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Nuclear Power Plant Safety Systems

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The basis of safety systems is the reliable retention of radioactive substances within the specified boundaries of nuclear power plants. The safety system includes five barriers: the fuel element shell, biological protection, the crystal lattice of fuel pellets, the border of the first circuit, and the hermetic shell. The fuel rod shell is made of zirconium alloys, practically devoid of impurities, with a small addition of niobium. Under normal operating conditions, all fission products remain inside the fuel element [1]. Biological protection is mainly represented by a screen or a system of screens made of protective materials (lead, steel, water, concrete). It is installed between the source of radioactive radiation and the area where people are located. The tablets are sintered at a temperature of 1650 °C before being assembled into a fuel cell, acquiring ceramic properties and retaining some nuclides [1]. The first circuit is designed to transfer heat from the active part of the reactor to the water of the second circuit to form steam. The water of the primary circuit is composed of boric acid, to slow down the reaction in the core. The water of the first and second circuits does not mix. Hermetic shell (container)-this is a thick layer of concrete that protects the environment from radiation. Inside the concrete layer, metal cables are stretched, which give the structure additional solidity and increase its stability. The container is designed and constructed in such a way as to withstand the

internal and external impact of a huge force. The powerful dome of the hermetic shell is so tightly pressed to the body that the reactor is not afraid of: a shock wave that creates a pressure of 30 kPa; a plane weighing 20 tons falling at a speed of 200 m/s (720 km / h); a hurricane and a tornado with a wind speed of up to 56 m/ s; a flood; earthquake up to 8 points. Each of these barriers ensures the safe operation of the reactor from both external influences and internal failures in the reactor control systems. On the example of the VVER-1000 nuclear reactor, the following safety systems are used, which include systems for emergency cooling of the high and low pressure core (SAOZ), systems for protecting the first and second circuits from excess pressure, systems for emergency gas removal and emergency feed water supply. In order to prevent a break in the cooling of the core, the SAOZ has a system called the passive part of the SAOZ-a system of hydraulic accumulators, designed to quickly supply a solution of boric acid. If the cooling systems fail, the molten core will start to drain into a special concrete cup called a melt trap. It contains steel sacrificial material and oxide sacrificial material(Fe_2O_3, Al_2O_3), which reduces the formation of volatile materials, lowers the temperature, and crystallizes the melt [1].

The design of safety systems is associated with a high risk of emissions of radioactive substances into the atmosphere as a result of possible accidents, so at present, almost half of the total cost of construction of nuclear power plants is spent on equipment for safety systems of nuclear power plants.

References:

1. Как устроена система безопасности АЭС: стержни, спринклер, контейнмент [Электронный ресурс]. Mode of access: https://www.popmech.ru/technologies/614943-sterzhni-sprinkler-konteynment-kak-ustroena-sistema-bezopasnosti-aes/. – Date of access: 25.02.2021.