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REQUIREMENTS TO ACCURACY CHARACTERISTICS OF CHANNELS OF INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY OF NUCLEAR POWER PLANTS

The analysis of new regulation and standard on nuclear and radiation safety of instrumentation and control (I&C) systems important to safety of nuclear power plants (NPP) is fulfilled and the peculiarities of the requirements to accuracy of such systems are defined. The definition of requirements to establishment and assurance of accuracy characteristics of measuring channels, alarm channels and control channels of I&C system important to NPP safety is considered. The confirmation of requirements to accuracy characteristics (metrological certification and calibration) are analyzed. The peculiarities of requirements to accuracy of the above mentioned channels taking into consideration their redundancy and methods of exclusion of unreliable data of the redundant measuring channels are considered.

Keywords: accuracy, metrological characteristics, information and control systems, regulation, standard, nuclear power plant.

New regulation NP 306.2.202-2015 "Requirements to nuclear and radiation safety of instrumentation and control systems important for safety of nuclear power plants" [1] came into force in Ukraine in 2015. Also new standard SOU NAEK 100:2016 "Instrumentation and control systems important for safety of nuclear power plants. General technical requirements" [2] was issued by National Nuclear Energy Generating Company (NNEGC) "Energoatom" in 2016. These two documents replaced the old regulation NP 306.5.02/3.035-2000 "Requirements to nuclear and radiation safety of instrumentation and control systems important for safety of nuclear power plants" [3]. The requirements to accuracy characteristics of channels of I&C systems important for the NPP safety are extended and defined more precisely in the new regulation and standard.

The requirements of new regulation and standard to accuracy characteristics of such I&C systems channels are considered below.

Requirements to accuracy characteristics of measuring, alarm and control channels

The requirements to accuracy as part of general requirements to I&C systems functioning quality are established in the developed regulation NP 306.2.202 [1] and standard SOU NAEK 100 [2].

According to NP 306.2.202 [1] requirements to the accuracy should be established for:

– measuring channels of I&C systems and software-hardware complexes (SHC). Measuring channels display, record, archive and / or transfer the numeric values of physical parameters (in the units accepted for them) which characterize:

- neutron-physical and heat-hydraulic processes;

- state of constructions, systems and components of technological equipment;
 - I&C systems (or SHC) indication channels intended for monitoring of the spatial distribution of physical parameters and / or their time-change (without the estimation of these physical parameters with the accuracy rated by state metrology system standards);
 - control channels which carry out generating and output of signals and commands for protection, interlock, automated control of technological systems and equipment, automated regulation;
 - alarm channels which are used for personnel notifications about going of the controlled parameters beyond design limits.

According to SOU NAEK 100 [2] it is necessary to follow the below mentioned rules for the assurance of the accuracy of measuring, control and alarm channels:

- parameters of technological processes, state of constructions, systems and components of technological equipment should be preferably monitored by the direct measuring method than calculated from the measured values of other parameters (by the methods of indirect measuring);
- the possibility of going of certain monitored parameters out of the range of operating values in emergency situations and accidents should be taken into account for the selection of a measuring range;
- it should be provided the overlap of adjacent measuring ranges and automatic switching of sensors if more than one sensor use for the coverage of the entire range of monitored parameter changes. It is necessary to exclude influences of saturation or distortion at the edges of the range for obtaining of results with the required accuracy;
- it is recommended to establish mutually coordinated accuracy characteristics for all I&C systems

(or SHC) components included into the measuring, control and alarm channel. It is essential to ensure their metrological compatibility and the ability to assess of the accuracy characteristics of the I&C systems (or SHC) channels;

- in case of a false input, malfunction or failure of one or more redundant measuring (control, alarm) channels, all other channels should satisfy the established accuracy requirements;

- measuring (control, signal) channel should satisfy the requirements to the accuracy in case of failure of any redundant component (if their redundancy is provided);

- accuracy characteristics of replacing components should not be worse than the characteristics of replaced components in case of modernization of operated I&C systems (or SHC).

According to SOU NAEK 100 [2], the following metrological characteristics should be established for each measuring channel:

- nominal measuring range;
- transformation function;
- error characteristics.

The error characteristics of measuring channel can be regulated in one of two ways:

- by the limits of allowable fractional, reduced or absolute error in service or extreme conditions;

- by the limits of allowable intrinsic (fractional, reduced or absolute) error in normal test conditions and by acceptable error changes in case of external factors changes. Only external factors influencing the accuracy in operating or limit conditions should be taken into account.

The operating or limit conditions should be determined for each external factor. It is essential to take into account of generalized operating or limit values established in SOU NAEK 100 [2]: temperature, humidity and other environmental parameters, mechanical and seismic influences, influences of electric fields, electromagnetic interference influences, changes of electrical power parameters.

NP 306.2.202 [1] and SOU NAEK 100 [2] allow (in valid cases) to determine metrological characteristics not for I&C systems measuring channels, but for their separate hardware components or SHC.

In this case, the requirements for metrological characteristics of I&C systems components should be established. It is necessary to ensure metrological compatibility of these components. It will give the possibility to compute metrological characteristics of measuring channels.

Also according to SOU NAEK 100 [2], accuracy characteristics of control and alarm channels should be regulated.

The accuracy characteristics of control channels include:

- limits of allowable absolute error of output and / or cancellation of the command or signal;

- limits of allowable fractional error of delay of output and / or cancellation of the command, if it is provided by an algorithm.

The accuracy of the alarm channels is characterized by the limits of absolute error for turning on or turning off the alarm devices.

Accuracy characteristics of control and alarm channels are regulated in the ranges of possible changes of external factor. These ranges are defined in the SOU NAEK 100 [2] for the operating or limit conditions (similarly to the above-mentioned measuring channels characteristics).

Requirements to the accuracy characteristics confirmation

According to DSTU 3989 [4] initial and subsequent periodic calibration of measuring channels and / or their components with regulated metrological characteristics should be performed. This is necessary to confirm the compliance with the specified requirements.

Initial calibration of measuring channels and / or individual components of the SHC with regulated metrological characteristics should be fulfilled by single SHC manufacturer:

- for the main (first) sample - in frame of validation procedure;

- for each of the following supplied samples - in frame of the acceptance tests.

Further periodic calibration of SHC measuring channels and / or SHC individual components with regulated metrological characteristics should be fulfilled by operating organization. Periodic calibration should be held:

- during the putting I&C systems into trial operation;

- during the maintenance;

- after recovery (replacement of failed I&C systems components).

Periodic calibrations should be held according to the procedure, which is regulated in appropriate maintenance documentation.

The calibration results should confirm the compliance of measuring channel and / or all components with requirements for metrological characteristics, specified in the I&C systems (or SHC) requirements specification.

Periodic calibrations should be performed at least during each preventive maintenance of power unit (or more often).

All I&C systems measuring channels should pass metrological certification according to DSTU 3215 [5] before the commissioning. Metrological certification is fulfilled by NPP specialists and / or specialized contractor experts. Metrological certification is performed according to program and method approved by NNEGC "Energoatom".

The check-out of accuracy characteristics of I&C systems control and alarm channels should be fulfilled:

- during the putting I&C systems into trial operation;
- during the operation maintenance;
- during the power unit preventative maintenance.

It is necessary for the confirmation of the characteristics compliance with the specified requirements.

Procedure, check methods of accuracy characteristics for the control and alarm channels should be specified in I&C systems operational documentation.

Requirements to the methods of exclusion of measuring data invalidation in redundant measuring and display channels

According to SOU NAEK 100 [2] measuring and display channels involved in the realization of functions important to the NPP safety, must be redundant.

The absence of redundancy for measuring or display channels is permitted only if it is proved that the failure of any of independent reserved channels can be detected and recovered faster than the acceptable time of data loss for this channel. Additional condition is that data obtained from this channel before its recovery are displayed together with the indication of their inauthenticity, which clearly understandable by the staff.

SOU NAEK 100 [2] pointed that for redundant measuring channels it is necessary to exclude the possibility of erroneous interpretation of data displayed in case of gradual failure (the observed deterioration of the metrological characteristics), sudden failure or withdrawal of one of independent channels. It can be reached by:

- simultaneous displaying of the measured parameter values received from all redundant channels for their visual comparison and detection of false values;
- automatic check of the accuracy of the information received from each redundant channel and displaying of only the values of the measured parameter, which are recognized as valid (or indication the appropriate sign for the invalid values);
- automatic diagnosis of the technical state of each of independent redundant channels and exclusion of the measured parameter values received from failed channels;
- displaying of only one, the most significant value of the measured parameter determined by the automatic processing of data obtained from all channels.

Conclusions

During the analysis of new regulation and standard requirements for the NPP safety important I&C systems channels accuracy:

- the types of I&C systems channels that establish accuracy characteristics requirements were pointed out;
- the features of the accuracy characteristics of I&C systems measuring channels and their components,

as well as the accuracy characteristics of alarm and control channels were described;

- the requirements to confirmation of the I&C systems channels (and their components) accuracy characteristics during the manufacturing and operation were considered;

- the features of authenticity and accuracy assurance for redundant measuring and display channels were described.

References

- [1] NP 306.2.202:2015. Requirements to nuclear and radiation safety of instrumentation and control systems important for safety of nuclear power plants.
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