DEFINITIONS

http://www.nukeworker.com/study/hp/fundamentals/fundamentals_of_radiation_physics.htm

Radioactivity - That property of certain materials to spontaneously emit penetrating ionizing radiation.

Radiation Interaction - Radiation loses kinetic energy, undergoes a change in direction or is absorbed.

Radioactive Decay - The process whereby an atom becomes more stable by emitting particulate or electromagnetic radiation.

Particulate Radiation - Radiation that has mass. (Example. Neutron, Beta, Alpha)

Mass - The quantity of matter in an object measured by its resistance to a change in its motion.

Ionization - The process by which radiation imparts enough excitation energy to the electrons of atoms in the target substance to remove one or more electrons from their orbits, producing free electrons & ions.

Ion Pair - The positively charged atom and free electron resulting from an ionization event.

Ion - A positively charged atom (one from which an orbital electron has been removed).

Free Electron - An electron existing outside the orbits of an atom.

Excitation - The process by which radiation imparts some part or all of its energy to the target atoms, causing the target atoms to exist in some higher energy state.

Atomic Excitation - Raising of an atom to an excited state.

Nuclear Excitation - Raising of a nucleus to an excited state.

Target - An item or material upon which a radiation is incident.

Direct Ionizing Radiation - A radiation that carries an electrical charge and exerts electrical forces upon the electrons of a target substance.

Indirect Ionizing Radiation - A radiation that does not carry an electrical charge.

Kinetic Energy - Energy due to motion.

Negatron - Negatively charged beta particle.

Positron - Positively charged beta particle.

Electromagnetic Radiation - Traveling wave motion resulting from changing electric or magnetic fields.

Gamma - High energy, short wavelength, electromagnetic radiation emitted from the nucleus.

X-ray - Penetrating electromagnetic radiation having a wavelength that is shorter than that of visible light, emitted from an excited electron.

Prompt Neutron - A neutron emitted less than 1 E-14 seconds after fission.
(1 E-14 = 10 to the power -14 = 1/(10 X 14 0s)

Delayed Neutron - A neutron emitted at least 1 E-14 seconds after fission.

Fission - The splitting of an atomic nucleus into two (or, sometimes, more) lighter fragments, accompanied by the release of a large amount of energy.

Fission Fragments - The two (or more) lighter nuclei produced by the fission process. Generally unstable due to a high neutron-to-proton ratio. Also called fission products.

Fissile Material - Material in which fission can be induced by the absorption of a thermal neutron. (U-235)

Mass Defect - A measure of the loss of mass in an assembled nucleus. The difference between the sum of the masses of the atomic components (W) and the measured mass of the atom (M). Mass Defect = W-M

Binding Energy - The energy released to assemble the nucleus. The energy equivalent of the Mass Defect. B.E. = (mass defect)(931 MeV/u)

Critical Energy - The energy required to induce fission in a nucleus.

Standard Nuclide Notation - $^{A}_{Z}X_{N}$ A = Neutrons + Protons Z = Protons N = Neutrons

The ionizing radiations of concern at a nuclear power plant and for each radiation

	Alpha Radiation	Beta Radiation	Neutron Radiation	Photon Radiation
Classify it as particulate or electromagnetic.	Particulate	Particulate	Particulate	Electromagnetic
Classify it as directly or indirectly ionizing.	Directly Ionizing	Directly Ionizing	Indirectly Ionizing	Indirectly Ionizing
Identify its relative mass.	4 times mass of proton	Equal in mass to an electron	Slightly > than a proton	Zero mass
Identify its charge.	+2 Charge	-1 Charge (Negatron) +1 Charge (Positron)	Zero Charge	Zero Charge
Identify its origin.	Unstable Nucleus	Unstable Nucleus	Fissioning Nucleus and unstable nucleus	◎- excited nucleus X-ray excited atom
Identify its relative range in tissue-equivalent materials.	Lowest	Low	High	Highest
Classify it as an internal or external hazard.	Internal	Internal External to skin & eyes	External	External
Identify typical shielding materials.	Paper Other light materials	Plastics, cloth, cardboard (low-Z materials)	Water, Polyethylene, borated poly, concrete	Lead, steel, concrete (High-Z materials)

Mass to energy and energy to mass equivalent calculations.

$E = mc^2$:
E = total energy (joules) / m = mass (kilograms) / c = 3.0 E+08 m/sec (speed of light)

Example:
m_e = 9.1093897 x 10-31 kg&1
MeV = 1.60 x 10-13 J

1) Determine the mass equivalent to 1.02 MeV.
Convert from MeV to Joules: (1.02MeV)(1.60E-13J) = 1.632E-13J
$E = mc^2 \rightarrow$ (divide both sides by c^2) $\rightarrow m = E/c^2$
m = (1.632E-13J) / (3.0E8 m/sec)
m = 1.81E-30 kg

The three principle chemical groups of **fission** products and the major radionuclide of concern in each group (include the half-life of each radionuclide.

1) Halogens - major nuclide: Iodine-131 T ½ = 8 days
2) Noble Gases - major nuclide: Krypton-85 T ½ = 10.7 years
3) Mixed Metals - major nuclide: Cesium-137 T ½ = 30.17 years

The three **fission** product radionuclides with the longest half-lives that are commonly present in the reactor coolant (including the half-life of each radionuclide).

1) Cesium-137 30.17 years
2) Strontium-90 29.1 years
3) Krypton-85 10.73 years

The main barrier containing the **fission** products within the fuel elements.

Fuel Cladding

The three ways that **fission** products enter the reactor coolant.

Diffusion - The gradual mixing of the molecules due to thermal motion and the diffusion of the noble gases & 3H (i.e. tritium)

Cladding Failures/Defects - Assumed that 1% of the fuel may have minor defects.

"**Tramp" uranium** - Uranium impurities in the fuel cladding, reach the reactor coolant following fission.

The dominant radio-nuclides found in the radioactive waste system (including the difficult-to-measure radio-nuclides)

Dominant
Cs-137 makes up roughly 41%
Cs-134 makes up 32%
Co-58 makes up 10%
Co-60 makes up 2%