IMPULSE

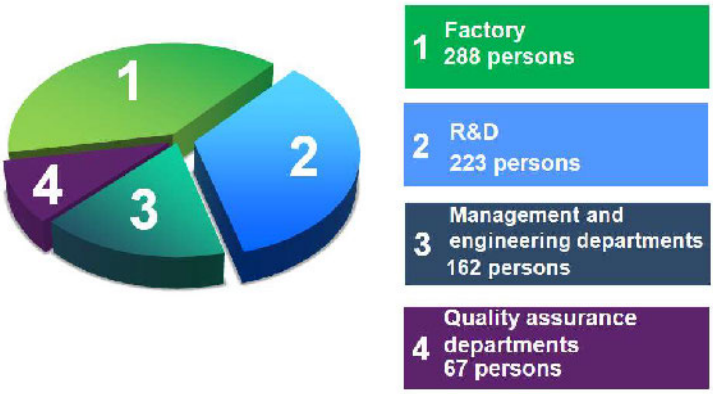
SRPA "IMPULSE"

HIGHLY-RELIABLE INSTRUMENTATION AND CONTROL SYSTEMS FOR NUCLEAR POWER ENGINEERING

TABLE OF CONTENTS

ABOUT THE ENTERPRISE

SRPA “Impulse” is a designer, manufacturer, and supplier of highly reliable instrumentation and control systems (I&C systems), market leader in the field of I&C systems for nuclear power engineering in Ukraine.



The company was established in 1956 as the basic enterprise for development of instrumentation and control systems for automation of technological processes. For more than sixty-five years of history of work, the enterprise has developed and commissioned tens of thousands of instrumentation and control systems for nuclear and thermal power engineering, railways, oil and gas, chemical, aerospace industries, metallurgy, mechanical engineering, geophysics, defence, etc.

EXPERIENCE IN NUCLEAR POWER ENGINEERING

SRPA “Impulse” has been working in nuclear power engineering since 1976. During this time several generations of developers have changed, a team of professionals with experience and skills for critical branches has been formed and has been constantly renewed. This experience includes all stages of automation systems life cycle – from inspection of a facility and design to author's support and technical support of operation.

Main products of SRPA “Impulse” are I&C systems based on own-developed automation hardware and software, complex of which assures execution of all functions important for safety of nuclear power plant units. SRPA “Impulse” is one of few companies in the world possessing technical solutions and technologies allowing implementation of full-function digital I&C systems of NPP units. Equipment manufactured by SRPA “Impulse” operates successfully at units of NPPs in Ukraine, Armenia, Bulgaria, Russia, Slovakia, and other countries.

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REFERENCE LIST FOR NPP INSTRUMENTATION AND CONTROL SYSTEMS

SYSTEM	IMPLEMENTATION FACILITY
Process information system of a unit's upper level (IVS)	Khmelnitsky NPP, units 1, 2 Rivne NPP, units 1-4 Zaporizhzhya NPP, units 1-6 Kola NPP, units 1, 2 Balakovo NPP, units 1-4 Rostov NPP, unit 1
In-core monitoring system (SVRK)	Zaporizhzhya NPP, units 1-6 Khmelnitsky NPP, units 1, 2 Rivne NPP, units 1-4 South-Ukraine NPP, units 1, 2
Neutron flux monitoring system (AKNP)	Zaporizhzhya NPP, units 1-6 Khmelnitsky NPP, units 1, 2 South-Ukraine NPP, units 1-3 Rivne NPP, units 1-4 Armenian NPP, unit 2
Electric equipment package of control and protection system (KE SUZ)	Kola NPP, unit № 4
Control rod control system (SGIU)	Rivne NPP, units 1-3 Zaporizhzhya NPP, units 1, 2, 6 Kola NPP, unit № 4 (as a part of KE SUZ)
Automatic reactor power controller (ARM-I)	Kola NPP, unit № 4 (as a part of KE SUZ)
Unit's safety control system using unconditional logic (USB)	Zaporizhzhya NPP, units 3-5 Khmelnitsky NPP, units 1, 2
Digital technological safety control system (USBT)	Zaporizhzhya NPP, units 1-5 Khmelnitsky NPP, unit 2
Standby diesel generator station automatic control system (SDGS ACS)	Zaporizhzhya NPP, units 1-6
Automatic regulating system of safety control systems (SAR USB)	Khmelnitsky NPP, unit 2
Unit's normal operation control system using unconditional logic (SNE)	Zaporizhzhya NPP, units 3, 4 Khmelnitsky NPP, units 1, 2
Digital normal operation system for reactor and turbine divisions (SNE RO, TO)	Zaporizhzhya NPP, units 1-5 Khmelnitsky NPP, unit 2
Automatic regulating system for a turbine division (ASR TO)	Zaporizhzhya NPP, units 1, 2
Turbine regulating system (SRT)	Zaporizhzhya NPP, units 1, 2
Complex diagnostics system for a reactor facility (KSD)	Zaporizhzhya NPP, units 1-5 Rivne NPP, units 1-4 Khmelnitsky NPP, units 1, 2 South-Ukraine NPP, units 1-3 Kozloduy NPP, units 5, 6
System for registration of important operational parameters (SRVPE, "Black Box")	Rivne NPP, units 1-4 Khmelnitsky NPP, units 1, 2 Zaporizhzhya NPP, units 1-5
Centre for technical support of operators in case of emergencies (CTP)	Rivne NPP, units 3, 4 Khmelnitsky NPP, units 1, 2
Reactor facility post-accident monitoring system (PAMS)	Zaporizhzhya NPP, units 1, 2 Rivne NPP, units 1-4 Khmelnitsky NPP, units 1, 2
System to control emergency "Coolant leak from a primary circuit to a secondary one" (SUA TPKV)	Zaporizhzhya NPP, units 1, 2 Khmelnitsky NPP, unit 2 Rivne NPP, power unit 4
System to monitor boron-10 isotope (boric acid) concentration	Rivne NPP, units 1-3 Armenian NPP, unit 2 Zaporizhzhya NPP, units 1-5 South-Ukraine NPP, unit 1, 3 Khmelnitsky NPP, units 1, 2 Mochovce NPP, units 3,4

FUNCTIONAL CAPABILITIES OF I&C SYSTEMS FOR NPP UNITS

Complex of instrumentation and control systems produced by SRPA “Impulse” assures performing all functions important for safety of NPP units:

- generating and outputting precautionary and emergency protection signals to reduce power and stop a reactor facility;
- measuring neutron power and reactivity in various modes of operation of a reactor facility;
- monitoring technological parameters and identifying initial events that lead to a disturbance in normal operation and can become a cause of a violation of unit safe operation conditions;
- outputting protective action commands to actuators in technological safety systems;
- notifying personnel on disturbances in normal operation and violations of unit safe operation conditions;
- monitoring technical state and operational modes of technological equipment;

- monitoring, display, and documenting information about parameters characterizing operation of a reactor facility and a unit as a whole;
- controlling technological normal operation systems automatically and remotely;
- gathering, processing, and storing information on occurrence of disturbances in normal operation and accidents, their development; on actual algorithms of operation of systems and elements important for safety; on personnel actions to eliminate detected disturbances;
- diagnosing hardware and software of I&C systems, providing information on faults in I&C systems to personnel.

LONG-TERM TECHNICAL SUPPORT

Starting from the earliest stages of system development, SRPA “Impulse” cooperates actively with customers to achieve the best results, as well as assures author’s support throughout the full life cycle of equipment and systems.

Cooperation when designing I&C systems

Close cooperation of developers and operating personnel, design, regulating, and research organizations, when designing I&C systems, is a guarantee that a system will developed as a result, where peculiarities of a specific automation facility are taken into account.

Support at commissioning

Specialists of SRPA “Impulse” perform installation supervision for equipment and cable connections and participate in the testing and commissioning of I&C systems guaranteeing economical, fast, and safe startup of a system.

Support of operation:

- constant technical support of operational services;
- modifications on customer's request;
- warranty and post-warranty repairs.

Constant technical support of operational services:

- engineering and technical support for operating organization personnel in “24/7” mode;
- consulting on operation and maintenance of I&C systems during a between-repairs period of operation of a unit, outage periods and startup of a unit.

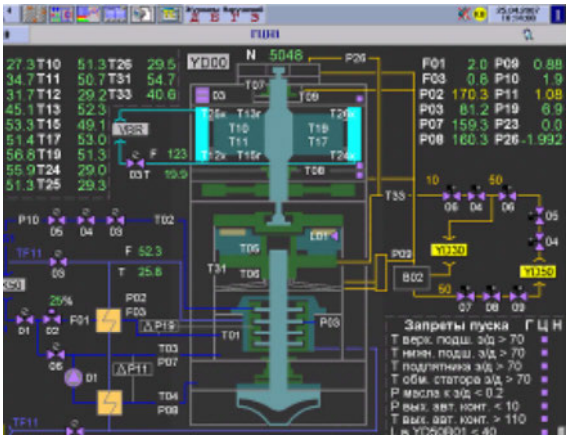
INSTRUMENTATION AND CONTROL SYSTEMS

PROCESS INFORMATION SYSTEM

(UNIT'S UPPER LEVEL)

The IVS process information system of a unit's upper level is one of the main components of an I&C system of NPP units.

Functions of IVS:

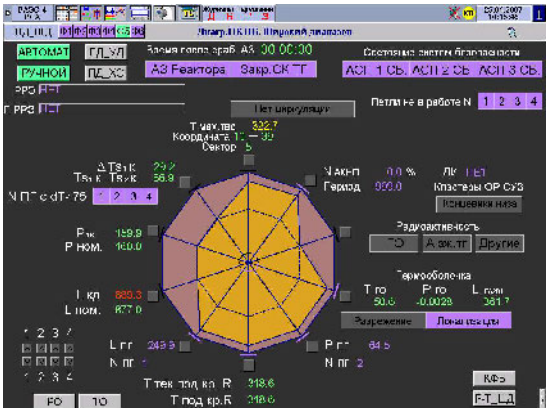


- providing information to personnel in an operating circuit of a main control room and local control stations;
- registering and documenting technological process parameters in all modes of operation of a unit;
- monitoring critical safety functions;
- monitoring basic safety parameters;
- providing recommendations as to equipment control in transient modes of operation of a unit;
- calculating and analyzing technical and economical parameters of unit's equipment;
- providing reference information about technological equipment and facilities of a unit's I&C system;
- calibrating measuring channels metrologically.

Composition of IVS:

- the lower level is implemented based on MSKU-4 failsafe industrial controllers;
- the upper level is implemented based on PS5140 industrial workstations.

System advantages:



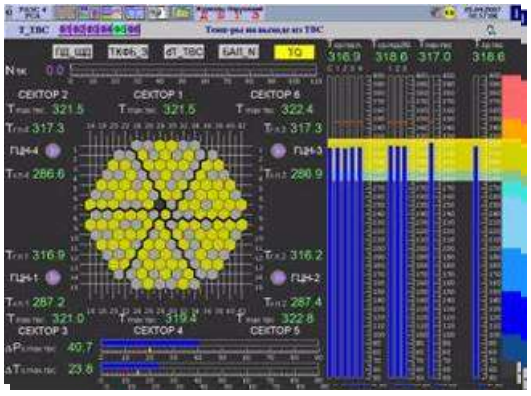
- possibility of step-by-step modernization of operating IVS systems with preservation of designed functions;
- built-in functions of a safety parameters display subsystem;
- implementation of unified protocols of data exchange with adjacent systems;
- wide list of additional functions, adaptation of control ergonomics to meet preferences of operating personnel;
- high degree of approbation of technical solutions due to a long-term experience of operation at NPP units;
- availability of built-in automated means for calibration of measuring channels.

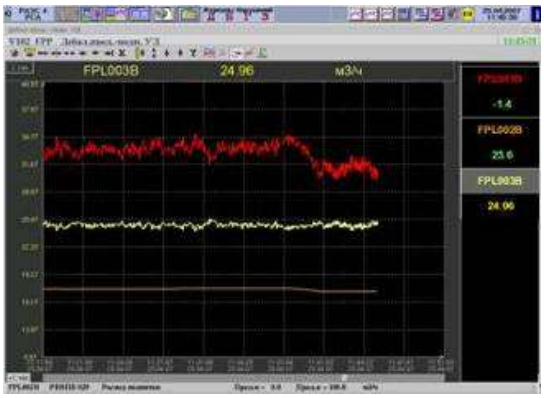
Safety class – 3.
Safety category – C.

Implementation facilities:

- Khmelnitsky NPP, units 1, 2
- Rivne NPP, units 1-4
- Zaporizhzhya NPP, units 1-6
- Kola NPP, units 1, 2
- Balakovo NPP, units 1-4
- Rostov NPP, unit 1

IVS equipment prepared for supply to Zaporizhzhya NPP





Video frames of IVS RMOT (workplace)

IN-CORE MONITORING SYSTEM

The SVRK-M in-core monitoring system assures monitoring of neutron-physical and thermohydraulic parameters of a reactor facility's (RF) primary circuit and information support to an operator to optimize RF technological processes behavior.

Functions of SVRK-M:

PS5140

- cyclically acquiring data from in-core and technological sensors of RF;
- correcting lag of direct charge sensor signals;
- calculating neutron-physical and thermohydraulic parameters of a core and an RF's primary circuit;
- monitoring current parameters and generating signals on deviations from technological setpoints;
- displaying parameters of a core and RF state in the form of videograms, protocols, and diagrams;
- keeping an archive of measured and calculated parameters, as well as non-continuous events and indications of deviation from limits of setpoints;
- quickly estimating parameters of energy-release distribution along the height of a core and comparing them with the setpoints that depend on a fuel burn-up degree;
- transferring a preliminary protection signal to a control and protection system when limits of setpoints of local energy-release and/or critical power ratio are exceeded;
- forecasting energy-release distribution in a current continuous way;
- forecasting energy-release distribution on operator's demand with given control impacts;
- monitoring quality of quick restore of energy-release field.

Composition of SVRK-M:

- the lower level is implemented based on MSKU-4 failsafe industrial controllers;
- the upper level is implemented based on PS5140 industrial workstations with redundant Ethernet switches for connection to a lower level.

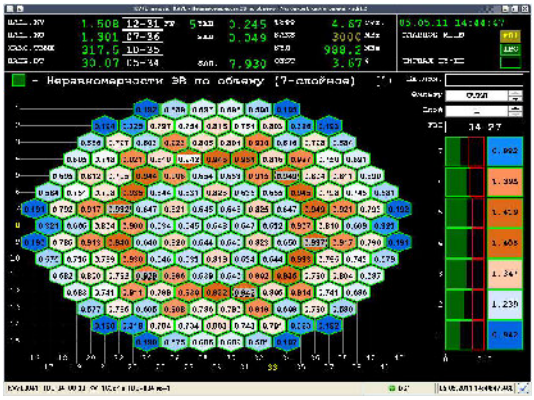
System advantages:

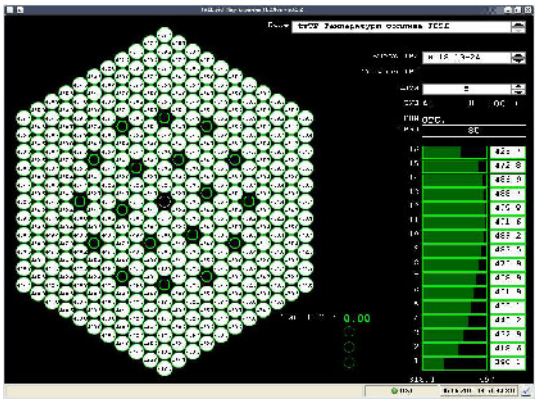
- possibility to monitor neutron-physical and thermohydraulic parameters of a core in stationary and transient modes, including modes of unit operation at increased power;
- possibility to monitor cores with TVS-WR fuel manufactured by Westinghouse, including cores with "mixed" loads (modification of SVRK-M with integrated software and hardware of a "BEACON" physical calculation subsystem is operated at Zaporizhzhya NPP);
- informational support for an operator to operate NPP in power maneuvering modes;
- possibility of implementation of new fuel cycles;
- high degree of approbation of technical solutions due to a long-term experience of operation at NPP units.

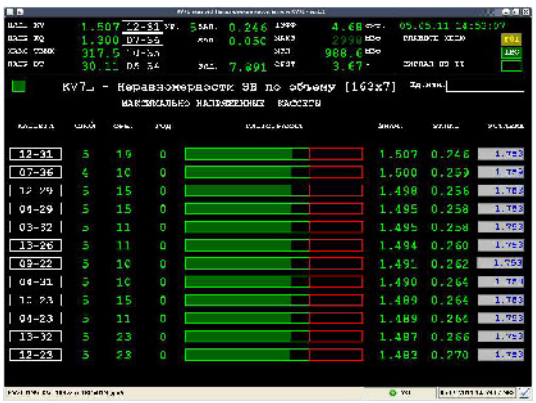
Safety class – 3.
Safety category – B.

Implementation facilities:

- Zaporizhzhya NPP, units 1-6
- Khmelnitsky NPP, units 1, 2
- Rivne NPP, units 1-4
- South-Ukraine NPP, units 1, 2







Video frames of SVRK RMOT (workplace)

NEUTRON FLUX MONITORING SYSTEM

The AKNP-IF neutron flux monitoring system is a part of a control and protection system (SUZ) of NPP units.

Functions of AKNP-IF:

- monitoring, continuously registering, and archiving current values of reactor relative physical power, velocity (period) of its change, and reactivity;
- generating discrete signals on exceeding emergency and preliminary protection setpoints, setpoints of control and regulation by relative physical power and period for SUZ and unit's I&C subsystems;
- presenting analog and discrete signals in the optical and acoustic form to operators of main, backup control rooms and a fuel reload machine, to operating personnel;
- automatically correcting neutron power measurements taking into account thermal physic and other parameters characterizing state of a reactor facility;
- monitoring fixation of in-core devices by results of neutron detector signal fluctuation analysis;
- monitoring subcriticality of a reactor facility.

Composition of AKNP-IF:

- two sets of AKNP-IF APZ-SKP for SUZ and a main control room;
- one set of AKNP-IF BCR for a backup control room.

Each set includes three independent channels of neutron flux monitoring. Each neutron flux monitoring channel consists of:

- detection devices containing:
  - detection units based on ionization chambers (for startup and operating ranges), on boron or helium corona radiation-resistant highly sensitive neutron counters (for an SKP fuel reload monitoring system);
  - amplification and digital conversion units;
- an accumulation and processing device;
- a device for input of power setpoints;
- registration and display units for a main control room and a fuel reload machine panel to display and archive current parameters, as well as to transfer information to unit's adjacent systems – common for three neutron flux monitoring channels.

Detection unit for start-up and operating ranges

Detection unit for SKP

System advantages:

- automation of calibration of neutron flux density monitoring channels during operation of AKNP-IF using a metrologically certified reactor kinetics simulator developed by SRPA “Impulse” (signals are simulated in a whole range of neutron flux monitoring without necessity of access to sensors in a restricted zone);
- high accuracy due to use of highly sensitive boron and helium neutron sensors;
- integration of a fuel reload monitoring system into AKNP;
- absence of influence of residual readings of detection devices after power operation due to use of fluctuation mode of an ionization chamber;
- possibility of operational calibration of power readings in MCR with automatic recalculation of calibration coefficients;
- high fail-safety of the system due to use of redundant hardware and diverse software.

Safety class – 2.
Safety category – A.

Implementation facilities:

- Zaporizhzhya NPP, units 1-6
- Khmelnitsky NPP, units 1, 2
- Rivne NPP, units 1-4
- South-Ukraine NPP, units 1-3
- Armenian NPP, unit 2

ELECTRIC EQUIPMENT PACKAGE OF A CONTROL AND PROTECTION SYSTEM

The KE SUZ electric equipment package of a control and protection system combines functions of SGIU and ARM-I and is an executive part of NPP units' SUZ.

Functions of KE SUZ:

- SGIU functions - automatically controlling movement of control rods (OR) of SUZ by protection signals, remotely controlling movement of control rods by commands from an operator, ARM-I, indicating current position and state of control rods in MCR and BCR;
- ARM-I functions – automatically controlling RF power and pressure in a main steam collector;
- guaranteed powering for drives of SUZ and equipment of KE SUZ;
- registering and displaying parameters, their changes and faults;
- transferring information to adjacent systems.

Composition of KE SUZ:

- an executive part of emergency protection, consisting of two redundant diverse sets;
- an SGIU control rod control system;
- an ARM-I automatic reactor power controller;
- a power supply subsystem;
- information and diagnostic equipment.

System advantages:

- exclusion of false AZ triggering due to use of three independent channels of emergency commands using "unconditional" logic;
- use of diversity principle (protection modules, intermediate relays, and power contactors of the first and second set of an AZ-PZ executive part are produced using diverse components);
- possibility of online switching of any drive and position sensor of control rods to reserve channels of power control and position monitoring;
- automatic support of physical experiments.

Safety class – 2.
Safety category – A.

Implementation facilities:

- Kola NPP, unit 4

CONTROL ROD CONTROL SYSTEM

The SGIU control rod control system is an executive part of SUZ of NPP units.

Functions of SGIU:

- automatically controlling OR movement by signals of protections, an automatic power controller or by operator's commands;
- indicating current position and state of ORs in main and backup control rooms;
- registering, visualizing, and archiving parameters;
- transferring information to unit's adjacent systems.

Composition of SGIU:

- a control rod control subsystem;
- a protection command generation subsystem (using "unconditional logic");
- a subsystem for monitoring of OR position and for individual power supply of position sensors;
- a subsystem controlling drives with devices for power supply of drives;
- a power supply subsystem assuring guaranteed power, backup, and operative power supply;
- equipment of control rooms (a manual control panel, a computerized panel for operating supervision, and a set of position indicators for control rooms);
- a monitoring and diagnostics server.

System advantages:

- doubling of each channel of drive power control with "hot" reserve of protection and control functions due to automatic unstressed switching of drive control from a failed channel to a reserve one with retention of all control functions;
- control of different types of drives with possibility of their online switching;
- possibility of OR control in any mode of both manual and automatic operation control and also in RF protection modes;
- power supply of power equipment with direct current, which allows to exclude mechanical automatic reserve switching and assure unstressed switching from a main power supply input to a reserve one in case of a fail or voltage reduction at the main input;
- automated support of a physical experiment to check control rod effectiveness;
- a developed diagnostic system with determination and registration of step skip, slipping, jamming of a cluster;
- inclusion of a testing stand for SUZ drives into a supply set.

Safety class – 2.
Safety category – A.

Implementation facilities:

- Rivne NPP, units 1-3
- Zaporizhzhya NPP, units 1, 2, 6
- Kola NPP, unit 4 (as a part of KE SUZ system)

AUTOMATIC REACTOR POWER CONTROLLER

The ARM-I automatic power controller is designed for automatic regulation of reactor power and main steam collector's pressure.

Automatic power regulation device

Functions of ARM-I:

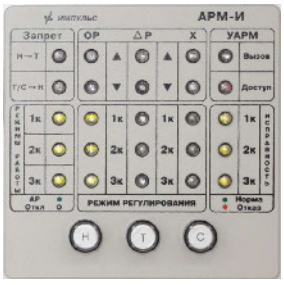
- automatically regulating RF power and limiting RF power depending on pressure in main steam collectors (GPK);
- automatically regulating pressure in GPKs;
- inputting and archiving values of technological parameters and current data (operation and regulation modes, control and information signals to external systems, technical state of ARM-I equipment, etc.);
- visualizing technological process data on a display of a registration and visualization device (URO);
- visually alarming on generation of ARM-I control actions, change of operating conditions, operation and regulation modes, change of a technical state of ARM-I channels;
- displaying parameter trends, state check and ARM-I channel setting reports;
- supporting operator actions during ARM-I channel setting change;
- visualizing current technological and diagnostic data on an ARM-I state in a text, digital, and graphical form on a display of an operating personnel's workstation.

Registration and visualization device

Composition of ARM-I:

- an automatic regulation subsystem – generates control actions to keep technological parameters in compliance with specified regulation algorithms (consists of three automatic power regulation channels implemented based on industrial controllers of MSKU series);
- a subsystem for communication with an operator – serves for selection of an operation and regulation mode, indication of an ARM-I state (implemented based on a switch of operation mode selection and a switch and indicator unit located in a main control room);
- a technical diagnostic and archiving subsystem – serves for storage, display and archiving of technological and diagnostic information, as well as for change of adjustable ARM-I operation parameters (implemented based on URO built into an automatic power regulation device and a remote workstation);
- a switching subsystem – serves for organization of message exchanges between channels of ARM, URO, and a remote workstation (implemented based on automatic power regulation device's (UARM) network equipment – a switchboard and a local network converter).

Switch of operation mode selection



Switch and indicator unit

System advantages:

- generation of control actions according to majority principle "2 of 3";

- possibility of automatic reactor power regulation in three modes – maintaining a set value of neutron flux density, maintaining a set value of pressure in GPK, power limitation depending on pressure in GPK;
- automation of non-operative operability tests and UARM measuring channel calibration.

Safety class – 3.
Safety category – B.

Implementation facilities:

- Kola NPP, unit 4 (as a part of KE SUZ)

SAFETY CONTROL SYSTEM TECHNOLOGICAL

The USBT digital technological safety control system for NPP units is designed to initiate actuation and control safety systems.

Functions of USBT:

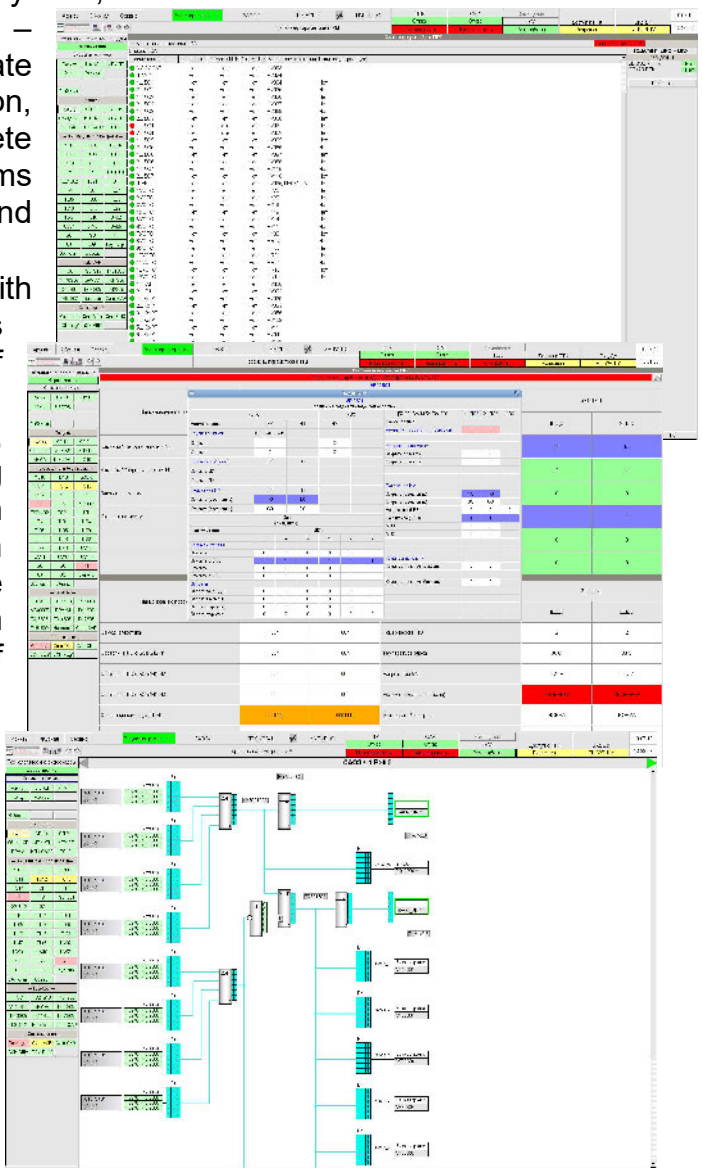
- monitoring technological parameters and identifying initial events by primary processing of input signals and generation of current signals in three mutually redundant MSKU channels;
- generating sequence of protective action commands by “2/4” logic that are stipulated for a detected initial event (protections of emergency core cooling system, pressurizer’s pulse valves protections, shut-down cooling protections, step-by-step diesel generator starting algorithms, etc.);
- generating technological protection and interlock commands by “2oo3”, “2oo2”, “1oo2”, “1oo1” logic (protections and interlocks of steam pipe and feeding pipe systems, main steam isolation valve, a technical water system, gas blowers, ventilation systems and conditioning, oil pumps, etc.);
- automatically regulating technological parameters;
- automatically controlling actuators;
- remotely controlling and indicating actuator state in MCR, BCR;
- generating technological and warning alarm signals in MCR, BCR;
- transferring data on technological parameter values, state of protections, interlocks, and actuators, diagnostic data to unit’s IVS;
- visualizing, archiving, and logging current data.

Composition of USBT:

- a subsystem of control and measurement instrumentation and current signal distributors – implements primary processing of input signals with assurance of redundant power supply of primary converters, generates current signals for external users (implemented based on industrial controllers of MSKU series);
- a control and switching subsystem – implements generation of sequence of protective action commands, commands of technological protections, interlocks, and alarm, as well as arrangement of internal information exchanges between USBT components via digital fiber-optical communication lines (implemented based on ShUK cabinets);
- an automatic regulating subsystem – assures generation of control actions for keeping technological parameters (pressure in steam generators, primary circuit cooling speed, level in steam generators in emergency modes, etc.) in accordance with specified regulating algorithms, monitoring of analog signal input channel operability, and realization of specified control algorithms in case of failures (includes MSKU SAR

implemented based on an MSKU industrial controller and an IS SAR engineering station implemented based on a PS5140 workstation). A SAR subsystem (automatic regulating subsystem) with equipment for communication with an operator's panel may be supplied separately as a SAR USB system;

- a subsystem of actuator control – generates signals of control and state of lock, air-operated isolation, regulating valves' actuators, discrete output signals to adjacent subsystems (is implemented based on ShDS and ShKr cabinets);
- a subsystem for communication with an operator – assures implementation of functions of remote control of actuators, indication of actuator state, technological alarm and warning alarm (implemented based on devices for communication with an operator's panel (USPO remote controllers in MCR) and alarm panels with a project based set of alarm annunciators);
- a technical diagnostics and archiving subsystem – assures reception, processing, visualization, archiving, and logging of data on state of technological parameters, actuators and data of technical diagnostics of USBT, adjustment of online changeable parameters, and transfer of current data to an upper level network of unit's IVS (includes diagnostic and archiving servers implemented based on a PS5140 industrial workstation).



System advantages:

- high tolerance to failures due to use of redundant hardware (MSKU three-channeled industrial controllers, redundant USPO, ShDS, ShUK cabinets and workstations);
- ergonomic and intuitively clear operator's interface;
- high level of system's security to cyber threats;
- convenience of operation and maintenance due to a modular structure of system's components with the possibility of fast swapping of faulty modules.

Safety class – 2.
Safety category – A.

Implementation facilities:

- Zaporizhzhya NPP, units 1- 5
- Khmelnitsky NPP, unit 2

STANDBY DIESEL GENERATOR STATION AUTOMATIC CONTROL SYSTEM (SDGS ACS)

SDGS ACS is one of the main parts of emergency power supply systems of all channels of a unit's safety system. SDGS ACS together with other adjacent systems assures control of startup, connection to a network and power operation of a DGU diesel-generator unit, control of excitation and protection of a generator, control of auxiliary equipment.

Functions of SDGS ACS:

- automatic maintenance in readiness and startup of DGU on receipt of commands fromthe safety control system;
- automatic, automated, and manual control of DGU startup/stop from controls;
- automatic maintenance of DGU power operation;
- emergency or normal stop of DGU on actuation of protections;
- control of equipment of a compressor plant and an air dryer package;
- continuous automatic archiving, warning, displaying, and recording of technologicaland electrical parameters, events, and states during operation of SDGS ACS;
- automatic emergency and preliminary alarm with generation of generalized signals ondisplay panels of MCR, BCR;
- transmission to unit's IVS of data on values of technological parameters, modes ofoperation of SDGS ACS, state of protections, interlockings.

System advantages:

- redundancy of equipment assuring functions of startup and maintaining DGU at power;

- implementation of hardware and software for instrumentation and control equipment of SDGS ACS using own developments of SRPA “Impulse”, including equipment to control and regulate rotational speed of DGU, relay protections, and automation;
- monitoring of electrical and technological parameters of DGU, continuous self-diagnostics of all components of the system;
- ergonomic and user-friendly operator interface.

Implementation facility:

- Zaporizhzhya NPP, units 1- 6

SYSTEM TO CONTROL EMERGENCY “COOLANT LEAK FROM A PRIMARY CIRCUIT TO A SECONDARY ONE WITH THE EQUIVALENT SECTION Dy 100”

The SUA TPKV system to control emergency “Coolant leak from a primary circuit to a secondary one with the equivalent section Dy 100” is intended to diagnose leaks from a primary circuit to a secondary one of NPP unit, identify emergency steam generators, and automate their localization algorithm.

Functions of SUA TPKV:

- measuring direct steam radioactivity in steam generators;
- receiving and primarily processing analog and discrete signals from adjacent systems (normal operation systems, safety control systems, reactor trip systems, MCR);
- carrying out calculation and logical operations in accordance with an emergency control algorithm approved by the regulator in the nuclear power engineering;
- forming and delivering SNE, USB actuator control commands (signals of switching on, prohibition of switching on);
- signaling on system operation in control rooms;
- transmitting data on technological parameter values, equipment state, and self-diagnostics results into IVS.

Composition of SUA TPKV:

- four data acquiring and processing devices based on industrial controllers of MSKU series;
- LAN switchboards, an engineering-diagnostic station, and a remote diagnostic station based on PS5140 workstations.

System advantages:

- decrease of quantity of manual operations fulfilled by operating personnel and minimization of possible personnel’s wrong actions in case of emergency;
- reliable isolation of a damaged steam generator;
- elimination of possibility of steam-release devices operation of a faulty steam generator on steam-water mixture and water, avoidance of release of primary circuit radioactive coolant to the environment;
- reliability of measurement results due to use of three detection units for each steam generator;
- possibility of autonomous check of functioning by means of signal simulation on inputs of accident control algorithms with displaying a checking process on a block diagram of a checked algorithm;
- possibility of integration of SUA TPKV and USBT.

Safety class – 3.
Safety category – B.

Implementation facilities:

- Zaporizhzhya NPP, units 1, 2
- Khmelnitsky NPP, unit 2
- Rivne NPP, unit 4

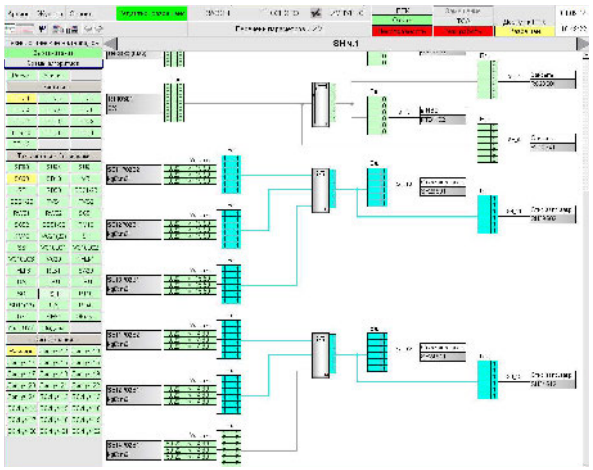
NORMAL OPERATION CONTROL SYSTEMS FOR REACTOR AND TURBINE DIVISIONS

The USNE RO, USNE TO digital normal operation control systems for reactor and turbine divisions are designated to implement functions of normal operation control of NPP units' technological systems.

Functions of USNE:

- primarily processing input signals and generating current signals;
- generating commands according to algorithms of technological protections, interlocks, and alarm;
- automatically regulating technological parameters with the possibility to change settings from a workplace of a SAR operator in MCR;
- remotely controlling and indicating states of actuators;
- visualizing, archiving, and logging of current technological and diagnostic information;
- transferring data on values of technological parameters, state of protections, interlocks, and actuators, diagnostic data to unit's IVS.

Composition of USNE:



- a subsystem of control and measurement instrumentation and current signal distributors;
- a control and switching subsystem;
- an automatic regulating subsystem;
- a subsystem to control actuators;
- a subsystem for communication with an operator;
- a subsystem for technical diagnostics and archiving.

Hardware, on which USNE RO and USNE TO instrumentation and control systems by SRPA "Impulse" are based, is analogous to hardware from the composition of USBT (except diverse sets) and has the same advantages.

Safety class – 3.
Safety category – B.

Implementation facilities:

- Zaporizhzhya NPP, units 1-5
- Khmelnitsky NPP, unit 2

AUTOMATIC REGULATING SYSTEM OF A TURBINE DIVISION

Functions of ASR TO:

- automatically regulating turbine division technological parameters;
- functional-group control of a turbine regulating electrohydraulic system;
- remote control of actuators;
- interlocking regulators and control valves;
- technological and warning alarm;
- visualizing and archiving data on values of technological parameters, state of interlocks and actuators;
- transmitting data on values of technological parameters, state of interlocks and actuators to IVS.

Composition of ASR TO:

- a control subsystem – assures implementation of algorithms by interlocking and technological signalling functions with delivering control commands to equipment controlling actuators, as well as transmission of technological and diagnostic data to a diagnostics and archiving server (implemented based on ShUK control and switching cabinets);
- an automatic regulating subsystem (SAR) – assures implementation of algorithms of SAR and delivery of commands of SAR to the control subsystem (includes MSKU SAR implemented based on an MSKU industrial controller, an IS SAR engineering station implemented based on a PS5140 workstation, and an RM SAR operator's workstation in MCR;
- an actuator control subsystem – serves to control actuators of stop and control valves (implemented based on ShDS discrete signals cabinets);
- a subsystem for communication with an operator – designated to receive commands controlling indication from the control subsystem, transmit remote control commands from switches to the control subsystem, deliver actuator position indicating signals (implemented based on USPO devices for communication with an operator's panel);

RM SAR

- a technical diagnostics and archiving subsystem assures receipt, processing, visualization, archiving, and logging of data on state of technological parameters, actuators and technical diagnostics data of ASR TO, as well as adjustment of quickly changed parameters (includes diagnostics and archiving servers implemented based on a PS5140 workstation).

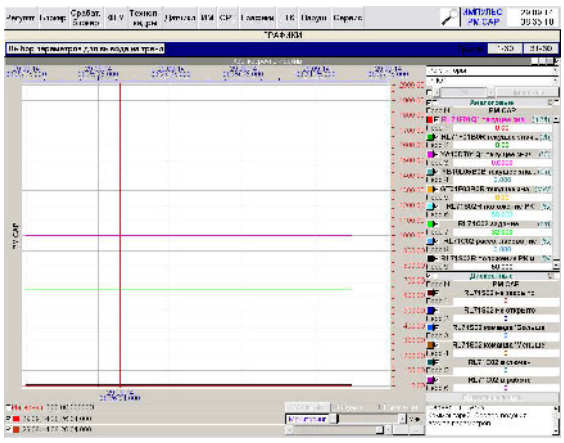
PS5140 (ASR TO)

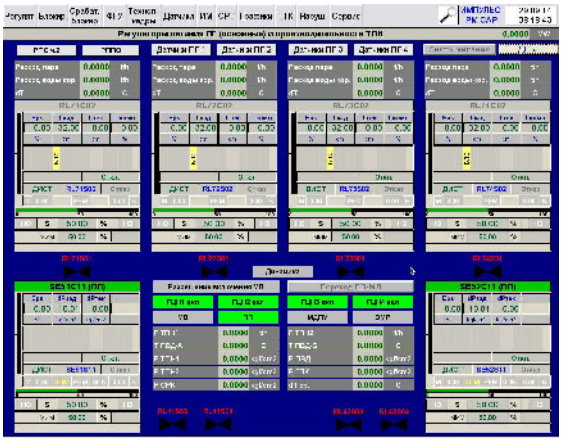
System advantages:

- high fail-safety due to use of redundant hardware (MSKU three-channel industrial controllers, redundant USPO, ShDS, ShUK, and workstations);
- implementation of data exchange between subsystems via redundant fiber-optical communication links;
- possibility of data exchange with I&C of USNE TO via a digital channel;
- ergonomic and intuitively clear operator's interface;
- convenience of operation and maintenance due to use of a modular structure of system's components with the possibility of fast swapping of faulty modules.

Safety class – 3.
Safety category – B.

Implementation facilities:
Zaporizhzhya NPP, units 1, 2





Video frames of RM SAR

TURBINE REGULATING SYSTEM

Functions of SRT:

- automatically and semiautomatically rotating a turbine;
- synchronizing a turbogenerator (TG) with an electric network;
- loading or unloading TG with a rate specified by an operator;
- maintaining parameters of a turbogenerator at a specified level (rate of rotation – regulating accuracy not worse than ± 10 rpm, capacity – regulating accuracy not worse than ± 10 MW, steam pressure in a main steam collector – regulating accuracy not worse ± 0.5 kgf/cm^2) in starting and operating modes;
- assuring unloading TG in load-relief modes when technological protections of a turbine, reactor facility or protections of a generator are active;
- remotely controlling control valves of a turbine by operator's commands;
- performing the following protective actions:
  - preventing unacceptable increase in turbine rotation speed during load-reliefs;
  - changing a turbine over to idling or to auxiliaries while maintaining nominal speed after load-relief;
  - forming protection signals when acceptable turbine speed is exceeded;
  - limiting planned capacity changes.

ShERS-1

Composition of SRT:

- an ShERS-1 cabinet of an electronic speed regulator, a ShSRT-1 cabinet of a turbine regulating system implemented based on MSKU industrial controllers;
- a diagnostics and archiving server, an engineering station of an automatic regulating system implemented based on PS5140 workstations;
- RMO operator's workstations.

ShSRT-1

System advantages:

- reliable execution of safety electronic automate functions (maintaining a turbine at a power level available at the moment of failure of a main electrohydraulic regulating system);
- high operation speed (duration of a main operational cycle – 10 ms, time of response to discrete signals from emergency automation and signals of generator's switch position – not more than 5 ms, generation time for a signal "Protection by TG's rotor speed" from an initial event (change of frequency) – not more than 5 ms);
- possibility of supply within USNE TO, which reduces quantity of equipment due to use of workstations of USNE in SRT;
- possibility of operation in three modes:
  - using an electronic part of electrohydraulic regulating system;
  - using an electronic speed regulator;
  - in a manual control mode.

Safety class – 3.
Safety category – B.

Implementation facilities:
Zaporizhzhya NPP, units 1, 2

COMPLEX DIAGNOSTICS SYSTEM FOR EQUIPMENT OF A REACTOR FACILITY'S PRIMARY CIRCUIT

Functions of KSD:

- deep complex technical diagnostics of main equipment of an RF's primary circuit using comparison and analysis of diagnostic information received from unit's instrumentation and control systems, local diagnostics systems, and own databases;
- providing a diagnostic engineer with centralized access to operating and archive diagnostic information received from different sources (IVS, local diagnostics systems, an automated radiation monitoring system, etc.) and allowing to determine and forecast technical state of operated RF's primary circuit equipment;
- transferring parameters to be displayed to a personnel to a unit's local area network.

Workstation

Composition of KSD:

- KSD's upper level system including:
  - a redundant computing server of KSD based on two mutually redundant workstations;
  - a workplace of a KSD diagnostic engineer based on two mutually redundant workstations;
- SVRShD vibration and noise diagnostics system;
- SOSP loose parts monitoring system;
- SKPT system of RF's primary circuit coolant leakage monitoring;
- SVKD GCN system for vibration monitoring and diagnostics of reactor coolant pumps;
- SDOR fatigue monitoring system;
- SKPTr system of pipeline displacement monitoring.

SVRShD vibration and noise diagnostics system

The system is intended for monitoring and diagnostics of vibration state of RF's primary circuit equipment, for monitoring of:

- trajectory of thermal displacement of RF's primary circuit main equipment in heating/cooling modes for detection of non-project displacement trajectories caused by defects in pillars of monitored equipment;
- vibration state of RF's primary circuit main equipment, including a reactor vessel, for detection of abnormal vibrations caused by change in pillar rigidity, weakening of equipment attachment points, or intensification of vibration causing powers;
- vibration state of fuel rod assemblies for detection of abnormal vibrations caused by weakening of attachment points or intensification of coolant influence;
- vibration state of a reactor shaft for detection of abnormal vibrations caused by wearout of attachment points or intensification of coolant influence.

Functions of SVRShD:

- inputting, converting, and comparing with setpoints signals from vibration sensors, vibration displacement sensors, neutron detection units, and direct charge sensors (possibility of reception of noise signals from all RF's DPZ sensors – totally 448 signals);
- receiving information on RF technological parameters from unit's IVS;
- archiving monitoring and diagnostic data;
- calculated diagnostics of vibration state considering current and archive data, generating reports;
- transferring information on state of diagnosed equipment to a computing server of KSD.

Composition of SVRShD:

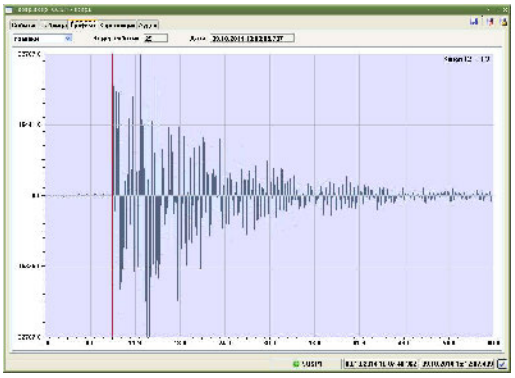
- piezoelectric vibration transducers, relative displacement sensors, detection units;
- neutron detector signal converters;
- measuring equipment based on AKSD.2 complex diagnostics system equipment;
- an SVRShD's computing server based on a PS5140 workstation.

AKSD.2

SOSP loose parts monitoring system

The system is intended for early detection and determination of loose parts and poorly fixed equipment details in coolant stream using acoustic sensors installed on the surface of RF's primary circuit equipment.

Functions of SOSP:



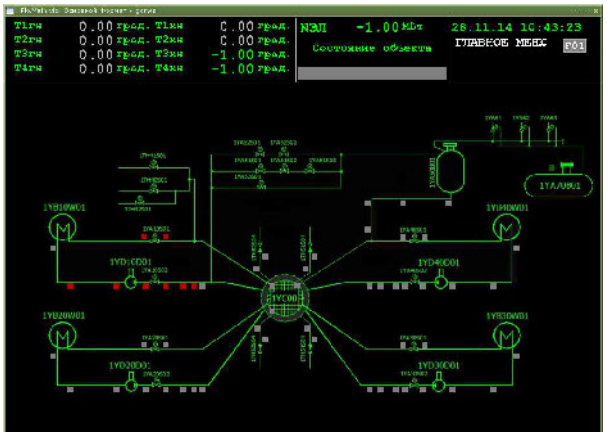
- inputting, converting, and comparing with setpoints noise signals from acoustic sensors;
- monitoring vessel noise of main equipment and RF's primary circuit pipelines, detecting loose and poorly fixed items (with the mass of 0.05 kg and more at the distance of 1 m from a primary transducer) in coolant stream;
- archiving data, listening and recording acoustic signals;
- monitoring operability of channels that receive and process signals of sensors;
- displaying diagnostics results to an operator and transferring to a computing server of KSD.

Composition of SOSP:

- acoustic sensors(piezoelectric vibration transducers);
- impulse hammers;
- a station for power supply of impulse hammers;
- measuring equipment based on AKSD.2 complex diagnostics system equipment;
- an SOSP's computing server based on a PS5140 workstation.

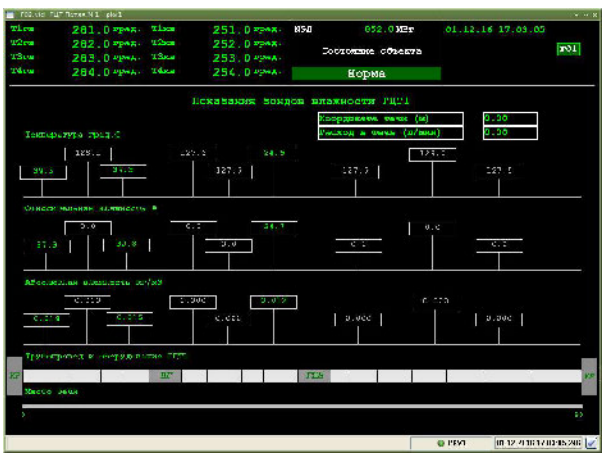
SKPT system of primary circuit coolant leakage monitoring

The system is intended to monitor tightness of equipment and pipelines of RF's main circulation circuit, to detect RF's primary circuit coolant leakage in time, to assess its magnitude in normal operation modes, with deviations from normal operation, and in a "small leakage" mode.



Functions of SKPT:

- inputting, converting, and comparing with setpoints signals from humidity and temperature sensors, acoustic sensors;
- receiving information from a unit's process information system;
- complex analysis on localization (with deviation not more than ± 2 m) and magnitude of a leakage with minimal registered coolant flow 1 l/min in the time period of not more than 10 min from the time of its actual occurrence;
- archiving data;
- displaying diagnostics results to an operator and transferring to a computing server of KSD;
- generating warning alarm.



Composition of SKPT:

- a subsystem of acoustic monitoring (PAK) including:
  - acoustic sensors;
  - measuring equipment based on AKSD.2 complex diagnostics system equipment;

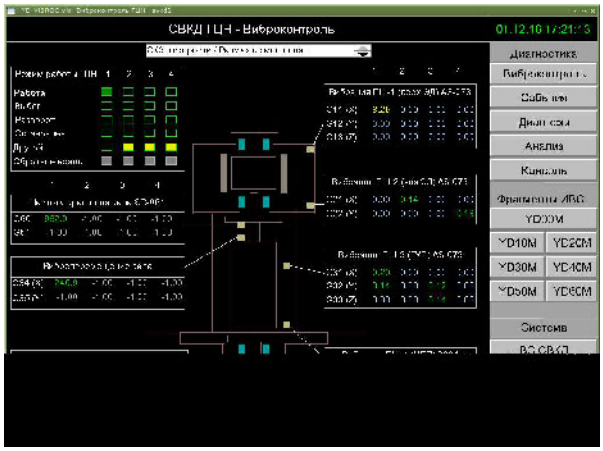
- an SKPT PAK's computing server based on a PS5140 workstation;

- a subsystem of humidity monitoring (PKV) including:
  - a relative humidity and temperature sensor;
  - measuring equipment based on AKSD.2 complex diagnostics system equipment;
  - an SKPT PKV's computing server based on a PS5140 workstation.

SVKD GCN system for vibration monitoring and diagnostics of reactor coolant pumps

The system is intended for monitoring of vibrational parameters of reactor coolant pumps (GCN) for early detection of abnormal states of mechanical and electrical parts, technical state forecasting based on complex analysis of vibrational characteristics and thermal parameters.

Functions of SVKD GCN:



- inputting, converting, and comparing with setpoints signals from vibration monitoring sensors;
- continuously monitoring GCN vibrational state and identifying slowly developed defects;
- monitoring vibrational characteristics in different modes of GCN operation, including rotor rundown mode during electric motor power supply shutdown;
- analyzing, archiving, and logging data;
- diagnosing GCN state with display of results to a diagnostic engineer and generation of alarm.

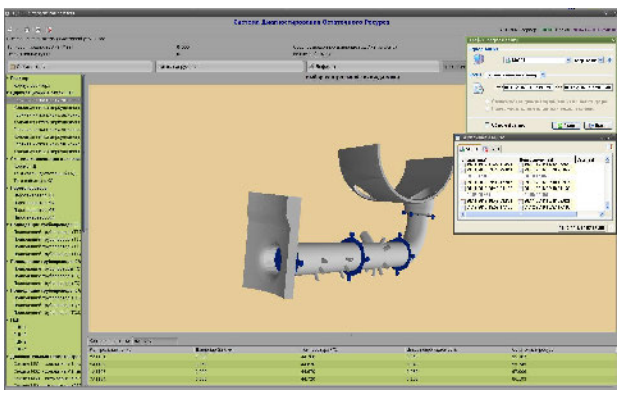
Composition of SVKD GCN:

- vibration monitoring sensors;
- primary converters of signals of GCN sensors;
- measuring equipment based on AKSD.2 complex diagnostics system equipment;
- an SVKD GCN's computing server based on a PS5140 workstation.

SDOR fatigue monitoring system

The system is intended to calculate cumulative fatigue damage dealt to metal in the most stressed points of a structure and to evaluate remaining lifetime of elements of main equipment of the RF's primary circuit (a reactor with a cover without in-core equipment, a pressurizer, steam generators, main circulatory pipelines, emergency core cooling system's and pressurizer's pipelines) based on continuous monitoring of thermotechnical parameters in different modes of RF operation.

Functions of SDOR:



- inputting and converting signals from thermal control sensors (monitoring of thermal pulsations and coolant stratification), collecting and accumulating information received from a computing server of KSD;
- calculating fatigue damage and remaining lifetime in control (the most stressed) points;
- assessing remaining lifetime of equipment and pipeline metal;

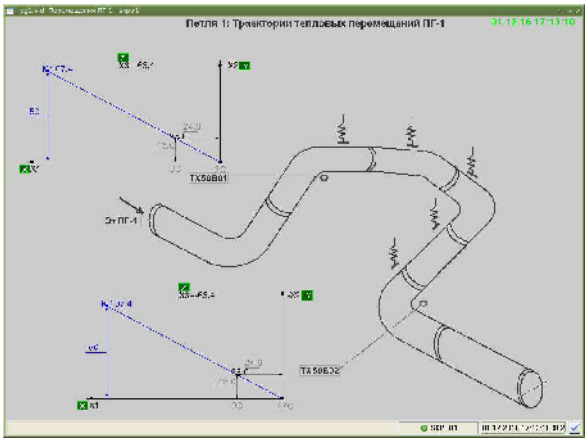
- maintaining databases, registering signals received from IVS, KSD, and own sensors;
- providing information to operative personnel.

Composition of SDOR:

- temperature sensors (thermocouples);
- an I&C complex based on an MSKU industrial controller;
- an SDOR's computing server based on a PS5140 workstation.

SKPTr system of pipeline displacement monitoring

The SKPTr system is intended to measure continuously and to record maximum pipeline displacements under conditions of unit normal operation and transient modes (startup, stop, partial load decreasing) for provision of operating and technical personnel with information.



Functions of SKPTr:

- receiving and processing signals of three-axis displacement sensors, receiving technological signals of pressure and temperature in a steam generator;
- continuously remotely monitoring pipeline displacement by three mutually perpendicular axes and maintaining a database;
- providing an operator with pipeline displacement information as videograms;
- transferring information on displacements and violations of permissible displacement limits to adjacent systems;
- providing unit personnel with information on faults and failures, generating alarm on impermissible pipeline displacements.
-

Composition of SKPTr:

- a DTP three-axis displacement sensor;
- an I&C complex based on an MSKU industrial controller;
- an SKPTr's computing server based on a PS5140 workstation.

System advantages:

- consolidation of a wide variety of RF's primary circuit equipment diagnostic functions in a unified system while maintaining autonomy of local diagnostics systems;
- complex and reliable determination of RF's damaged or worn out equipment due to availability of local diagnostics systems with different methods of assessment of monitored parameters;
- time-tested diagnostic algorithms of KSD allow to assess intensity of damaging factors and to recommend on a reasonable basis deeper assessment of technical state of unit's elements and repair procedures considering current technical state of RF's equipment;
- construction and location of sensor attachment nodes on pipelines assure easy mounting and unhindered periodic monitoring of pipeline metal without accompanying dismantling of the attachment nodes;
- comfort of operation due to the ergonomic user's interface and a developed system for provision of operating personnel with current and retrospective information;
- use of unified hardware.

Safety class – 4.
Safety category of KSD – not classified.

Implementation facilities:

- Zaporizhzhya NPP, units 1-5
- Rivne NPP, units 1-4
- Khmelnitsky NPP, units 1, 2
- South-Ukraine NPP, units 1-3
- Kozloduy NPP, units 5, 6

“BLACK BOX” SYSTEM TO PRESERVE INFORMATION IN DESIGN AND BEYOND-DESIGN ACCIDENT CONDITIONS

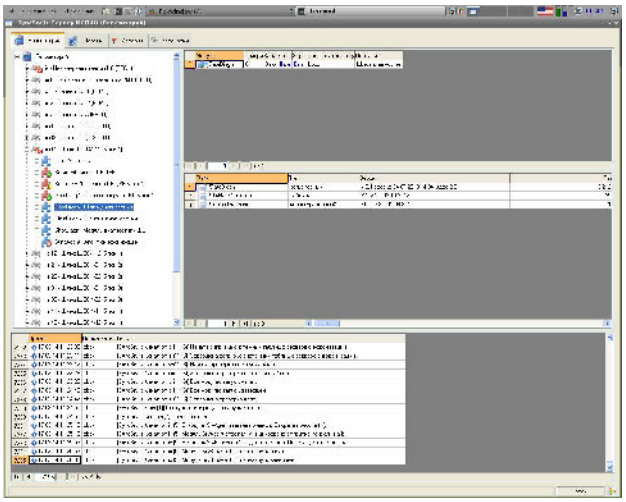
The “Black Box” system is designated to store and provide personnel with information on parameters of NPP units in accident and post-accident conditions of design and beyond design accidents.

Functions of the “Black Box” system:

- acquiring information from systems-data sources;
- registering and storing information in a long-term archive;
- providing personnel with information on parameters of NPP units in a form of diagrams and videograms.

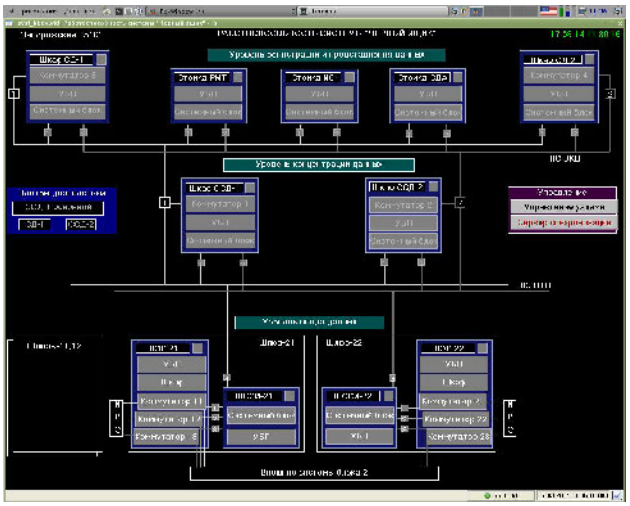
Composition of the “Black Box” system:

- a complex for registration and presentation of data received from a data concentration subsystem (KRPD), consisting of:
  - redundant data servers;
  - a server of a long-term archive;
  - a workstation of a technologist;
  - an engineering station;
  - hardware forming a radio channel for data transmission;
- a complex for concentration of data received from a data input subsystem (KKD), consisting of:
  - redundant data acquisition servers;
  - hardware forming a radio channel to transmit data to KRPD;
- a complex for input of data from systems-sources of unit data, consisting of:
  - redundant gateways for optical branching and communication, consisting of a gateway of communication with the source systems and an optical branching cabinet that assures receipt of data from external systems and transmission of signals to IVS and SRVPE (branching);
  - hardware forming a radio channel to transmit data to KKD.



System advantages:

- use of a highly-reliable approved radio channel for data transmission;
- implementation of data exchange between components via redundant fiber-optical communication links;
- high fail-safety of the system due to use of redundant hardware.



Safety class – 3.
Safety category – C.

Implementation facilities:

- Khmelnitsky NPP, units 1, 2
- Rivne NPP, units 1-4
- Zaporizhzhya NPP, units 1-5

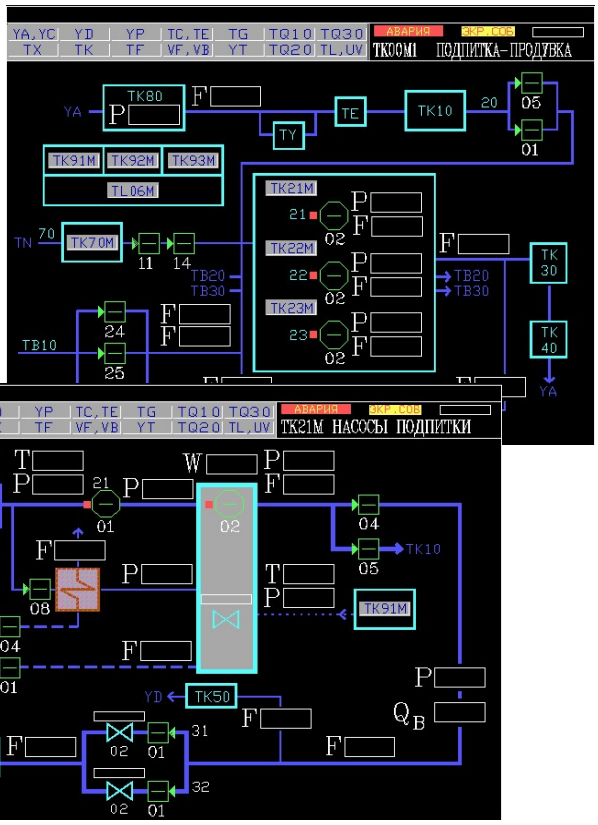
CENTRE FOR TECHNICAL SUPPORT OF OPERATORS

Functions of CTP:

- expert support of actions of operating personnel of MCR as to units control in an emergency mode and when liquidating accident consequences;
- monitoring a technological mode and forming recommendations as to its optimization at normal operation;
- receiving and processing information from adjacent diagnostic and information systems;
- providing operating personnel with information required.

Composition of CTP:

- I&C for information communication of CTP with adjacent systems and for presentation of state of unit parameters, consisting of:
  - engineering stations;
  - operator stations;
  - archiving servers of CTP;
  - a gateway for communication with an internal crisis centre;
  - portable workstations;
  - a remote viewing display;
- a complex of safety assuring facilities, consisting of:
  - radiation environment monitoring equipment (dosimeter-radiometer);
  - equipment for video surveillance of actions of operators of main and backup control rooms (video cameras, video recorders, communication equipment, video surveillance monitors).



System advantages:

- ergonomic and intuitively clear operator's interface;
- use of approved hardware and software solutions;
- high fail-safety of the system due to use of redundant hardware;
- continuous self-diagnostics of all components of the system with the depth up to a plug-in unit with generation of a warning on a fault.

Safety class – 4.
Safety category – not classified.

Implementation facilities:

- Khmelnitsky NPP, units 1, 2
- Rivne NPP, units 3, 4

ACCIDENT AND POST-ACCIDENT MONITORING SYSTEM

The PAMS accident and post-accident monitoring system is intended for monitoring of safety parameters and state of reactor facility's systems during design and beyond-design accidents at NPPs.

PAMS implements functions of accident and post-accident monitoring at any design-relevant initial events, as well as beyond-design accidents (including those connected with severe damage of fuel).

Functions of PAMS:

- monitoring the following RF parameters with the use of emergency measuring instrumentation (AKIP):
  - level of coolant in a reactor – for level measuring thermoelectric transducers, located inside a case of an in-core direct charge detector assembly, are used;
  - level in a cooling pond – for level measuring sensor elements, based on the impulse reflectometry principle, are used;
  - temperature in a cooling pond – for temperature measuring temperature transducers with the measuring range 0 - 300 °C are used;
  - temperature in a containment – for temperature measuring resistance thermometers with the measuring range 0 - 300 °C are used;
  - containment radiation dose rate – for monitoring of radiation dose rate detection units (ionization chambers) with the measuring range 10^{-4} - 10^{5} Gy/hour are used;
  - pressure above a core – for pressure measuring pressure sensors of 0 - 25 MPa are used;
  - pressure in an accident confinement area – for pressure measuring pressure sensors of 0 - 1 MPa are used;
  - level in containment sumps – for level measuring differential pressure sensors of 0 - 70 kPa are used;
- providing operating personnel of NPP and emergency work headquarters with information on state of main safety functions and reactor facility's systems with the help of PAMS hardware resistant to emergency conditions, as well as data received from standard systems if they keep their operability;
- providing information on state and efficiency of protective barriers based on direct readings of AKIP when standard monitoring systems fail during beyond-design accidents;
- PAMS data transferring into the "Black Box" system and crisis centres.

Composition of PAMS:

- upper level of PAMS – MSKU industrial controllers and panel computers qualified according to application conditions;
- lower level of PAMS - emergency measuring instrumentation qualified for conditions of design and beyond-design accidents.

System advantages:

- high failure tolerance due to use of a distributed two-level structure with the use of two independent channels of data measuring, processing and displaying;
- use of hardware qualified for conditions of design and beyond-design accidents, including loss of coolant accidents (LOCA);
- use of AKIP with an advanced measurement range of monitored technological parameters of RF;
- assurance of PAMS operability under conditions of a maximum design earthquake and full blackout of a unit;
- reliable power supply of PAMS equipment due to use of a UBP-15 uninterruptible power supply assuring power supply for PAMS in case of unit blackout for a time period up to 8 hours.

Safety class – 3.
Safety category – B.

Implementation facilities:

- Zaporizhzhya NPP, units 1, 2
- Rivne NPP, units 1-4
- Khmelnitsky NPP, units 1, 2

SYSTEM TO MONITOR BORON-10 ISOTOPE (BORIC ACID) CONCENTRATION

The main function of the NAR-I boron concentration monitoring system based on neutron solution analyzers – automatic continuous measurement of boron-10 (boric acid) concentration in coolant at NPP units with WWER-type reactors.

Composition of NAR-I:

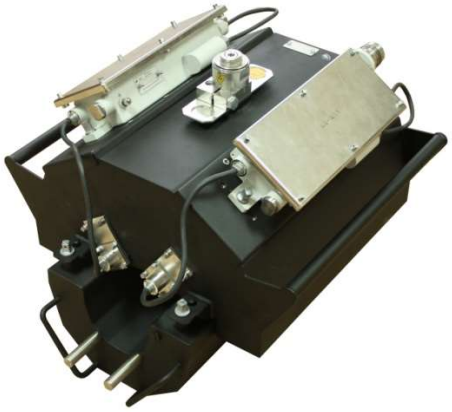
- main equipment – detection devices (sensors) and data conversion and processing devices (UPO) arranged as follows:
  - NAR-I-N – completed with a UDt-1N mounted sensor (is installed on technological pipelines);
  - NAR-I2-N – completed with a UDt-1N mounted sensor with lower radiation level;
  - NAR-I2-NE – completed with a UDt-2N mounted sensor (includes a hydrogen-containing material shielding from neutron radiation);
  - NAR-I-P – completed with a submersible sensor (is installed in tanks and reservoirs);
  - NAR-I-Pr1 – completed with a UDt-2Pr1 one-channel flow-type sensor with one cuvette connected with a sampling line to a technological system;
  - NAR-I-Pr2 – completed with a UDt-2Pr2 two-channel flow-type sensor with two cuvettes connected with sampling lines to technological systems;
  - NAR-I-K – completed with a UDt-2K control-type sensor (is installed in a laboratory room);
  - NAR-I-N-IS – completed with a mounted sensor and a symbol indicator indicating boric acid concentration in control rooms;
  - NAR-I-P-IS – completed with a submersible sensor and a symbol indicator indicating boric acid concentration in control rooms;
- additional equipment (forms a part of supply as an option):
  - Am-Be and Pu-Be fast neutron sources;
  - an InS symbol indicator;
  - an URO registration and display unit;
  - a ShT technological cabinet for UPO, URO installation;
  - a container to store and transport fast neutron sources.

UDt-1N mounted detection device

Assures measurement of boron-10 isotope (boric acid) concentration in pipelines with diameters equal to 89, 108, 133, 159, 325, 630 mm.

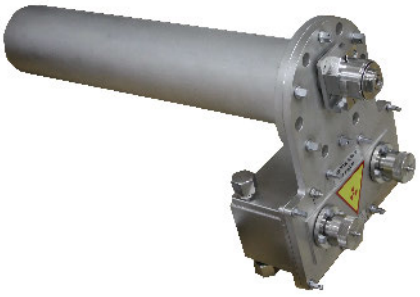
UDt-2N mounted detection device

Assures measurement of boron-10 isotope (boric acid) concentration in pipelines with diameters equal to 108, 159, 325 mm (separate versions of UDt for different diameters).



UDt-1P submersible detection device

Assures measurement of boron-10 isotope (boric acid) concentration in technological tanks and reservoirs with a protective sleeve with a diameter equal to 120 mm.



UDt-2Pr flow-type detection device

UDt-2Pr carries out measurement of boron-10 isotope (boric acid) concentration in sleeves connected with sampling lines to NPP technological systems.

Two versions have been developed: UDt-2Pr1 (one-channel version) and UDt-2Pr2 (two-channel version).

The technological part assures solution flow rate regulation, measurement of flowing solution parameters (pressure, flow rate).

UDt-2K control-type detection device

UDt-2K assures:

- measurement of boron-10 isotope (boric acid) concentration in working standard solutions used for calibration of working mounted, submersible, and flow-type boron meters;
- measurement of boron-10 isotope (boric acid) concentration in solutions with unknown concentration;
- determination of a boron-10 isotope atomic fraction in boric acid.

UPO conversion and processing device

Functions:

- calculating boron-10 isotope (boric acid) concentration;
- indicating values in digital and graphical forms;
- transmitting information via redundant communication links of RS-485 interface and as a current signal (0-5 mA or 4-20 mA) to external subsystems.

InS symbol indicator

Functions:

- indicating current boron-10 isotope (boric acid) concentration in a digital form on panels of control rooms;
- generating a warning alarm discrete signal.

Container to store and transport

A container certified by absorbed dose rate, which is designated to store and transport one fast neutron source (Am-Be or Pu-Be).

The container is manufactured as a cart with a frame (rigidly fixed on it), into which a removable container is installed.

Removable container

Source

Container

URO registration and display unit

Functions:

- generating NAR-I archive;
- monitoring operability of all NAR-I devices of a unit;
- displaying archive data, including boron-10 (boric acid) concentrations in any technological point on a panel computer's touch screen;
- checking (calibrating) flow-type NAR-I.

To supply power to a panel computer an MPt power supply module is used.

Panel computer

MPt power supply module

ShT technological cabinet

Assures possibility to install and connect external communications to UPO or URO. Power cables and signal cables of UPOs are connected to strips of connectors of a ShT cabinet (cables from strips of connectors to UPOs form a part of the system).

Power consumption of ShT with four installed UPO doesn't exceed 160 W.

Protection degree of ShT – IP23.

NAR-I key metrological characteristics

Version	Concentration values, g/kg		Absolute error, g/kg		Concentration values, g/kg		Relative error, %
	boron-10	boric acid	boron-10	boric acid	boron-10	boric acid	
NAR-I-N	0÷0.192	0÷6	0.0048	0.15	0.192÷1.6	6÷50	2.5
NAR-I-P			0.0048	0.15			2.5
NAR-I2-NE			0.0058	0.18			3.0
NAR-I2-N			0.0067	0.21			3.5
NAR-I-Pr1	0÷0.32	0÷10	0.0032	0.1	0.32÷1.6	10÷50	1.0
NAR-I-Pr2			0.0032	0.1			1.0
NAR-I-K			0.00192	0.06			0.6

System advantages:

- high accuracy in continuous analysis of boron-10 (boric acid) concentration in process loops of NPP;
- small equipment readiness time after power-on (not more than 20 min) and output signal setting time by a single abrupt change of concentration (not more than 20 s);
- absence of additional errors of NAR-I because of influence of external factors (gamma-radiation with absorbed dose rate 0.22 Gy/h, temperature of external environment up to 90 ºC, temperature of measured solution up to 110 ºC);
- possibility to complete boron meters with Am-Be fast neutron sources with the life of 20 years;
- provision of possibility of NAR-I operation in accident conditions at temperature of external environment and solution up to 150 ºC (for mounted sensors at temperature of solution up to 265 ºC);
- testing-confirmed compliance with severe requirements of industrial standards for electromagnetic compatibility, environmental resistance, seismic resistance, vibration and shock loads.

Safety class – 2.

Safety category – A.

Implementation facilities:

- Rivne NPP, units 1-3
- Armenian NPP, unit 2
- Zaporizhzhya NPP, units 1-5
- South-Ukraine NPP, units 1, 3
- Khmelnitsky NPP, units 1, 2
- Mochovce NPP, units 3, 4

AUTOMATION HARDWARE

The automation hardware (AHW) developed and manufactured by SRPA “Impulse” is the basis to I&C design.

AHW to be supplied to NPPs as a part of I&C systems is developed and manufactured meeting norms and rules of national and international standards, hardware components by leading world manufacturers are used in products, at that all components undergo thorough incoming inspection.

AHW manufactured by SRPA “Impulse” used within I&C systems has the following key characteristics:

- high fail-safety due to use of a redundant modular structure with the possibility of replacing functional units and modules without power-off (“hot” swapping);
- use in AHW of proprietary software and programming tools verified and received practical approval within systems important for NPP safety;
- testing-confirmed compliance with severe requirements of industrial standards for electromagnetic compatibility, environmental resistance, seismic resistance, vibration and shock loads;
- deep continuous self-diagnostics of equipment with localization of faults up to a plug-in unit and alarm generation;
- high reliability of equipment due to use of industrial serial components and high-quality technologies of development and manufacture of hardware and software;
- possibility of long-term operation (average life – not less than 30 years).

MSKU-3 INDUSTRIAL CONTROLLERS

The MSKU-3 industrial controllers - a series of design-arranged, flexibly programmable industrial controllers intended to be used as:

- subsystems of a lower level of I&C;
- intelligent autonomous instrumentation and control systems;
- industrial controllers for fail-safe automation systems of critical facilities.

Functions of MSKU-3:

- inputting and processing data from the sensors of analog and discrete signals;
- implementing monitoring and control algorithms, different regulating laws, protections, interlocks, start, and stop of the equipment;
- generating and outputting analog and discrete signals, control commands;
- intercommunication with external users via interfaces based on fiber-optical communication links:
  - Ethernet;
  - UART.

Composition of MSKU-3:

Composition of specific MSKU-3 is determined by specific features of its use in the instrumentation and control system.

Components of MSKU-3:

- KMp microprocessor controllers equipped with ports of Ethernet interface and operated under control of real-time system software (SW) developed at SRPA “Impulse”;
- MSO modules for communication with a facility designated for input/output of discrete and analog signals;
- BPSv communication modules designated for digital external communications of MSKU-3;
- MKO equipment monitoring modules designated to monitor operability and state of equipment located in an MSKU-3 cabinet;
- PKr cross panels designated to connect field cables;
- PSd connective panels designated for connection of cross panels with modules for communication with a facility and for protection against electromagnetic interference;
- mounting crates designated to install controllers and modules for communication with a facility.

Key characteristics:

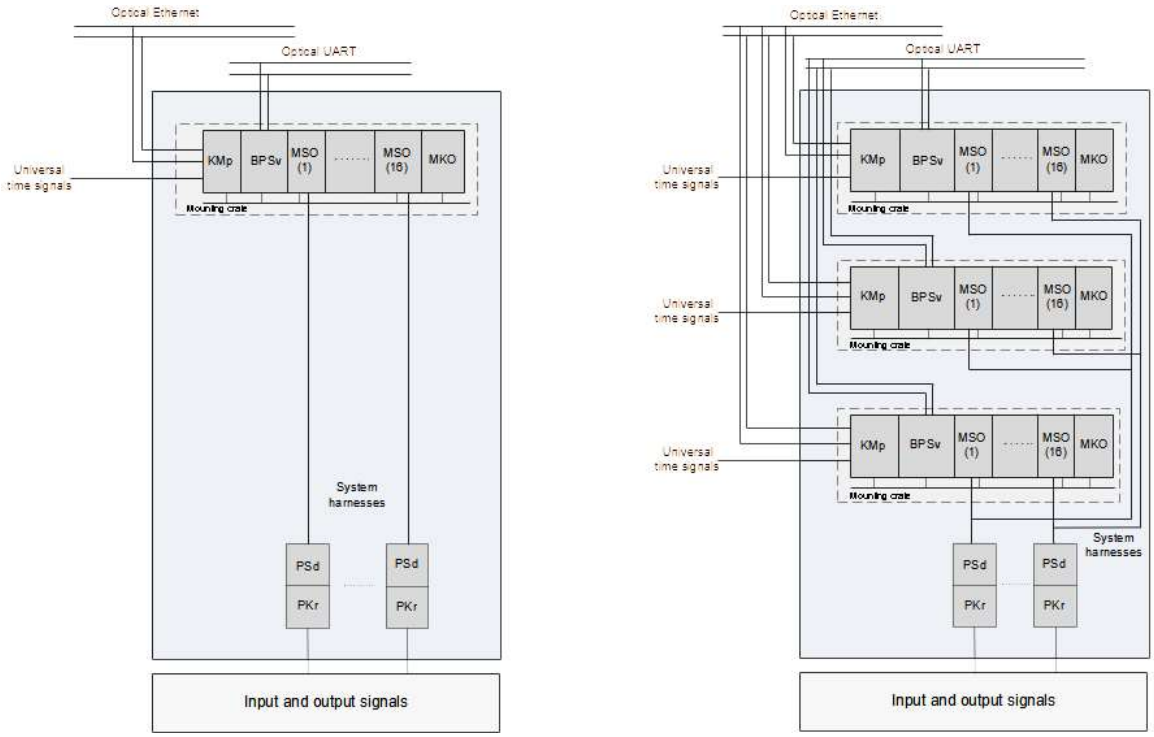
- possibility of usage of non-redundant MSKU-3 or MSKU-3 with triple redundancy of controllers and modules for communication with a facility;
- usage of own-developed real-time system SW and ISAPR programming tools verified and tested within systems important for NPP safety;
- MSKU-3 are registered measuring tools, metrological calibration and attestation are assured with service SW developed at SRPA “Impulse”;
- absence of forced ventilation (cooling is implemented due to a natural air flow through the ventilation grates);
- high reliability of power supply due to use of a redundant power supply system of a cabinet with both alternating and direct current.

Safety class – 2.
Safety category – A.

Key technical characteristics of MSKU-3

Characteristic	Value
Input/output channel quantity:	256
Parameters of input analog signals of direct current and voltage: - medium level voltage / error…… - direct current / error…… - low level voltage / error…… - resistance / error ……	 0-2.5; 0-10 V / ±0.025% 0-5, 0-20 mA / ±0.1% ±10, ±20, ±40 mV / ±0.05% 0-100, 0-200, 0-400 Ohm / ±0.05%
Parameters of input discrete signals : - closed contact resistance……..…….. - open contact resistance……..…….. - direct current voltage……	 less than 500 Ohm more than 10 kOhm 0-4.8 V / 19.2-28.8 V
Parameters of output analog signals: - current / error …..……..	 0-5, 0-20 mA / ±0.2%
Parameters of output discrete signals: - electromagnetic relay……... - solid-state relay…….	 0.5 A / 50 V up to 0.5 A / 12-36 V
Controller’s processor type	Intel Atom
Communication interfaces	Ethernet 100BASE-FX, RS-422, UART
Physical medium of a communication channel: - Ethernet 100BASE-FX, UART……..……. - RS-422……	 fiber-optical cable “twisted pair”
Operating conditions:	

- temperature range…..……..	5-50 °C
- relative humidity……..	up to 95%
Power consumption, not more than..……	300 W
Power supply	up to 6 feeders of 220 V AC and/or DC
Configuration – a floor-standing cabinet (height×width×depth)…….……	1942×610×862 mm
Mass, not more than..……...	350 kg



Structural schemes of MSKU-3 (non-redundant and with a triple redundancy)

MSKU-4 INDUSTRIAL CONTROLLERS

The MSKU-4 industrial controllers by their functional capabilities are close to the MSKU-3 industrial controllers while assuring software and hardware diversity as related to MSKU-3. This feature provides possibility of designing diverse I&C systems.

Functions of MSKU-4:

- inputting and processing data from sensors of analog and discrete signals;
- implementing monitoring and control algorithms, different regulating laws, protections, interlocks, start, and stop of the equipment;
- generating and outputting analog and discrete signals, control commands;
- intercommunication with external users via interfaces based on fiber-optical communication links:
  - Ethernet;
  - UART.

Composition of MSKU-4:

Composition of specific MSKU-4 is determined by specific features of its use in the instrumentation and control system.

Components of MSKU-4:

- KMp microprocessor controllers equipped with ports of Ethernet interface and operated under control of real-time system SW developed at SRPA “Impulse”;
- MSO modules for communication with a facility designated for input/output of discrete and analog signals;
- MSv communication modules designated for organization of data exchange between KMp and MSO and assuring external communications of MSKU-4;
- MKO equipment monitoring modules designated to monitor operability and state of equipment located in an MSKU-4 cabinet;
- PKr cross panels designated to connect field cables;
- PSd connective panels designated for connection of cross panels with modules for communication with a facility and for protection against electromagnetic interference;
- mounting crates designated to install controllers and modules for communication with a facility.

Key characteristics:

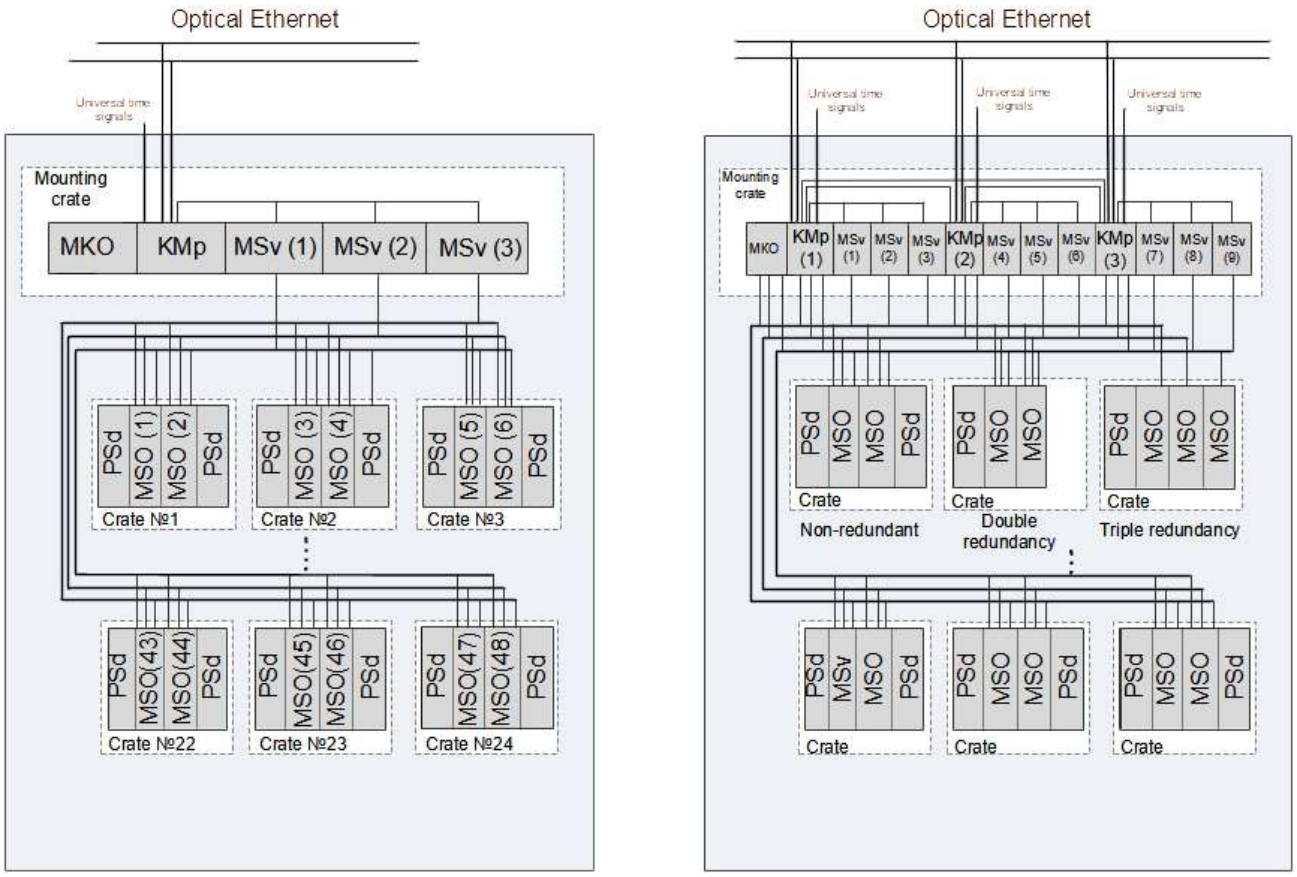
- more flexible adaptation to customer’s demands due to availability of different redundancy schemes for both a central part (KMp controllers) and input/output channels (MSO modules for communication with a facility);
- usage of own-developed system and instrumental SW diverse as related to SW of MSKU-3;
- MSKU-4 are registered measuring tools, metrological calibration and attestation are assured with service SW developed at SRPA “Impulse”;
- absence of forced ventilation (cooling is implemented due to a natural air flow through the ventilation grates);
- high reliability of power supply due to use of a redundant power supply system of a cabinet with both alternating and direct current.

Safety class – 2.

Safety category – A.

Key technical characteristics of MSKU-4

Characteristic	Value
Number of input/output channels (slave cabinets included):	up to 10 944
Parameters of input analog signals of direct current and voltage:	
- medium level voltage / error……	0-2.5; 0-10 V / ±0.025%
- direct current / error……..	0-5, 0-20 mA / ±0.05%
- low level voltage / error……	±10, ±20, ±40, ±80 mV / ±0.025%
resistance / error ……	0-50-150, 0-50-250, 0-100-300, 0-100-500 Ohm / ±0.025%
- low level direct current / error……	0-5 μA / ±0.05%; -0.5…0.5 μA / ±0.25%
- frequency / error ……..	from 45 to 55 Hz / $\pm 4 \cdot 10^{-3}$ % of 50 Hz
Parameters of input discrete signals:	
- closed contact resistance ……	less than 650 Ohm
- open contact resistance ….....	more than 4.84 kOhm
- voltage of “0” level ……..……	0-15, 0-20, 0-40 V
- voltage of “1” level ……	15-30, 79-120, 164-253 V
Parameters of output analog signals:	
- current / error ……	0-20 mA / ±0.025%
Parameters of output discrete signals:	
- electromagnetic relay …….....	direct current – 0.1 A / 250 V alternating current – 0.5 A / 250 V
- solid-state relay ……	direct current – 0.4 A / 12-36 V alternating current – 0.2 A / 187-242 V
Controller’s processor type:	Intel Atom
Communication interfaces:	
- type ……	Ethernet 100BASE-FX, RS-485, RS-422
- number:	
– Ethernet 100BASE-FX, not more……	14
– RS-422, RS-485, not more……..	418
Physical environment of a communication channel:	
- Ethernet 100BASE-FX ….……....	fiber-optical cable
- RS-422, RS-485……..……	“twisted pair”
Power consumption, not more ……	400 W
Power supply:	up to 2 feeders of 220 V AC and/or DC
Section of field cables connected onto spring terminal blocks:	from 0.35 to 2.5 mm^2
Operating conditions:	
- operating temperature range ……..	0-50 °C
- humidity……	up to 95%
Design – a floor-standing cabinet (height×width×depth)……..	2056×610×900 mm
Mass of a cabinet, not more ……...	500 kg



Structural schemes of MSKU-4 (non-redundant and redundant)

USPO DEVICE FOR COMMUNICATION WITH AN OPERATOR'S PANEL

The USPO device for communication with an operator's panel is a remote controller mounted in panels of control rooms and designated for interaction with controls and alarms (switches, lamps, and annunciators) located on panels.

Functions of USPO:

- receiving "dry contact"-type signals with commands from switches for remote control of the actuators (including from switches with redundant coding), mode selecting switches, switches and buttons for testing, blinking and sound removal;
- generating potential signals controlling actuator position indicators;
- generating potential signals controlling technological alarm annunciators and potential signals controlling sound alarm devices.

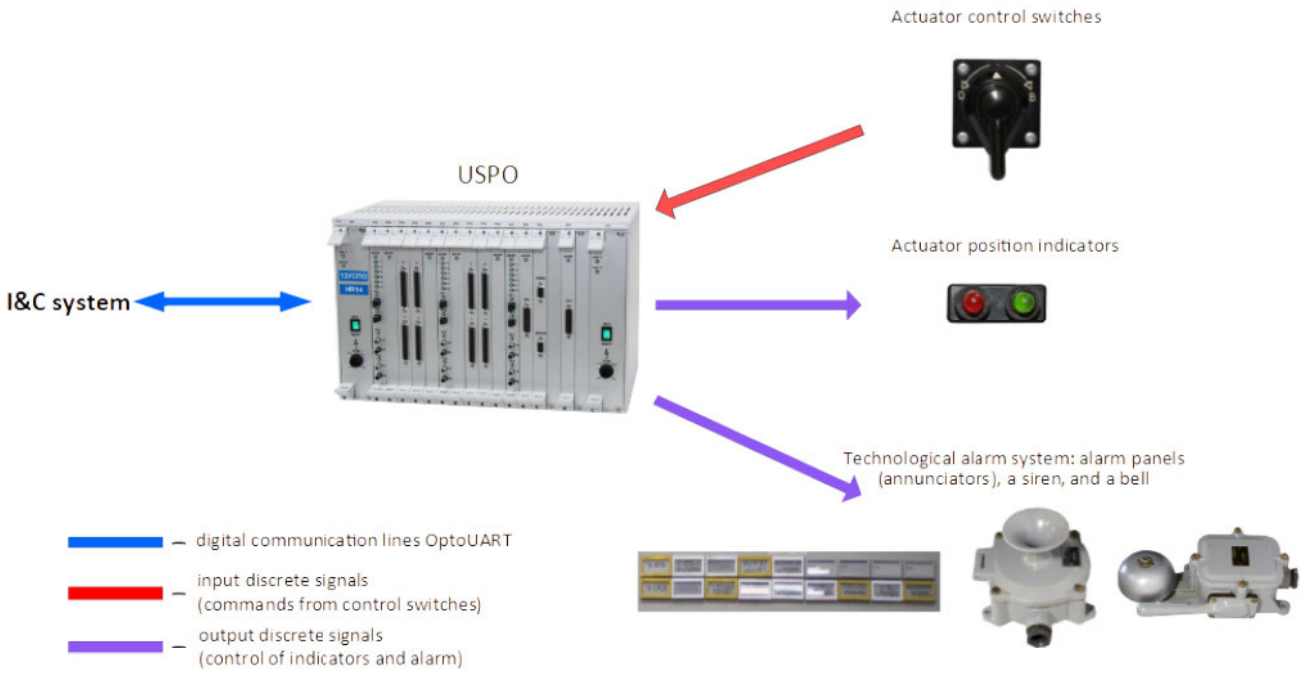
Composition of USPO:

- a mounting crate 6U 19";
- power supply units;
- communication modules assuring data exchange with the other I&C devices via fiber-optical communication lines;
- functional assemblies of such types:
  - an assembly of BPI information receiving modules for inquiry of coded switches;
  - an assembly of BPI information receiving modules for inquiry of switches without coding;
  - an assembly of BId indicating modules for control of actuator position indicators;
  - an assembly of BS alarm modules for control of technological alarm annunciators and sound alarm devices.

Key characteristics:

- high tolerance to failures due to use of redundant structures of functional assemblies (modules in assemblies are double-redundant) and a power supply system;
- signals from switches, lamps, and alarm annunciators are transferred in a digital form via redundant optical communication links, which significantly reduces cable connections between I&C systems and control panels.

Safety class – 2.
Safety category – A.



Interaction scheme of USPO with connected equipment

EQUIPMENT FOR CONTROL OF ACTUATORS – ShDS DISCRETE SIGNALS CABINET

The ShDS discrete signals cabinets are used in I&C systems to fulfill an actuator control function.

Functions of ShDS:

- generating signals of control and monitoring of state of actuators of shut-off, air-operated isolating, regulating valves and electric motors;
- generating discrete output signals to adjacent systems;
- inputting discrete signals from adjacent systems.

Composition of ShDS:

- distributors of power supply from two inputs;
- power supply units (two for each signal generating device);
- signal generating devices based on the mounting frames 6U 19”, containing:
  - functional modules (maximum number of the functional modules installed into ShDS is 72 pcs.);
  - communication modules assuring data exchange with the other I&C devices via fiber-optical communication lines;
  - a monitoring module.

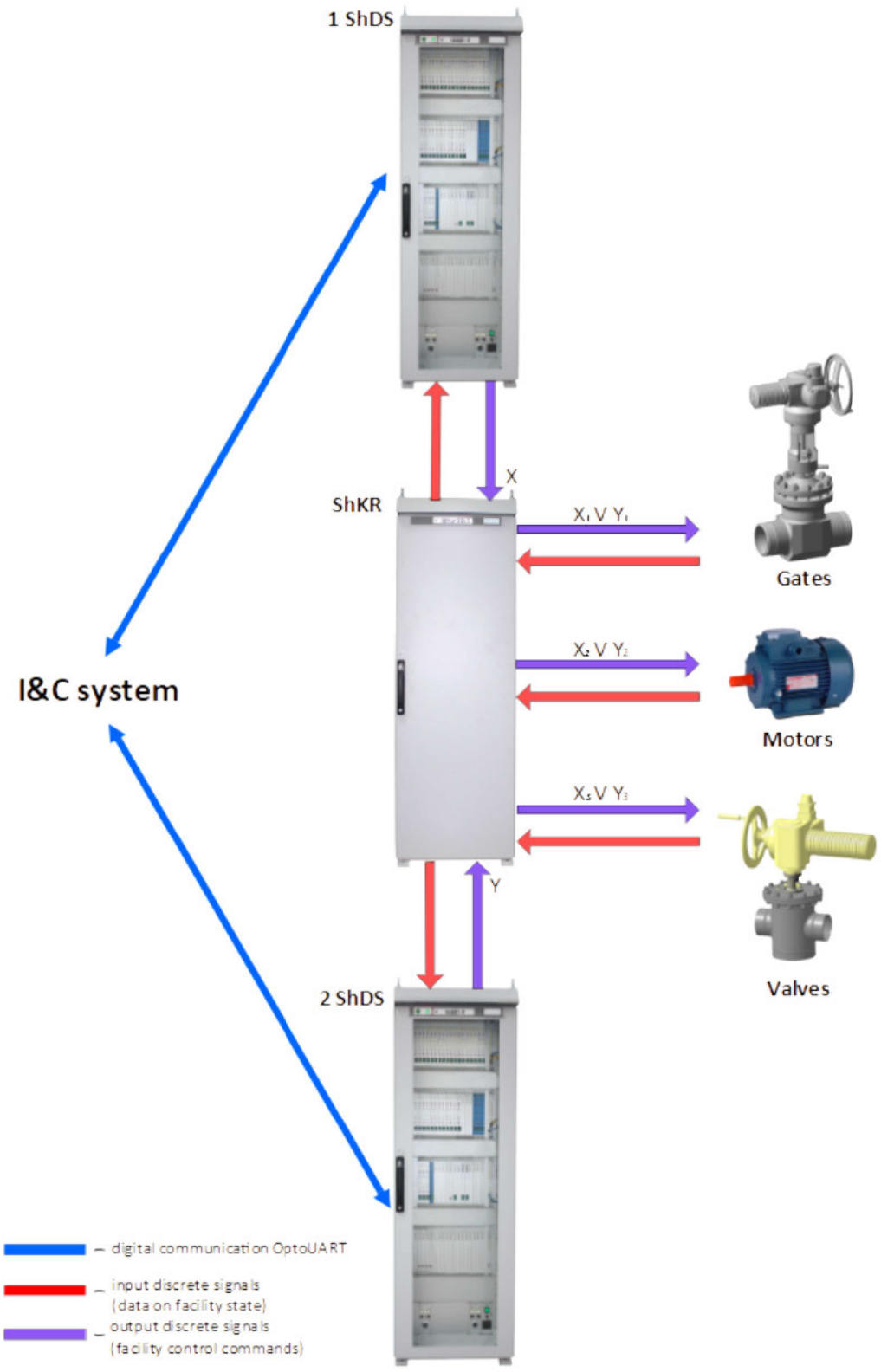
The ShDS discrete signals cabinets can be installed in pairs with the identical arrangement for their mutual redundancy.

An ShKr cross cabinet is used to connect circuits of two mutually redundant ShDS cabinets to actuators by the “OR” scheme (parallel connection). The ShKr cross cabinet includes 72 passive PSd backplanes assuring combining signals from two mutually redundant ShDS cabinets (connectors from one side of ShKr) to connection to actuators (terminal blocks from the other side of ShKr).

Key characteristics:

- possibility of redundancy of functional modules (within a pair of ShDSs) and a power supply system (redundancy of power supply units and distributors);
- significant quantity of possible connections (up to 72 actuators per one ShDS cabinet).

Safety class – 2.
Safety category – A.



Interaction scheme of ShDS and ShKr with connected equipment

REDUNDANT CENTRAL CONTROLLER – ShUK CONTROL AND SWITCHING CABINET

The ShUK control and switching cabinet is designated for execution of technological algorithms and for data exchange between I&C components in safety control systems and normal operation systems. ShUK can be used for composition of redundant control and switching subsystems by installation of mutually redundant cabinets performing identical functions and executing identical algorithms.

Functions of ShUK:

- executing algorithms by functions of protective actions (protection algorithms with “2oo4” logical schemes), technological protections and interlocks (protection algorithms with “2oo3”, “2oo2”, “1oo2”, “1oo1” logical schemes), and alarm;
- switching digital data between devices of an I&C systems via digital optical communication channels.

Composition of ShUK:

- power supply distributors;
- power supply units;
- fiber-optical cable crosses;
- a microprocessor controller operating under control of real-time system SW developed at SRPA “Impulse”;
- a control module;
- communication modules;
- a monitoring module.

Key characteristics:

- assurance of the high failure tolerance of a central part and a control network due to use of redundant ShUK cabinets within I&C systems;
- use of own-developed real-time system SW and ISAPR programming software tools verified and tested within systems important for NPP safety;
- high reliability of power supply due to use of independent redundant primary power supply units and distributors of direct or alternating current.

Safety class – 2.
Safety category – A.

PS5140 WORKSTATIONS

The PS5140 workstations are design-arranged industrial computers used as diagnosing and archiving servers, engineering stations, workplaces of operators and gateways operated under control of operator's station software developed at SRPA "Impulse" based on OS Linux.

Functions of PS5140:

- as a workplace of an operator – gathering technological process information and displaying this information to an operator;
- as a diagnosing and archiving server – gathering technological and diagnostic information from all I&C devices, archiving, and displaying actual and retrospective information to an operator;
- as an engineering station – gathering, archiving, and displaying information to an operator, possibility of changing functional settings of I&C systems;
- as a gateway – gathering and transferring information.

Composition of PS5140:

- a processor module containing:
  - a steel high-strength case with an aluminium front panel;
  - an exhaust ventilation unit;
  - three compartments for 5.25" storage devices, two compartments for 3.5" or 2.5" storage devices in a basket on a shock-resistant hanger;
  - PICMG-backplane for 14 PCI/PCI-e slots;
  - a processing unit with an Intel Core I5/I7 processor;
  - a DDR3 random-access memory;
  - a video controller;
  - information storage devices on HDD hard magnetic disks and on SSD solid-state disks;
  - a redundant power source with the possibility of "hot" swapping;
- an uninterruptible power supply device;
- display devices – large-screen monitors;
- an emergency transfer switch;
- networking equipment;
- a construction with such possible composition elements:
  - a table – an operator's workplace;
  - a supporting pedestal – placing monitors of operator's workstations;
  - a pedestal – placing a processor module, an uninterruptible power supply device;
  - a cabinet-pedestal – placing a processor module, an uninterruptible power supply device, networking or other additional equipment;

- a cabinet – placing industrial monitors, processor modules, and networking equipment.

Key characteristics:

- possibility of universal usage in instrumentation and control systems;
- use of highly-reliable industry-version uninterruptible power supply devices with redundant power supply units and accumulator batteries operating in parallel on output, which makes it possible to perform swapping of power supply units and accumulator batteries without switching-off a workstation;
- use of own-developed operator's station software verified and tested within systems important for NPP safety;
- possibility of connection of up to four monitors to one workstation;
- possibility to be used for continuous operation;
- an easily operated and maintainable construction.

Safety class – 3.
Safety category – B.

Operating conditions

Influencing factor	Values of influencing factors	
	Operating	Limiting
Temperature, °C: – lower value – upper value	 18 27	 - 50
Relative humidity, %: – lower value – upper value	 20 80	 - 90 (duration of influence is 2 h)
Barometric pressure, kPa: – lower value – upper value	 86 108	 - -

Variants of workstation designs

NKU RTZO-I LOW-VOLTAGE SWITCHGEARS

The NKU RTZO-I low-voltage switchgears – three-phase alternating current distributors of closed version, one-way service are designated to distribute electric power to low-power users.

RTZO-I assembly

Composition of NKU RTZO-I:

- an input cabinet (ShV);
- a functional control cabinet (ShFnU) with the following types of units: BUZ – stop valve control unit; BUD – motor control unit; BUK – valve control unit; BRs – distribution unit. Up to 12 BUZ, BUK, BUD units or up to 36 BRs units can be installed into ShFnU.

Up to seven ShFnUs with one ShV can be consolidated into RTZO assembly.

Functions of NKU RTZO-I:

- ShV is intended to perform following functions:
  - receiving three-phase alternating current on two inputs;
  - distributing AC electric power into the main circuits of ShFnU cabinets and protecting the main circuits against overload currents and short circuit;
  - automatic backup actuation assuring input power supply with the possibility to adjust the following parameters:
    - U_{min} - if a value of input voltage of any phase is less than U_{min}, transition to the backup input is carried out;
    - U_{max} - if a value of input voltage of any phase is more than U_{max}, transition to the backup input is carried out;
    - automatic transition from the backup input to the main one;
    - delay time for transition from the main input to the backup one; delay time for transition from the backup input to the main one;
  - acquiring and transferring diagnostic information into an input-output module of ShFnU through electric communication lines;
  - voltage availability monitoring and displaying operating voltage parameters of the main circuit, alarm generating in case of its deviation from a norm or a fault;
- ShFnU is intended to perform the following functions:
  - distributing with BRs electric power of three-phase alternating current with voltage 400/230 V, with frequency 50 Hz, with current consumption monitoring;
  - controlling actuators with BUZ, BUK, and BUD units having software adjusted for a certain type of actuators;
  - broadcasting three-phase alternating current up to 100 A on each phase and with voltage 400/230 V to other ShFnUs of an RTZO assembly;
  - outputting drive control commands;

- diagnosing actuator equipment operability and outputting diagnostic information via a digital interface;
- alarm generating by results of diagnostics.

Key characteristics:

- significant reduction of equipment as compared to RTZO-69 and RTZO-88 due to increase of quantity of connections in one cabinet (up to 12 connections depending on version);
- reduction by up to 8 times of cable connections in comparison with current RTZO-69 and RTZO-88 due to a digital optical interface with the upper control level;
- quick change of cabinet configuration to assure interaction with different types of actuators defined by a customer;
- possibility of fast recovery of operability without switching off the power supply of a cabinet or an RTZO assembly;
- ease of operation and maintenance due to use of unified replaceable modules;
- a power cable can be inputted into an ShV cabinet both from the top and from the bottom of the cabinet;
- connection type of control units (BUZ, BUD, BUK) and BRs – pull-out;
- settings of control units are changed from the front panel;
- availability of a built-in valve diagnostics function allowing quick evaluation of current technical state of valves and its separate nodes;
- a checking algorithm is implemented in control units, the algorithm assures simulation of control command execution without its physical generation;
- control units can be in three states: operating, testing, and switched off. Check and adjustment are carried out in the testing state, herein power, input, and output circuits are switched off;
- load power range – from 0.1 to 22 kW;
- operating voltages – ~230, ~ 400 V;
- operating voltages of control circuits – ~ 230, —24 V;
- rated current of an RTZO assembly – 100 A;
- insulation strength of power circuits – 2100 V DC;
- insulation strength of control circuits – 1500 V DC.

RTZO-I assembly with open ShFnU

Diagnostic functions:

- monitoring power supply;
- monitoring currents of load on three phases;
- monitoring state of end switches;

- monitoring execution of control commands with determination of a command source;
- determining cos φ;
- monitoring symmetry of supply voltage and current consumption of actuators;
- monitoring phase interlacing;
- acquiring and transmitting diagnostic information.

Seismic resistance: cat. I according to PNEG-5-006 (7 points).
EMC: group IV according to SOU NAEK 100:2016.
Protection types of an electric motor:

- thermal protection;
- against short-circuit currents.

Ambient temperature range – from plus 5 to plus 60 °C.
Safety class – 2.
Safety category – A.
Degree of protection – IP31.
Life – 30 years.

Implementation facilities:
Zaporizhzhya NPP

IA-3, IA-4 SOFT STARTERS

Functions of IA-3, IA-4:

- controlling electric drives of regulating valves;
- softly starting an electric motor;
- electrodynamically braking an electric motor.

Technical characteristics of IA-3:

- capacity of controlled electric motors – from 3 to 15 kW;
- range of operating ambient air temperatures – from +5 to +75 °C;
- DU-O and DU-Z control commands are characterized by direct or pulsating voltage 24 V;
- power supply of IA-3 – three-phase voltage 220/380 V.

Technical characteristics of IA-4:

- capacity of controlled electric motors – from 0.06 to 3.5 kW;
- range of operating ambient air temperatures – from +5 to +50 °C;
- DU-O and DU-Z control commands are characterized by a range of direct or pulsating voltage from 18 to 34 V;
- power supply of IA-4 – three-phase voltage 220/380 V.

Key characteristics:

- structural design (a remote device for wall or panel mounting) assures ease of installation and maintenance;
- possibility of implementation of different variants of actuator control:
  - from local regulators;
  - from controllers of instrumentation and control systems;
  - from a console of a process operator (manually);
- use of several modes of operation:
  - continuous;
  - short-term;
  - intermittent with frequency up to 630 activations per an hour.

Safety class – 3.
Safety category – B.
Protection degree – IP 54.

Implementation facilities:

- Khmelnitsky NPP
- Zaporizhzhya NPP
- Rivne NPP
- South-Ukraine NPP
- Kozloduy NPP (Bulgaria)

RShch-1 PANEL ELECTRONIC MULTI-CHANNEL REGISTRATOR

Functions of RShch-1:

- inputting and processing signals of thermal electric transducers, resistive temperature transducers, voltage sensors, current signal sensors, resistance sensors, as well as discrete signals;
- recording and archiving values of input analog and discrete signals;
- linearizing characteristics of thermal electric transducers and resistive temperature transducers;
- extracting a square root from a value of a current input signal;
- generating output discrete signals as functions of values and signs of transitions out of setpoints of input analog signals, values of input discrete signals, signs of RShch-1 state;
- generating output discrete signals as functions of values and setpoints of input analog and discrete signals, signs of RShch-1 state;
- showing measuring results and diagnostic information on a built-in TFT display as digital values, diagrams, and histograms;
- monitoring connection of sensors.

Technical characteristics of RShch-1:

- versions have been developed with 4, 8, 12, and 16 galvanically isolated universal input analog channels;
- versions have been developed with 8, 16, and 24 galvanically isolated output analog channels;
- time of inquiry of 16 channels – not more than 200 ms;
- data exchange is carried out via an RS-485 interface;
- error of measurement is 0.1 %;
- data archiving time – from 2 days to 1 year (depending on an archiving interval);
- possibility to save archive information to a USB drive;
- environment temperature – from +5 °C to +60 °C.

Key characteristics:

- structural design assuring ease of installation and maintenance, as well as installation to places of displaying devices have been used earlier on NPP unit control boards;
- ease of operation due to a user-friendly operator interface;
- use of universal galvanically isolated input analog channels;
- wide range of signals received from sensors;
- two versions of a display with the dimensions 6.4" and 10.4".

Safety class – 2.
Safety category – A.

Protection degree: a front panel - IP 54, a case – IP 20.

Implementation facilities:
Zaporizhzhya NPP

PrS SIGNAL CONVERTER

The PrS signal converter – a device for panel mounting designated for replacement of EP 4700 AS, EP 4701 AS measuring transducers and EP 4710 AS rooting units.

Functions of PrS:

- converting a signal of a thermoelectric transducer or a resistance temperature transducer to a unified signal of direct current or DC voltage with the possibility of linearization of a rated static characteristic of a sensor;
- converting a direct current input signal to a unified signal of direct current or voltage with the possibility of square-rooting function fulfillment;
- feeding primary measuring transducers of “Sapphire-22” type;
- delivering measurement results to an RS-485 main;
- delivering measurement results and diagnostic information to a built-in liquid-crystal display;
- delivering a discrete signal of “dry contact” type as a monitored parameter overruns an upper or lower limit.

Key characteristics:

- monitoring of input and output channel operability;
- delivery of all required information (a value of an input analog signal, a range of an input analog signal, a temperature value of cold junction, a value of an output analog signal, fault indication) to a liquid-crystal display;
- protection against short circuit in a load circuit of an analog output;
- possibility of carrying out adjustment to a chosen sensor type and a range of work, as well as calibrating in an automatic mode;
- galvanic isolation of power circuits, an input analog signal, an output analog signal, output to an RS-485 main, input discrete and output discrete signals;
- possibility of quick replacement of a device without rearrangement of power supply, information, and controlling circuits.

Protection degree – IP31.

Implementation facilities:

- Khmelnitsky NPP
- Zaporizhzhya NPP
- Rivne NPP
- South-Ukraine NPP

ENERGY-RELEASE AND THERMAL-MONITORING STUBS

The energy-release (EV) and thermal-monitoring (TK) stubs are designed to be used in in-core monitoring systems.

Function of the stubs – transmission of electric signals to a connection node:

- the EV stubs – from connectors of assemblies of in-core detectors (SVRD) to an electrical connection node on a concrete vault;
- the TK stubs – from connectors of compensating devices of UK-82, UT-0186 type, a connecting box for thermal monitoring of cases of control and protection system rod drives or their analogues.

Composition of the stubs:

- high-temperature insertion in EV stubs;
- a heat and moisture protected cable enclosed into a stainless braid;
- a connector for connection to SVRD or compensating devices;
- a device to seal the connector after it has been connected to SVRD;
- elements for protection against mechanical damages;
- a set of installation parts.

Key characteristics:

- high resistance to temperature and radiation;
- moisture protection, can operate under air-steam mixture conditions;
- survival in emergency and post-emergency conditions, including at a loss-of-coolant accident (LOCA);
- survival at local overheating to a level of primary coolant temperature.

Implementation facilities:

- Zaporizhzhya NPP
- Khmelnitsky NPP

I&C SOFTWARE

The complex of the software products developed at SRPA “Impulse” makes, together with the hardware, basis for design of I&C systems.

The software has been developed according to the technology recommended by IEC 60880, IEC 62138 standards, each development phase is completed with development of documents, verification, and documentation of the verification process.

Composition of the system software:

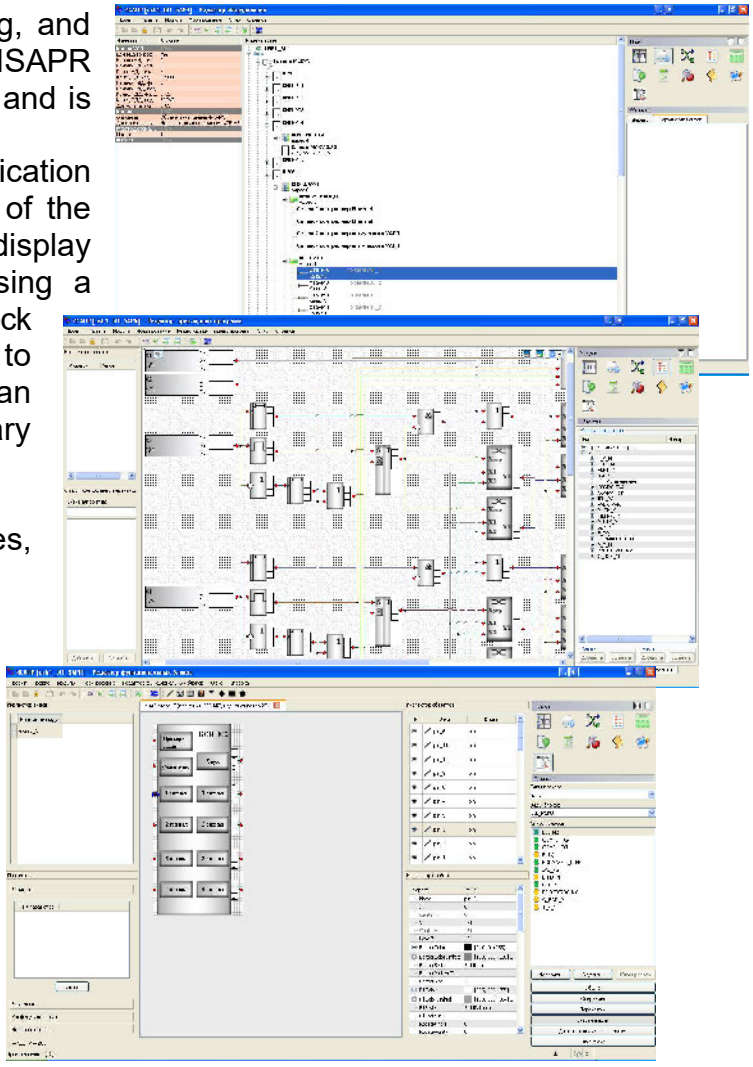
- SW tools to prepare and debug application software;
- real-time system SW;
- SW of operator stations;
- test and service SW.

SOFTWARE TOOLS

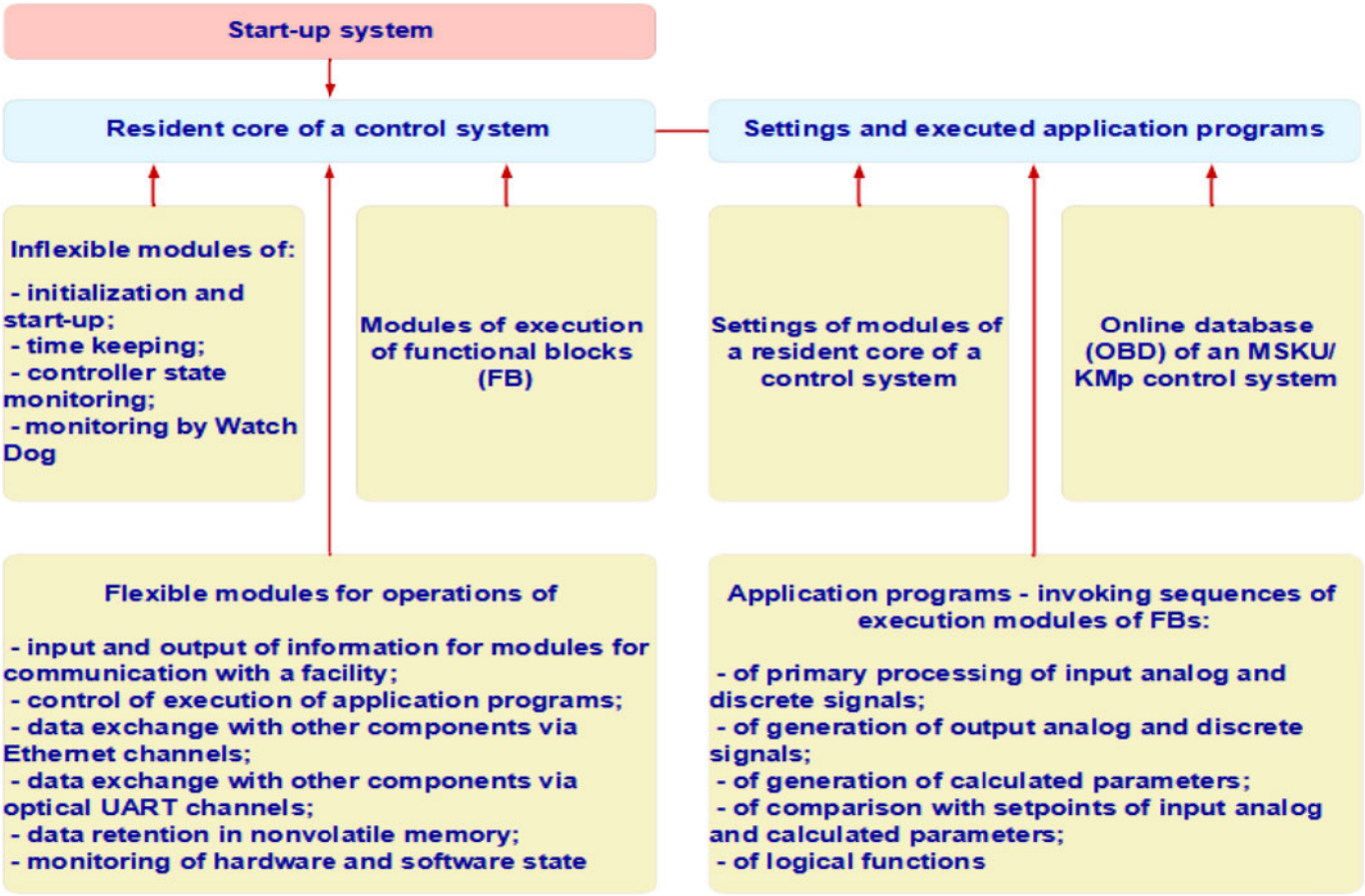
As the SW tools to prepare, debug, and support application software the ISAPR program system has been developed and is used at SRPA “Impulse”.

ISAPR assures creation and modification of settings and application programs of the real-time system SW, as well as display settings SW of operator stations using a graphic language of functional block diagrams (FBD language). User is able to utilize logical functional blocks from an already existing comprehensive library or to create an own block in a special editor.

ISAPR has a wide set of capabilities, a user-friendly graphical interface, as well as modular structure, which assures reliability and ease of use, quickens the process of mastering skills to operate the software product.



REAL-TIME SYSTEM SOFTWARE



The real-time system software is represented with the following components:

- a start-up system of a controller;
- a core of a control system.

Main functions of the start-up system of a controller:

- initial testing of a controller;
- initializing a controller;
- starting a control system.

The start-up system is recorded into a Flash memory of system programs during manufacturing and is inaccessible by a user. The start-up system is started from Flash memory automatically when a controller is switched on.

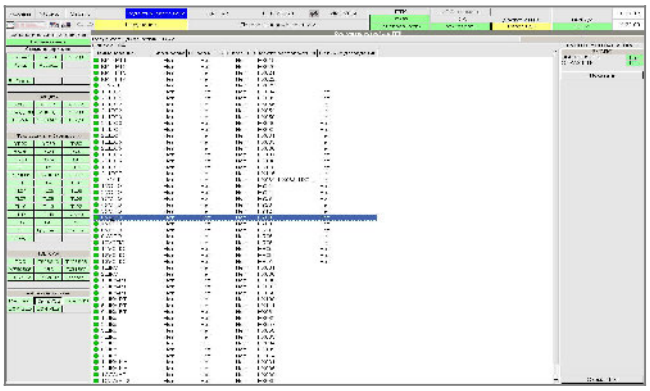
Main functions of the resident core of a control system:

- inputting, outputting, and processing data through signal input-output modules;
- synchronizing controllers;
- mutually monitoring data received between redundant controllers;
- maintaining universal time in controllers;
- exchanging information between I&C components via communication lines of a local network;
- monitoring equipment state and transmitting data on equipment state into a diagnosing and archiving server;
- controlling start of application programs.

Settings of modules of a control system core and application programs invoking sequences of execution modules of functional blocks are formed using ISAPR tools.

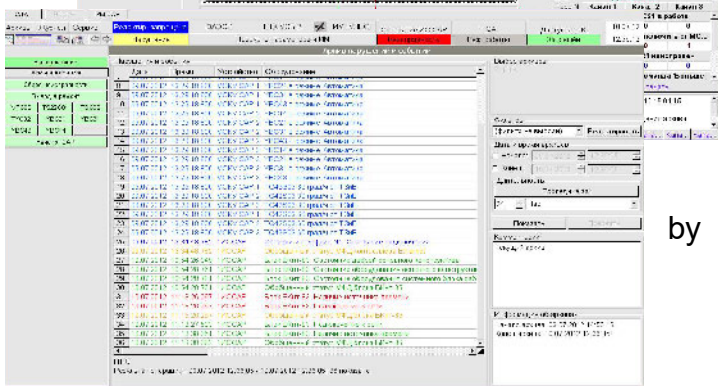
SOFTWARE OF OPERATOR STATIONS

The software of operator workstations is presented with a system of programs to receive, process, display, and archive data that is designated to perform the following functions:



- receiving and processing data from I&C components, forming an online database of parameters;
- creating video frames and visualizing current information on a technological process;
- keeping an event log;
- archiving current information on a technological process, events, logging operation of I&C systems;
- monitoring (background) state of I&C equipment;
- transmitting data via an information network to other I&C systems of a power unit.

Cybersecurity of the software of operator stations is assured with the following:

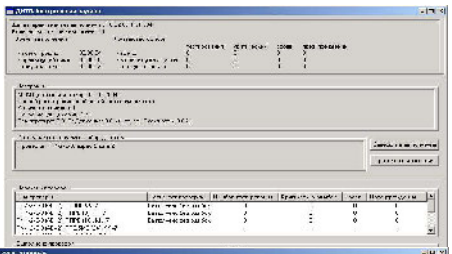


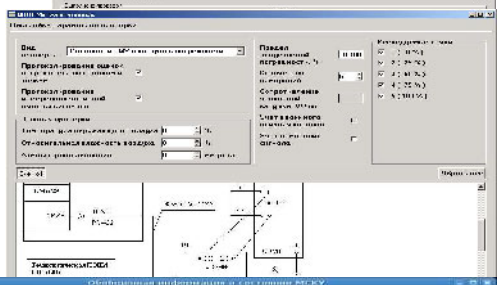
- compliance of the used protection methods with the requirements and recommendations of IAEA NS-G-1.1 Guide, RG 5.71 Guide, standards of ISO/IEC 27001:2013 series, etc.;
- integrity monitoring of installed programs with notification on errors detected;
- periodic monitoring of data integrity in archives of parameters, events, and protocols;
- monitoring of resources used by archives as related to installed resources;
- interaction between servers by means of specialized TCP/IP ports;
- authorization and distinction of a level of user access to technological parameters of a database;
- interaction with users via a network using a specialized protocol;
- periodic monitoring of execution of minimum required services and restart of failed services.

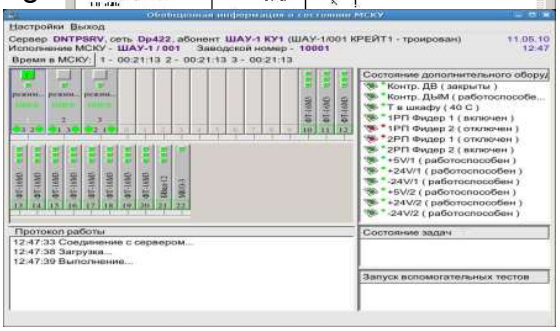
TEST AND SERVICE SOFTWARE

Service SW is presented with the following components:

- a system of programs for maintenance of industrial controllers of MSKU series;
- a system of programs for metrological calibration and certification of measuring channels of I&C systems.







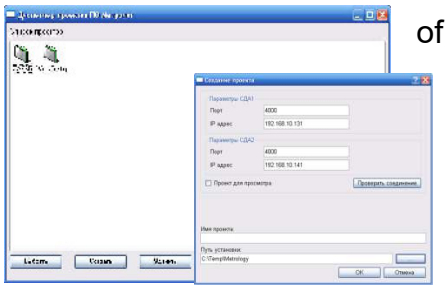
Main functions of SW for maintenance of industrial controllers of MSKU series:

- monitoring measurement errors of electric lines of measuring channels;
- evaluating and monitoring metrological characteristics of electric lines of measuring channels;
- adjusting electric lines of measuring channels;
- monitoring and displaying current state of hardware;
- archiving and logging processes of testing and adjustment.

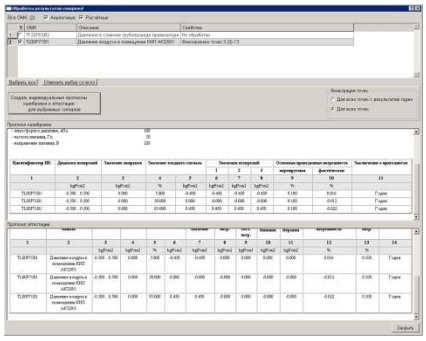
SW for maintenance of industrial controllers of MSKU series reliably assures possibility to evaluate and monitor metrological characteristics of MSKU both during an outage and during a period between repairs.

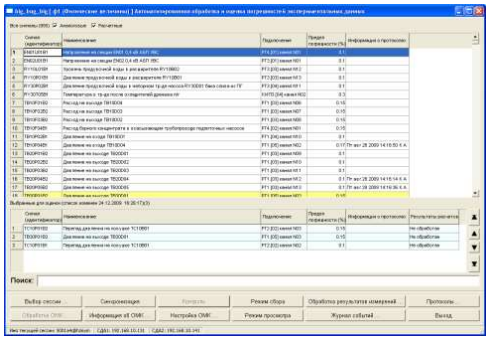
Main functions of SW for metrological calibration and certification of measuring channels of I&C systems:

- receiving experimental data from a diagnosing and archiving server according to a given list of measuring channels;
- processing experimental data, calculating an error of measuring channels;
- rejecting measuring channels in case of incompliance with a given error;
- monitoring and displaying current state of measuring channels;
- forming records of calibration and certification of measuring channels.



This software product has a user-friendly interface and allows carrying out metrological calibration and certification of measuring channels of I&C systems reliably and within the shortest terms.





LICENCES, CERTIFICATES

SRPA “Impulse” is a corporative supplier of SE NNEGC “Energoatom”, as well as large companies – system integrators of NPP I&C systems.

The quality control system for manufactured products has been certified for meeting the requirements of DSTU ISO 9001:2015, ISO 9001:2015, the environmental management system has been certified for meeting the requirements of DSTU ISO 14001:2015, the labor health and safety management system has been certified for meeting the requirements of DSTU ISO 45001:2019, the information security management system has been certified for meeting the requirements of BS EN ISO 27001:2013.

The software has been developed in strict correspondence with international standards. The equipment has passed testing and meets the requirements of standards of Ukraine and international standards for electromagnetic compatibility, resistance to environmental conditions, and seismic conditions.

Achievements of SRPA “Impulse” in development, manufacturing, testing, and support of the systems important for NPP safety have been confirmed in the official report of the IAEA Expert Mission.

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INTERNATIONAL ATOMIC ENERGY AGENCY

FINAL MISSION REPORT

INDEPENDENT ENGINEERING REVIEW OF INSTRUMENTATION AND CONTROL SYSTEMS (IERICS)

IAEA REVIEW OF THE DIGITAL COMPUTER I&C SYSTEM (MSKU 3M) DESIGNED BY SRPA “IMPULSE”

Review Mission: Severodonetsk / Zaporizhzhya / Kiev, Ukraine
21 to 27 April 2013

Follow-up Mission: Vienna, Austria
12 to 14 November 2015

INDEPENDENT ENGINEERING REVIEW OF
INSTRUMENTATION AND CONTROL SYSTEMS
(IERICS)

IAEA REVIEW OF THE DIGITAL COMPUTER I&C SYSTEM (MSKU 3M)
DESIGNED BY SRPA “IMPULSE”

IAEA DEPARTMENT OF NUCLEAR ENERGY
DIVISION OF NUCLEAR POWER

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