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Nuclear Radiations

1. In a nuclear power plant, nuclear fission/fusion generates a large quantity of heat and ionization. The heat needs to be extracted by the cooling water to keep the temperature of different components of the reactor under control to escape a probable meltdown due to high temperature. Since the central core of the reactor under concern is mode of Uranium dioxide (UO2) , it is continuously disintegrating (radioactive) releasing large quantity to that. This process of radioactive disintegration cannot be slowed down. It takes place with pre-set halflife of disintegration.
2. If pumping of cooling water is stopped, the available water gets heated and evaporated leading to further depletion of water. The temperature of the vessel rises raising the pressure beyond the capacity of the vessel. The process of gas and steam build-up starts and radiation leakage to the atmosphere follows.In the worst-case scenario, the plant explodes.
3. It is really difficult to understand the consequences because not only operational fuel rods (core) , but spent fuel rods also nee cooling provisions; otherwise radioactive substances into the atmosphere, if kept dry. Before understanding the various effects of radiation, let us get to understand the language of radiation.

Units of Radiation

1. One has to fathom through a sea of units. Take, for instance, the unit called Roentgen (R) , which is defined as amount of radiation produced in 1 cm3 of dry air at 00C and 760 mm Hg pressure erg/g and is a measure of exposure. An alternate SI unit for exposure is Coulumb per kilogram (C/kg = 3876 R) . Yet another unit called rad (= 100 erg/g) was also devised, which is a unit of absorbed dose.
2. However, the International Committee for Radiological Protection (ICRP) set up in 1928 took several measures to standardize and unify the radiation dose and dose rate.In 1975, it commended a new series of units in the SI system for dose measurement. A unit of absorbed dose is defined as Gray (Gy) and one Roentgen is equal to $8.732 \times 10 - 3$ Gy. One gray is equal to 100 rads or 1 J/kg. Another term called kerma (kinetic energy released in media) is also used to indicate absorbed dose. Another unit called

rem (roentgen-equivalent-man) is a complicated unit, which considers the effect of ionizing radiation on human body. Such unit of dose equivalent is named Sievert (Sv) and 1 Sievert is equal to 100 rem.

Effects of Radiation

1. Radiation in the form of electromagnetic radiation is present everywhere. However, the most disastrous effects are seen with ionizing radiations, which are released from disintegration of certain radioactive materials. When they irradiate living tissue, cells are damaged or destroyed. The ultimate effect may be burns, dermatitis, cancer induction and blood changes. Reproduction may also be affected as chromosomes are damaged by the ionizing radiations. This genetic damage could be passed on to future generations as well.
2. The biological effects of ionizing radiation may be in terms of deposited energy in the tissue and organs. This may aggravate damage. Depending on the level of exposure, many biological effects of ionizing radiations are possible:
    a. Stopping of cell division: The epidermis of our skin forms new cells in the bottom layer, which move towards the top, where dead cells are accumulated. Each second 10,000, 000 cells die and are replaced in the human body. If cell creation by cell division is stopped, the effect will be catastrophic.
    b. Introducing defects in chromosomes: Breaking of chromosomes by ionizing radiation may result in non-transfer of all the genetic materials from one generation to the other.
    c. Gene mutation: The DNA structure alters completely and new species may be formed. Exposure to ionizing radiation can lead to such process.
    d. Sterility: The genetic effects can appear as sterility, as genetic organs are affected by radiation more readily than other parts of the body. Temporary sterility is caused in men and women by exposure to a level of 0.25 Sv and 1.6Sv respectively.
    e. Temporary useasiness: Nausea, vomiting and diarrhea (NVD) are stated to occur if humans are exposed to more than the recommended dose of radiation.
    f. Chronic disease: On exposure to radiation, chances of cancer, leukemia, cataract and hereditary effects rise. Local exposure of 8 Sv in the eyes may cause cataract after 5 – 10 years.
    g. Cell death: This property of ionizing radiation is already used in treatment of cancer, but if excessive dose is administered, healthy cells with start dying, leading to change in or death of physical properties of vital cell structures.
3. The most disturbing part of these ionizing radiations is their integrating nature. Once exposed to certain radiation level, further exposure adds up to the already received exposure. There is very little effect of time on such accumulated radiation dose in a body.

4. Earlier the tolerance dose was thought to be 1 R per week and that there was no measurable biological effect if exposure was less than this. The ICRP replaced this tolerance dose with the Maximum Permissible Dose (MPD) in 1954 and in 1958 MPD was fixed as 0.3 rem per week (3 mGy per week) , for critical human organs.In 1977, the concept of ALARA (As Low As Reasonably Achievable) was introduced. Based on natural background dose-level, the whole body does per year is defined or different types of workers. Radiation worker: 50 mSv per year (5 rem per year) General public: 5 mSv per year (0.5 rem per year)
5. For radiation worker, 50 mSv per year is equivalent to around 1 mSv per ween (52 week per year) or 25 mSv per hour (working hours: 8 hours per day) . To be on the safer side generally seven & half mSv per hour is considered as the average dose rate over a period. *Courtesy: Science Reporter*