MAIN TRENDS IN MODERNIZATION OF I&C SYSTEMS AT NPPs IN THE RUSSIAN FEDERATION

A.B. POBEDONOSTSEV
OKB Mechanical engineering,
Nizhny Novgorod

A.G. CHUDIN
Russian Federation Ministry for Atomic Energy,
Moscow

Russian Federation

Abstract

There are more than 20 nuclear power reactors in operation in Russia, which have been operated over 10 years [5, 6]. Operational time of I&C systems of those NPPs is about 30 years, though the lifetime of individual parts of I&C systems is limited by 10–15 years. I&C systems were designed in 60-70-th in accordance with the existing regulations and available technical solutions. Obsolesce of those I&C systems require the reconstruction of existing systems. There are considerations that don't allow to perform equipment replacement one-to-one but require to modernize I&C systems at NPP.

1. INTRODUCTION

There are more than 20 nuclear power reactors in operation in Russia, which have been operated over 10 years [5, 6]. Operational time of I&C systems of those NPPs is about 30 years, though the lifetime of individual parts of I&C systems is limited by 10-15 years.

I&C systems were designed in 60–70-th in accordance with the existing regulations and available technical solutions. Obsolesce of those I&C systems require the reconstruction of existing systems. There are considerations that don't allow to perform equipment replacement one-to-one but require to modernize I&C systems at NPP.

2. REASONS FOR I&C SYSTEMS MODERNIZATION

There are some reasons for I&C modernization at NPP. One of them is the equipment obsolesce. In most cases it is not possible to perform equipment replacement to a similar one. The reasons are as follows:

- evolutionary changes took place in the field of I&C systems. Analogue equipment have being replaced by digital equipment based of computer technology;
- in many cases the existing operational I&C equipment has not been produced any more.

The next reason to make modernization of I&C systems are the changes in regulations, which now include more stringent requirements related to quality, safety and reliability. Codes OPB-88 and PBY RU AS-89 contain the new requirements for NPP I&C systems such as:

- requirement for diagnostics applied not only to technological equipment but also to I&C s hardware and software;
- requirement for information support of the operator;
- requirement for independence and redundancy of protection system channels, etc.

3. GENERAL APPROACH TO MODERNIZATION

The I&C systems modernization at NPP is the complex task. Complex approach to I&C systems modernization regarding a new NPP takes into account an ability for I&C systems modernization in the future. I&C systems design should meet the following main requirements that allow for I&C systems modernization in the future:

- I&C structure should be decentralized and open; I&C systems hardware should utilise modern technology and have a module design;
- standard (including international) interfaces should be applied to connect different components of I&C systems;
- I&C systems hardware should be designed such that sufficient reserves will be available to increase in future the number of input/output signals without making changes in the hardware.

Complex approach to modernization of an operated NPP requires the development of a longtime schedule of I&C systems modernization for each NPP power unit. That schedule should provide step by step modernization strategy.

Modernization should be related not only to hardware but to functional part of I&C systems as well. For example, during the modernization of the reactor control and protection system (CPS) it is necessary to analyse compliance of CPS design to new regulation requirements (single failure criteria, common cause failures). It could require the addition of protection signals, changes in measurement channel schemes, etc.

In the cause of modernization process it is necessary to take into account the human factors. At the earliest stage of requirements specification for system modernization, an appropriate NPP personnel should take part in the development of them and finally to agree on the developed set of requirements. Sometimes the modernization includes changes in the operator interface, in this case the operator interface changes should be discussed with NPP operators.

NPP operators training in modernized human–machine interface should precede the implementation of modernized interface in NPP.

4. CURRENT PRACTICE OF RUNNING THE NPP MODERNIZATION PROJECT

Modernization of I&C systems at operating NPP is under way in Russia now. Modernization usually consist of individual system hardware replacement or implementation in addition to existing I&C systems new additional systems. Such activity is not intended for large-scale modernization. Great efforts are undertaken in the field of operator support system (OSS) development and implementation. The working group composed by the specialists of several organizations developed the concept of information support system for operation personnel of operating NPP on the request of Concern Rosenergoatom.

The main objective of an information support system is to help an operator in the main control room to evaluate a safety status of power unit. The first priority functions of operator support that intended for the implementation at the operating NNPs are a critical safety functions display, intellectual annunciation system, early fault detection and diagnosis. Information support system of operator can be implemented as a separate computer module integrated in operating process control system of a power unit. The work of the implementation of an information support system is being carried out in the framework of modernization of operating process control system. It is supposed to introduce OSS at operating NPP through several stages, in a step-by-step way. The implementation of

OSS should be performed on the basis of the analysis at every power unit of available information, personnel activity and definition of a set of the OSS functions to be developed [1].

The development of OSS is carried out by several Russian organizations. Such work is performed not only in the scope of I&C modernization but for new NPPs as well. For example, the OSS design for Voronezh nuclear heating plant has been developed by OKB Mechanical Engineering.

One of the directions in the field of OSS is the development of Safety Parameters Display Systems (SPDS). The pilot programme for SPDS design and implementation at Balakovo NPP (PWR) and Leningrad NPP (RBMK) are developed in Russia. The Russian organizations and American firm Westinghouse took part in SPDS development in the framework of this programme. Westinghouse has successful experience in the area of development and implementation of SPDS systems in USA [2].

Activity for diagnostic system development and implementation for NPP technological equipment and processes diagnosis are being also performed in Russia. Examples are: vibration monitoring, equipment lifetime assessment, leakage monitoring, loose parts monitoring. Those systems are implemented as local autonomous information systems. Data about the status of the technological process is received by diagnostic system from existing information systems. The diagnostics systems begin to be implemented at NPP. At the beginning of 1993 the expert on-line diagnosis system was put into trial operation at Leningrad - 1 NPP. At present this system is used to diagnose 11 technological subsystems. The diagnosis system provide the following functions:

- monitoring the technological subsystems at the macro-level (healthy-unhealthy);
- identification the type of malfunction, its cause and location;
- presentation on the display screen numeric and trend data on any subsystem being diagnosed;
- recording the diagnosis result and storing in the archive on the user request.

Moscow Science and Research Center SNIIP developed new modern hardware complex for WWER-440 reactor control and protection system (AKNP-7, AZTP, ALOS, AOP and AKNP-7-02 for WWER-1000). It meets modern normative requirements. It provides for neutron flux monitoring, data and protection signal processing, representation and recording of information. This modern control and protection system was installed at South-Ukraine NPP and Rovno NPP in the Ukraine as well as at Kola NPP-1.2 and Novovoronezh NPP in Russia. Reactor control & protection system (CPS) modernization has been performed for the unit 3 of Beloyarsk NPP (fast breeder reactor) by NPO, "Avtomatika" (Omsk, Russia).

Russian organizations take part in CPS systems' modernization for Ukraine NPPs as well. It is intended that for South-Ukraine NPP several CPS subsystem (ROM, ARM, control of control rod drives) be realized on the base of microprocessors. Operation will be possible after the completion of software and hardware licensing [7]. It is necessary to note that the quality of production technology of reactor control & protection systems in Russia does not always correspond to the level of the system design. This is the main reason why foreign firms co-operate in a number of CPS designs projects. The successful experience of Russian and French firms collaboration has been already experienced while developing the functional part of CPS for Kola NPP-3 and 4 [4].

Collaboration of Russian organizations with foreign firms has some specific features. Design of I&C systems in the scope of modernization always is done by Russian organizations. Russian design organizations define the modernization strategy, key technical solutions, perform safety provision substantiation and are responsible for correctness of a design. Such approach is conditioned by large experience and knowledge in the field of NPP technological processes, Russian standards and

regulations related to I&C systems for NPPs, current practice of I&C systems development and operation in Russia. Collaboration of Russian organizations with foreign firms includes a development of methodology for individual tasks solving (for example, SPDS). Russian organizations perform in this case the analysis of methods for problem solving and their adaptation for Russian conditions. Sometimes foreign hardware for I&C systems modernization is utilized. In this case it is expedient to involve foreign firms that have the experience in such technology application in the modernization project. Collaboration provides for optimal technical solutions and helps to eliminate design errors related to foreign hardware utilization.

5. CONCLUSION

- It is intended to modernize I&C systems on NPP on a basis of a complex approach. The long-time schedule of I&C systems modernization for each NPP power unit should be developed. Such schedule should provide for a stage-by-stage modernization strategy.

- Modernization should be related not only to hardware but to functional part of I&C system as well.

- Current practice of information system modernization usually consist in adding to existing I&C systems new systems (OSS, SPDS, diagnostic systems) that are realized as local systems connected with existing I&C systems for process information acquisition . It is supposed to introduce new systems into operation gradually and increase their functionality step-by-step.

- Control system modernization is performed in the first turn for safety important systems including reactor control and protection systems.

- Design for I&C systems modernization for Russian NPPs must be done by Russian organizations that are specialized in the field of I&C systems for NPPs development. The main reason is that Russian design organizations have large experience and knowledge in the field of NPP technological processes, Russian standards and regulations related to I&C systems for NPPs, current practice of I&C systems development and operation in Russia. When it is expedient from economical and technical point of view foreign firms together with Russian organizations take part in the works on I&C systems modernization.

REFERENCES

[1] V.G.Dounaev, V.V.Golovanov. The concept of an information support system for operational personnel of operating nuclear power plants. Operator support systems in nuclear power plants. IAEA, Vienna, 1994, IAEA-TECDOC-762.

[2] J.Boucau, S.Smirnov, A.I.Gorelov and all. The SPDS as a tool to improve post-accident strategy on VVER and RBMK reactors. Operator support systems in nuclear power plants. IAEA, Vienna, 1994, IAEA-TECDOC-762.

[3] E.O.Adamov, O.N.Glazov, A.P.Eperin, N.V.Strepetov. The design concept of an on-line diagnosis system of a sophisticated technological object: the shell of expert diagnosis system "Dasha". Operator support systems in nuclear power plants. IAEA, Vienna, 1994, IAEA-TECDOC-762.

[4] G.I.Biryukov, N.P.Konoplev, I.V.Pogorelov. Reconstraction of control and protection systems of VVER-type reactors in Russia. Instrumentation and control of WWER type nuclear power plants. Proceedings of the IAEA meeting, Prague, Czech Republic, 27-29 September 1994, Nuclear Research Institute REZplc, 1995.

[5] Nuclear Power Reactors in the World. Reference Data Series '2. IAEA, Vienna, 1992.

[6] Instrumentation and control of WWER type nuclear power plants. Proceedings of the IAEA meeting, Prague, Czech Republic, 27-29 September 1994, Nuclear Research Institute REZplc,1995.
[7] D.A.Anufriev, A.M.Afrov, N.P.Konoplev, I.V.Pogorelov. Main trends of VVER-type RP control, monitoring and protection systems modernization. OKB "Gidropress", 1996.