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# ENVIRONMENTAL SAFETY MEASURES AND OVERALL MANAGEMENT OF RADIOACTIVE WASTE FROM NUCLEAR POWER PLANT

**Hayatu Abba Ibrahim**
Department of Physics,
University of Maiduguri, P M B 1069, Maiduguri, Nigeria
Email: hayatuabbaibrahim5@gmail.com

**ABSTRACT**

This study examined the safety measures and effective management of radioactive waste in an environment especially from radioactive waste from nuclear reactor, through theoretical review of some of the basic principle involved in waste management of radioactive material. Radioactive waste comprises a variety of materials requiring different type of management to protect human and their environment. They are normally classified as low – level, medium level and high-level waste according to the amount and types of radioactivity in them. The waste is both concentrated and then isolated, or it is dilute to acceptable level and then discharged to the environment. Delay and decay involve the storage of the waste and its radioactivity is allowed to decrease naturally through decay of the radioisotopes in it. This study is aim to enlighten the public on the way to manage radioactive waste in such a way which can safeguards human health and minimizes the impact to the environment nuclear plant is install.

**Keyword:** Types of Radioactive Waste, Treatment and methods of disposal, Environment and safety Measures

## INTRODUCTION

Radioactive wastes are materials generated as byproduct from nuclear power plant. Like all industries, the thermal generation of electricity, produce waste whatever fuel is used, these wastes must be managed in ways which safeguard human health and minimize their import on the environment. Nuclear power is the only energy industry which takes full responsibility for all its waste and cost this into the product.

Nuclear power is characterized by the very large amount of energy available from a very small amount of fuel. The amount of waste is also relatively small. However much of the waste is radioactive and therefore must be carefully manage as hazardous waste.

Radioactivity arises naturally from the decay of particular forms of some elements called isotopes. Some isotopes are radioactive most are not, though in this study, we concentrate on the former. There are three kinds of radioactive to consider which are alpha, beta and gamma. A fourth kind, neutron radiator generally only occurs inside a nuclear reactor. Different types of radiation require different form of protection. Alpha radiation cannot penetrate the skin and can be blocked out by a sheet of paper, but is dangerous in the lung. Beta radiation can be blocked out by a sheet of aluminum foil. Gamma radiation can go right through the body and requires several centimeters of lead or concrete or a meter of waters to blocked it. All of these kinds of radiation are at low level in naturally part of our environment. Any or all of them may be present in any classification of waste.

## ENERGY RELEASED IN FISSION CHAIN REACTION

The disintegration of uranium nuclear into two relatively-heavy nuclei is called nuclear fission where a large amount of energy is released in this process. Natural uranium consists of about 1 part by mass of uranium atoms $U^{235}_{92}$ and 140 parts by mass of uranium atoms $U^{238}_{92}$, in a nuclear reaction with natural and slow neutrons. it is usually the nucleus $U^{235}_{92}$ which is fission type. If the resulting nucleus are lanthanum $La^{148}_{57}$ and Bromine $Br^{85}_{35}$ together with neutrons then

$$U^{235}_{92} + n^{1}_{0} \rightarrow La^{148}_{57} + Br^{85}_{35} + 3n^{1}_{0}$$

Now $U^{235}_{92}$ and $n^1_0$ together have a mass of ( 235.1 + 1.009 ) or 236.1u , the lanthanum , bromine and neutron produce together have a mass

$= 148.0 + 84.9 \times 3 \times 1.009 = 235.9$u.

...energy release = mass difference.

$= 0.2u = 0.2 \times 931$ MeV $= 186$ MeV

$= 298 \times 10^{-31}$ J ( approx) .

This is the energy release per atom of uranium fission.

In 1kg of uranium are about:

$\frac{100}{235} \times 6 \times 10^{23}$ or $26 \times 10^{23}$ atom.

Since the Avogadro's constant. The number of atoms a mole of any element is $6.02 \times 10^{23}$. So if all the atoms in 1kg of uranium were fission total energy released.

$= 26 \times 10^{23} \times 298 \times 10^{-13}$ J (approx).

$== 2 \times 10^7$Kilowatts/ hours .

Which is the amount of energy given out by burning about 3 million tons of coal.

**ENERGY RELEASED IN FUSION**

In fusion reaction two elements are combined to produced a single isotope and subsequent release of energy. Consider the fusion of nuclei of deuterium $H^2_1$. Deuterium is isotope hydrogen known as heavy hydrogen and its nucleus is called a deuteron. The fusion of two deuterons can result in a helium nucleus $H^3_2$ as follows:

$H^2_1 + H^2_1 \rightarrow H^3_2 + n^1_0$

Now mass of two deuterons

$= 2 \times 2.015 = 4.030u.$

And mass of helium plus neutron.

$= 3.017 + 1.009 = 4.026u$

Mass converted to energy by fusion.

$= 4.03 - 4.026 = 0.004u$

$= 0.004 \times 931 \text{ MeV} = 3.7 \text{ MeV}$

$= 3.7 \times 1.6 \times 10^{-19}d = 6.0 \times 10^{-31} J$

…. Energy released per deuteron $= 3.0 \times 10^{-31}$

$6 \times 10^{26}$ is the number of atoms in a kilometer of deuterium which has a mass of about 2kg. So of all the atom could undergo fusion.

Energy released per kg

$= 3.0 \times 10^{-3} \times 3 \times 10^{26} = 9 \times 10^{13}$ J (approx.)

Other fusion reaction can release more energy for example the fusion of the nuclei of deuterium H and tritium H isotopes of hydrogen released about $30 \times 10^{13}$ Joules of energy per kg according to the reaction.

## RADIOACTIVE MATERIALS IN THE NATURAL ENVIRONMENT

Naturally, occurring radioactive materials are widespread throughout the environment, although concentrations are very low and they are not normally harmful. Soil naturally contains a variety of radiation material Uranium, Thorium and the radioactive gas Radon, which is continually escaping to the atmosphere more radioactive than the low – level waste describe above. Radiation is not something which arises dust from using uranium to produce electricity, although the mining and milling of uranium and some other ores bring this radioactive material into closer contact with people and in the case of random and its as daughter products speed up releases to the atmosphere.

$$-dN \propto N.dt \qquad (1)$$

$$-dN = \lambda.N.dt \qquad (2)$$

$$-\frac{dN}{N} = \lambda.dt \qquad (3)$$

$$-\int_{N_0}^{N_t}\frac{dN}{N} = \lambda\int_0^t dt \qquad (4)$$

$$\ln\left(\frac{N_t}{N_0}\right) = -\lambda t \qquad (5)$$

$$\frac{N_t}{N_0} = \exp(-\lambda t) \qquad (6)$$

$$Therefore\ N_t = N_0 exp(-\lambda t) \qquad (7)$$

This final expression of equation 7 is known as the **Radioactive Decay Law**

## PROCESSES WITHIN A REACTOR

The power level of which a reactor operates proportional to the number of fissions occurring per unit time and this is in turn is proportional to the number of neutrons in the reactor. Hence the power level of the reactor can be controlled by controlling the number of neutrons in it. A common method of doing this is to introduce neutron-absorbing materials usually in the form of a steel rod containing boron and to adjust the position of this rod in the core. This essentially changes the value of Ke in the desired direction. As the reactor continues in operation fissionable material is used up and the ratio $\frac{F}{A}$ decreases. To keep the power level constant the rods containing the neutron-absorbing material should be moved out of the reactor at a suitable rate. When the limited level in the reactor is reached then become substantial and die down unless new fissionable material is added.

## TYPES OF RADIOACTIVE WASTE (RADWASTE)

### A. LOW LEVEL WASTE

Is generated from hospitals laboratories and industries as well as nuclear fuel cycle. It comprises paper rags tools clothing filter, etc. Which contains small amounts of mostly short- lived radioactivity. It is not dangerous to handle but must be disposed off more carefully than normal garbage. Usually, it is buried in shallow landfill sites. To reduce its volume, it is often compacted or incinerated (in a closed container), before disposed world wide it comprises 90% of the volume but only 1% of radioactivity of all radwaste.

### B. INTERMEDIATE LEVEL WASTE

It contains higher amounts of radioactivity and may require special shielding. It is typically comprising: Chemical Sludges and reactor components from reactor decommissioning worldwide it make up 7% of the volume and has 4% of the radioactivity of all radwaste. It may be solidified in concerted or bitumen for disposal. Generally short – lived wasted (mainly from radwaste) is buried but long lives waste (from reprocessing nuclear field) will be disposed in deep underground.

### C. HIGH LEVEL WASTE

This may be spent fuel itself, or the principles waste from reprocessing this, while 3% of the volumes of this radwaste. It holds 95% of the radioactivity. If contain the highly- radioactive fission product and some heavily elements with long live radioactivity.

It generates a considerable amount of heat and requires cooling as well as special shielding during handling and transport if the spent fuel is repressed, the separate waste is verified by incorporating it into borosilicate (Pyrex) glass which is eventual disposal deep underground on the other. If spent fuel is not processed, all the highly radioactive isotopes remain are treated as high level waste. This spent fuel takes up about nine times the volume of equivalent vitrified high – level waste is encapsulated ready for disposal. But high – level waste and spent fuel are very radioactive and people handling them must be shielded from their radiation , such materials are shipped in special containers which prevent the radiation leaking out and which will not rupture in an accident whether reprocessed or not , the volume of high level waste is modest about ( 3 ) three cubic meters per – year or vitrified or 25-30 tones of pent fuel for a typical large nuclear involved is allowed to be effectively and economically isolated .

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## RADIOACTIVE WASTE MANAGEMENT AT NUCLEAR POWER PLANTS

In many countries nuclear power plants are an important part of the national energy system. Nuclear power is economically competitive and environmentally clean compared to most other forms of energy used in electricity production. Used in conjunction with them, it contributes to the security of national electricity supplies. It seems certain that in the medium term and beyond, a growing contribution to national energy supplies from nuclear energy will continue to be necessary if the standard of living in industrialized countries of the world is to be maintained and the energy needs of the developing countries are to be met. As a result of the operation of nuclear reactors, some radioactive wastes are produced. Yet compared to the amount of waste produced by coal-fired electrical generating plants, these are of considerably smaller volume. The wastes generated at nuclear power plants are rather low in activity and the radionuclides contained therein have a low radioactivity and usually a short half –life. However, nuclear power plants are the largest in number among all nuclear facilities and produce the greatest volume of radioactive wastes.

The nature and amounts of wastes produced in a nuclear power plant depend on the type of reactor, its specific design features, its operating conditions and on the fuel integrity. These radioactive wastes contain activated radionuclides from structural, moderator, and coolant materials, corrosion products, and fission product contamination arising from the fuel. The methods applied for the treatment and conditioning of waste generated at nuclear power plants now have reached a high degree of effectivity and reliability and are being further developed to improve safety and economy of the whole waste management system.

## WASTE GENERATED AT NUCLEAR POWER PLANTS

Low – and intermediate –level radioactive waste (LILW) at nuclear power plants is produced by contamination of various materials with theradionuclides generated by fission and activation in the reactor or released from the fuel or cladding surfaces. The radionuclides are primarily released and collected in the reactor coolant system and, to a lesser extent, in the spent fuel storage pool. The main wastes arising during the operation of a nuclear power plant are components which are removed during refueling or maintenance 9 mainly activated solids, e.g. stainless-steel containing cobalt-60 and nickel-63) or operational wastes

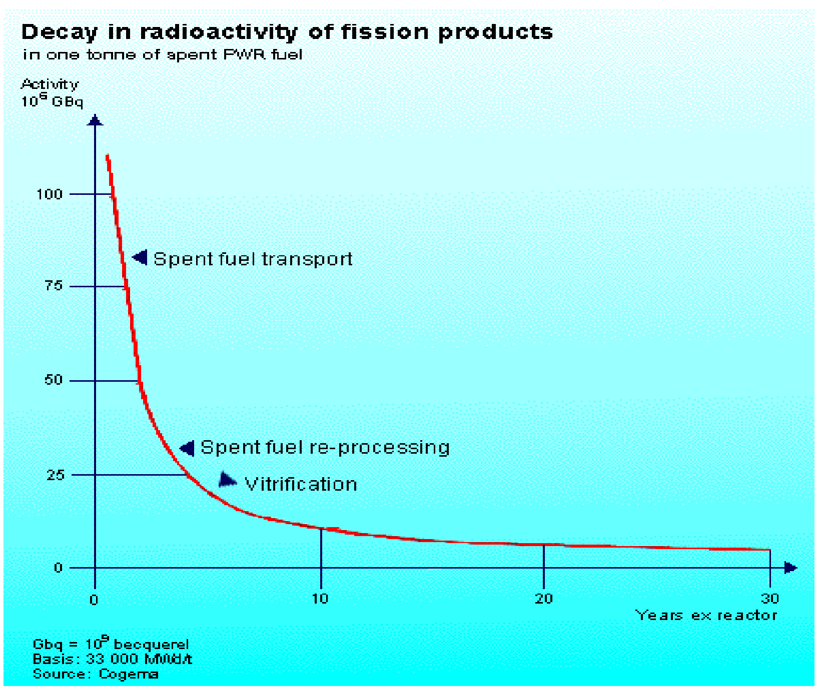


Figure: Showing how Radioactivity takes place such as radioactive liquids, filters, and ion-exchange resins which are contaminated with fission products from circuits containing liquid coolant. In order to reduce the quantities of waste for interim storage and to minimize disposal cost, all countries are pursuing or intend to implement measures to reduce the volume of waste arising where practicable. Volume reduction is particularly attractive for low –level waste which is generally of high volume but low radiation activity. Significant improvements can be made through administrative measures, e.g. replacement of paper towels by hot air driers, introduction of reusable long-lasting protective clothing, etc., and through general improvements of operational implementation or "housekeeping".

## LIQUID WASTES AND WET SOLID WASTES

According to the different types of reactors now operating commercially all over the world, different waste streams arise. These streams are different both in activity content and in the amount of liquid waste generated. Reactors cooled and moderated by water generate more liquid waste than those cooled by gas. The volumes of liquid waste generated at boiling-water reactors (BWRs) are significantly higher than at pressurized water reactors (PWRs). Because the cleanup system of heavy-water

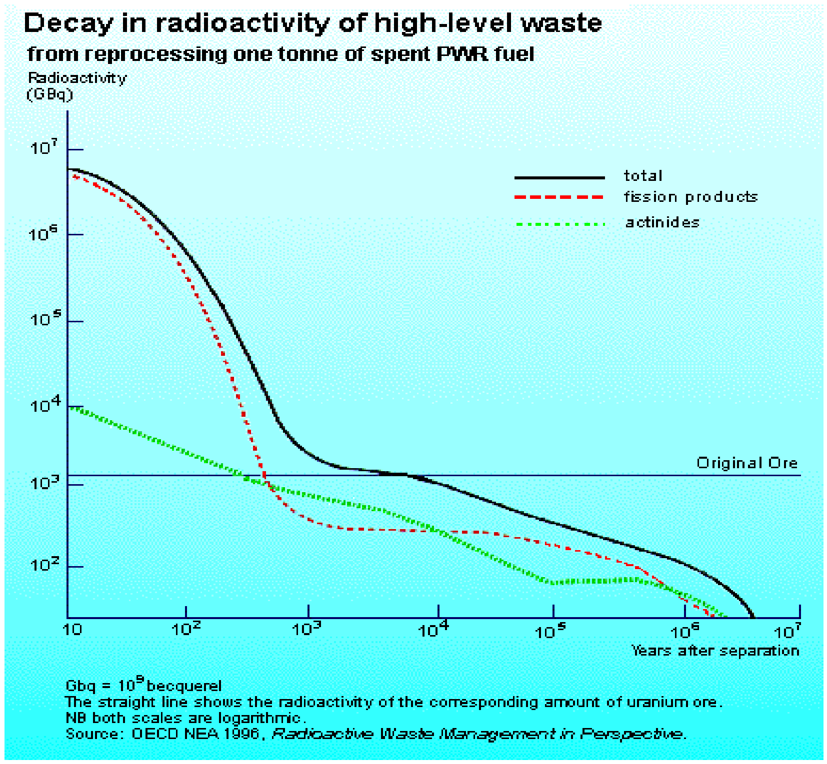


**Figure 2: Showing how radioactive waste management is taken place**

reactors (HWRs) works mainly with once-through ion-exchange techniques to recycle heavy water, virtually no liquid concentrates are generated at them.

Active liquid wastes are generated by the cleanup of primary coolants (PWR, BWR), cleanup of the spent fuel storage pond, drains, wash water, and leakage waters. Decontamination operations at reactors also generate liquid wastes resulting from maintenance activities on plant piping and equipment. Decontamination wastes can include crud (corrosion products) and a wide variety of organics, such as oxalic citric acids. Wet solids are another category of waste generated at nuclear power plants. They include different kinds of spent ion-exchange resins, filter media, and sludges. Spent resins constitute the most significant fraction of the wet solid waste produced at power reactors. Bead resins are used in deep demineralizers and are common in nuclear power plants. Powdered resins are seldom used in PWRs, but are commonly used in BWRs with pre-coated filter demineralizers. In many BWRs, a large source of powdered resin waste is the "condensate polishers "used for additional cleaning of condensed water after evaporation of liquid wastes. Pre-coated filters used at nuclear power plants to process liquid waste produce another type of wet solid waste-filter sludges. The filter aids – usually diatomaccous earth or cellulose fibres – and the crud that is removed from the liquid waste together form the filter sludges. Some filtration systems do not require filter aid materials. The sludges arising from such units therefore do not contain other minerals.

## TREATMENT AND CONDITIONING OF LIQUID/SOLID WASTE

Liquid radioactive waste generated at nuclear power plants usually contains soluble and insoluble radioactive components (fission and corrosion products) and non-radioactive substances. The general objective of waste treatment methods is to decontaminate liquid waste to such an extent that the decontaminated bulk volume of aqueous waste can be either released to the environment or recycled. Waste concentrate is subject to further conditioning, storage, and disposal. Because nuclear power plants generate almost all categories of liquid waste, nearly all processes are applied to treat radioactive effluents. Standard techniques are routinely used to decontaminate liquid waste streams. Each process has a particular effect on the radioactive content of the liquid. The extent to which these are used in combination depends on the amount and source of contamination. Four main technical processes are available for treatment of liquid waste:

evaporation; chemical precipitation/flocculation; solid-phase separation; and ion exchange. These treatment techniques are well established and widely used. Nevertheless, efforts to improve safety and economy on the basis of new technologies are under way in many countries. The best volume reduction effect, compared with the other techniques, is achieved by evaporation. Depending on the composition of the liquid effluents and the types of evaporators, decontamination factors between $10^4$ and $10^6$ are obtained.

Evaporation is a proven method for the treatment of liquid radioactive waste providing both good decontamination and volume reduction. Water is removed in the vapour phase of the process leaving behind non-volatile components such as salts containing most radionuclides. Evaporation is probably the best technique for wastes having relatively high salt content with a wide heterogenous chemical composition. Although it can be considered a fairly simple operation which has been successfully applied in the conventional chemical industry for many years, its application in the treatment of radioactive waste can give rise to same problems such as corrosion, scaling, or foaming. Such problems can be reduced by appropriate provisions. For example, the pH value can be adjusted to reduce corrosion, organics can be removed to reduce foaming or anti-foaming agents can be added, and the evaporator system can be cleaned by nitric acid to eliminate scaling and subsequent passivation of construction material. Up till now, volume reduction by evaporation of low- level radioactive effluents have always been so effective that the clean condensate could be discharged to the environment without further treatment.

Chemical precipitation methods based on the coagulation-flocculation separation principle are mostly used in nuclear power plants for the treatment of liquid effluents with low activity and high salt and mud contents. Their effectiveness depends largely on the chemical and radiochemical composition of the liquid waste. Most radionuclides can be precipitated, co-precipitated, and adsorbed by insoluble compounds, e.g. hydroxides, carbonates, phosphates, and ferrocyanides, and so be removed from the solution. The precipitates also carry down suspended particles from the solution by physical environment. However, the separation is never complete for several reasons, and the decontamination factors achieved can be relatively low. For this reason, chemical treatment is usually used in combination with other more efficient methods.

Solid-phase separation is carried out to remove suspended and settled solid matters from the liquid waste. There are several types of separation equipment available, all based on those which have been regularly used in the conventional water and effluent treatment plants in the industries. The most popular types are filters, centrifuges, and hydro cyclones. Particle separation is awell-established technology. Almost all nuclear facilities use mechanical devices to separate suspended solids from liquid waste streams. Generally, separation equipment is needed to remove particles which could interfere with subsequent liquid waste treatment processes, e.g. ion exchange, or with the re-use of the water. Typical filters can remove particles down to sub-micron sizes, particularly when a precoat is used. Once exhausted, the filter is either "backwashed "to yield a sludge of around 20 – 40% solids, or in the case of cartridge types, the entire unit is replaced. Ion-exchange methods have extensive application in the treatment of liquid effluents at nuclear power plants. Examples of these include the cleanup of primary and secondary coolant circuits in water reactors, treatment of fuel storage pond water, and polishing of condensates after evaporation.

Liquid radioactive wastes usually have to satisfy the following criteria to be suitable for ion-exchange treatment ; the concentration of suspended solids in the waste should be low; the waste should have low( usually less than 1 gram per litre ) total salt content; and the radionuclides should be present in suitable ionic form ( Filters pre-coated with owdered resin can be used to remove colloids ). In most technical systems, ion-exchange processes are applied using a fixed bed of ion-exchange material filled in a column which is passed through by the contaminated effluent either from top to bottom or vice-versa. The ion-exchange material may be regenerated after having reached saturation of the active groups (break through capacity). Some types of ion-exchangers are also removed as waste concentrate to be solidified. Therefore, the ion-exchange process represents a semi-continuous process and requires major efforts in maintenance like flushing, regeneration, rinsing, and refilling operation. Wet solids resulting from liquid waste treatment must still be transformed into solid products for final disposed. Immobilization processes involve the conversion of the waste to chemically and physically stable forms that reduce the potential for migration or dispersion of radionuclides by processes that could occur during storage, transport, and disposal. If possible, waste conditioning should also achieve a volume reduction.The most frequently applied methods for conditioning wet solids cementation, bituminization, or incorporation into polymers. Immobilization of radioactive waste using cement has been practiced widely for many years in many countries. Cement has a number of advantages, notably its low cost and the use of relatively simple process plant. Its relatively high density provides the waste forms with a considerable degree of self-shielding thereby reducing requirements for additional package shielding. In certain cases, in order to achieve a product of acceptable quality, chemical or physical pre-treatment steps may be employed. Sometimes additional alternative materials, such as pulverized fuel ash and blast furnace slag, can be used. These behave in a similar way to simple cement.

Bitumenization also has been used for a number of years invarious countries for solidification of wet solids. Bitumenization is a hot process which allows the wet stream to be dried off before being immobilized and packaged. This greatly reduces the volume of conditioned waste requiring disposal with a consequent saving in cost. However, bitumen is potentially flammable requiring special precaution to prevent its accidental ignition. Nevertheless, bitumenization has found growing acceptance with waste producers and is used for conditioning of radioactive waste at nuclear power plants in the U.S.A, Japan, Sweden, USSR, Switzerland, and other countries. Incorporation of wet solids into plastics or polymers is a relatively new immobilization process when compared to the use of cement or bitumen. The use of polymers such as polyester, vinyl ester, or epoxide resins is generally limited to those applications where cement or bitumen are technically unsuitable. Such polymers are considerably more expensive and a relatively complex processing plant is needed. Polymers have the advantages of offering greater leak resistance to radionuclides and of being generally chemically inert. There has recently been increased interest in the use of mobile units to condition radioactive waste from nuclear power plants. This has arisen mainly because they provide saving in capital cost where on-site arising of waste are small. Mobile immobilization units for conditioning of radioactive waste of nuclear power plants are used, for example, in the U.S. A, Federal Republic of Germany, and France. Most of them utilize the cementation process, although several designs for utilizing polymers have been developed.

## GASEOUS WASTE AND RADIOACTIVE AEROSOLS

In normal operation of nuclear power plants, some airborne radioactive wastes are generated in either particulate or aerosol of gaseous form. Particulate radioactive aerosol can be generated in a wide range of particle sizes in either liquid or solid form, possibly in combination with non-radioactive aerosols. Three main sources of aerosols are generated by emission of activated corrosion products; radioactive decay of gases to involatile elements; and adsorption of volatile radionuclides formed in the fission process on existing suspended material. The most important volatile radionuclides, which form gaseous radioactive waste generated during normal operation of nuclear power plants, are halogens, noble gases, tritium, and carbon-14. The composition and the amount of radioactivity present in the various airborne waste stream largely depend on the reactor type and the release pathway. All gaseous effluents at nuclear power plants are treated before discharge to the atmosphere to remove most of the radioactive components from the effluence.

## TREATMENT OF GASEOUS EFFLUENTS

It is common practice at all nuclear power plants for contaminated gases and building ventilation air to be first passed through filters to remove particulate activity before discharge to the atmosphere via stacks. Ventilation and air cleaning system usually employ coarse pre-filters followed by high-efficiency-particulate-air (HEPA) filters. These have typical particle removal efficiencies of 99.9% or better for 0.3 mm particles. Radioactive iodine arising from power plant operation is routinely removed by impregnated charcoal filters, used in combination with particulate filters. Impregnation is required to trap the organic iodine compounds from gas effluents. Because noble radioactive gases released from fuel elements in a small amount are mainly short-lived, delaying their release will allow radioactive decay processes to greatly reduce the quantities finally released to the environment. Two delay techniques are used for this purpose: storage in special tanks or passage through charcoal delay beds. For decay storage, the noble gases and their carrier gas are first pumped into gas tanks which are then sealed. After a storage time between 30 and 60 days, the cement of the tanks is ventilated to the atmosphere through a ventilation system. If release is not permissible, the storage period is extended as necessary. Delay beds consist of a number of vessels filled with charcoal, which relatively retards the passage of noble gases in relation to the carrier gas and allows radioactive decay to take effect.

## TREATMENT AND CONDITIONING OF SOLID WASTE

During the operation of a nuclear power plant, various types of dry solid wastes conditioning radioactive materials are generated. The nature of these wastes varies considerably from facility to facility and can include redundant items of the reactor plant, ventilation system filters, floor coverings, contaminated tools, etc. Another source of solid waste is the accumulation of miscellaneous paper, plastic, rubber, rugs, clothing, small metallic or glass objects, and during the operation and maintenance of the nuclear power plant. Depending on the physical nature and further treatment methods, dry solid waste usually is classified and segregated into four main categories: combustible, non-combustible, compactible, and non-compactible waste. However, each facility usually has its own level of classification according to the prevailing conditions. One of the essential aims in the treatment of solid waste is to reduce as much as possible the waste volumes to be stored and disposed of and to concentrate and immobilize as much as possible the radioactivity contained in the waste. As solid radioactive waste at nuclear power plants consists of a broad spectrum of materials and forms, no single technique can adequately treat this waste; a combination of processing techniques is generally used. The basic and most common technique used for processing most voluminous portions of solid waste has been based on compaction. The method reduces the storage and disposal volume requirements by a reasonable amount, but achieves little in terms of improvement of the waste properties from the view point of longer term management.

Experience has shown that between 50% and 80% of solid radioactive waste produced at nuclear power plants can be classified as burnable waste. Incineration of this waste represents a substantial improvement from a number of viewpoints over simple compaction. Very high-volume reduction and mass reduction can be achieved. The final product is a homogenous ash which can be packaged without further conditioning into containers for storage and disposal. While incineration is only suitable for combustible waste, it has the advantage of being capable of destroying organic liquids, e.g. oils, greases or solvents, which otherwise are difficult to treat. Incineration of small quantities of solid waste is routinely carried out in relatively simple units. Such incineration facilities have now been installed at the nuclear power plants in the U.S.A, Japan, Canada, and other countries. As a pretreatment step for compaction or incineration, cutting, shredding and crushing are used to reduce the physical size of individual waste items .Paper, plastic, cloth ,cardboard, wood, and metals can be shredded into ribbon-like pieces, while brittle materials such as glass or concrete blocks can be crushed into smaller fragments. These techniques can also be used as stand – alone processes for volume reduction of solid waste.

## NEW DEVELOPMENT

Most treatment and conditioning processes for LILW have now reached an advanced industrial scale. Although these processes and technologies are sufficient for effective management of radioactive waste at nuclear power plants , further improvements in this technology are still possible and desirable .The increasing cost radioactive waste disposal provides an incentive to adopt procedures and techniques to minimize waste quantities and to develop new techniques to minimize volumes at the treatment and conditioning step. It is not possible here to summarize all new developments and improvements which are being made in this direction in Member States. Some examples of such new developments include the use of specific inorganic sorbents to improve liquid waste treatment ; use of membrane techniques for liquid waste treatment ; dewatering and drying of bead resin and filters slurries ; incineration of spent ion-exchange resins ; dry cleaning of protective cloth to reduce quantity of laundry drains ; use of high integrity containers for packaged dried filter sludges ; vitrification of some intermediate-level waste to reduce volumes of waste to be disposed of; and super compaction of unburnable waste. Perhaps not all of these developments will find broad implementation in waste management technologies, in particular at nuclear power plants. However, the research and development reflect the fact that the nuclear industry and utilities take great care in a safe and economic management of radioactive waste at nuclear power plants, and that improvements in existing technology are foreseen.

## CONCLUSION AND RECOMMENDATION

Nuclear radiation is hazardous to health but nuclear power seeks to demonstrate that the benefit can outweigh the detrimental effect if handle properly. Nuclear power produces a very large amount of energy from a very small amount of fuel. The waste is also small but must be carefully managed as hazardous waste, because it is a radioactive isotope. Bearing this in mind, some constructive suggestion and recommendation should be applied as stated below:

i. Adequate health check should be made on workers in nuclear station to ensure that the dosage received per worker is not above 1000 micrisievards (1000μSu annually.

ii. The number of years a worker should spend working in the nuclear power station should also be restricted.

iii. After certain years a worker should be retired whether due to age factor or not.

iv. The government and the management of nuclear power station should also ensure that the fuel is not use for different purpose such as nuclear bomb (atomic) which is deadly to humanity and environment as a whole.

I strongly suggest that the government should attach importance to public enlightenment about the dangers of radioactive exposures. The government should give powers of regulatory and monitoring aspect to Energy Regulatory Commission council. So that it can observed and be involved in RWMCs in areas such as:

i. possible deterioration of the waste during storage.

ii. Key constraints on how the waste will be managed in the future, such as storage conditions and monitoring requirements.

iii. Arrangements for preserving information that might be needed to ensure safety and environmental protection during the future management of the waste stream and to make sure the waste can be accepted in a future long-term storage or disposal facility.

iv. Management, including disposal, of secondary radioactive waste arisings, especially those from the waste conditioning storage.

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