

PRACTICES OF PROLONGATION OF THE I&C EQUIPMENT LIFETIME

O.B. SAMOYLOV, V.S. PRONIN, I.D. SAVELOV,
V.A. BOGOMAZOV, V.V. DRUMOV
OKB Mechanical Engineering,
Nizhny Novgorod, Russian Federation



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

Abstract

The lifetime of nuclear power plants (NPP) always exceeds the operational time of I&C systems. Ageing of I&C equipment in NPPs have many aspects. Research of these aspects is being performed in OKB Mechanical Engineering. Under condition of fast development of I&C systems and applying more stringent safety requirements, modernization of the equipment irrespective of its operational condition is getting important. However, an equipment of I&C systems operated in Russia was designed and manufactured applying highest requirements for a reliability of their work during its whole operational time. Therefore, in many cases it is not necessary to replace them in spite of expiration of their specified lifetime. During operation this equipment is maintained in a proper operation condition by a special service procedures stipulated by its development. When the equipment lifetime approaches to its end, lifetime extension for the certain period should be considered.

1. GENERAL CONSIDERATIONS

In Russia the questions of ageing of the NPPs I&C equipment are solved, first of all, together with questions of the substantiation of serviceability of the equipment during its required operation time. The significant part of the work in this direction is connected to careful experimental researches of behavior of the developed equipment in normal and extreme conditions, that is usual practice for development and design work. The system of the standards of various levels, programmes-technique of realization of tests concerning revealing influence of such effects, as temperature, humidity, vibration, etc. are used. The results of tests, in particular, enable to make the conclusion about mechanisms of ageing and about its influence on main operating performances with the course of time. These data, in turn, are used for assignment of service life of the appropriate system.

The special researches of influence of ageing for the NPP's equipment at Center of Accelerated Tests of the Electronic and Electrical Equipment and Cables (Research Institute of Scientific Instruments of the Russian Federation Ministry for Atomic Energy) are carried out. Major goals of the Center are:

- qualification tests and operating life evaluation of electronics, electrical engineering articles and cables for NPP;
- study of processes of thermoradiation ageing in articles and assembly materials;
- control of technical condition and determination of residual operating life of cables.

The Center's equipment provides for simultaneous or separate simulation of radiation, thermal and environmental effects in articles under test and for measurement of articles' and materials' properties. Methods have been developed for qualitative and quantitative analysis of defects detection, determination of the mechanism and kinetics of insulating materials' ageing, testing electrical engineering equipment on its resistance to degradation factors of nuclear plants.

Recently scale of special researches on ageing has decreased, as well as in other countries. The program of researches with reference to cables is now carried out most effectively. During the operation of I&C systems equipment regular researches of its availability index of product according to the operational documentation are carried out. So, for systems, important for safety, the various kinds of operations in this part are carried out with frequency from an once in change up to an once per one year (for shipment of fuel). The researches include check of quality of operation for direct

purpose in all modes, and direct check of parameters connected to ageing - resistance of isolation, state of contacts of the relay, physical state of elements of the equipment, etc.

Such work is executed by the specialist of organizations providing maintenance, by developers and equipment's manufacturers, the representatives of other interested organizations, including supervision bodies, participate in researches.

On the basis of received results terms of replacement of the equipment of I&C systems have determined, the problems of development of the new equipment instead of served are accordingly solved. The main problems are connected to replacement of the served equipment. Usually till the time of required replacement of the system the elements, used in it, aren't being already manufactured any more and the development of blocks and devices or whole systems with new elements is required. It requires the certain financial costs, and also search of the new developers and/or manufacturers, if former have replaced a sphere of activity. In this connection prolongation of systems operation time has great importance. An experience of work in this direction is considered below.

Nowadays the term "ageing" is not completely determined for specific application. In a context of questions considered here we understand this term as change of the equipment's state during the time with increase of frequency of deviations from a normal state and refusals with loss any functions of this equipment. The causes of such changes may be physic-chemical processes in materials of elements, influence of a humidity, irradiation, etc. while in operation.

When equipment of I&C system is being developed, an opportunity of refusals is not only taken into account, but in a part of safety is even postulated. There are stipulated some means and methods of definition of refusals in systems, the procedures of definition of the refused elements, their replacement and the fast restoration of functions. There is provided a necessary duplication of elements and channels, whole complete sets of protection, etc. Therefore, as a rule, any individual refusal in a system can not cause the essential damage and in a part of ageing the considered question is not to prevent refusals in general, but to exclude an opportunity of operation of the system in the following conditions:

- with sharp increase of frequency of deviations from a normal condition and refusals;
- with impossibility of restoration of functions of system caused by fast exhaustion of spare parts;
- with impossibility of updating of spare parts owing to the termination of issue of suitable components for replacement and repair of blocks.

It is necessary to emphasize that during the development of the system all measures are undertaken all to postpone occurrence of such condition as far as possibly. In particular, for increase of reliability when the systems are being designed the components are put in such conditions of operation, with which the actual loadings are much lower than not only limits, but also nominal. It is supposed, that the ageing in such situation will occur slower. The most reliable and durable technical means are applied, the special acceptance of components will be carried out, etc. Procedures of service, check of serviceability, preventive maintenance, repair, work with spare parts, etc. had been carefully worked.

There are tests, including resource tests, with imitation of the various influencing factors of operation. On the basis of the data received by development and tests, in view of the data on reliability of elements, etc. there is being defined the nominated operation term of the equipment a I&C systems. The accepted measures to achieve the reliability have allowed to obtain devices with resource that exceeds a resource of components in some times. The practice has shown also, that real term of operation of the equipment of the I&C systems before occurrence of a condition of ageing, as we have determined above, can considerably exceed determined by the design documentation.

Therefore, works on prolongation of the lifetime of the equipment of the I&C systems has become the rather usual events. Thus it is important to fulfill the procedures, determined in the special

documents, to achieve expected effect with required reliability, i.e. to prevent attributes of ageing, defined above, during time of prolongation of the permitted term of operation.

2. APPROACHES TO THE DEFINITION OF THE CONDITIONS OF THE I&C EQUIPMENT ALLOWING FOR A LIFETIME EXTENSION

During the exploitation of equipment of I&C systems maintenance instructions and regulation documents determine procedures of check of its serviceability, readiness for performance of the functions with occurrence of the certain conditions, etc. In particular, when reactor stops there will be fulfilled the check of circuits of formation and passage of protection commands. However these procedures are intended, first of all, for the checking of serviceability of system to the main purpose.

On the other hand, in the task of definition of a prolongation opportunity of the operation term it is necessary, besides, to estimate in a possible degree tendency of change of an equipment's condition, i.e. to predict change of a condition of system during the certain time and to reveal possible increase of frequency of deviations from normal work and refusals up to a unacceptable degree. For this the methods and means of diagnostics are used which allow to make required conclusion after realization of appropriate set of researches.

The works in this field nowadays are in a stage of development. The means and methods essentially depend on a kind of the equipment, with which the appropriate work are being carried out. It is enough difficulty to choose and to carry out the analysis of a condition of system just on those parameters, which are really in the maximal degree allow to carry out the required forecast. There are some experiences and practices considered below for a specific kind of the equipment of I&C systems - to the system for indication of a reactor's control rods position.

3. TECHNIQUE FOR MONITORING THE CONDITION OF A REACTOR CONTROL RODS POSITION INDICATION SYSTEM

The experience has shown that an indication system, developed by OKBM, has significant resistance to ageing. Taking into account this circumstance, the significant number of systems has passed procedures of prolongation of equipment's operation term. The received experience has allowed to generate now-in-use program - technique of auditing of system. The auditing of the system is fulfilled by four stages.

At the first stage a degree of system's deterioration for the previous operation phases and volume of required repair were defined. At the second stage a repair work is made, necessity of which is revealed at the first stage. Besides, if necessary, the replacement of separate units, and also updating of spare parts are made. At the third stage the functional checks of system and check of conformity of its basic characteristics to the characteristics specified in the engineering specifications were fulfilled. At the fourth stage on the basis of the results of the previous stages the opportunity of prolongation of system's lifetime are examined. The auditing are made when reactor is shutdown.

Before the beginning of the work the analysis of the data on a previous operation period is fulfilled. On this stage the important factor is the absence of growth of frequency of deviations from normal work of system, refusals in this period of time. The external survey is included into a structure of works on the first stage. It allows, in particular, to define a beginning of physical changes of an equipment's condition, which characterize ageing and increase of probability of refusals in a near future. There is fulfilled the measurement of electrical resistance to isolation. Decreasing of it also rather authentically characterizes process of ageing. There is fulfilled the measurement of output voltage of system's internal power supplies, etc. There is fulfilled the check of completeness a spare parts.

On the base of results of the first stage of auditing there is made the Act of survey of a technical condition of the system. This document contains results of the fulfilled checks, list of necessary repair

work, list of elements & blocks, etc., necessary for updating a spare parts and realization of replacements. At the second stage of auditing there are made all works determined in the Act of survey. There is made the necessary repair, replacement of devices, updating of spare parts. An Act of performance of works on the second stage of auditing is made. At the third stage the serviceability of system on direct purpose and conformity of its characteristics to the technical specifications is actually checked. Check of serviceability of power supply lines, alarm elements, devices of formation of malfunction signals, trailer switches, on check of errors, etc. are included. When the third stage of auditing is finished an Act of realization of functional checks containing results of all fulfilled checks is made. In case of a deviation of any characteristic from engineering specifications it is offered to reveal the causes of this deviation and remove them. If they cannot be removed in terms, allotted for auditing, this question should be reflected in the Act for consideration at the fourth stage of auditing.

At the fourth stage the analysis of the received data is fulfilled and in case of the positive results of the fulfilled auditing a technical decision on prolongation of operational time of the system is made. This document should contains the following information:

- an operating time of the system;
- a generalisation of the results of the previous operation phase;
- results of the fulfilled auditing, confirmed an opportunity of prolongation of operation term of the system;
- and also results of the previous auditing for observation of dynamics of change in time of the basic characteristics of system.

Besides, a technique contains all security measures which should be undertaken during auditing. As the experience shows, the applying of the described technique allows to effectively solve the tasks of prolongation of operational time of the system.

4. ADDITIONAL RESEARCH FOR A SUBSTANTIATION OF A PROLONGATION OF OPERATIONAL TIME OF THE I&C SYSTEM

For the reactor control rods position indication system the additional research was fulfilled. That research was fulfilled on the completely efficient specimen allotted for it when its nominated operation time expired. The research was fulfilled for the separate elements of the system, such as transistors, diodes and capacitors removed from the system. The purpose of this research is a revealing of possible deviations of characteristics of these elements from the limits established by technical specifications. It was concluded that a majority of characteristics remain within the limits established by the documentation. The obvious attributes of ageing, on which it is possible to make the conclusion about decrease of reliability of system, are not found. On the basis of the data about deviations from normal work and refusals received during operation, including systems which operation lifetime has been already prolonged, the analytical research was also fulfilled. The received results confirm legitimacy of the used approaches.

5. CONCLUSION

The experience of I&C operation at NPPs shows a possibility of long-term trouble-free operation of the equipment of I&C systems with appropriate performance of the accepted rules of service. It has become the usual phenomenon a complete exhaustion of a design lifetime of I&C systems, and then its prolongation after research of the factors of ageing. The procedures of prolongation of operation lifetime are fulfilled under the established documents, with issue of Acts and Technical decisions. The procedures include tests of system for functioning on direct purpose, check of characteristics, and also research of diagnostic parameters, on which it is possible to predict growth of frequency of deviations from normal operation and refusals during time by which it is supposed to prolong operation lifetime of system.