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V.P. Zimin, R.A. Ivanov, V.N. Shitkov. **Potential Approaches to Energy and Transportation Challenges in Remote Regions of Russia.** Pp. 5–11.

The authors examine possible ways of resolving power supply problems in remote regions of the Russian Federation through the use of indigenous stand-alone gas turbines and hybrid power plants configured around them. The paper outlines engineering solutions for fuelling the turbines with synthetic gases produced of cheap-grade solid fuels.

Besides, the paper reviews various issues associated with the development of transportation in difficult remote regions of Russia.

The authors show that using gas turbines offers indubitable advantages in terms of designing compact power-generation modules, which can efficiently run on conventional liquid and gas hydrocarbons as well as on unconventional local fuels. Hovercraft platforms present an attractive option for areas that lack sufficient transportation infrastructures.

It is concluded that Russian industries are well prepared for producing and delivering the discussed power-generation packages and vehicular power plants.

G.M. Pliskin. **Main Equipment Characteristics for a Highly Efficient Floating Power Station Using Indigenous Gas Turbines with Exhaust Heat Recovery.** Pp. 12–21.

The suggested engineering solutions enable to configure a highly efficient environment-friendly floating power station using converted Russian-built gas-turbine engines that offer better efficiency performances than the so far utilized Ukrainian second-generation turbines.

The gas-turbine power plant of the intended floating station consists of three simultaneously operating modules containing Type 20PM turbines from Perm and three tube waste-heat boilers, one auxiliary Type TVZ-117 gas turbine from Klimov Works and one Type KVVA 6/5 auxiliary boiler.

With a rating of 52MW and all three main modules running at their top output, this turbine-based power station can deliver 50MW of electricity and 53MW of commercial heat with a specific fuel oil consumption of 0.233kg/kW·hr. The heat efficiency of such a power station, or its fuel utilization efficiency, constitutes 77% with the rated continuous power of the gas-turbine engines taking into account the auxiliary electricity and heat take-off. With two of the main modules running with the same SFOC, the facility outputs 66% of its commercial electricity and heat capacity. In this case, the heat efficiency considering the auxiliary take-off amounts to 76%.

The suggested gas-turbine plant can be installed in the hull of the *Severnoye Sijanie* floating station. It has been already validated by practical experience that such a hull could be towed along numerous shallow Siberian rivers, which allows not only positioning new floating stations, but also upgrading power equipment of the existing ones.

With the available shipyard capacities, building such an advanced gas-turbine power station would take 1.5~2 years. The construction of similar fixed land installations in remote areas presently requires 5 to 7 years and the work quality is notoriously poor.

E.K. Vasilkov, V.N. Shitkov. **A Comparative Review of Main Power Plant Particulars for a Fast Container Ship.** Pp. 22–28.

The Pr.1609 *Atlantika* fast container ship commissioned over twenty years ago had a gas-turbine power plant configured of two M25 turbine units of 25,000hp (18,400kW) each, starboard and portside, individually driving respective propeller shafting. Each M25 unit incorporated a Type DT59 main gas turbine, a gearbox, a waste heat recovery circuit and a steam turbine. The specific oil consumption of such a unit was 255g/kW·hr.

Today, such vessels need much more efficient powering that could be based on either advanced gas turbines or internal combustion engines. For the former option, one may suggest a gas-turbine unit with a complex heat cycle involving intermediate air cooling and exhaust heat recovery. Such a machine could be built around a converted aircraft turbine 16PM rated for 16MW. The propulsion plant would have two complex-cycle gas turbines, one gearbox and contra-rotating propellers. With this configuration, the specific oil consumption should be 190g/kW·hr.

Investigations for the optimum main power plant configuration included considering a system with one Type 9DKRN 80/230-15 Diesel engine fitted with a waste heat recovery gas turbine. The design anticipated driving a fixed-pitch propeller.

Comparative assessments were made exclusively for the main power units. Economic and technical comparison criteria included the delivery contract price, consumed fuel and lubrication oil prices, repair, scheduled maintenance and SPT&A prices.

It was established that the most efficient option is the Diesel-engine power plant. However, burning heavy oils could enable the gas-turbine option to become a tough competitor.

R.A. Ivanov, V.A. Soskov. **Design Feasibility Assessments of a Closed-Cycle Internal Combustion Engine in an Air-Independent Power Generation Module for Underwater Vehicles.** Pp. 29–39.

The article presents results of R&D investigations on an air-independent (AIP) power module configured around an internal combustion engine that operates on diesel oil and oxygen in the limited space of a spherical pressure hull. These results include:

– Basic thermal-hydraulic arrangement of the AIP plant;
– Estimated coolant parameters and auxiliary machinery power;
– Weight and size particulars, and the AIP plant layout diagram;
– Power module characteristics as functions of the diving depth.

The authors compare power, weight and size characteristics of the suggested internal combustion power-generation module against those of storage batteries.

Design estimations indicate that for a submersible with an operational depth of H_p<2000m and a required power yield capacity of at least 240kW·hr with a specified negative buoyancy, the internal-combustion AIP power-generation module is superior to storage lea-acid or silver-zinc batteries. The achievable weight and size particulars could respectively be 2~3 and 1.2~1.6 times better. Besides, compared to silver-zinc batteries, the AIP module has many times better service life parameters.

M.Sh. Denisova, Yu.M. Dlougoborsky, V.A. Frisk. **Combined Underwater Power-Gas Generation Plants Based on Hydrone Fuel Cells.** Pp. 40–56.

The paper presents results of numerical and experimental justification studies on combined power-gas generation plants configured around hydrone fuel cells and demonstrates their efficiency for underwater vehicles.

Research and design studies indicate that proper selection configuration and operation parameters allows catering for both power generation and boosted gas production functions virtually without any weight and volume increases compared to conventional fuel cell systems for underwater vehicles. An additional requirement is to install a light tank of a volume within 3% of the subject vehicle displacement.

The efficiency of depth manoeuvring with the help of the power-gas generation plant was assessed through the consumption of power resources (the anode material) for gas production and electricity production as necessary to perform same manoeuvres using the propulsion system. It was found that depending on manoeuvring depth and direction, applying the boosted gas production capability could save 30~50% of the energy resource or accordingly reduce the time necessary for depth manoeuvring with equal power resource expenses.

The suggested combined power-gas generation fuel-cell plant could be most efficient on vehicles that have mission profiles involving multiple depth manoeuvres.

R.A. Ivanov, V.A. Soskov. **Types and Particulars of Systems Intended to Remove Hydrocarbon Burning Products from Underwater Air-Independent Plants.** Pp. 57–62.

The authors compare performances of various techniques for removing hydrocarbon fuel burning products from air-independent propulsion plants assuming either discharging outboard to storing inside the vehicle to compensate for the spent reaction consumables.

The comparison covers the removal of the carbon dioxide, which is the dominant burning product, from exhausts cooled down to ~330K using the following techniques:

– Direct discharge outboard by a gas take-off compressor;
– The British system from Coswort Deep Sea System Ltd.;
– Carbon dioxide chemical bonding;
– Carbon dioxide liquefaction and subsequent storage in for liquid carbonic acid form.

The liquefaction option of burning product removal with carbonic acid storage in heat-insulated ballast tanks appears to be the most attractive one considering the totality of relevant factors, including the AIP operation stealth.

This technique is recommended for AIP systems that are based on closed-cycle thermal engines. Future prospects of this method may be also related to advanced AIP vehicles with hydrocarbon/oxygen fuel cells.

S.V. Vyshegorodsky, V.M. Pchelintsev. **A New Monitoring Methodology and Assurance Tools for Marine Boiler Water Quality.** Pp. 63–74.

The paper examines specific marine boiler fluids (feed, make-up and boiler water) mineral content features and demonstrates that the effects of their replenishment sources (distilled water from desalination plants or shore fresh water supplies). The authors identify major admixtures that should be covered by on-line monitoring of the marine boiler water quality, establish the required scope of such control and suggest its methodology.

They justify the need for designing a new unified small-size shipboard laboratory for water quality monitoring on ships with various power plants, demonstrate the advisability of applying primarily instrumental methods and tools. Wherever it is essential to use any chemical analysis techniques, they should be substantially simplified. A new method to find major parameters of the boiler water quality is suggested based on instrumental salinity, alkaline number and relative alkalinity measurements. Updated, faster and more reliable procedures are suggested for monitoring boiler water total hardness and phosphate content without additional hardware or time-consuming chemical tests. A dedicated water analyzer has been designed and enables to establish major boiler water quality parameters. The authors also suggest a new unified small-size laboratory package to cater for onboard boiler water quality monitoring.

I.V. Koudinovich, A.S. Kyziurov. **On the Possibility of Applying the RELAP5/MOD3 Thermohydraulic Code for Heat Transfer Analysis in the Case of Steam and Steam-Gas Mixture Condensation inside a Pipe.** Pp. 75–83.

The paper assesses the applicability of the RELAP5/MOD3 code to the analysis of heat transfer processes associated with steam or steam-gas mixture condensation in high-velocity flows inside pipes. The authors compare computations made with the RELAP5/MOD3 code and with various correlations that have been validated by experimental data on steam condensation in pipes. Computations were made for a 1.5m-long horizontal pipe with an inner diameter of 10mm. The considered water steam and steam-gas mix parameters were: inlet pressure 0.1~0.23MPa; outlet pressure 0.08~0.2MPa; inlet velocity 50~300m/s; inlet quality X=1; air and hydrogen for the non-condensing gas; partial gas fraction ε=0.1~0.36.

Key conclusions drawn in the paper are:

(1) The RELAP5/MOD3 code is applicable to heat transfer analysis for pure-steam condensation in pipes under atmospheric pressure and steam velocities below 200m/s. Higher velocities increase heat transfer rates due to partial separation of the condensed film, but the RELAP5/MOD3 code does not account for this effect.

(2) The RELAP5/MOD3 code correlation for the heat transfer coefficient associated with steam condensation does not account for the effect of the pipe material heat conductivity, which are occur in practical applications.

(3) The values of heat flux in case of pure-steam high-velocity condensation inside a tube calculated by the RELAP5/MOD3 code with homogeneous equilibrium model are lower by comparison with the unhomogeneous model.

(4) Compared to the pure-steam case, the presence of a non-condensing gas in the high-velocity flow under the atmospheric pressure causes a 2~3-times reduction of the heat transfer coefficient. Local heat transfer coefficients for high-velocity steam with a low gas fraction (ε<0.01) found with the RELAP5/MOD3 code are 2~3 times less than for the pure-steam case, which contradicts with experimental data.

A.A. Bobrov, M.A. Ogibin, M.Yu. Yudin. **Demand-Driven Pump-House Water Supply Control Optimization.** Pp. 84–88.

A priority task of any pump-house automatic control system is to adjust the water supply line head top match the actual consumption rate. Since it is practically impossible to stabilize the head at every point of a complex of a water supply network, it is necessary to do that for individual governing demands. The governing demands are chosen so that maintaining their heads at the specified level ensures same or even higher heads at all other points of the net. Locations of the governing points are found either by hydraulic computations or experimentally from manometer readings.

The paper reports a project that involved manometer measurements in the water supply system of the Vasilyevsky Island Gavan District in St.Petersburg, which is a typical network that has parallel zoning and consists of the Gavan lift III pump-house and high-pressure lift IV stations.

The pump-house control philosophy anticipates control optimization in terms of a single criterion: power consumption for water supply under restrictions formulated as $H_j \geq H_j^{req}$ where H_j is the actual head at the j-th demand and H_j^{req} is the required head at the j-th demand. This task is equivalent to the task of minimizing the governing-demand head since meeting $H_{GD}=H_{GD}^{req}$ automatically satisfies the above restriction.

Optimized control algorithms enable to minimize the pump-house output head depending on the current water consumption. Additional benefits include electric power savings, cutting down of water losses by reducing leaks, slower wear of hydraulic and electric equipment and lesser risks of accidents associated with excessive head in the system.

S.P. Bolgarov, A.V. Vorontsov, I.V. Koudinovich, M.G. Khorkov. **A Marine Nuclear Steam Plant Using a Water-cooled Reactor with Saturated or Superheated Steam Generation in the Core.** Pp. 89–94.

A way to enhance marine steam-generating nuclear plants is to utilize the steam-condensate process in the primary circuit, which means producing saturated or superheated steam directly in the reactor core and then condensing it in the steamgenerator to provide heat for steam generation in the secondary loop. It is suggested to configure the saturated/superheated steam-generating core as a Field’s tube fuel channel consisting of an annular fuel elements and a coaxial non-fuel tubes mounted inside ones. A combination of strongly swirled flow at the inner surface of the fuel element with a slight swirl at its external surface enables to achieve heat transfer without burn-up on the inner face of the fuel element and post dry-out heat transfer on the outer face. This solution eliminates the possibility of the burn-up.

Despite a considerable lengthening of the hydraulic circuit, including taking into account its swirl, and a higher flow velocity due to a greater steam quality, the 6~7 times lower coolant flow rate ensures that the hydrodynamic resistance of such a core stays within values typical of conventional water-moderated reactors. This makes nuclear plants with direct steam-generating inside fuel channel of core work suitable for both forced as and natural coolant circulation options.

Based on the performed computations, the authors conclude that applying the primary-circuit steam-condensate process in a modular steam-generating plant could offer several important advantages:

– About 10% lower pressure in the primary circuit without decreasing the coolant temperature at the core outlet;

– Considerably lesser (about 7 times) coolant flow rate in the primary circuit and accordingly smaller circulation pump capacity requirements;

– About 30% smaller heat-exchanging surface of the steam generator;

– Reductions in reactor and steam generator weight and cost.

I.V. Koudinovich, Yu.A. Svistounov. **The Feasibility of a Small-Size Electronuclear Power Plant.** Pp. 95–108.

The authors examine prospects and challenges associated with the development of a small-size electronuclear power plant eliminating any possibility of uncontrolled chain fission reaction through fission in a sub-critical reactor with an additional neutron source. The neutron source is anticipated to be a heavy-element target irradiated with a beam of charged particles accelerated to several hundreds of mega-electron-volts.

The intensity of the external neutron source for an electronuclear reactor rated under 200MW may be much less than for greater ones, and that allows reducing accelerator performances to limits that are already run in the national industry. Potential applications of such electronuclear plants include municipal, industrial and other electricity and heat supply utilities in remote areas.

The article justifies the necessary parameters of the charged particle beam, the target, the accelerator and the sub-critical reactor for a small-size electronuclear power plant.

These findings give grounds for the following conclusions:

(1) Present-day reactor and accelerator technologies allow to create electronuclear power plants of up to 200MW.

(2) A promising option of a small-size electronuclear power plant could be based on a sub-critical fast-neutron-core reactor, a solid neutron generating target and a linear high-frequency proton accelerator.

(3) The electronuclear plant sub-critical reactor power (k_{ef}=0.96 by the end of the core lifetime) with a neutron generating target may reach 200MW with a 5mA mean current of protons accelerated to 200~400MeV.

(4) A possible way to increase the electronuclear plant power efficiency is to rise the starting core k_{ef} from 0.98 to 0.99, which offers a 35%-higher output but involves more enforced nuclear safety measures. Another possibility is to rise the linear accelerator mean current to 10mA with changing from 433MHz to 350MHz, which means a 2-times higher output but increases the dimensions of the plant.

L.N. Gerasimov, I.V. Koudinovich, Yu.A. Svistounov. **A Tantalum Neutron-Generating Target.** Pp. 109–120.

Achievements in accelerator technologies allow to create powerful neutron sources by irradiating targets made of various materials with fluxes of high-energy charged particles that have intensities by several orders of magnitude greater then those of radioactive sources of neutrons. In an electronuclear power plant, the target is an element that has to operate under the most difficult conditions. It is subjected to intensive irradiation by high-energy charged particles and neutrons, thermal stresses and mechanical loads (the target separates the vacuum ion duct from the internal volume of the reactor vessel, which contains high-pressure coolant).

The paper discusses a possible design of a helium-cooled tantalum target for the core of an electronuclear plant with a 200MW gas-cooled reactor and a 400MeV proton accelerator. The described target is a 0.35m-diameter 0.4m-high tantalum cylinder containing 463 12mm-diameter channels for cooling. The authors present estimations of the neutron generation intensity taking into account target dimensions, its thermal energy yield due to the irradiation by high-energy protons and by the neutron and gamma-radiation of the core, and thermohydraulic analyses of the coolant circuit and the temperature state of the target.

With a 5mA proton current, the target neutron generation intensity rests within $2.9 \cdot 10^{17}$~$7.8 \cdot 10^{17}$ neutron/s with the 400MeV proton energy or $8.4 \cdot 10^{17}$~$2.2 \cdot 10^{17}$ neutron/s with 200MeV. The reason for this rather broad range of the achievable neutron production rates is the sizeable varies of neutron yield experimental data available from different publications. The heat release in the target irradiated by a 400MeV beam of 5mA protons inside the core of a 400MW electronuclear reactor comes to 1.5MW. The proton beam diameter at the target inlet end should be at least 12.6cm for the maximum temperature of the target material to stay within 1000 °C.

L.N. Gerasimov, I.V. Koudinovich, Yu.A. Svistounov, V.P. Strouev. **A Small-Size Electronuclear Power Plant with a Sub-Critical High-Temperature Gas-Cooled Reactor and a Linear Proton Accelerator: Design Options.** Pp. 121–133.

Electronuclear power plants (ENPP) are inherently safe to severe reactivity accidents involving fast-neutron reactor runaway since the fission takes place in a sub-critical reactor whereas the required flux density comes from of an additional neutron source of high-intensity, i.e. a target irradiated with beam of charged particles accelerated to several hundreds of mega electron-volts in an accelerator.

The paper describes a design option of a 200MW-heat ENPP is comprised of a sub-critical high-temperature gas-cooled reactor (HTGR), a linear proton accelerator and a single-circuit gas-turbine installation. The ENPP is placed in a protective container of a size consistent with marine nuclear power plant compartment dimensions (10m in diameter, 25m long).

The ENPP perfomances are as follows: 200MW heat power of the helium-cooled HTGR, 0.98~0.99 effective multiplication factor (start to end of the core lifetime), $4.2 \cdot 10^{17}$ neutron/s neutron generating target intensity, 200~400MeV proton-beam energy at the linear accelerator output, 5mA average beam current, 70MW/m^3 core energy intensity, 70MPa helium pressure in the reactor, 20% efficiency of the gas-turbine installation.

The paper suggests a basic configuration of the high-frequency linear proton accelerator. Using special-purpose magnets enable to turn the accelerating duct through 180°, which reduces the accelerator length by 50%.

The paper also includes design suggestions for the multiplying target (UN+W) with tube neutron-producing elements, and for the helium-cooled HTGR.

It is given cycle parameters and composition of gas-turbine installation.

General suggestions are worked out for the ENPP design layout.

V.A. Bobrov, I.V. Koudinovich, V.G. Markov, N.A. Mikhailov, V.P. Strouev, G.V. Stoulnikov. **Experimental Investigations into Physical and Dynamical Characteristics of Advanced Marine Nuclear Reactors at Critical Test Assemblies.** Pp. 134–149.

The Krylov Shipbuilding Research Institute has for a number of years carried out experimental investigations into characteristics of water-moderated water-cooled reactors with natural coolant circulation and gas-cooled reactors for advanced ship nuclear power plants.

The paper describes the MER test rig that was used for investigating the dynamics of water-moderated water-cooled reactors. The MER test rig includes a critical assembly with three integrated electrically heated channels. The power of the electrically heated channels is controllable in accordance with reactivity variation due to a change of coolant density in the channels. The paper offers the results of investigations in neutron-physical stability and accident situations in a single-circuit nuclear steam-generating plant with a boiling water reactor with natural coolant circulation, and investigations in hydrodynamic stability and heating-up of a two-circuit steam-generating plant with a boiling water reactor with natural coolant circulation.

The paper also describes the G-1 critical assembly with electrically heated core that was used for research on neutron-physical characteristics of the high-temperature gas-cooled reactor core. The reactor core consisted of fuel assemblies with spherical fuel elements (4mm in diameter) made of uranium nitrite (UN) with tungstem (W) coating, a moderator in the form of $ZrH_{1.85}$ cylindrical blocks. The reactor core was surrounded by a reflector made of Be. Burnable poison rods made of various materials (Er_2O_3 , Sm_2O_3 , Gd_2O_3 , B_4C) were placed in the reactor core in order to study methods of temperature effect forming.

The authors discuss the obtained results of their investigations into neutron-physical characteristics of high-temperature gas-cooled reactor cores.

I.V. Koudinovich. **Steady Operation Analysis for a Sub-Critical Reactor in an Electronuclear Power Plant Driven by a Linear Accelerator.** Pp. 150–157.

In an electronuclear power plant (ENPP), the nuclear fission occurs in a sub-critical reactor, and an additional source of neutrons is produced when a target located in the core is exposed to a beam of charged particles from an accelerator.

The paper analyses steady-operation neutron flux density and fuel temperature time variations for an ENPP sub-critical reactor core driven by a linear accelerator.

An asymptotic (steady-state) solution of the point kinetics equation was obtained for a sub-critical reactor with an external periodic neutron source (neutron source intensity time variation was represented as a sequence of rectangular pulses). Furthermore, variations in the temperature of core fuel elements of the ENPP with a gas-cooled reactor were analyzed.

The paper offers calculated results for steady-state neutron flux variations in the ENPP with a linear proton accelerator (pulse duration is 10^{-4}s, pulse period-to-pulse duration ratio is 10) and a sub-critical core (k_{ef}=0.98) with different fuels (^{235}U, ^{239}Pu) and neutron spectra (thermal, fast).

The results allow drawing the following conclusions:

– When an electronuclear plant with a linear accelerator operates under steady conditions, there occurs a periodic variation in the reactor-core neutron flux density and its period corresponds to the accelerator pulse period.

– The greatest neutron flux density variations in the reactor core occur in electronuclear plants with fast-neutron plutonium-fuel reactors ($n_{max} / n_{min} \approx 100$);

– The core fuel temperature remains virtually invariable due to the thermal inertia of fuel elements.

I.V. Koudinovich. **External Neutron Source Spatial Distribution Influence on the Sub-Critical Reactor Capacity.** Pp. 158–169.

One of the problems in optimizing of electronuclear power plant characteristics is obtaining maximum energy release in the reactor with specified core sub-criticality and external neutron source intensity.

The paper analyses the influence of the external neutron source spatial distribution on the sub-critical reactor capacity. The problem in determining uniform sub-critical reactor capacity with an arbitrary spatial distribution of the external neutron source is analytically solved using the two-group Fermy age-diffusion model. The paper includes results of calculating capacity and energy release distribution in sub-critical fast and thermal neutron reactors showing the following:

– Positioning the external neutron source in the centre of the reactor core almost doubles the reactor capacity as compared with the case when the external neutron source of the same integral intensity is spatially uniformly distributed in the core;

– A significant difference between the energy release spatial distribution in a sub-critical reactor with the external neutron source and the energy release distribution in a standard critical reactor is observed only at a large sub-criticality (k_{ef}<0.98) for a fast neutron reactor;

– The influence of the external neutron source spatial distribution on the energy release distribution in a thermal neutron reactor is less expressed than in the case of a fast neutron reactor.

N.L. Kouchin, S.N. Roubanov, I.V. Sergeev. **Estimations of Radiation Effects in the Handling of Liquid Radioactive Wastes at Shipyards Involved in Nuclear Submarine Decommissioning.** Pp. 170–179.

The paper offers analysis of radiation consequences of emergency situations possible to occur when dealing with liquid radioactive wastes (LRW) resulting from repair and complex nuclear submarine decommissioning in Russian shipyards and dockyards.

The paper also presents estimations of water and bottom sediment radioactive contamination and probable radiation doses of critical population groups in coastal areas in case of accidents such as unauthorized LRW disposal, sinking of a specialized tanker carrying LRW near the shipyard, fire and destruction of a LRW storage.

Consequences of emergencies under consideration are compared with the known IAEA scale for classifying nuclear incidents and emergencies. It is shown that the consequences of emergencies possible when dealing with LRW in shipyards and dockyards are of local character and do not pose hazard to people and environment beyond the water area and territory of the shipyard.

A.V. Vorontsov, I.V. Koudinovich, A.Zh. Souteeva. **Radiation Situation Estimations when Handling Exposed Fuel Core Assembly Tube Heads in the Case of Two-Level Storage of Nuclear Ship Spent Fuel.** Pp. 180–189.

The storage of marine reactor spent fuel has become nowadays one of the burning problems owing to the depletion of existing storage capacities. A feature of ship reactor cores is that they have comparatively long tube heads that are almost twice as long as the fuel assemblies. An effective method for increasing the storage capacity is a compact two-level storing of spent fuel: another fuel assembly is placed in the core storage containment whereas the cut-off tube heads are put into the solid radioactive waste repository.

The paper is based on analyses of radiation situation and discusses the exposed core tube heads storage optimization by introducing the two-level arrangement for nuclear-ship spent fuel storage.

The radiation situation around the head tube container-repository heavily depends on the distance between the tube head line cutting point from the fuel assembly. It is shown that the optimal distance is 30cm: at this distance the activity of cut-off tube heads is two orders of magnitude less than in the case of cutting immediately atop the active part. In the case under consideration the length of fuel assembly active parts permits to stack them in two levels in the cask that are used for spent fuel storage and transportation.

The paper suggests a method for placing exposed tube heads in the container-repository so that half of the tube heads are put with their lower (most active) ends towards one side of the container whereas similar ends of the other half are put towards the opposite side. This method permits one to reduce the thickness of radiation shield by half.

N.A. Anisimov. **Radionuclide Deposition Rate Numerical Modelling for Ship Compartments in Case of Fire Accidents.** Pp. 190–200.

The paper suggests a calculation model for predicting ship compartment surface contamination in case of a radiation accident accompanied by a fire. The model is based on a mathematical model of radioactive aerosol transfer through rooms, which accounts for the deposition of radioactive substances on the walls with the help of a constant wall-sedimentation rate λ_S .

The analysis of radioactive aerosol dispersed composition and forces that cause radioactive particle migration towards deposition surfaces has permitted calculating the quantity of radioactive deposits on compartment walls using distribution characteristics of smoke particles associated with the burning of certain particular structural materials, and radioactive substance inflow intensity.

It is shown that fires involving mostly wood or cellulose result in almost equal contamination of all room surfaces whereas the combustion of rubber-containing materials contaminates primarily the upward-facing horizontal surfaces.

The performed research permitted to formulate an algorithm for numerical modelling of radionuclide deposition rates inside ship compartments in case of fires, and to establish what input data are required for such calculations.

N.A. Anisimov, D.M. Bogdanov, N.L. Kouchin, I.V. Sergeev. **Comparative Analysis of Radioactive Release Dispersion Models for Broken Terrain Conditions.** Pp. 201–207.

Radiation-hazardous operations require predictions of accidental radioactivity releases. Many foreign and Russian procedures for such predictions are based on the Gaussian model of impurity diffusion in the atmosphere.

The most common practice is to use the Smith-Hosker approximation of the Gaussian model. However, effective manuals on radiation environment and human risk analysis for atmospheric radioactivity release accidents (MPA-98) apply not Smith-Hosker and Briggs formulae for dispersion factors but an approximation by Airy, which permits varying the surface roughness within 0.001m to 4m instead of choosing from a discrete set of values.

In order to determine the error of this approximation, dispersion factors and dilution coefficients were calculated for various weather conditions, surface roughness and distances from the radioactive release source. It was demonstrated that in most cases the error of the Airy approximation is rather big. Therefore, the use of this approximation in the nuclear shipbuilding industry is not always justified.

Besides, the paper shows that for considering very uneven terrain cases it is advisable to find dispersion factors with the help of K.Voigt's scattering model recommended by the IAEA.

M.N. Ganoul, N.L. Kouchin, I.V. Sergeev. **A Study on Radioactive Pollution Deposition in Equipment Installed on Nuclear Servicing Vessels.** Pp. 208–212.

The paper sets forth results of experimental research into the rate of internal-surface contamination by incoming radioactive waters in a treatment plant installed onboard a special-purpose nuclear servicing vessel. It is demonstrated that under normal operation conditions the residual contamination of the equipment is minor and the effects of this pollution upon instrumentation readings rests within 3%. However, in case of long intervals between water intake cycles the residual equipment contamination may increase owing to polluting deposits of received-water droplets, which remain on equipment surfaces after draining. The authors suggest a method for reducing this residual contamination.

M.N. Ganoul, I.V. Sergeev. **An Experimental Study for Superheater Surface Pollution Deposition Coefficients.** Pp. 213–216.

The paper sets forth results of experimental investigations into corrosion-product mass transfer process in coolant lines of a water-moderated plant with steam superheating. The study was conducted using a superheater installed in the coolant loop of a special-purpose test rig. Corrosion products were simulated with iron, manganese and copper hydroxides labelled with radionuclides of the respective elements. Deposition surfaces were simulated by stainless steel and titanium-alloy samples placed inside the superheater. The results demonstrated that corrosion products deposited on heat-source surfaces in the steam superheating zone and the deposition rate increased together with the steam temperature. The paper also offers results of numerical evaluations of maximum and weighted-average values of deposition coefficients for the simulated compounds and specimen surfaces.

V.P. Balabin. **Experimental Research on Iodine Removal by a Sprinkler System.** Pp. 217–229.

Experimental research into the efficiency of iodine removal using a sprinkler system was conducted at IKAR and AK-25 test rigs of the Krylov Shipbuilding Research Institute. The sprinklers were centrifugal non-adjustable injectors. The initial iodine concentration during the experiments varied within $1.7 \cdot 10^{-3}$~0.14mg/l at a temperature of 10~80 °C.

The experiments were carried out in order to investigate the impacts environment (temperature, humidity, iodine concentration in the gas phase) and sprinkler system (capacity, injection rate, injected fluid dispersion, low-rate injector installation height, etc.) parameters on the iodine removal efficiency. The model suggested for the analysis of test results allowed taking into account the influence of iodine surface deposition and blowing. An approximating dependence was obtained for evaluating iodine deposition rates within the investigated range of parameter variations (temperature and initial iodine concentration).

The paper includes evaluation of efficiency factor dependence on the time of drop passing, and relations between the iodine removal constant and system capacity and iodine concentration in the air for various temperature ranges.

The performed iodine removal experiments have shown a high efficiency of the sprinkler system within a wide range variations of initial iodine concentrations and temperatures, which permits using the system for air decontamination purposes in marine reactor compartments in case of coolant leakage accidents.

V.P. Balabin. **Efficiency Evaluation for Iodine Removal by a Sprinkler System for Initially Low Iodine Concentrations.** Pp. 230–244.

A sprinkler system may be used as an emergency decontamination system in ship nuclear powerplant compartments in case of primary circuit leak accidents. Taking into account that iodine radionuclides pose one of the highest radiation hazards, the author evaluates the iodine removal efficiency of the system.

The paper gives an algorithm for calculating the coefficient of iodine water/air distribution with low iodine concentration in the gas phase, and provides a generalized model of iodine removal with water drops that permits determining coefficients of drop saturation with iodine. Also the paper offers results of calculating efficiency factor with various iodine concentrations in the air.

The suggested generalized model of droplet saturation with the iodine and the computation algorithm for the iodine phase distribution coefficient may be used for calculating radioactive iodine post-accident concentration variations with the operating sprinkler system, and for calculating system parameters to achieve the specified iodine removal efficiency.

*O.Yu. Samodourov, Yu.F. Samodourov***. A Mathematical Model of Gadolinium Nitrate Salt Aqueous Solution Substitution by the Primary Circuit Distillate.** Pp. 245–255.

The paper suggests a mathematical model that permits evaluating parameter variations when substituting gadolinium nitrate salt aqueous solution for the primary circuit distillate as a result of displacing absorber from the annular gap embracing the core. At the same time reactivity is released, which may cause an uncontrolled reactor power excursion.

The existing numerical mathematical apparatus does not permit to use it in this particular case for it requires additional physical assumptions that should be confirmed (including experimental verification). Therefore, it has been decided to conduct full-scale modelling of the processes under consideration.

O.Yu. Samodourov, Yu.F. Samodourov. **A Full-scale Model of the Right-Bank Research Facility Reactor Vessel.** Pp. 256–263.

Present-day requirements to nuclear power engineering are listed in general guideline documents of the Russian Federation Nuclear-Power Engineering Safety. These requirements cover the entire scope of work from design and construction to the eventual decommissioning of the subject reactor. Structural strength, nuclear-physical, heat-hydraulic and other calculations included into the design package not always fully cover integrity and buckling resistance issues relevant for individual assemblies and systems of the nuclear installation. In such cases, use is made of scale modelling. The paper considers full-size modelling of the RBRF reactor vessel failure and nuclear hazard consequences of this process.

A dedicated test set-up was designed, manufactured and installed at the St.Petersburg Nuclear Physics Institute in order to investigate the consequences of the RBRF reactor pressure vessel failure and to investigate reactivity release rates as functions of the size of through-wall cracks in the vicinity of reactor core.