

## FRCM GLOSSARY

### Revision History

<b>Author</b>	<b>Description of Change</b>	<b>Revision Date</b>
<i>J. D. Cossairt</i>	<i>Header and footer updated – Glossary needs no updates at this time.</i>	<i>April 2016</i>
<i>J. D. Cossairt</i>	<ol style="list-style-type: none"><li><i>1. Incorporate suggestions made since the last revision.</i></li><li><i>2. Incorporate modifications needed to implement ammendments of 10 CFR 835 finalized on April 13, 2011 pertaining to Derived Air Concentrations.</i></li><li><i>3. Incorporate modifications to implement the new Derived Concentration Standards announced in DOE-STD-1196-2011 April 2011.</i></li><li><i>4. Correct editorial errors.</i></li></ol>	<i>September 2011</i>

## GLOSSARY

**abnormal situation** Unplanned event or condition that adversely affects, potentially affects or indicates degradation in the safety, security, environmental or health protection performance or operation of a facility.

**absorbed dose** See dose.

**absorber** Any material that absorbs or lessens the intensity of ionizing radiation.

**absorption** The process by which a radiation flux is reduced in intensity by interaction with the matter.

**accessible surfaces** A surface that can be contacted without the use of immoderate force or mechanical means

**accountable sealed radioactive source** A sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in appendix E of 10CFR835.

**activation** Process of producing a radioactive material by bombardment with neutrons, protons or other atomic or nuclear particles.

**activation products** See induced radioactivity.

**activity** Radioactive materials are quantified by the rate at which spontaneous nuclear transformations (disintegrations) characteristic of each specific nuclear species occur within a particular material sample. The special unit of activity is the Curie (Ci):

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ transformations/sec}$$

$$1 \text{ nCi} = 10^{-9} \text{ Ci} = 2200 \text{ transformations/min}$$

(in S.I. units 1 transformation/sec = 1 Becquerel (Bq))

**acute exposure** An exposure to a hazardous agent that is received in a short period of time, not on an ongoing continuous basis over a longer period of time (see chronic exposure).

**AMAD (activity median aerodynamic diameter)** A particle size in an aerosol where fifty percent of the activity in the aerosol is associated with particles of aerodynamic diameter greater than the AMAD.

**Administrative Control Level** Level of radiation exposure established, generally well below regulatory limits, by management to help reduce individual and collective radiation dose.

**aerosol** Solid particles or liquid suspended in air.

**airborne radioactive material** See airborne radioactivity.

**airborne radioactivity** Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors or gases.

**Airborne Radioactivity Area** Any area, accessible to individuals where (1) the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in Appendix A or Appendix C of 10 CFR 835 or (2) an individual in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

**ALARA (As Low As Reasonably Achievable)** The approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public at levels as low as is reasonable, taking into account social, technical, economic, practical and public policy considerations. As used in this Manual, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits as is reasonably achievable.

**ALARA Committee** A forum that reviews and advises management on improving progress toward minimizing radiation exposure and radiological releases. At Fermilab this function is provided by the Radiation Safety Subcommittee of the Fermilab Environment Safety and Health Committee (FESHCom).

**alpha particle** A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electronic charge of +2. Some radionuclides decay by spontaneous emission of alpha particles.

**Annual Dose Equivalent** The dose equivalent (H) received in a year.

**Annual Effective Dose Equivalent** The effective dose equivalent received in a year.

**ALI (Annual Limit on Intake)** The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the Reference Man (ICRP Publication 23) that would result in a committed effective dose of 5 rem (0.05 sievert) or a committed equivalent dose of 50 rem (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based International

Commission on Radiation Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July 1994..

**assessment** Evaluation or appraisal of a process, program or activity to estimate its acceptability.

**atom** The smallest particle of an element that cannot be divided or broken up by chemical means. It consists of a central core called the nucleus, which contains protons and neutrons. Electrons revolve in orbits in the region surrounding the nucleus.

**atomic number** The number of protons in the nucleus of an atom (equal to the number of electrons on an electrically neutral atom).

**atomic weight** See mass number.

**attenuation** Processes by which a radiation flux is reduced in intensity and/or energy when passing through some material. It is a combination of absorption and scattering processes.

**authorized limit** A limit on the concentration of residual radioactive material on the surfaces or within the property that has been derived consistent with DOE directives including the as low as is reasonably achievable (ALARA) process requirements, given the anticipated use of the property and has been authorized by DOE to permit the release of the property from DOE radiological control.

**background radiation** Radiation from: (1) naturally occurring radioactive materials which have not been technologically enhanced; (2) cosmic sources; (3) global fallout as it exists in the environment (such as from the testing of nuclear explosive devices); (4) radon and its progeny in concentrations or levels existing in buildings or environment which have not been elevated as a result of current or prior activities; and (5) consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

**beam absorber** A beam line element designed to absorb the incident particle beam and substantially contain the secondary radiations generated. Synonymous with “beam dump”, a much less desirable term because of confusion with waste disposal issues.

**beam area** Any area through which accelerator produced beams of particles pass.

**beam enclosure** Any area containing beam lines and surrounded by walls or fences, normally with all access points interlocked to turn off the beam during access.

**Bq (Becquerel)** The International System (SI) unit for activity of radioactive material. One becquerel is that quantity of radioactive material in which one atom is transformed per second or undergoes one disintegration per second.

**beta particle** A charged particle emitted from a nucleus during radioactive decay with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

**bioassay** The determination of kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis, and evaluation of radioactive materials excreted or removed from the human body.

**biological half-life** The time required for a biological system such as that of a human to eliminate by natural processes half the amount of a substance (such as a radioactive material) that has entered it.

**bone seeker** A radioisotope that tends to accumulate in the bones when it is introduced into the body. An example is strontium-90.

**breathing zone air sampling** Air sampling taken in the vicinity of personnel and representative of the air they actually breathe.

**calibration** To adjust and/or determine either: (1) the response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values; or (2) the strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true values.

**charged particle** An atomic, subatomic, or elementary particle carrying a positive or negative electric charge.

**chronic exposure** An exposure to a hazardous agent that is received on an ongoing, though not necessarily uniform basis (see acute exposure).

**collective dose equivalent** See dose.

**committed equivalent dose (sometimes denoted  $H_{T,50}$ )** See dose.

**committed effective dose (sometimes denoted  $E_{50}$ )**. See dose.

**committed effective dose equivalent ( $H_{E,50}$ )** See dose.

**containment device** Barrier such as a glovebag, glovebox, dikes, ventilation or tenting for inhibiting the release of radioactive material from a specific location.

**contamination** The deposition of unwanted material on the surfaces of structures, objects or personnel. See also Radioactive Contamination.

**contamination control point** A location on the perimeter of a surface contamination area through which all entries and exits are made and where action is taken to prevent the spread of contamination to adjacent controlled or uncontrolled areas.

**Contamination Area** Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Chapter 2, Table 2-2, but do not exceed 100 times those values.

**contamination survey** Use of swipes or direct instrument surveys to identify and quantify radioactive material on personnel, on equipment or in areas.

**continuing training** Training scheduled for the purpose of maintaining and improving technical knowledge and skills.

**continuous air monitor (CAM)** Instrument that continuously samples and measures the levels of airborne radioactive materials on a “real-time” basis and has alarm capabilities at preset levels.

**contractor** Any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility.

**contractor senior site executive** The person at a DOE contractor-operated facility or site who has final on-site corporate authority and responsibility. At Fermilab, this individual is the Director of the Laboratory.

**Controlled Area** Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

**counseling** Advice, information exchange and guidance provided to employees on radiologically related topics, such as dose perspectives; potential health effects from radiation exposure; skin contaminations; contaminated wounds; internally deposited radioactivity; pregnancy; and radiation exposure. This advice and guidance is normally provided by knowledgeable, senior professionals from the Radiological Control Organization and other organizations, such as the Medical Department, as appropriate.

**critical devices** Any power supply, beam stop, collimator, or device which prohibits the entry of a particle beam or prohibits the generation of ionizing radiation.

**critical mass** The smallest mass of fissionable material that will support a self-sustaining chain reaction under specified conditions.

**critical organ** The organ in the body receiving a radionuclide or radiation dose that results in the greatest overall damage to the body.

**critique** Meetings of personnel involved in or knowledgeable about an event (either a success or an abnormal event) to document a chronological listing of the facts.

**cumulative total effective dose** See dose.

**Curie (Ci)** A basic unit used to describe the amount of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second ( $37 \times 10^9$  Becquerel in SI units) which is approximately the rate of decay of 1 gram of radium. Named for Marie and Pierre Curie who discovered radium in 1898.

**DAC - hour** The product of the concentration of radioactive material in the air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours.

**declared pregnant worker** A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in Table 2-1. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

**decontamination** The reduction or removal of contaminating radioactive material from a structure, area, object or person.

**deep dose equivalent** See dose.

**depleted uranium** Uranium having a percentage of uranium 235 smaller than the 0.7% found in natural uranium.

**Derived Air Concentration (DAC)** 1) For the radionuclides listed in 10 CFR 835 Appendix A, the DAC is the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 m<sup>3</sup>). 2) For the radionuclides listed in 10 CFR 835 appendix C, the air immersion DACs are calculated for a continuous, non-shielded exposure via immersion in a semi-infinite cloud of radioactive material. Except as noted in the footnotes to 10 CFR 835 Appendix A, the values are based on dose coefficients from International Commission on Radiological Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July, 1994 and the associated ICRP computer program, *The ICRP Database of Dose Coefficients: Workers and Members of the Public*.

**Derived Concentration Guide (DCG)** **See Derived Concentration Standard**

**Derived Concentration Standard (DCS)** A quantity representing the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem effective dose (1 mSv) following continuous exposure for one year for each of the following pathways; ingestion of water, submersion in air, and inhalation. In this Manual,

DCS values are specifically those set forth in DOE-STD-1196-2011 in support of implementation of DOE O458.1, “Radiation Protection of the Public and the Environment”. DCSs are used for approximately the same purpose of the Derived Concentration Guides (DCGs) set forth in DOE O5400.5, the Order superseded as of April 2011 by DOE O458.1. Older reference documents will refer to DCGs.

**detection limit** The smallest quantity of radioactive material which can be detected with some specified degree of confidence (usually 95% ) by a detector system.

**deterministic effects** Effects due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists (e.g., radiation-induced opacities within the lens of the eye).

**directly ionizing particles** Electrically charged particles (electrons, protons, alpha particles, muons, etc.) having sufficient energy to produce ionization by collision.

**disintegration per minute (dpm)** The rate of radiation emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

**Department of Energy (DOE)** The United States Department of Energy.

**DOE activity** An activity taken for or by DOE in a DOE operation or facility that has the potential to result in the occupational exposure of an individual to radiation or radioactive material.

**DOELAP** Department of Energy Laboratory Accreditation Program for personnel dosimetry specified by 10 CFR 835.402.

**dose** A general term for absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or total effective dose as defined 10 CFR 835. , total dose equivalent, etc. Aside from absorbed dose, a quantity in principal physically measurable in matter, all other quantities utilize various radiation and tissue weighting factors to incorporate radiobiological effects. While these efforts are only approximations, the intent is that a dose of 1 rem of any type of radiation has the same biological detriment. Aside from absorbed dose, a quantity that can be applied to any organism or material, all other quantities are applicable only to exposures of human beings. Technical definitions for dose terms necessary for various exposure calculations and recordkeeping purposes include the following:

**absorbed dose (or just “dose”) D** The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in the material. The concept is valid for all materials. The special unit of

absorbed dose is the rad. (1 rad = 100 ergs gm<sup>-1</sup>). In S.I. units, 1 Gray (Gy) = 1 J kg<sup>-1</sup> = 100 rads:

**collective dose equivalent**, is the sum of the dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem (or person-sievert). For example, if 12 workers each have 1 rem, then the collective dose is 12 person-rem.

**committed effective dose\_(E<sub>50</sub>)** The sum of the committed equivalent doses to various tissues or organs in the body (H<sub>T,50</sub>), each multiplied by the appropriate tissue weighting factor (w<sub>T</sub>)--that is,  $E_{50} = \sum w_T H_{T,50} + w_{\text{Remainder}} H_{\text{Remainder},50}$ . Where w<sub>Remainder</sub> is the tissue weighting factor assigned to the remainder organs and tissues and H<sub>Remainder,50</sub> is the committed equivalent dose to the remainder organs and tissues. Committed effective dose is expressed in units of rems (or Sv) .

**committed equivalent dose\_ (H<sub>T,50</sub>)** The equivalent dose calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed equivalent dose is expressed in units of rems (or Sv).

**committed effective dose equivalent (H<sub>E,50</sub>)** The sum of the committed dose equivalents to various tissues in the body (H<sub>T,50</sub>), each multiplied by the appropriate weighting factor (w<sub>T</sub>) (H<sub>E,50</sub> =  $\sum w_T H_{T,50}$ ). Committed effective dose equivalent is expressed in units of rem (or sievert).

**cumulative total effective dose** The sum of the total effective dose equivalents recorded for a individual plus for occupational exposure received before June 8, 2007, the cumulative total effective dose equivalent values recorded for an individual, where available, for each year occupational dose was received beginning January 1, 1989.

**deep dose equivalent** The dose equivalent from external radiation determined at a tissue depth of 1 cm.

**dose equivalent (H<sub>T</sub>)** The product of absorbed dose (D) in rad (or gray) in tissue, a quality factor (Q), and other modifying factors (N) . This quantity expresses on a common scale for all ionizing radiations the biological damage to exposed individuals. Dose equivalent is expressed in units of rem (or sievert).

**effective dose (E)** The summation of the products of the dose equivalent received by specified tissues of the body ( $H_T$ ) and the appropriate weighting factor ( $w_T$ )--that is,  $H_E = \sum w_T H_T$ . It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem (or sievert).

**equivalent dose ( $H_T$ )** The product of average absorbed dose ( $D_{T,R}$ ) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor ( $w_R$ ). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rems (or Sv).

**external dose or exposure** That portion of the dose equivalent received from radiation sources (e.g., "external sources") outside the body.

**internal dose or exposure** That portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources").

**lens of the eye dose equivalent** The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

**shallow dose equivalent** The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissues. Primarily applies to the external exposure of the skin.

**TED (total effective dose)** The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). This is normally expressed in units of person-mrem or person-rem. In the past and in past documentation the term total effective dose equivalent (TEDE) was used for this same purpose.

**dose assessment** Process of quantifying radiological dose and uncertainty included in the dose estimate, through the use of exposure scenarios, bioassay results, monitoring data, source term information and pathway analysis.

**dose equivalent (sometimes denoted  $H_T$ )** See [dose](#).

**dosimeter** A portable device for measuring and registering the integrated exposure to ionizing radiation for a period of time.

**dosimetry** The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

**effective dose (sometimes denoted E)** See dose.

**effective half-life** The time required for the amount of a radioactive element deposited in a living organism to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

**efficiency check** A procedure used to verify an instrument's efficiency is within specified limitations.

**electromagnetic radiation** Radiations of the electromagnetic spectrum range from X-rays and gamma rays of short wavelength through the ultraviolet visible and infrared regions to radar and radio waves of relatively long wavelength. All electromagnetic radiations travel in a vacuum with the velocity of light.

**electron** An elementary particle with a unit negative charge and mass 1/1837 that of the proton. In an atom, electrons surround the positively charged nucleus and determine the chemical properties of the atom.

**embryo/fetus** Developing human organism from conception until birth. Same as unborn child.

**engineering controls** Use of physical components and systems (piping, containments, ventilation, filtration or shielding) to control exposure of individuals to radiation and/or radioactive materials.

**entrance or access point** Any location through which an individual could gain access to areas controlled for the purposes of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

**environmentally stabilized area** An outdoor area on which remedial action has been taken to stabilize radioactive surface contamination.

**equivalent dose (sometimes denoted H<sub>T</sub>)** See dose.

**exclusion area** An area, generally an accelerator or beamline enclosure, subject to radiological and/or other hazards to which access during accelerator or beamline operations is prohibited and prevented by means a system of locks, interlocks, and passive shielding.

**exposure** A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the Roentgen (R). It is specifically restricted to photon fields, i.e., X-rays and gamma rays from a few keV to 3 MeV.

**exposure, extremity** An exposure of the body extremities to radiation.

**external dose or exposure** That portion of the equivalent dose received from radiation sources outside the body (i.e., "external sources").

**extremities** Includes hands and feet, arms below the elbow and legs below the knee.

**FESHM** The Fermilab Environment, Safety, and Health Manual

**Fermilab-issued clothing** Clothing provided by Fermilab, such as work coveralls and shoes. For radiological control purposes, Fermilab issued clothing shall be considered the same as personal clothing. It is not the same as the disposable garments provided for protection against contamination.

**film badge** A term commonly, and incorrectly, used at Fermilab to refer to the personnel dosimetry due to the fact that for many years the personal dosimeter of record at Fermilab was based on photographic film technique. "Personnel dosimetry monitoring badge" is the preferred term to use.

**filter integrity test** Test performed on High-Efficiency Particulate Air (HEPA) filters to identify any damage to the filter or leakage around the filter. Techniques used to conduct the tests are described in ANSI/UL 586-1990, "High Efficiency Particulate Air Units."

**fixed contamination** See radioactive contamination, fixed contamination.

**flash x-ray unit** Any device that is capable of generating pulsed x-rays.

**flux** A term applied to the amount of some type of radiation crossing an area per unit time. The unit of flux is the number of particles, energy, etc., per square centimeter per second.

**FRCM** The Fermilab Radiological Control Manual (this Manual)

**frisk or frisking** Process of monitoring personnel for contamination.

**functional check** A procedure that is followed periodically after routine calibration of radiation protection instrumentation. The purpose of the functional check is to verify proper instrument operation. Functional checks are normally performed in the field.

**gamma ray** High-energy short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are similar to X-rays but are usually more energetic.

**Geiger-Mueller counter** A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes between which there is an electrical voltage but no current flowing. When ionizing radiation passes through the tube a short intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of radiation. It was named for Hans Geiger and W. Mueller who invented it in the 1920s. It is sometimes called simply a Geiger counter or a G-M counter.

**general employee** An individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities.

**GERT** (General Employee Radiological Training)

**gestation period** The time from conception to birth, approximately 9 months for human beings.

**Gray (Gy)** SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (= 100 rads).

**half-life** The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. This quantity is also called physical half-life.

**half-life, biological** See biological half-life.

**half-life, effective** See effective half-life.

**half value layer** The thickness of any given absorber that will reduce the intensity of a beam of radiation to one-half its initial value.

**HEPA (high efficiency particulate air) filter** A filter that is certified to be capable of removing at least 99.95% of the airborne particles of aerodynamic equivalent sizes of 0.3 microns or larger from the air that passes through it when installed in a filtration system based on particle size.

**High Contamination Area** Any area, accessible to individuals, where removable contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Chapter 2, Table 2-2, of this Manual.

**High Radiation Area** An area, accessible to individuals, in which radiation levels could result in an individual receiving an equivalent dose to the whole body, or effective dose (if internal exposure is not significant) in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

**hot particle** Fuel, activated corrosion product, or other particles of small (micron) size that have a high specific activity as a result of nuclear fission or activation.

**hot spot** Localized source of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 mrem (1 mSv) per hour on contact.

**indirectly ionizing particles** Uncharged particles (neutrons, photons, etc.) which can liberate (by decay or interaction) directly ionizing particles or can initiate nuclear transformations.

**individual** Any human being.

**induced radioactivity** Radioactivity that is created through bombardment of materials by particles, nuclei, or atoms.

**infrequent or first-time activities** Radiological work activities or operations that require special management attention and consideration of new or novel radiological controls. The designation of infrequent or first-time activities is specifically applicable to facilities that conduct routine and recurring process operations, and is not applicable to facilities that routinely conduct first-time activities, such as experimental or research facilities.

**interlocked gate** Any gate which is interlocked in a fail-safe, redundant manner (see Chapter 10 of this Manual) to prevent unauthorized access to the area it encloses.

**in-vivo** For the purposes of this manual a direct measurement of radioactive material in an individual's body. Sometimes performed by a whole body count, lung count, or bone scan.

**ion chamber** An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber.

**ionization** The process of adding one or more electrons to or removing one or more electrons from atoms or molecules thereby creating ions. High temperatures, electrical discharges, and the absorption of nuclear radiation can cause ionization.

**ionizing radiation** Any radiation capable of displacing electrons from atoms or molecules thereby producing ions. Examples: alpha, beta, gamma, X-rays, neutrons, and ultraviolet light.

**isotope** Two or more atoms with the same number of protons but different numbers of neutrons in their nuclei. Thus carbon-12 carbon-13 and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights.

**kerma** The sum of the initial kinetic energies of all charged particles liberated by indirectly ionizing particles in a volume, divided by the mass of matter in that volume. Kerma may be expressed in the same units as absorbed dose (rad, etc.) although it is physically a different quantity.

**large area wipe** A qualitative contamination survey sample gathered by passing a cloth over an area to transfer loose surface contamination from the surface to the cloth which is then surveyed with a contamination survey meter.

**lifetime dose** Total occupational exposure over a worker's lifetime, including external and committed internal dose.

**low-level waste** Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, spent nuclear fuel or byproduct material as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended. Test specimens of fissionable material irradiated only for research and development and not for production of power or plutonium may be classified as low-level waste provided the concentration of transuranic activity is less than 100 nCi/g.

**mass number** The number of nucleons (neutrons and protons) in the nucleus of an atom.

**maximum (beam-on) dose rate in an area** This term is the maximum dose rate which could be produced by a beam whose intensity is limited by accelerator intensity, beam optics, redundant magnet interlocks, radiation activated interlocks, etc.

**member of the public** An individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives occupational exposure.

**minimal occupancy area** Any area which is not normally occupied by people more than 1 hour in 8 consecutive hours. Some examples of such areas are storage areas, passageways, relay racks, road crossings, parking lots, and along radiation fencing.

**minor** An individual less than 18 years of age.

**mixed waste** Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act of 1954 and the Resources Conservation and Recovery Act, respectively.

**monitoring** The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation. See also survey.

**muon** A lepton with charge of +1 or -1 and mass of 105.6 MeV, commonly produced as a meson decay product and as a result of proton beam absorption in targets, beam absorbers or other proton loss points. Muons are produced in the forward (beam) direction and have a penetration range of about 2 meters in earth per GeV at energies above 10 GeV.

**natural uranium** Uranium as found naturally. It contains 0.7 percent uranium-235 and 99.3 percent uranium-238 and a trace of uranium-234.

**neutron** An uncharged elementary particle with a mass slightly greater than that of the proton and found in the nucleus of every atom heavier than the lightest isotope of hydrogen.

**noble gas** A gaseous chemical element having full electron shells. Noble gases do not readily enter into chemical combination with other elements.

**non-stochastic effects** Effects due to radiation exposure for which the severity varies with dose, and for which a threshold usually exists. For example, radiation-induced opacity in the lens of the eye is a non-stochastic effect.

**nucleus (of the atom)** The small, central, positively charged region of an atom that carries essentially all the mass.

**nuclear criticality** A self-sustaining chain reaction, i.e., the state in which the effective neutron multiplication constant of system of fissionable material equals or exceeds unity.

**nuclide** A general term referring to all known isotopes, both stable and unstable of the elements.

**occupancy time** The maximum time in which a radiological worker could be anticipated to spend doing a given task without exceeding 100 mrem of external exposure during 5 consecutive working days.

**optically stimulated luminescence (OSL)** Radiation monitoring device used to record radiation exposure. The current personnel dosimetry monitoring badge in use at Fermilab is based on OSL technology.

**occupational dose** An individual's ionizing radiation dose as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient, background radiation, or participation as a subject in medical research programs.

**person** Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State or political subdivision of, or any political entity within a State, any foreign government or nation or other entity, and any legal successor, representative, agent or agency of the foregoing; provided that person does not include DOE or the United States Nuclear Regulatory Commission.

**personal protective equipment (PPE)** Equipment such as respirators, face shields and safety glasses used to protect workers from excessive exposure to radiation, hazardous situations, or hazardous materials.

**personnel dosimetry** Devices designed to be worn by a single person for the assessment of dose. Included and preeminent are the personnel dosimetry monitoring badges, the legal dosimeter of record.

**personnel dosimetry monitoring badge** - The personnel dosimetry device that constitutes the legal record of radiation exposures received at Fermilab.

**personnel monitoring** Systematic and periodic estimate of radiation dose received by personnel during working hours. Also, the monitoring of personnel, their excretions, skin or any part of their clothing to determine the amount of radioactivity present.

**photon** A quantum (or packet) of energy emitted in the form of electromagnetic radiation. Gamma rays and X-rays are examples of photons.

**physical inventory** A check conducted to verify the location and number of accountable sources. Physical inventories are performed by sighting or otherwise positively verifying (such as through radiation level measurements) the presence of a source.

**Planned Special Exposure** Preplanned, infrequent occupational exposure to radiation, separate from and in addition to the annual dose limits.

**portable enclosure** A means of containment in the form of a tent, or glove box/bag that is used to contain the spread of radioactive contamination. Portable enclosures may be used as primary or secondary containers.

**portable radiation protection instrumentation** Radiation protection instrumentation that, during normal use, is hand carried.

**positron** Particle equal in mass, but opposite in charge, to the electron; a positive beta particle.

**prefilter** Filter that provides first stage air filtration to remove larger particulates and prolongs the efficient use of a HEPA filter.

**prenatal radiation exposure** The exposure of an embryo/fetus to radiation.

**primary containment** The first barrier to the spread of contamination from a work area.

**primary dosimeter** A dosimeter worn on the trunk of the body used to obtain the formal record of whole body radiation dose.

**primary/routine calibration** A procedure that is followed on each instrument channel using standardized sources and/or instruments.

**proportional counter** An instrument in which an electronic detection system receives pulses that are proportional to the number of ions formed in a gas-filled tube by ionizing radiation.

**protection factor** The ratio of the ambient concentration of an airborne substance to the concentration of the substance likely to be inside a respirator during extended use. The protection factor is a measure of the degree of protection provided by a respirator to the wearer.

**protective clothing** Clothing provided to personnel to minimize the potential for skin, personal and company issued clothing contamination. Also referred to as “anticontamination clothing,” “anti-Cs” and “PCs.”

**proton** An elementary nuclear particle with a positive charge which is the nucleus of the hydrogen atom.

**qualification standard** A document that states and defines the required physical attributes and the technical, academic and practical knowledge and skills developed through training, education and on-the-job performance for the successful completion of a training program.

**quantitative respirator fit test** A type of respirator fit test in which the user wears a respirator in an aerosol test atmosphere and the penetration of the atmosphere into the face piece is measured quantitatively.

**quality factor** The modifying factor used, traditionally, to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor (Q). Quality factors are provided in chapter 8 of this Manual. Radiation weighting factors are the preferred terminology in the context of the 2007 amendments to 10 CFR 835.

**rad** Unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joules per kilogram (0.01 gray) of energy delivered to material.

**radiation** Ionizing radiation: alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this Manual, does not include non-ionizing radiation, such as radio-waves or micro-waves, visible, infrared, or ultraviolet light.

**Radiation Area** An area, accessible to individuals, in which radiation levels could result in an individual receiving a equivalent dose to the whole body, or effective dose (if internal exposure is insignificant) in excess of 5 mrem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

**radiation protection instrumentation** Instruments that measure radiation for the purpose of protecting workers or documenting occupational exposures for the purposes of this manual, radiation protection instrumentation does not include effluent monitors.

**radiation standards** Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation and control of radioactive material by legislative means.

**radiation weighting factor (w<sub>R</sub>)** The modifying factor used to calculate the equivalent dose from the average tissue or organ absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate radiation weighting factor (see FRCM Chapter 8).

**radioactive contamination** Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful.

**loose surface or removable contamination** Radioactive material that can be removed from surfaces by non-destructive means, such as casual contact, wiping, brushing or washing.

**fixed contamination** Contamination to which a coating is applied in order to render the material not to be “loose”, contamination that has been isolated by the application of a barrier and does not have a significant potential for spreading without the application of immoderate force.

**radioactive material** Radioactive material at Fermilab is defined in article 411.1 of this manual.

**Radioactive Material Area** Any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values of appendix E of 10CFR835.

**radioactive material transportation** The movement of radioactive material by aircraft, rail, vessel, or highway vehicle. Radioactive material transportation does not include preparation of material or packaging for transportation, storage of material awaiting transportation or application of markings and labels required for transportation.

**radioactive source** See Source, Radioactive.

**radioactive waste** Solid, liquid or gaseous material that contains radionuclides that are regulated under various laws and regulations.

**radioactivity** A natural and spontaneous process by which the unstable atoms of an material emit or radiate excess energy, charge, or mass from their nuclei and, thus, change (or decay) to atoms of a different element or to a lower energy state of the same element.

**radiography** Examination of the structure of materials by nondestructive methods, using a radioactive source or a radiation generating device.

**radioisotope** An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5000 natural and artificial radioisotopes have been identified.

**radiological area** Any area within a Controlled Area defined as a "Radiation Area," "High Radiation Area," "Very High Radiation Area," "Contamination Area," "High Contamination Area," or "Airborne Radioactivity Area" in accordance with the requirements of FRCM Chapter 2.

**RCT** (Radiological Control Technician)

**radiological posting** Sign or label that indicates the presence or potential presence of radiation or radioactive materials.

**radiological work** Any work that requires the handling of radioactive material or which requires access to Radiation Areas, High Radiation Areas, Very High Radiation Areas, Contamination Areas, High Contamination Areas or Airborne Radioactivity Areas.

**RWP (Radiological Work Permit)** Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The Radiological Work Permit serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

**RWT** (Radiological Worker Training)

**radiation warning symbol** An officially prescribed symbol (a black or magenta tri-foil) on yellow background that must be displayed to warn of radiation or radioactivity.

**radiological worker** A general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose.

**radiological control hold point** Cautionary step in a Technical Work Document requiring the Radiological Control Organization to perform some action or verification.

**real property** Land and anything permanently affixed to the land such as buildings, fences and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures.

**real-time air monitoring** Measurement of the concentration or quantities of airborne radioactive materials on a continuous basis.

**release to uncontrolled areas** Release of material from administrative control after confirming that the residual radioactive material meets the guidelines set forth in Chapter 4 of this manual.

**rem** Unit of measure of dose equivalent, equivalent dose, effective dose, etc. (see other definitions) A quantity measured in units of rem in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, radiation weighting factor, distribution factor and any other necessary modifying factor (1 rem = 0.01 sievert) needed to provide the weighting needed to take into account health effects of the radiation exposure.

**removable contamination** See radioactive contamination, loose surface or removable

**representative sample** Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the extended material it is supposed to represent (e.g., particle size and solubility in the case of air sampling of the aerosol to which workers may be exposed).

**respiratory protective device** An apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials.

**response check** A check performed on a portable or semi-portable instrument to verify that the instrument responds to the presence of radiation.

**rigid beam barriers** Physical barriers which prevent personnel from accidentally getting into a beam. This normally applies to barriers inside an enclosure and includes such things as vacuum pipe, beam line components, cardboard or PVC tubes, or some experimental apparatus.

**Roentgen (R)** A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions.

**scattered radiation** Radiation that has interacted with one or more atoms of a material during its passage through that material. The radiation usually experiences a change in

direction of propagation during these interactions. It may also have been modified by a decrease in energy.

**scintillation detector or counter** The combination of phosphor, photomultiplier tube, and associated electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.

**sealed source** See source, sealed.

**secondary containment** An additional enclosure that encompasses a primary containment system or component.

**secondary radiation** Radiation originating as the result of absorption or scattering of other radiation in matter. It may be either electromagnetic or particulate in nature.

**shall** Denotes requirements that are mandatory based on laws, regulations, or directives and which are required in order to implement best management practices. All facilities and operations are required to comply with the “shall” requirements of this manual.

**should** Denotes statements that are recommendations or preferences that are not mandatory. These guidelines normally provide an acceptable method of complying with, or demonstrating compliance with, a mandatory requirement or they are based on good engineering practices. They do not preclude other equally acceptable or better methods for obtaining compliance with “shall” requirements.

**Sievert (Sv)** SI unit of any of the quantities expressed otherwise in units of rem. . For example, the effective dose in sieverts is equal to the absorbed dose in grays multiplied by the appropriate radiation weighting and organ weighting factors (1 Sv = 100 rems).

**smear** A technique for sampling for removable surface contamination using a small, round piece of cloth or paper. Also called a “swipe”, but the preferred terminology at Fermilab is a “wipe”. It usually samples a surface area of 100 cm<sup>2</sup>.

**STC (special tritium compound)** Any compound, except for H<sub>2</sub>O (tritiated water), that contains tritium, either intentionally (e.g., by synthesis) or inadvertently (e.g., by contamination mechanisms).

**removable contamination** See radioactive contamination, loose surface or removable.

**source, radioactive** Radioactive material that is used exclusively for its emitted radiations and retains its physical form and configuration during use.

**source, sealed** A radioactive source manufactured to obtained or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known quantity

of radioactive material contained within a sealed capsule, sealed between layers of nonradioactive material or firmly fixed to a nonradioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotopic thermoelectric generators. See also accountable sealed radioactive source.

**source, unsealed** Radioactive material affixed to a surface by electroplating prepared by evaporation of liquid on a backing material by chemical means, or contained by the use of foil, mylar, or other coverings which allow penetration of alpha or beta radiations, or any other source not meeting the definition of a sealed source.

**source leak test** A test to determine if a sealed radioactive source is leaking radioactive material.

**specific activity** An expression of the amount of radioactive emissions per unit of time and per unit of weight for the host material. Usually expressed as disintegrations per unit time or Ci (or subunits) per gram or cubic centimeter of material.

**stay time** The period during which personnel may remain in a restricted area. This time is predetermined by the radiological control organization and based on the accumulation of some permissible radiation dose.

**step-off pad** Transition area between contaminated and non-contaminated areas that may be used to allow exit of personnel and removal of equipment.

**stochastic effects** Malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

**standard radiation symbol** Symbols designed and proportioned as illustrated in accordance with ANSI N2.1 for radiation symbols and ANSI N12.1 for fissile material.

**sticky pad** Step-off pad provided with a tacky surface to reduce the potential for inadvertently tracking contamination out of a contaminated area.

**survey** See monitoring.

**swipe** See Smear.

**technical work document** A term used to generically identify formally approved documents that direct work, such as procedures, work packages, or job or research plans.

**temporary shielding** “Portable” materials used to reduce dose rates during certain operations. Examples include the application of lead blankets, steel and/or lead bricks, and polyethylene.

**tenth value layer** The thickness of a given material that will decrease the amount of radiation to one-tenth of the amount incident upon it.

**thermoluminescent dosimeter (TLD)** Radiation monitoring device used to record radiation exposure. This term is commonly, but incorrectly, used to refer to the personnel dosimetry monitoring badge, which was formerly based on thermoluminescent technology. “Personnel dosimetry monitoring badge” is the preferred term.

**tissue weighting factor (w<sub>T</sub>)** The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The dose equivalent to tissue T is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue. Weighting factors are provided in Appendix 2A of the FRCM.

**total effective dose (TED)** See dose.

**transuranic waste** Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

**tritium** A radioactive isotope of hydrogen (one proton, two neutrons). Because it is chemically identical to natural hydrogen, tritium can easily be taken into the body by any ingestion path. Decays by beta emission. Its radioactive half life is about 12.3 years. Tritiated water (HTO) is commonly called “tritium” at Fermilab.

**unsealed source** See Source, Unsealed.

**unusual occurrence** Non emergency occurrence that has significant impact or potential for impact on safety, environment, health, security, or operations. Examples of the types of occurrences that are to be categorized as unusual occurrences are contained in DOE Orders.

**Very High Radiation Area** An area, accessible to individuals, in which radiation levels could result in a person receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

**visitor** Person requesting access to Laboratory facilities that will not be performing hands-on work in radiological areas or with radioactive materials.

**week** A period of seven consecutive days.

**weighted sum rule** The rule for comparing concentrations of mixtures of radionuclides against regulatory standards by evaluating the sum of the ratios of the concentrations of the individual radionuclides to their individual limiting values. If this summation is  $< 1$ , then the applicable limit is met. An example is a mixture of radionuclides in air where one determines whether or not the concentration is less than on derived air concentration (DAC) by this method.

**whole body** For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, and legs above and including the knee.

**whole body dose** The sum of the annual deep dose equivalent from external exposures and the committed effective dose equivalent from internal exposures.

**wipe** A technique for sampling for removable surface contamination using a small, round piece of cloth or paper. It usually samples 100 cm<sup>2</sup>.

**year** The period of time beginning on or near January 1 and ending on or near December 31 of that same calendar year used to determine compliance with the provisions of 10 CFR 835. The starting and ending date of the year used to determine compliance may be changed, provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years. One year of occupational work is commonly considered to be equivalent to 2000 hours of such activity.