Nuclear reactor working pdf

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This article requires the attention of an expert on this issue. See the details on the conversation page. When you post this tag, consider linking this request to WikiProject. (October 2020) This article is about built nuclear fission reactors. For nuclear thermonuclear reactors see natural nuclear reactors, see the core of CROCUS, a small nuclear reactor used for research at EPFL in Switzerland, the Nuclear Reactor, formerly known as the Atomic Heap, is a device used to initiate and control an independent nuclear chain reaction. Nuclear reactors are used in nuclear power plants to generate electricity and nuclear marine engines. Heat from nuclear fission is transferred to a working liquid (water or gas), which in turn passes through steam turbines. They either control the propellers of the ship or rotate the shafts of the generators. Nuclear vapor in principle can be used for industrial heat production or for heating the area. Some reactors are used for isotope production for medical and industrial use or for the production of weapons-grade plutonium. According to the IAEA, as of the beginning of 2019, there are 454 nuclear reactors and 226 nuclear research reactors in the world. Operation Main article: Nuclear Reactor Physics An Example of an Induced Nuclear Division Event. The neutron is absorbed by the nucleus of the uranium-235 atom, which in turn breaks down into fast-moving lighter elements (fission products) and free neutrons. Although both reactors and nuclear weapons rely on nuclear chain reactions, the reaction rate in the reactor is much slower than in a bomb. Just as conventional thermal power plants generate electricity using thermal energy from the burning of fossil fuels, nuclear reactors convert energy generated by controlled nuclear division into thermal energy for further conversion into mechanical or electrical forms. Fission Main article: Nuclear fission When a large fissile atomic nucleus such as uranium-235 or plutonium-239 absorbs a neutron, it may undergo nuclear division. The heavy nucleus breaks down into two or lighter nuclei (fission products), releasing kinetic energy, gamma radiation and free neutrons. Some of these neutrons can be absorbed by other fissile atoms and cause further fission events that release more neutrons, and so on. This is known as a nuclear chain reaction. To control such a nuclear chain reaction, control rods containing neutron poisons and neutron moderators can alter some of the neutrons that will cause more division. Nuclear reactors typically have automatic and manual systems to turn off the fission response if monitoring detects Conditions. The thermal generation of the reactor core generates heat in several directions: the kinetic energy of fission products is converted into thermal energy when these collide with nearby atoms. The reactor absorbs some of the gamma rays produced during fission and converts their energy into heat. Heat is produced as a result of radioactive decay of products and fission materials that have been activated as a result of neutron absorption. This heat source will remain for some time even after the reactor is shut down. Kilograms of uranium-235 (U-235), converted by nuclear processes, releases about three million times more energy than a kilogram of coal burned conventionally (7.2 × 1013 joules per kilogram of uranium-235 against 2.4 × 107 joules per kilogram of coal). Original research? cooling of the coolant of a nuclear reactor - usually water, but sometimes gas or liquid metal (e.g. liquid sodium or lead) or molten salt - circulates past the reactor core to absorb the heat it generates. Heat is taken away from the reactor and then used to generate steam. Most reactor systems use a cooling system that is physically separated from the water, which will be boiled to produce steam under pressure for turbines like a water pressure reactor. However, in some reactors, water for steam turbines boils directly at the core of the reactor; for example, a reactor with boiling water. Reactivity Control Main Articles: Nuclear Reactor Control, Nuclear Reactor Physics, Passive Nuclear Safety, Neutron Delay, Iodine Pit, SCRAM and Melt Of Heat Speed Fisal Reactions in the reactor core can be adjusted by controlling the number of neutrons that are capable of causing further fission events. Nuclear reactors typically use several neutron control techniques to adjust reactor power. Some of these methods naturally arise from the physics of radioactive decay and are simply accounted for during the operation of the reactor, while other mechanisms are developed in the reactor design for various purposes. The fastest way to adjust the levels of neutrons that cause division in the reactor is to move the control rods. Control rods are made of neutron poisons and therefore absorb neutrons. When the control rod is inserted deeper into the reactor, it absorbs more neutrons than the material it displaces, often by the moderator. This action reduces the number of neutrons available for fission and reduces the reactor's power. Conversely, the removal of the control rod will increase the speed of the division events and increase the power. The physics of radioactive decay also affects the population of neutrons in the reactor. One such process is the delay of neutron radiation near neutron-rich fission isotopes. These delayed neutrons account for about 0.65% of the total number of neutrons produced in the division, and the rest (so called fast neutrons) immediately after the division. Fisal products that produce neutron delay have half a life for their neutron neutron decay which range from milliseconds to a few minutes, and therefore takes considerable time to determine exactly when the reactor will reach a critical point. Maintaining the reactor in the chain reactivity zone, where neutron delays are needed to reach a critical mass state, allows mechanical devices or human operators to control the chain reaction in real time; otherwise, the time between the achievement of a critical measure and the nuclear crisis as a result of an exponential power surge as a result of a normal nuclear chain reaction would be too short to allow intervention. This last stage, in which delayed neutrons are no longer required to maintain criticality, is known as the operational critical point. There is a scale to describe the criticality in numerical form, in which naked criticality is known as zero dollars and a quick critical moment is one dollar, and other points in the process are interpolated in cents. In some reactors, the pendant also acts as a moderator of neutrons. The moderator increases the power of the reactor, forcing fast neutrons that are released from the fission, lose energy and become thermal neutrons. Heat neutrons are more common than fast neutrons cause division. If the pendant is a moderator, then temperature changes can affect the density of the liquid/moderator and therefore change the power output. A higher cooling temperature will be less dense, and therefore less effective moderator. In other reactors, the cool works like poison, absorbing neutrons in the same way as control rods. In these reactors, the power can be increased by heating the heat, which makes it a less dense poison. Nuclear reactors usually have automatic and manual systems to scram the reactor in an emergency shutdown. These systems insert large amounts of venom (often boron in the form of boric acid) into the reactor to close the fission reaction down if unsafe conditions are detected or expected. Most types of reactors are sensitive to a process known as xenon poisoning, or iodine pit. The common Xenon-135 fission product produced during the fission process acts as a neutron poison that absorbs neutrons and therefore tends to shut down the reactor. The accumulation of Xenon-135 can be controlled by maintaining a high enough power level to destroy it by absorbing neutrons as quickly as it is produced. The cleavage also produces iodine-135, which in turn breaks down (from half-family 6.57 hours) to a new xenon-135. When the reactor shuts down, iodine-135 continues to disintegrate to xenon-135, making it difficult to restart the reactor for a day or two, as xenon-135 breaks down into cesium-135, which is not as poisonous as xenon-135, with a half-life of 9.2 hours. It's a temporary condition - iodine pit. The reactor has enough extra reactivity capacity and can be restarted. Because the additional xenon-135 is transmuted into xenon-136, which less neutron venom, within a few hours the reactor experiences xenon burnout (power) transient. Control rods should be additionally inserted to replace the neutron absorption of the lost xenon-135. Failure to do so is a key step in the Chernobyl disaster. Reactors used in nuclear marine engines (especially nuclear submarines) are often unable to operate at continuous capacity around the clock, just as ground-based power reactors normally operate, and often have to have a very long core life without refueling. For this reason, many designs use highly enriched uranium, but include combustible neutron poison in fuel rods. This allows the reactor to be built with an excess of fissile material, which is nevertheless made relatively safe in the early stages of the reactor fuel combustion cycle by the presence of neutron-absorbing material, which is later replaced by normally produced long neutron poisons (much longer than xenon-135), which gradually accumulate during the entire duration of the fuel load. Electrical generation Energy, released during the fission process, generates heat, some of which can be converted into energy. A common method of using this thermal energy is to use it to boil water to produce steam under pressure, which then drive a steam turbine that turns into an alterator and generates electricity. Early reactors see also: Nuclear Division - The History of the Chicago Saw, the first nuclear reactor built in secret at the University of Chicago in 1942 during World War II as part of the American Manhattan Project. Lisa Meitner and Otto Khan in their lab. Some of the Chicago Peel team, including Enrico Fermi and Leo Silard. Neutron was discovered in 1932 by British physicist James Chadwick. The concept of a nuclear chain reaction, caused by nuclear reactions mediated by neutrons, was first realized shortly thereafter by Hungarian scientist Leo Silard in 1933. He applied for his idea of a simple reactor the following year while working at Admiralty University in London. However, Silard's idea did not include the idea of nuclear fission as a neutron source, as the process had not yet been discovered. Silard's ideas for nuclear reactors using neutron nuclear chain reactions in light elements proved to be inoperable. The inspiration for a new type of uranium reactor came from the discovery of Liz Meitner, Fritz Strassman and Otto Khan in 1938 that the bombardment of uranium with neutrons (subject to alpha-on-beryllium synthesis reaction, neutron howitzer) produced the remnants of barium, which they reasoned was created by dividing the uranium nucleus. Subsequent conducted in early 1939 (one by Silard and Fermi), showed that several neutrons were also released during the division, allowing reaction that Silard envisioned six years ago. On August 2, 1939, Albert Einstein signed a letter to President Franklin D. Roosevelt (written by Silard) stating that the discovery of uranium fission could lead to the development of extremely powerful new types of bombs, giving impetus to the study of reactors and division. Silard and Einstein knew each other well and worked together many years ago, but Einstein never thought about this possibility for nuclear power until Silard informed him, at the beginning of his quest to prepare a letter from Einstein-Silard to warn the U.S. government. Shortly thereafter, Hitler's Germany invaded Poland in 1939, triggering World War II in Europe. The U.S. was not yet officially at war, but in October, when he received a letter from Einstein-Silard, Roosevelt said the purpose of the study was to make sure that the Nazis don't blow us up. The U.S. nuclear project followed, albeit with some delay, as there was skepticism (some of them from Fermi), as well as little action by a small number of government officials who were initially accused of moving the project forward. The following year, the U.S. government received a memorandum from the United Kingdom from Frisch-Peyerles stating that the amount of uranium needed for a chain reaction was much lower than previously thought. The memorandum was a product of the MAUD Committee, which worked on the British atomic bomb project known as pipe alloys, which was later included in the Manhattan Project. In late 1942, a team led by Italian physicist Enrico Fermi built the first artificial nuclear reactor Chicago Pile-1 at the University of Chicago. By this time, the program was under pressure during the year because of the U.S. entry into the war. On December 2, 1942, at 3:25 p.m., Chicago Peel reached critical criticism. The reactor support structure was made of wood, which supported a bunch (hence the name) of graphite blocks embedded in which there were pseudospheres of natural uranium oxide or briquettes. Shortly after the Chicago Saw, the U.S. military developed a number of nuclear reactors for the Manhattan Project, beginning in 1943. The main purpose of the largest reactors (located at the Hanford test site in Washington) was the mass production of plutonium for nuclear weapons. Fermi and Silard applied for a patent for the reactors on December 19, 1944. His extradition was postponed for 10 years because of wartime secrecy. The world's first nuclear power plant is a claim made by signs on the site of EBRD-I, which is now a museum near Arco, Idaho. Originally called Chicago Pile-4, it was conducted under the direction of Walter Sinn for the Argonne National Laboratory. This experimental LMFBR, operated by the U.S. Atomic Energy Commission, 0.8 kW in the test on December 20, 1951 and (electric) the next day, with a design capacity of 200 kW (electric). In addition to the military use of nuclear reactors, there are political reasons for the civilian use of nuclear energy. U.S. President Dwight Eisenhower delivers his famous Atoms for Peace speech to the UN General Assembly on December 8, 1953. This diplomacy has led to the spread of reactor technology to American institutions and around the world. The first nuclear power plant built for civilian purposes was the Obnin nuclear power plant AM-1, launched on June 27, 1954 in the Soviet Union. It produced about 5 MW (electric). After World War II, the U.S. military sought other uses for nuclear reactor technology. Studies by the army and air force have not been successful; however, the US Navy succeeded when they hovered the USS Nautilus (SSN-571) on nuclear power January 17, 1955. The first commercial nuclear power plant, Calder Hall in Sellafield, England, was opened in 1956 with an initial capacity of 50 MW (later 200 MW). The first alco PM-2A portable nuclear reactor was used to generate electricity (2 MW) for Camp Century from 1960 to 1963. The primary cooling system showing the reactor pressure vessel (red), steam generators (purple), sealant (blue) and pumps (green) in three Hualong One cooling loops under the pressure of the PWR reactor design: 277 (63.2%) BWR: 80 (18.3%) GCR: 15 (3.4%) PHWR: 49 (11.2%) LWGR: 15 (3.4%) FBR: 2 (0.5%) Number of reactors by type (end of 2014) (21) PWR: 257,2 (68,3%) BWR: 75.5 (20.1%) GCR: 8.2 (2.2%) PHWR: 24.6 (6.5%) LWGR: 10.2 (2.7%) FBR: 0.6 (0.2%) The GWe (end of 2014) is a North Carolina-class PULSTAR research reactor consisting of UO2 pellets in circadian cladding. Nuclear reaction classifications All commercial energy reactors are based on nuclear fission. They usually use uranium and its plutonium product as nuclear fuel, although a thorium fuel cycle is also possible. Fisal reactors can be divided roughly into two types, depending on the energy of the neutrons that support the fission chain response: Thermal neutron reactors (the most common type of nuclear reactor) use slow or thermal neutrons to keep up the splitting of their fuel. Almost all current reactors of this type. They contain neutron moderator materials that slow down neutrons until their neutron temperature is thermalized, that is, until their kinetic energy approaches the average kinetic energy of the surrounding particles. Thermal neutrons have a much higher cross-section (probability) of fissile uranium-235 fissile nuclei, plutonium-239 and plutonium-241, as well as a relatively low probability of neutron capture by uranium-238 compared to the faster neutrons that are originally the result of fission, which allows the use of uranium-238 (U-238) compared to faster neutrons, which are originally the result of fission, allowing the use of uranium-238 (U-238) uranium or even natural uranium fuel. The moderator is often also a cool liquid, usually water under high pressure to increase the boiling point. They are surrounded by a reactor vessel, reactor monitoring and control devices, radiation shielding and containment building. Fast neutron reactors use fast neutrons to divide fuel. They don't have a neutron moderator, and less moderators are used. Maintaining a chain reaction requires that the fuel be more highly enriched with fissile material (about 20% or more) due to the relatively lower probability of division compared to the capture of U-238. Fast reactors have the potential to produce less transuranal waste because all acticides are broken down with fast neutrons, but they are harder to build and more expensive to operate. In general, fast reactors are less common than thermal reactors in most applications. Some early power plants were fast reactors, as were some Russian naval power plants. The construction of prototypes continues (see rapid breeder or Generation IV reactors). In principle, thermonuclear energy can be produced by nuclear fusion of elements such as hydrogen deuterium isotope. Although the topic of rich research has been going on since at least the 1940s, no self-affirming thermonuclear reactor for electricity generation has ever been built. By moderating the material used by thermal reactors: Graphite-moderate reactors Water moderated reactors of heavy water reactors (used in Canada, India, Argentina, China, Pakistan, Romania and Korea). Light Water Reactors (LWRs). Light-water reactors (the most common type of thermal reactor) use conventional water to cool and cool reactors. At operating temperature, if the water temperature rises, its density drops, and the smaller number of neutrons passing through it slows down enough to cause further reactions. This negative feedback stabilizes the reaction rate. Graphite and heavy-water reactors tend to be more carefully thermalized than light water reactors. Because of the additional thermalization, these types can use natural uranium/unenipped fuel. Reactors with a light element. Molten salt reactors (MSRs) are moderated by light elements such as lithium or beryllium, which are part of the LiF and BeF2 cooling/fuel matrix salts. Liquid-metal-cooled reactors, such as those whose cool-cooling is a mixture of lead and bismuth, can use BeO as a moderator. Organically moderated reactors (OMR) use biphenyl and terphenyl as a moderator and cooling. Using liquid Processing the inside of the reactor frame Atommash. In thermal nuclear reactors (LWRs in specific), thermal power energy acts as a moderator that must slow down neutrons before they can be effectively absorbed by fuel. Water-cooled reactor. They make up the vast majority of existing nuclear reactors: as of 2014, 93% of 93% reactors are cooled by water, providing about 95% of the world's total nuclear generation capacity. The Water Pressure Reactor (PWR) Under pressure of water reactors represents most of all Western nuclear power plants. The main characteristic of PWRs is an sealant, a specialized pressure vessel. Most commercial PWRs and marine reactors use sealants. During normal operation, the sealant is partially filled with water, and the bubble vapor is maintained above it by heating the water with submerged heaters. During normal operation, the sealant is connected to the reactor's primary pressure vessel (RPV), and the pressure bubble provides space to expand the volume of water in the reactor. This location also provides a pressure control for the reactor by increasing or reducing the vapor pressure in the sealant with the help of sealant heaters. Heavy water pressure reactors are a subset of pressure-under-pressure water reactors, sharing the use of an airtight, insulated thermal transport loop, but using heavy water as a heat cool and moder for the large neutron economies it offers. Boiling Water Reactor (BWR) BWRs is characterized by boiling water around the fuel rods at the bottom of the reactor's primary pressure vessel. The boiling water reactor uses 235U, enriched as uranium dioxide, as fuel. The fuel is collected in rods located in a steel vessel, which is immersed in water. Nuclear fission causes water to boil, generating steam. This steam flows through the pipes into the turbines. The turbines are operated by the ferry and this process generates electricity. During normal operation, the pressure is controlled by the amount of steam, flowing out of the pressure vessel of the reactor into the turbine. A pool-type reactor may refer to outdoor basin reactors (questionable - discuss) that are cooled by water, but should not be confused with LMFBRs-like basins that are cooled by sodium Some reactors have been cooled by heavy water, which also served as a moderator. Examples include: Early CANDU reactors (later they use a heavy water moderator, but light water cooling liquid) DIDO class research reactors liquid metal cooled reactor. Because water is a moderator, it cannot be used as a liquid in a fast reactor. Liquid metal cools include sodium, nak, lead, lead-vismut lead euthict, and mercury in early reactors. A rapidly refrigerated lead-powered reactor, cooled rapidly by the gas reactor, cooled reactors are cooled by circulating gas. In commercial nuclear power plants, carbon dioxide is commonly used, for example, at current British nuclear power plants AGR and previously in a number of British, French, Italian and Japanese first-generation power plants. Also used and helium, helium was considered particularly suitable for highly-current structures. The use of heat varies depending on the reactor. Commercial nuclear power plants control gas heat-free to make steam for the steam turbine. Some experimental designs work hot enough that the gas can directly power the gas turbine. Molten salt reactors (MSRs) are cooled by spreading molten salt, usually an euthetic mixture of fluoride salts such as FLiBe. In a typical MSR, the pendant is also used as a matrix in which the fissile material dissolves. By Generation I reactor (early prototypes such as the Shippingport nuclear power plant, Research Reactors, Non-Commercial Energy Reactors) Generation II Reactor (most modern nuclear power plants, 1965-1996) Reactor III (evolutionary improvements to existing structures, 1996-present) Generation III Reactor (evolutionary development of Gen III reactors, offering safety improvements compared to Gen III reactor projects, 2017-present) , perhaps 2030) A: Reactors that are purely theoretical and are not the subject of intensive research. In 2003, the French commissary and the atomice Energy (CEA) were the first to refer to the gen II types in Nucleonics Week. The first mention of Gen III was in 2000, in connection with the launch of the plans of the International Generation IV Forum (GIF). Gen IV was named in 2000 by the U.S. Department of Energy (DOE) to develop new plant types. By the fuel phase Solid fuel liquid is fueled by the Aqueous homogeneous reactor Of the Molten Salt Reactor Gas is fueled (theoretically) by the nucleus-shaped Cubic cylindrical spherical slab Annulus Using electric nuclear power plants, Including small modular reactors Propulsion, see nuclear engines Nuclear Marine Propulsion Installation Various proposed forms of rocket engines Other types of heat use Desalination heat for domestic and industrial heating production of hydrogen for use in the hydrogen economy Manufacturing reactors for transmutation elements Breeder reactors are able to produce more fissile material than consumed during a chain reaction of division (by converting the fertile U-238 into Pu-239, or Th-232 into U-233). Thus, the reactor of the uranium breeder, once it works, can be refueled with natural or even depleted uranium, and the reactor-reactor of the thorium breeder can be filled with thorium; however, an initial supply of fissile material is needed. Create various radioactive isotopes, such as americia for use in smoke detectors, and cobalt-60, molybdenum-99 and others used for imaging and treatment. Production of materials for nuclear weapons, such as weapons-grade plutonium, which provides a source of neutron radiation (e.g. with Godiva pulse device) Positron radiation (e.g. neutron activation analysis and potassium dating) Research reactor: Typically reactors used for research and training, testing of materials or or or production of radioisotopes for medicine and industry. They are much smaller than the power reactors or those that moved the ships, and many of them are on university campuses. There are about 280 such reactors in 56 countries. Some of them are fueled by highly enriched uranium fuel, and international efforts are under way to replace low-enriched fuel. Modern technology This section does not cite any sources. Please help improve this section by adding links to reliable sources. Non-sources of materials can be challenged and removed. (June 2015) (Learn how and when to delete this template message) Diablo Canyon - pwR water pressure reactors (PWR) moderator: high-pressure water; Cold Water: High Pressure Water These reactors use a pressure vessel to contain nuclear fuel, control rods, moderator and liquid. Hot radioactive water, which leaves the pressure vessel, passes through the steam generator, which in turn heats the secondary (non-radioactive) loop of water to steam, which can run the turbine. They make up the majority (about 80%) of the population. current reactors. This is the design of a thermal neutron reactor, the newest of which are the Russian VVER-1200, the Japanese pressurized reactor, the American AP1000, the Chinese pressurized reactor Hualong and the Franco-German European pressurized reactor. All of the United States' naval reactors are of this type. Boiling Water Reactors (BWR) Moderator: Low Pressure Water; Hladal: low-pressure water A BWR is similar to PWR without a steam generator. The lower pressure of the cooling water allows it to boil inside the pressure vessel, producing steam that triggers the turbine. Unlike PWR, there is no primary and secondary cycle. The thermal efficiency of these reactors may be higher and they may be easier, and even potentially more stable and safe. This is the design of a thermal neutron reactor, the newest of which are improved boiling water reactors and an economic reactor with simplified boiling water. THE CANDU Tsingshan nuclear power plant under pressure of the Heavy Water Reactor (PHWR) Moderator: high-pressure heavy water; Cold Installation: Heavy high-pressure water Canadian design (known as CANDU), very similar to PWRs, but using heavy water. While heavy water is much more expensive than conventional water, it has greater neutron economy (creates more thermal neutrons), allowing the reactor to operate without fuel enrichment equipment. Instead of using one large pressure vessel, as in PWR, the fuel is contained in hundreds of pressure pipes. These reactors are re refueled with natural uranium and are projects of thermal neutron reactors. PHWRs can be refueled while at full capacity, making them very effective in uranium (this allows for accurate control of the flow in the nucleus). CANDU PHWRs were built in Canada, Argentina, China, India, Pakistan, Romania and Korea. India also manages a number of Often referred to as CANDU derivatives, built after the Canadian government suspended nuclear relations with India after the 1974 Smiling Buddha nuclear weapons test. Ignaly nuclear power plant - RBMK type (closed in 2009) Reaktor Bolshoy Moschnosti Kanalniy (RBMK) (moderator: graphite; cool installation: high-pressure water) Soviet design, RBMKs in some respects similar to CANDU in that they refuel during power work and use the construction of a pressure tube instead of a PWR-style vessel. However, unlike CANDU they are very unstable and large, making restraining buildings expensive for them. A number of critical safety weaknesses have also been identified with the RBMK design, although some have been corrected following the Chernobyl accident. Their main attraction is their use of light water and unlogized uranium. As of 2019, 10 remain open, mainly due to increased security and assistance from international security agencies such as the Ministry of Economic Movement. Despite these safety improvements, RBMK reactors are still considered one of the most dangerous reactor designs in use. RBMK reactors were deployed only in the post-Soviet space. Magnox Sizewell Nuclear Power Plant Aes Thorness - AGR Gas-Cooled Reactor (GCR) and Advanced Gas Cooling Reactor (AGR) Moderator: Graphite; thermal power plants: Carbon dioxide These projects have a high thermal efficiency compared to PWRs due to higher operating temperatures. There are a number of existing reactors in this design, mainly in the United Kingdom, where the concept was developed. Old structures (i.e. Magnox stations) are either closed or will be closed in the near future. However, AGRs have an expected lifespan of another 10 to 20 years. This is the design of a thermal neutron reactor. Decommissioning costs can be high due to the large volume of the reactor core. Liquid Metal Reactor (LMFBR) Moderator: No; Cool: Liquid Metal Scaled down the model of the nuclear reactor TOPAz This completely unmeailated reactor design produces more fuel than it consumes. They are said to breed fuel because they produce fissile fuel during operation due to the capture of neutrons. These reactors can function just like PWR in terms of efficiency, and do not require much high pressure restraint, as liquid metal does not need to be kept under high pressure, even at very high temperatures. These reactors are fast neutrons, not thermal neutrons. These reactors come in two types: Superph'nix, closed in 1998, was one of the few lead-cooling FBRs using lead as liquid metal provides excellent radiation protection, and work at very high temperatures. In addition, lead is (mostly) transparent to neutrons, so less neutrons are lost in the liquid, and the cold does not become radioactive. Unlike sodium, lead is mostly inert, so the risk of exploding is less accident, but such a large amount of lead can be problematic in terms of toxicology and removal. Often a reactor of this type will use lead-temporal euthetic mixture. In this case, bismuth will present some minor radiation problems, since it is not as transparent to neutrons, and can be transmuted into a radioactive isotope more easily than lead. The Russian submarine of the type Alpha uses as the main power plant a reactor with lead-temporal cooled. Sodium-chilled Most LMFBRs of this type. TOPAz, BN-350 and BN-600 in the USSR; Superfenix in France; and Fermi-I in the United States were reactors of this type. Sodium is relatively easy to get and work with, and it also manages to actually prevent corrosion on different parts of the reactor submerged in it. However, sodium explodes strongly when exposed to water, so you need to take care, but such explosions will not be more severe than (for example) leaking heated liquid from the reactor with water pressure. The Monju reactor in Japan was affected by a sodium leak in 1995 and cannot be restarted until May 2010. EBR-I, the first reactor to flatten the core in 1955, was also a sodium-cooled reactor. Reactors with pebbles (PBR) moderator: graphite; They use fuel cured of ceramic balls and then circulate gas through the balls. The result is efficient, low maintenance, a very safe reactor with low-cost, standardized fuel. The prototype was AVR, and the HTR-10 operates in China, where HTR-PM is being developed. HTR-PM is expected to be the first iv-generation reactor to be commissioned. Molten salt reactors (MSR) (moderator: graphite; cold: molten salt mixture) They dissolve fuel in fluoride-containing salts or use fluoride-containing salts to cool. They have many safety features, high efficiency and high power density suitable for vehicles. Remarkably, they do not have high pressure or flammable components in the nucleus. The prototype was MSRE, which also used the Thorium fuel cycle. As a breeder-type reactor reactor, it recycles spent fuel by extracting both uranium and transuranics, leaving only 0.1% of transuranic waste compared to conventional one-off uranium fuel reactors. A separate issue is radioactive fission products that are not recyclable and need to be disposed of, as in conventional reactors. Water homogeneous reactor (AHR) moderator: high pressure light or heavy water; Cold Lamp: Light or heavy high-pressure water These reactors are used as fuel soluble nuclear salts (usually uranium sulfate or uranium nitrate) dissolved in water and mixed with liquid and To date, only five AHRS have been in operation. The future and development of Advanced Reactor Technologies More than a dozen advanced reactor designs are at various stages of development. Some of them are evolutionary ones from PWR, BWR and PHWR designs above, some of them are more radical departures. The first include an advanced boiling water reactor (ABWR), two of which are currently working with others under construction, and the planned passively secure economic simplified boiling water reactor (ESBWR) and AP1000 units (see Nuclear Power 2010 Program). The Integral Fast Reactor (IFR) was built, tested and evaluated in the 1980s and then retired under the Clinton administration in the 1990s due to the administration's nuclear nonproliferation policy. The recycling of the fuel is the basis of its design, and therefore it produces only a part of the waste of the current reactors. The pebble-bed reactor, a high-temperature gas-cooled reactor (HTGCR), is designed to reduce power by extending the Doppler transverse section of neutrons. It uses ceramic fuel, so its safe operating temperatures exceed the range of power reduction temperatures. Most structures are cooled by inert helium. Helium is not prone to vapor explosions, resists the absorption of neutrons, which leads to radioactivity, and does not dissolve pollutants that can become radioactive. Typical structures have more layers (up to 7) of passive containment than light water reactors (usually 3). A unique feature that can help safety is that the fuel balls actually form the mechanism of the core, and are replaced one by one as they age. Fuel design makes fuel recycling expensive. The small, sealed, transportable, autonomous reactor (SSTAR) is being primarily researched and developed in the U.S., designed as a rapid breeder reactor that is passively safe and can be remotely closed in the event of suspicion that it is being tampered with. The Clean and Environmentally Safe Advanced Reactor (CAESAR) is a concept nuclear reactor that uses steam as a moderator - this design is still in development. The reduced temperate water reactor builds on the advanced boiling water reactor (ABWR) which is currently in use, is not a complete fast reactor instead using mostly epithermal neutrons, which are between thermal and fast neutrons in speed. The self-regulating hydrogen self-regulating HPM is a reactor design emanating from the Los Alamos National Laboratory, which uses uranium hydride as fuel. Subcritical reactors are designed to be safer and more stable, but create a number of engineering and economic difficulties. One example is an energy amplifier. Reactors based on thorium. It is possible to convert Thorium-232 into U-233 specially designed for this purpose. Thus, thorium, which is four times more abundant than uranium, can be used to dilute U-233 nuclear fuel. The U-233 is also believed to have favourable nuclear properties compared to the traditionally used U-235, including a better neutron economy and lower production of long-term transuranic waste. Extended heavy water water (AHWR) - Proposed heavy water-modeal reactor to be a new generation of PHWR. Under development at the Bhabha Atomic Research Centre (BARC), India. KAMINI is a unique reactor using uranium-233 isotopes as fuel. Built in India by BarC and Indira Gandhi Center for Atomic Research (IGCAR). India also plans to build rapid-breeding reactors using thorium -233 fuel cycle. FBTR (Fast Breeder Test Reactor), operating in Kalpakkam, India, uses plutonium as fuel and liquid sodium as liquid. China, which has control of the Cerro Ilbo field, has a reactor and hopes to replace coal-fired power with nuclear power. Rolls-Royce plans to sell nuclear reactors to produce synfuel for aircraft. Generation IV generation IV reactors are a set of theoretical nuclear reactor projects that are currently being explored. It is expected that these projects will not be available for commercial construction until 2030. Current reactors around the world are generally considered second- or third-generation systems, with first-generation systems decommissioned some time ago. Research into these types of reactors has been officially initiated by the International Generation IV Forum (GIF), based on eight technological purposes. The main objectives are to improve nuclear safety, increase proliferation resilience, minimize waste and use of natural resources, and reduce the cost of building and operating such power plants. A gas-cooled fast lead-cooled reactor, a lead-cooled, fast-moving melted salt reactor with a sodium-cooled fast reactor, the Supercritical Water Reactor Very High Temperature Reactors of Generation V Reactors are projects that are theoretically possible, but which are not currently actively considered or researched. While some Generation V reactors can potentially be built with current or short-term technology, they generate little interest for economic, practicality or safety reasons. A reactor with a liquid core. The closed cycle of the liquid core of the nuclear reactor, where the fissile material is molten uranium or uranium solution is cooled by working gas, is pumped through holes at the base of the containment vessel. Gas-nuclear reactor. The closed loop is a version of the nuclear light bulb rocket, where the fissile material is the gasious hexafluoride of uranium contained in the fused silica vessel. A working gas (such as hydrogen) will flow around this vessel and absorb the ultraviolet light produced by the reaction. This reactor design can also function as a rocket engine, as shown in Harry's sci-fi novel 1976 Skyfall. Theoretically, using UF6 as working fuel directly (rather than as a stage to one, as is currently the case) would mean lower processing costs and very small reactors. In practice, operating a reactor at such a high power density is likely to lead to a restless neutron flow, flow, most reactor materials, and therefore, since the flow would be similar to that expected in thermonuclear reactors, it would require similar materials selected by the International Thermonuclear irradiation mechanism. The gas core of the EM reactor. As in the gas core reactor, but with photovoltaic arrays converting UV radiation directly into electricity. This approach is similar to the experimentally proven photovoltaic effect, which converts the X-rays generated from anetronic synthesis into electricity, transmitting high-energy photons through an array of conductive foils to transmit some of its energy to electrons, the energy of the photon imprinted electrostatically, like a capacitor. Because X-rays can pass through much greater thickness of material than electrons, many hundreds or thousands of layers are required to absorb X-rays. Divide fragment reactor. A fragment of a fission reactor is a nuclear reactor that generates electricity by slowing down the ion beam of fission by-products instead of using nuclear reactions to generate heat. By doing so, it bypasses the Carnot cycle and can achieve efficiency of up to 90% instead of 40-45% achievable by efficient thermal reactor turbines. The ion beam of the fission fragment will pass through a magnetohydrodynamic generator to produce electricity. Hybrid nuclear fusion. Will use neutrons emitted by fusion to divide a blanket of fertile material like U-238 or Th-232 and transmute other reactors of manufactured nuclear fuel/nuclear waste into relatively more benign isotopes. Synthesis Reactors Main article: Fusion Power Controlled nuclear fusion in principle can be used in thermonuclear power plants to produce energy without the complexities of processing actinides, but significant scientific and technical obstacles remain. Several thermonuclear reactors were built, but only recently were the reactors able to release more energy than the amount of energy used in the process. Despite research initiated in the 1950s, no commercial thermonuclear reactor is expected until 2050. The ITER project is currently leading efforts to use thermonuclear energy. Nuclear Fuel Cycle Main Article: Nuclear Fuel Cycle Thermal Reactors usually depend on refined and enriched uranium. Some nuclear reactors may operate with a mixture of plutonium and uranium (see MOX). The process of extraction, processing, enrichment, use, possibly processing and disposal of uranium ore is known as the nuclear fuel cycle. Less than 1% of the uranium found in nature is easily fissile isotope U-235, and as a result most reactor designs require enriched fuel. Enrichment involves an increase in the share of U-235 and, as a rule, with gas effects or gas centrifuges. The enriched result is then converted into uranium dioxide powder, which is pressed and dismissed into a form of pellets. These pellets are stacked in tubes, which are then then and are called fuel rods. Many of these fuel rods are used in every nuclear reactor. Most commercial BWR and PWR reactors use uranium enriched to about 4% U-235, and some commercial reactors with high-economy neutrons do not require fuel enrichment (i.e. they can use natural uranium). According to the International Atomic Energy Agency, there are at least 100 research reactors in the world fueled by highly enriched (weapons enrichment/90% enrichment) uranium. The risk of theft of this fuel (potentially used in the production of nuclear weapons) has led to campaigns promoting the conversion of this type of reactor into low-enriched uranium (which poses a lesser risk of proliferation). The fissile U-235 and the indestruction but fissile and fertile U-238 are used in the fissile process. U-235 is broken down by thermal (i.e. slow-moving) neutrons. The thermal neutron moves at about the same speed as the atoms around it. Since all atoms vibrate in proportion to their absolute temperature, the thermal neutron has the best opportunity to divide U-235 when it moves at the same vibrational speed. On the other hand, U-238 is more likely to capture a neutron when the neutron moves very fast. This U-239 atom will soon disintegrate into plutonium-239, which is another fuel. The Pu-239 is a viable fuel and should be taken into account even when using highly enriched uranium fuel. Plutonium fission will dominate the U-235 cracks in some reactors, especially after the initial U-235 load. Plutonium is broken down with both fast and thermal neutrons, making it ideal for both nuclear reactors and nuclear bombs. Most reactor projects are thermal reactors and usually use water as a neutron moderator (moderator means it slows the neutron to thermal speed) and as a heat electronet. But the rapid breeder reactor uses some other kind of liquid that will not moderate or slow down neutrons. This allows fast neutrons to dominate, which can be effectively used to continuously replenish fuel reserves. Simply by placing cheap unre enriched uranium in such a core, the unmarked U-238 will be turned into Pu-239, a tribal fuel. In the tori fuel cycle, thorium-232 absorbs neutron in a fast or thermal reactor. The beta version of thorium-233 breaks down into protactium-233 and then uranium-233, which in turn is used as fuel. Thus, like uranium-238, thorium-232 is a fertile material. Refueling nuclear reactors with the amount of energy in a nuclear fuel tank is often expressed in terms of full days of power, i.e. the number of 24-hour periods (days) the reactor is planned for at full capacity to generate thermal energy. The number of days of full power in the reactor operation cycle (between times of refueling down) is related to the amount of fissile uranium-235 (U-235) contained in the fuel builds at the beginning of the cycle. A higher percentage of U-235s in the core at the beginning of the cycle will allow the reactor to operate for more days of full capacity. At the end of the operating cycle, fuel in some assemblies is consumed after spending 4 to 6 years in an energy-producing reactor. This heavy fuel is rescreated and replaced with new (fresh) fuel assemblies. Although considered spent, these fuel assemblies contain large amounts of fuel. In practice, it is the economy that determines the life of nuclear fuel in the reactor. Long before all possible division occurred, the reactor was unable to maintain 100%, full capacity, and therefore the revenue for the utility was reduced as the power of the plant's production was reduced. Most nuclear power plants operate at very low profitability due to operating overhead costs, mainly regulatory costs, so operating below 100% of capacity is economically unviable for a very long time. The share of the reactor's fuel core, which is replaced during refueling, is usually one-third, but depends on how long the plant works between refueling stations. Plants typically operate on 18-month refueling cycles, or 24-month refueling cycles. This means that one gas station, which replaces only a third of the fuel, can keep the nuclear reactor at full capacity for almost 2 years. Recycling and storing this spent fuel is one of the most complex aspects of a commercial nuclear power plant. These nuclear wastes are highly radioactive and have been hazardous for thousands of years. Once discharged from the reactor, the nuclear fuel produced is transferred to a well-established fuel pool in place. The fuel-making pool represents a 50,000-pool water that provides cooling and protection for nuclear fuel. After the energy has broken down somewhat (approximately 5 years), the fuel can be transferred from the fuel basin to dry protected barrels that can be safely stored for thousands of years. After loading into dry protected barrels, the barrels are stored in place in a specially guarded facility in impenetrable concrete bunkers. On-site fuel storage facilities are designed to withstand the impact of commercial airliners, with little or no damage to the fuel produced. The average in-place fuel storage can pull off fuel in space for 30 years less than a football field. Not all reactors should be closed for refueling; for example, pebble goyke reactors, RBMK reactors, molten salt reactors, Magnox, AGR and CANDU reactors allow fuel to be pumped through the reactor during operation. In the CANDU reactor, this also allows separate fuel cells in the reactor core, which are best suited to the amount of U-235 in the fuel cell. The amount of energy extracted from nuclear fuel is called burning it, burning it, in terms of thermal energy produced per initial fuel unit. Burn Up is usually expressed as megawatt days of heat per metric ton of the original heavy metal. Nuclear Safety Main Article: Nuclear Safety Nuclear Safety covers measures taken to prevent nuclear and radiation accidents and incidents or limit their effects. Nuclear power has improved the safety and performance of reactors and proposed new safer (but generally untested) reactor designs, but there is no guarantee that reactors will be designed, built and operated properly. Mistakes happen, and the reactor designers at Fukushima in Japan did not expect the tsunami caused by the earthquake to shut down the backup systems that were supposed to stabilize the reactor after the earthquake, despite numerous warnings from NRG and the Japanese Nuclear Safety Administration. According to UBS AG, the Fukushima-1 nuclear power plant accident has cast doubt on even an advanced economy such as Japan's ability to master nuclear safety. Catastrophic scenarios related to terrorist attacks are also possible. An interdisciplinary team from the Massachusetts Institute of Technology has calculated that, given the expected growth of nuclear power in 2005-2055, at least four major nuclear accidents could be expected during this period. Nuclear accidents See also: Lists of nuclear disasters and radioactive incidents Three reactors at Fukushima I overheated, causing the water to cool off and leading to hydrogen explosions. This, along with fuel crises, releases a large amount of radioactive material into the air. Serious, albeit rare, nuclear and radiation accidents have occurred. These include the SL-1 accident (1961), the Tri-Mile Island accident (1979), the Chernobyl disaster (1986) and the Fukushima Daiichi nuclear disaster (2011). Accidents on nuclear submarines include an accident at the K-19 reactor (1961), an accident at the K-27 reactor (1968), an accident at the K-431 reactor (1985). Nuclear reactors are launched into low-Earth orbit at least 34 times. As a result of a number of incidents related to the unmanned nuclear reactor program of the Soviet radar satellite program RORSAT, the nuclear fuel produced has returned to the Earth's atmosphere from orbit. (quote is needed) Natural Nuclear Reactors Home article: Natural nuclear fission reactor Nearly two billion years ago a series of self-propelled nuclear fission reactors self-assembled in an area now known as Oklo in Gabon, West Africa. Conditions at this location and at that time allowed natural nuclear division to occur under circumstances similar to those in the nuclear reactor built. Fifteen fossil natural fission reactors were found in three separate ore at the Oklo uranium mine in Gabon. First discovered in 1972 by French physicist Francis Francis they are known as oklo fossil reactors. Self-captured reactions to nuclear weapons division occurred in these reactors about 1.5 billion years ago and for several hundred thousand years worked at an average of 100 kW of capacity during this time. The concept of a natural nuclear reactor was organized back in 1956 by Paul Kuroda of the University of Arkansas. Such reactors can no longer be formed on Earth during the current geological period. The radioactive decay of previously abundant uranium-235 for hundreds of millions of years reduced the proportion of this natural fissile isotope to below the amount needed to maintain a chain reaction with only plain water as a moderator. Natural nuclear reactors were formed when the uranium-rich mineral deposit was flooded with groundwater, which acted as a moderator of neutrons, and there was a strong chain reaction. The water moderator will boil as the reaction increases, slowing it back down and preventing the crisis. The reaction of division has been steady for hundreds of thousands of years, cycling in order hours to several days. These natural reactors are widely studied by scientists interested in geological disposal of radioactive waste. They provide an example of how radioactive isotopes migrate through the Earth's crust. This is an important area of dispute, as opponents of geological waste disposal fear that isotopes from stored waste may end up in the water supply or be moved to the environment. Emissions Nuclear reactors produce tritians as part of normal operation, which is eventually released into the environment in trace amounts. As a hydrogen isotope, tritium (T) often binds to oxygen and forms T2O. This molecule is chemically identical to H2O and therefore colorless and odorless, but additional neutrons in hydrogen nuclei cause tritium to undergo beta decay with a semi-family lifespan of 12.3 years. Despite the measurable results, the triti freed up by nuclear power plants is minimal. The United States NRC estimates that a person who drinks water for one year from a well-contaminated water that he or she considers to be a significant spill would receive a radiation dose of 0.3 millire. By comparison, this is an order of magnitude less than the 4 millireams a person receives during a flight from Washington to Los Angeles, which is a consequence of less atmospheric protection against high energy cosmic rays at high altitudes. The amount of strontium-90 released from nuclear power plants during normal operation is so low that it can be detected above natural background radiation. The detected strontium-90 in groundwater and in the general environment can be traced back to weapons tests that took place in the mid-20th century (which account for 99% of strontium-90 in and the environment) and Accident (given the remaining 1%). 57 See also List of Nuclear Reactors List of Small Modular Reactor Designs List of U.S. Navy Neutron Reactors Nuclear Marine Propulsion Plant Nuclear Power on the Country One Less Nuclear Power Plant Radioisotope Thermoelectric Generator Safety Engineering Sayonara Nuclear Power Plant Small Modular Reactor Toria-based Nuclear Energy Travel Wave Reactor (TWR) World Nuclear Industry Report on the State of Nuclear Power in Space References to PRIS pris.iaea.org. - Search RRDB. nucleus.iaea.org. - MeE Basics Handbook : Nuclear Physics and Reactor Theory (PDF). U.S. Department of Energy. Archive from the original (PDF) dated April 23, 2008. Received on September 24, 2008. Reactor protection and safety engineering systems. A nuclear tourist. 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