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Chapter 1 : Storage and Disposal Options for Radioactive Waste - World Nuclear Association

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Front end[edit] Waste from the front end of the nuclear fuel cycle is usually alpha-emitting waste from the extraction of uranium. It often contains radium and its decay products. Uranium dioxide UO2 concentrate from mining is a thousand or so times as radioactive as the granite used in buildings. It is refined from yellowcake U3O8 , then converted to uranium hexafluoride gas UF6. As a gas, it undergoes enrichment to increase the U content from 0. It is then turned into a hard ceramic oxide UO2 for assembly as reactor fuel elements. It is stored, either as UF6 or as U3O8. Some is used in applications where its extremely high density makes it valuable such as anti-tank shells , and on at least one occasion even a sailboat keel. These isotopes are formed in nuclear reactors. It is important to distinguish the processing of uranium to make fuel from the reprocessing of used fuel. Used fuel contains the highly radioactive products of fission see high level waste below. Many of these are neutron absorbers, called neutron poisons in this context. These eventually build up to a level where they absorb so many neutrons that the chain reaction stops, even with the control rods completely removed. At that point the fuel has to be replaced in the reactor with fresh fuel, even though there is still a substantial quantity of uranium and plutonium present. In the United States, this used fuel is usually "stored", while in other countries such as Russia, the United Kingdom, France, Japan and India, the fuel is reprocessed to remove the fission products, and the fuel can then be re-used. While these countries reprocess the fuel carrying out single plutonium cycles, India is the only country known to be planning multiple plutonium recycling schemes. Long-lived fission product Activity of U for three fuel types. In the case of MOX, the U increases for the first thousand years as it is produced by decay of Np which was created in the reactor by absorption of neutrons by U Total activity for three fuel types. In region 1 we have radiation from short-lived nuclides, and in region 2 from Sr and Cs On the far right we see the decay of Np and U The use of different fuels in nuclear reactors results in different spent nuclear fuel SNF composition, with varying activity curves. Long-lived radioactive waste from the back end of the fuel cycle is especially relevant when designing a complete waste management plan for SNF. When looking at long-term radioactive decay , the actinides in the SNF have a significant influence due to their characteristically long half-lives. Depending on what a nuclear reactor is fueled with, the actinide composition in the SNF will be different. An example of this effect is the use of nuclear fuels with thorium. Th is a fertile material that can undergo a neutron capture reaction and two beta minus decays, resulting in the production of fissile U The SNF of a cycle with thorium will contain U Its radioactive decay will strongly influence the long-term activity curve of the SNF around a million years. A comparison of the activity associated to U for three different SNF types can be seen in the figure on the top right. This has an effect in the total activity curve of the three fuel types. The initial absence of U and its daughter products in the MOX fuel results in a lower activity in region 3 of the figure on the bottom right, whereas for RGPu and WGPu the curve is maintained higher due to the presence of U that has not fully decayed. Nuclear reprocessing can remove the actinides from the spent fuel so they can be used or destroyed see Long-lived fission product Actinides. Nuclear proliferation and Reactor-grade plutonium Since uranium and plutonium are nuclear weapons materials, there have been proliferation concerns. Ordinarily in spent nuclear fuel , plutonium is reactor-grade plutonium. In addition to plutonium , which is highly suitable for building nuclear weapons, it contains large amounts of undesirable contaminants: These isotopes are extremely difficult to separate, and more cost-effective ways of obtaining fissile material exist e. This is a concern since if the waste is stored, perhaps in deep geological storage , over many years the fission products decay, decreasing the radioactivity of the waste and making the plutonium easier to access. The undesirable contaminant Pu decays faster than the Pu, and thus the quality of the bomb material increases with time although its quantity decreases during that time as well. Thus, some have argued, as time passes, these deep storage areas have the potential to become "plutonium mines", from which material for nuclear weapons can be acquired with relatively little difficulty. Critics of the latter idea have pointed out the difficulty of recovering useful material from sealed deep storage areas makes other methods preferable. Specifically, the high radioactivity and heat 80 C in surrounding rock greatly increases the difficulty of mining a storage area, and the enrichment methods required have high capital costs. Thus plutonium may decay and leave uranium However, modern reactors are only moderately enriched with U relative to U, so the U continues to serve as a denaturation agent for any U produced by plutonium decay. One solution to this problem is to recycle the plutonium and use it as a fuel e. In pyrometallurgical fast reactors , the separated plutonium and uranium are contaminated by actinides and cannot be used for nuclear weapons. Nuclear weapons decommissioning[edit] Waste from nuclear weapons decommissioning is unlikely to contain much beta or gamma activity other than tritium and americium. It is more likely to contain alpha-emitting actinides such as Pu which is a fissile material used in bombs, plus some material with much higher specific activities, such as Pu or Po. In the past the neutron trigger for an atomic bomb tended to be beryllium and a high activity alpha emitter such as polonium ; an alternative to polonium is Pu For reasons of national security, details of the design of modern bombs are normally not released to the open literature. Some designs might contain a radioisotope thermoelectric generator using Pu to provide a long lasting source of electrical power for the electronics in the device. It is likely that the fissile material of an old bomb which is due for refitting will contain decay products of the plutonium isotopes used in it, these are likely to include U from Pu impurities, plus some U from decay of the Pu; due to the relatively long half-life of these Pu isotopes, these wastes from radioactive decay of bomb core material would be very small, and in any case, far less dangerous even in terms of simple radioactivity than the Pu itself. The beta decay of Pu forms Am ; the in-growth of americium is likely to be a greater problem than the decay of Pu and Pu as the americium is a gamma emitter increasing external-exposure to workers and is an alpha emitter which can cause the generation of heat. Naturally occurring uranium is not fissile because it contains Legacy waste[edit] Due to historic activities typically related to radium industry, uranium mining, and military programs, numerous sites contain or are contaminated with radioactivity. In the United States alone, the Department of Energy states there are "millions of gallons of radioactive waste" as well as "thousands of tons of spent nuclear fuel and material" and also "huge quantities of contaminated soil and water. It can be divided into two main classes. In diagnostic nuclear medicine a number of short-lived gamma emitters such as technetiumm are used. Many of these can be disposed of by leaving it to decay for a short time before disposal as normal waste. Other isotopes used in medicine, with half-lives in parentheses, include: Y , used for treating lymphoma 2. Gamma emitters are used in radiography while neutron emitting sources are used in a range of applications, such as oil well logging. After human processing that exposes or concentrates this natural radioactivity such as mining bringing coal to the surface or burning it to produce concentrated ash , it becomes technologically enhanced naturally occurring radioactive material TENORM. The main source of radiation in the human body is potassium 40K , typically 17 milligrams in the body at a time and 0. The sulfate scale from an oil well can be very radium rich, while the water, oil and gas from a well often contain radon. The radon decays to form solid radioisotopes which form coatings on the inside of pipework. In an oil processing plant the area of the plant where propane is processed is often one of the more contaminated areas of the plant as radon has a similar boiling point to propane. Uranium tailings Removal of very low-level waste Uranium tailings are waste by-product materials left over from the rough processing of uranium -bearing ore. They are not significantly radioactive. Mill tailings are sometimes referred to as 11 e 2 wastes, from the section of the Atomic Energy Act of that defines them. Uranium mill tailings typically also contain chemically hazardous heavy metal such as lead and arsenic. Vast mounds of uranium mill tailings are left at many old mining sites, especially in Colorado , New Mexico , and Utah.

Chapter 2 : Radioactive contamination from the Rocky Flats Plant - Wikipedia

Programme Progress Report JRC Ispra January-June MANAGEMENT OF NUCLEAR MATERIALS AND RADIOACTIVE WASTE Abstract This document is the progress report of the programme Management of Nuclear.

Radioactive Waste Management Updated April Nuclear power is the only large-scale energy-producing technology that takes full responsibility for all its waste and fully costs this into the product. The amount of waste generated by nuclear power is very small relative to other thermal electricity generation technologies. Used nuclear fuel may be treated as a resource or simply as waste. Nuclear waste is neither particularly hazardous nor hard to manage relative to other toxic industrial waste. Safe methods for the final disposal of high-level radioactive waste are technically proven; the international consensus is that geological disposal is the best option. Like all industries, the generation of electricity produces waste. Whatever fuel is used, the waste produced in generating electricity must be managed in ways that safeguard human health and minimise the impact on the environment. For radioactive waste, this means isolating or diluting it such that the rate or concentration of any radionuclides returned to the biosphere is harmless. To achieve this, practically all radioactive waste is contained and managed, with some clearly needing deep and permanent burial. From nuclear power generation, unlike all other forms of thermal electricity generation, all waste is regulated â€" none is allowed to cause pollution. Nuclear power is characterised by the very large amount of energy produced from a very small amount of fuel, and the amount of waste produced during this process is also relatively small. However, much of the waste produced is radioactive and therefore must be carefully managed as hazardous material. All parts of the nuclear fuel cycle produce some radioactive waste and the cost of managing and disposing of this is part of the electricity cost i. All toxic waste needs be dealt with safely â€" not just radioactive waste â€" and in countries with nuclear power, radioactive waste comprises a very small proportion of total industrial hazardous waste generated. Radioactive waste is not unique to the nuclear fuel cycle. Radioactive materials are used extensively in medicine, agriculture, research, manufacturing, non-destructive testing, and minerals exploration. Unlike other hazardous industrial materials, however, the level of hazard of all radioactive waste â€" its radioactivity â€" diminishes with time. Types of radioactive waste Radioactive waste includes any material that is either intrinsically radioactive, or has been contaminated by radioactivity, and that is deemed to have no further use. Government policy dictates whether certain materials â€" such as used nuclear fuel and plutonium â€" are categorised as waste. Every radionuclide has a half-life â€" the time taken for half of its atoms to decay, and thus for it to lose half of its radioactivity. Eventually all radioactive waste decays into non-radioactive elements. The more radioactive an isotope is, the faster it decays. LLW does not require shielding during handling and transport, and is suitable for disposal in near surface facilities. LLW is generated from hospitals and industry, as well as the nuclear fuel cycle. To reduce its volume, LLW is often compacted or incinerated before disposal. Due to its higher levels of radioactivity, ILW requires some shielding. ILW typically comprises resins, chemical sludges, and metal fuel cladding, as well as contaminated materials from reactor decommissioning. Smaller items and any non-solids may be solidified in concrete or bitumen for disposal. As a result, HLW requires cooling and shielding. HLW contains the fission products and transuranic elements generated in the reactor core. There are two distinct kinds of HLW: Used fuel that has been designated as waste. HLW has both long-lived and short-lived components, depending on the length of time it will take for the radioactivity of particular radionuclides to decrease to levels that are considered non-hazardous for people and the surrounding environment. If generally short-lived fission products can be separated from long-lived actinides, this distinction becomes important in management and disposal of HLW. HLW is the focus of significant attention regarding nuclear power, and is managed accordingly. The waste is therefore disposed of with domestic refuse, although countries such as France are currently developing specifically designed VLLW disposal facilities. Where and when is waste produced? Radioactive waste is produced at all stages of the nuclear fuel cycle â€" the process of producing electricity from nuclear materials. The fuel cycle involves the mining and milling of uranium ore, its processing and fabrication into nuclear fuel, its use in the reactor, its reprocessing if conducted , the treatment of the used fuel taken from the reactor, and finally, disposal of the waste. Where the used fuel is reprocessed, the amount of waste is reduced materially. Mining through to fuel fabrication Traditional uranium mining generates fine sandy tailings, which contain virtually all the naturally occurring radioactive elements found in uranium ore. The tailings are collected in engineered dams and finally covered with a layer of clay and rock to inhibit the leakage of radon gas, and to ensure long-term stability. In the short term, the tailings material is often covered with water. Strictly speaking these are not classified as radioactive waste. It is refined then converted to uranium hexafluoride UF6 gas. As a gas, it undergoes enrichment to increase the U content from 0. It is then turned into a hard ceramic oxide UO2 for assembly as reactor fuel elements. Some DU is used in applications where its extremely high density makes it valuable, such as for the keels of yachts and military projectiles. Electricity generation In terms of radioactivity, the major source arising from the use of nuclear reactors to generate electricity comes from the material classified as HLW. Highly radioactive fission products and transuranic elements are produced from uranium and plutonium during reactor operations, and are contained within the used fuel. Where countries have adopted a closed cycle and reprocess used fuel, the fission products and minor actinides are separated from uranium and plutonium and treated as HLW see below. In countries where used fuel is not reprocessed, the used fuel itself is considered a waste and therefore classified as HLW. Reprocessing of used fuel Any used fuel will still contain some of the original U as well as various plutonium isotopes which have been formed inside the reactor core, and U Several European countries, as well as Russia, China, and Japan have policies to reprocess used nuclear fuel. Reprocessing allows for a significant amount of plutonium to be recovered from used fuel, which is then mixed with depleted uranium oxide in a MOX fabrication plant to make fresh fuel. Commercial reprocessing plants currently operate in France, the UK, and Russia. Another is being commissioned in Japan, and China plans to construct one too.

Chapter 3 : Key documents and FAQs | National Radioactive Waste Management Facility

Radioactive Waste Management (Updated April) Nuclear power is the only large-scale energy-producing technology that takes full responsibility for all its waste and fully costs this into the product.

All buildings have since been demolished from the site. Originally under management of the Dow Chemical Company , management was transferred to Rockwell in Production of parts for nuclear weapons began in At the time, the precise nature of the work at Rocky Flats was a closely guarded secret. The plant produced fission cores for nuclear weapons, used to "ignite" fusion and fissionable fuel in all modern nuclear weapons. They are often referred to as "triggers" in official and news documents to obfuscate their function. Additional sources of actinide contamination include inadequate pondcrete vitrification attempts and routine releases during the decades of plant operations. HEPA filter banks meant to remove microscopic particles of plutonium from the glove box exhaust streams were destroyed by the fire, allowing radioactive smoke to escape the building. On the evening of September 11, , plutonium shavings in a glove box located in building the Plutonium Recovery and Fabrication Facility spontaneously ignited. The fire spread to the flammable glove box materials, including plexiglas windows and rubber gloves. The fire rapidly spread through the interconnected glove boxes and ignited the large bank of High-efficiency particulate air HEPA filters located in a plenum downstream. Within minutes the first filters had burned out, allowing plutonium particles to escape from the building exhaust stacks. The building exhaust fans stopped operating due to fire damage at Fire fighters initially used carbon dioxide fire extinguishers because water can act as a moderator and cause plutonium to go critical. They resorted to water hoses when the dry fire extinguishers proved ineffective. Plutonium milling operations produced large quantities of toxic cutting fluid contaminated with particles of plutonium and uranium. Thousands of gallon drums of the waste were stored outside in an unprotected earthen area called the pad storage area, [28]: Fire fighters again resorted to fighting the fire with water after dry extinguishers proved ineffective. Despite recommendations after the fire, suppression systems were not built into the glove boxes. The fire, however, led local health officials to perform independent tests of the area surrounding Rocky Flats to determine the extent of the contamination. This resulted in the first releases of information to the public that populated areas southeast of Rocky Flats had been contaminated. These were stored in the open under tarps on asphalt pads. A large portion of the plutonium released into the creeks sank to the bottom and is now found in the streambeds of Walnut and Woman Creeks, and on the bottom of local public reservoirs just outside Rocky Flats: Great Western Reservoir, no longer used for city of Broomfield drinking water consumption as of but still used for irrigation , [44] and Standley Lake , a drinking water supply for the cities of Westminster, Thornton, Northglenn and some residents of Federal Heights. At the time of the fire, AEC officials told the Denver Post that the fire "resulted in no spread of radioactive contamination of any consequence. Releases from previous years had not been reported publicly prior to the fire; [50] airborne-become-groundborne radioactive contamination extending well beyond the Rocky Flats plant was not publicly reported until the s. Fish and Wildlife Service surveyed tissues harvested from deer that lived at Rocky Flats for plutonium and other actinides. Isotopes of plutonium, americium , and uranium were detected, with the highest measured activity being 0. Plutonium in the environment Plutonium and emit ionizing radiation in the form of alpha particles. Inhalation is the primary pathway by which plutonium enters the body, though plutonium can also enter the body through a wound. Researchers noted that plutonium contamination from the plant was present, but did not match the wind conditions of the fire. The fire and leaking barrels on Pad have since been confirmed to be the main sources of plutonium contamination. The study also noted that plutonium levels just outside the boundaries of the plant were hundreds of times higher than the background level caused by global fallout from nuclear testing , and that contamination to the north of the plant was probably caused by normal operations rather than accidental releases. Tritium, a radioactive element which was found in scrap material from Rocky Flats, was therefore directed in to the Great Western Reservoir. This was uncovered in and following this, urine samples were taken from people living or working near Broomfield who could have drunk water from the reservoir. The findings of the samples showed that those who were exposed to contaminated water had tritium concentrations near seven times higher than normal 4, picocuries per liter versus picocuries per liter. However, when the same group underwent urine sampling three years later, their tritium concentrations had returned to the standard. Carl Johnson, health director for Jefferson County , showed a 45 percent increase in congenital birth defects in Denver suburbs downwind of Rocky Flats compared to the rest of Colorado. A study by Crump and others did not find the cancer rates in the northwestern portion of Denver to be significantly higher than other parts of the city and attributed variance in cancer rates to the population density of urban areas. Therefore, Crump et al. Cobb and the EPA reported plutonium concentrations from about persons who had died in Colorado. A comparison study was done of those who lived near Rocky Flats with those who lived far from this nuclear weapons production site. In this analysis, health risk estimates for off-site humans had a variance of four orders of magnitude, from "between 2. This report listed Rocky Flats as having 5 of the 14 most vulnerable facilities based on plutonium environmental, safety, and health vulnerability at all Department Of Energy facilities. The member Health Advisory Panel included multiple medical doctors, scientists, PhDs, and local officials. The Studies had three main objectives: James Ruttenber led a study on the health effects of plutonium. Conducted by the University of Colorado Health Sciences Center and the Colorado Department of Public Health and Environment, the study concluded that lung cancer is linked to plutonium inhalation. Their research also found that these workers were 2. Information about the council is available on their website. This amount was less than the company had been paid in bonuses for running the plant as determined by the GAO , and yet was also by far the highest hazardous-waste fine ever; four times larger than the previous record. Justice Department and Rockwell the cost of paying any civil penalties would ultimately have been borne by U. While any criminal penalties allotted to Rockwell would not have been covered by U. Attorney, Ken Fimberg later Ken Scott , [74]: Press leaks by both members of the DOJ and the grand jury occurred in violation of secrecy Rule 6 e regarding Grand Jury information. The public contest led to U. The hearings, whose findings include that the Justice Department had "bargained away the truth," [74]: Ch 6, note 54 The special grand jury report was nonetheless leaked to Westword and excerpts published in its September 29, issue. Circuit Court of Appeals subsequently threw out the verdict and ordered a retrial. District Judge John L. Nearly 26 years later, approximately 13, to 15, eligible property owners could receive monetary payments for damages and decreased property values. Property and homeowners who owned property on June 7, , the day the FBI raided the plant, are eligible to file a claim for property devaluation. The deadline to file a claim is June 1, He alleged that his termination was due to concerns by the board members that his reports of contamination would lower property values. The court observed that plaintiffs statements in support of this motion were "conclusory. The activists had previously sued in The court dismissed this lawsuit and awarded costs to the U. According to the USFWS, "the refuge has remained closed to the public due to a lack of appropriations for refuge management operations". Plutonium , with a 24, year half life, will persist in the environment hundreds of thousands of years. This organization was the successor organization to the Rocky Flats Coalition of Local Governments, which advocated for stakeholders during the site cleanup. Information and Council meetings minutes and reports are available on its website. In , the U. Fish and Wildlife Services proposed a controlled burn on acres of the Wildlife Refuge. In , they reported that they will postpone those burns until In , there was a "soft opening" of the Rocky Flats Wildlife Refuge where small groups of people could reserve space on a three-mile guided nature walk. The official opening of the Refuge in now planned for The group set up an online health survey conducted by Metropolitan State University of Denver. Anti-nuclear movement On the weekend of April 28, , more than 15, people demonstrated against the Rocky Flats Nuclear Weapons Plant. The protest was coordinated with other anti-nuclear demonstrations across the country. Daniel Ellsberg and Allen Ginsberg were among the people who were arrested. The demonstration followed more than six months of continuous protests that included an attempted blockade of the railroad tracks leading to the site. On October 15, , about 10, demonstrators turned out for protest at the Rocky Flats Nuclear Weapons Plant well short of the 21, hoped for by protest organizers. No arrests were made. As of , the Jefferson Parkway Public Authority was still searching for private and public funding to complete the beltway. A group named Candelas Glows is opposed to a large housing and commercial development planned in the area, which the group calls a "plutonium dust bowl.

Chapter 4 : Radioactive waste - Wikipedia

The NRC's Programmatic Environmental Impact Statement (PEIS) related to decontamination and disposal of radioactive waste resulting from the TMI accident (NUREG) concluded that the decontamination of the TMI-2 facility, including the removal of the nuclear fuel and radioactive waste from the TMI site, was necessary for the long-term.

Chapter 5 : Event Calendar - Hanford Site

calendrierdelascience.com Technical Report: Nuclear waste management. Quarterly progress report, April-June Quarterly progress report, April-June Title: Nuclear waste management.

Chapter 6 : Radioactive Waste Management | Nuclear Waste Disposal - World Nuclear Association

Vol. June Revised atomic energy legislation has been in force in Switzerland since July It deals mainly with licensing of nuclear installations, introducing new procedures and clarifying conditions under which licenses may be granted.

Chapter 7 : High-Level Radioactive Wastes in Canada -- The Plutonium Agenda

Radioactive Waste Management For these reasons, coal cannot provide a complete solution to the energy needs of the United States. Thus, the United States is.