Radiation UNITS

Roentgen: Is the measurement of energy produced by Gamma or X-Ray radiation in a cubic centimeter of air. It is abbreviated with the capital "R". One milliroentgen, abbreviated "mR" is one-thousandth of a roentgen. One microroentgen, abbreviated “uR” is one-millionth of a roentgen.

RAD: Radiation Absorbed Dose. Original measuring unit for expressing the absorption of all types of ionizing radiation (alpha, beta, gamma, neutrons, etc) into any medium. One rad is equivalent to the absorption of 100 ergs of energy per gram of absorbing tissue.

REM: Roentgen Equivalent Man is a measurement that correlates the dose of any radiation to the biological effect of that radiation. Since not all radiation has the same biological effect, the dosage is multiplied by a "quality factor" (Q). For example, a person receiving a dosage of gamma radiation will suffer much less damage than a person receiving the same dosage from alpha particles, by a factor of three. So alpha particles will cause three times more damage than gamma rays. Therefore, alpha radiation has a quality factor of three. Following is the Q factor for a few radiation types.

Radiation:	**Quality Factor (Q)**
Beta, Gamma and X-rays	1
Thermal Neutrons	3
Fast n, a, and protons	10
Heavy and recoil nuclei	20

The difference between the rad and rem is that the rad is a measurement of the radiation absorbed by the material or tissue. The rem is a measurement of the biological effect of that absorbed radiation. For general purposes most physicists agree that the Roentgen, Rad and Rem may be considered equivalent.

System International (SI) Units

The System International (S.I. unit) units for radiation measurements are “gray” (Gy) and “sivert” (Sv) for absorbed dose and equivalent dose respectively.

The conversion from one system to another is simple:

1 Sv = 100 rem	1 rem = .01 Sv
1 mSv = 100 mR (mrem)	1 mR = .01 mSv
1 Gy = 100 rad	1 rad = .01 Gy
1mGy = 100 mrad	1 mrad = .01 mGy

How Much Radiation is Safe? In the United States the U.S. Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for worker is limited to 5000 mrem per year. For the general population, the exposure is 500 mrem above background radiation in any one year. However for long term, multi-year exposure, 100 mrem above background radiation is the limit set per year. Let’s extrapolate the 100 mrem number to an hourly radiation

exposure rate. There are 365 days/yr x 24 hr/day equals 8760 hours. Divide 100 mrem by 8760 hours equals .0114 mrem/hr or 11.4/hr microrem. This is an extremely low radiation level. The background radiation in my lab hovers around 32 uR/hr. Am I in trouble? No. Typically background radiation in the United States averages 300 mrem/yr, or 34 microrem/hr. The NRC specifications is for radiation above this 34 urem/hr background radiation. Notice that my lab readings are in microrad (uR/hr) and the exposure limit is given in microrem (urem/hr). I do not know what type of radiation (a , b or y) the geiger counter is reading in my lab at any particular instant, so I do not know the Q factor of the radiation and therefore can not calculate the mrem. However for general purposes I consider them the one and the same. Remember the digital geiger counters are calibrated using a Cs-137 radioactive source.
Therefore the highest accuracy in reading radiation levels will be from Cs-137 sources.

Common Radiation Exposure (General Population)

Exposure Source	Dose(conventional)	Dose (SI)
Flight from LA to NY	1.5 mrem	.015 mSv
Dental X-ray	9 mrem	.09 mSv
Chest X-ray	10 mrem	0.1 mSv
Mammogram	70 mrem	0.7 mSv
Background Radiation	620 mrem/year	6.2 mSv/year

Background radiation consists of three sources ; **Cosmic** radiation from the sun and stars. **Terrestrial** radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. **Internal** radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found inside our bodies.

Digital Geiger Counters are extremely sensitive and will detect and measure background radiation in addition to detecting and measuring radioactivity above background radiation.