1 BWR 1976	750	5 092	3 852	74.2	67.1	63.1	89.9	80.5	74.8
R2 PWR 1975	800	4 401	3 582	58.6	57.0	58.0	84.4	80.7	71.7
R3 PWR 1981	915	6 476	5 383	77.0	76.5	58.8	85.4	85.3	71.9
R4 PWR 1983	915	6 002	5 598	70.7	79.1	73.2	89.4	88.5	85.8
B1 BWR 1977	600	4 726	3 669	87.7	81.5	75.1	91.6	94.3	81.7
B2 BWR 1977	585	4 641	3 696	88.3	84.2	81.6	94.2	88.4	88.3
F1 BWR 1980	970	6 774	5 723	76.7	77.6	78.0	94.6	85.7	90.5
F2 BWR 1981	970	6 824	5 663	78.5	80.5	75.5	93.6	90.4	87.8
F3 BWR 1985	1 050	7 301	6 134	75.7	75.9	80.4	89.8	86.7	90.5
TOTAL:	9 640	67 385	55 860	Mean 77.4	76.1	72.6	Mean 90.2	86.0	82.5

OKG AB: Oskarshamn, 01–03 reactors.
State Power Board (Vattenfall): Ringhals, R1–R4 reactors, Forsmark, F1–F3 reactors.
Sydkraft: Barsebäck, B1 and B2 reactors.

Good examples are the recorders in the control rooms, which to a great extent are being replaced by more flexible, newly designed recorders. Another example is the colour graphic screen system for surveillance of the process operation. The old computer based systems have been replaced by new modern computer systems, in which the software is far more user-oriented and capable of both more far reaching surveillance and process analysis.

Renewal of the instrumentation and control systems

There does not seem to be an expressed policy for the renewal of the instrument and control systems in the Swedish nuclear power plants. The renewals and improvements which take place are the result only of rigorous economic and functional considerations, made by the groups responsible within the plants themselves.

Operators are normally conservative in their attitude to the renewal of the instrument and control systems. They are more open for the addition of components and systems which fall in line with the existing techniques, than to new systems which might interfere with the control philosophy they are used to. A computerised control system is not something they would adopt easily. But a gradual computerisation of the nuclear plants seems to be inevitable.

The advanced computerisation of the surveillance systems has been mentioned already. The advancement of the computer systems and the tendency of these to become more user-oriented facilitates readier acceptance by the non-computer-specialised operators. The approach seems to be to first computerise more peripheral systems, for instance operation of the refuelling machine, and to introduce digitised control systems. Another example is to build redundant systems with computerised control, which was done for the pressure control system in one of the Forsmark units.

The use of the simulation technique and process simulators has become an important part in the development and application of new process techniques and systems for control and surveillance. The Swedish built Compact Simulators, tailored to most of the plant units, are being used to an increased extent for these purposes. An example is illustrated by the development and installation of a so-called Process Surveillance Panel in the control rooms of the units Forsmark 1 and 2. The operators request was: "to have an oversight of the process via a number of instruments so designed and placed that one from any place in the main control room would be able to see if something unexpected occurs, and also to trace and follow large transients.... and if any of the surveyed parameters were to approach limits this would be recognised so that adequate actions might be taken". Exceptionally large instruments are being used (140x140 mm), and made so that all indicators point straight upwards at the normal condition (100 % power), and the curved scales are coloured to indicate degree of departure from normal.

An important step in the development of this panel, which has taken several years, was to have it tested and commented by every shift group which would make use of it. The panel was connected to the Compact Simulator and tested in a custom designed programme. As a result of these tests a major redesign was made.

Another example of Compact Simulator utilisation is the on-going programme for testing a new disturbance analysis system for the units Forsmark 1 and 2.

<u>Training</u>

The activities in the area of training nuclear power plant staff has expanded considerably the recent years. There is now a programme for installing a tailored replica type simulator for each of the 12 reactor units in Sweden. These are all located in Studsvik and are operated by the utility owned company KSU. The replica simulator for the identical units Forsmark 1 and 2 is being installed at the present time, the replica simulator for Ringhals 1 is being specified, and the final replica simulator for Oskarshamn 1 is in the planning stage.

An important factor for completing the set-up of replica simulators might be the concern for the planned nuclear phase-out in Sweden. The staff turn-over is feared to increase as the decisions and the time come closer.

An expansion of the training programmes is a natural result of the increased number of replica simulators available. The basic training will become more detailed and differentiated. The turbine operators will also receive more specific in-depth training on the turbine system and functions, at the expense of reduced reactor training. The retraining programme might also be changed toward more frequent training and reduced course time.

The retraining of a shift group or individual operators, which is required after a longer period away from control room work (leisure, illness, etc.), is presently met by a 3-4 hours talk-through session. This is generally not considered to give adequate up-dating. The use of simulators for that purpose would be an efficient way of refreshing the operators know-how, but the replica simulators are located too far from the stations, and the Compact Simulators are not yet adapted adequately to that need.

The Compact Simulators are being continuously developed to a higher degree of detail and flexibility. But there always seems to be a lag between the potential utilisation and the actual use of the simulators. The preparatory work required by the instructors appears to be a drag.

An expanded training programme for the maintenance staff is a recent requirement set by the safety authorities. Training on the Compact Simulators gives a useful contribution to this training programme, as changes of important parameters can be introduced easily and their consequences followed in transient studies.

NUCLEAR POWER PLANT CONTROL AND INSTRUMENTATION ACTIVITIES IN THE UNITED KINGDOM

A. GOODINGS
Atomic Energy Establishment Winfrith,
United Kingdom Atomic Energy Authority,
Dorchester, Dorset,
United Kingdom

Abstract

The paper describes the status of the NPP control and instrumentation in the United Kingdom. The general technology underlying most aspects of power reactor C&I in the UK has not altered since the last progress report although there have been many improvements in detail. In one field, however, that of computer applications, the change has almost been one of kind rather than degree.

The following fields are briefly described:

- the status of nuclear power in the UK,
- the development of sensors,
- the development of electronic equipment,
- signal processing - information technology,
- quality assurance and the validation and verification of software,
- expert systems,
- training simulators.

1. INTRODUCTION

The general technology underlying most aspects of power reactor C&I in the UK has not altered since the last progress report although there have been many improvements in detail. In one field, however, that of computer applications, the change has almost been one of kind rather than degree.

This paper cannot report progress on individual items but tries to cover the field as a whole with comment on the salient areas and on difficulties which have been encountered. The author is indebted to many colleagues for the information on which these comments are based but it is important to emphasise that they represent his own personal views and should not be taken in any way as a United Kingdom consensus.