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Standard Terminology of C26.10 Nondestructive Assay Methods[1]

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ε[1] NOTE—Text was added editorially to the definition of "working standard" in August 2011.

1. Scope

1.1 The terminology defined in this document is associated with nondestructive assay of nuclear material.

1.2 All of the definitions are associated with measurement techniques that measure nuclear emissions (that is, neutrons, gamma-rays, or heat) directly or indirectly.

1.3 definitions are relevant to any standards and guides written by subcommittee C26.10.

2. Referenced Documents

2.1 *ASTM Standards:*[2]
E456 Terminology Relating to Quality and Statistics

2.2 *DOE Orders:*[3]
DOE Order 435.1 Low-level Waste Requirements
DOE Order 5820.2 Radioactive Waste Management

3. Terminology

(alpha, n) reaction, *n*—a reaction that occurs when energetic alpha particles collide with low atomic number nuclei resulting in the emission of a neutron

^{240}Pu-effective mass, $^{240}Pu_{eff}$, *n*—the mass of ^{240}Pu that would produce the same coincident neutron response in the instrument as the assay item.

DISCUSSION—It is a function of the quantity of even mass isotopes of plutonium in the assay item and fundamental nuclear constants, sometimes referred to as effective ^{240}Pu mass.

absorber foils, *n*—foils, usually of copper, tin, cadmium, or lead, used to attenuate the gamma flux reaching a detector.

DISCUSSION—Absorber foils are used to reduce the count rate, typically from intense low-energy X or gamma rays.

accidentals, *n*—the detection of multiple neutron events within the gate width that are not produced from the same fission.

DISCUSSION—Accidental events take their name from the fact that it is the accidental or random summing of neutrons, which are not time correlated with a common origin (fission or cosmic-ray burst), that give rise to the appearance of a signature like that from genuine correlated events.

active assay, *n*—assay based on the observation of radiation(s) induced by irradiation from an external source.

alpha, α, *n*—the ratio of the uncorrelated neutron emission rate from (α, n) reactions to the spontaneous neutron emission rate from a non-multiplying item.

aperture, *n*—the size of the opening in the collimator through which the radiation of interest is intended to pass.

assay, *v*—to determine quantitatively the amount of one or more nuclides of interest contained in an item.

attenuation correction, *n*—correction to the measured count rate for attenuation of radiation that provides an estimate of the unattenuated radiation emission rate of the radionuclides being assayed.

attenuation, *n*—reduction of radiation flux due to the interaction of radiation with material between the source of the radiation and the detector.

background, *n*—extraneous signal superimposed on the signal of interest.

Beers Law, *n*—the fraction of uncollided gamma rays transmitted through layers of equal thickness of an absorber is a constant.

benign matrix, *n*—bulk material that has a negligible effect on the result of the measured parameter.

blank, *n*—a prepared item containing a matrix as similar as practical to the items being measured that is free, to the extent possible, of the radionuclides of interest.

DISCUSSION—The most important matrix parameters are those that affect the result of the measurement technique being used.

[1] This terminology is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.10 on Non Destructive Assay.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from the U.S. Department of Energy (DOE), 1000 Independence Ave., SW Washington, DC 20585.

calibration standard, *n*—an item similar to the items to be assayed, for which the parameters of interest and all properties to which the measurement technique is sensitive are known.

calorimeter, *n*—a device to measure heat or rate-of-heat generation.

calorimetric assay, *n*—determination of the mass of radioactive material through the measurement of its thermal power by calorimetry and the use of nuclear decay constants and, if necessary, additional isotopic measurements.

certification, *n*—a written declaration from a certifying body or its legitimate designee that a particular measurement process or measurement personnel comply with stated criteria or that a measured item has the stated characteristics.

code validation, *n*—process to determine that the software performs its intended functions correctly, ensure that it performs no unintended functions, and provides information about its quality and reliability.

coincidence gate length, *n*—the time interval following the detection of a neutron during which additional neutrons are considered to be in coincidence with the original neutron.

coincident neutrons, *n*—two or more neutrons emitted simultaneously from a single event, such as from a nucleus during fission.

collimated detector, *n*—a detector surrounded by a shield that imposes a directional response on the collimated detector.

collimator, *n*—a shield that imposes a directional response on the detector. Generally, for gamma ray detection the collimator is a hollow cylinder or rectangular prism of high atomic number (Z) and high density material, mounted coaxially to the detector and extending over the detector and beyond the detector face.

Compton scattering, *n*—scattering of gamma rays that may or may not be from the radionuclide of interest.

DISCUSSION—The scattering reduces the energy of the gamma ray and results in a continuum of gamma ray energies.

computed tomography, *n*—see *tomography*.

confidence interval, *n*—The range of values, calculated from the probability distribution (often sufficiently well characterized by the estimate of the mean and standard deviation), which is expected to include the population mean with a stated level of confidence or likelihood.

DISCUSSION—For more details see Test Method E456.

contact measurement, *n*—a special case of a near-field measurement in which measurements are made with the detector assembly in contact with the item, for example, tank, pipe, ductwork, being assayed.

control chart, *n*—a graphical plot of test results with respect to time or sequence of measurement together with limits in which they are expected to lie when the system is in a state of statistical control.

control limits, *n*—the limits beyond which it is statistically highly improbable that one or several point(s) could lie while the system remains in a state of statistical control.

data quality objective, *n*—measurement uncertainty and confidence levels specified by the scope of work.

dead time, *n*—the period following the detection of an event during which the detection electronics cannot register a subsequent event.

DISCUSSION—Dead time is usually expressed as a percentage of elapsed time.

delayed neutrons, *n*—neutrons emitted by the item that are produced from decay of the fission products.

DISCUSSION—These neutrons are produced at a time after the initial fission event.

depleted uranium, *n*—uranium containing less than the naturally occurring fraction of ^{235}U isotopes (<0.7 weight percent).

die-away time, *n*—the average life time of the neutron population as measured from the time of emission to detection, escape, or absorption. The average lifetime is the time required for the neutron population to decrease by a factor of 1/e.

doubles, *n*—the detection of neutron pairs produced from the same fission event.

DISCUSSION—The doubles terminology is often used in reference to multiplicity counting, but it is the same as the reals from coincidence counting.

effective specific power, p_{eff}, *n*—the rate of energy emission per unit mass of radionuclide at the time of measurement.

far-field measurement, *n*—a measurement geometry where the analyst can assume that all gamma rays emitted from the item enter the detector along paths parallel to each other.

field of view, *n*—the entire solid angle subtended by the collimated detector.

fissile isotopes, *n*—isotopes that can be induced to fission by thermal neutrons.

DISCUSSION—^{233}U, ^{235}U, ^{239}Pu, and ^{241}Pu are the most common fissile isotopes.

flux monitors, *n*—detectors in the measurement chamber that measure the neutron flux of interrogating neutrons (cavity flux monitor) or item neutrons (drum flux monitor).

heat-flow calorimeter, *n*—a calorimeter so constructed that the heat generated in the calorimeter flows past a temperature sensing element, through a thermal resistance, to a constant temperature heat sink.

holdup, *n*—the residual nuclear material remaining in process equipment and facilities.

homogeneous matrix, *n*—a matrix whose characteristics important to the measurement result is uniform throughout the item.

infinite thickness, *n*—the thickness of material through which 99.9 % of the gamma rays of the designated energy cannot penetrate.

DISCUSSION—This is nominally equal to 7 mean-free paths in pure material.

item, *n*—material potentially containing radioisotope to be measured.

low level waste, *n*—is radioactive containing material that is not classified as high-level waste, transuranic waste, spent nuclear fuel, or by-product material.

lower limit of detectability, *n*—a stated limiting value which designates the lowest concentration, mass, or activity that can be detected with confidence and which is specific to a particular measurement.

lump, *n*—that contiguous mass of nuclear material that is sufficiently large to affect the measured signal.

matrix, *n*—the material that comprises the bulk of the item, except for the radionuclide(s) of interest and the container.

matrix-specific calibration, *n*—a calibration that uses a matrix similar to the matrix to be measured.

DISCUSSION—No matrix correction factors are used. This calibration is normally not appropriate for other matrices.

model validation, *n*—process to determine the suitability of the model for a given application.

multiplicity distribution, *n*—this is the distribution of the number of neutrons emitted in fission events.

near-field measurement, *n*—measurement made at intermediate or close distances from the item where the measured radiation enters the detector from a variety of distances and angles.

neutron absorbers, *n*—materials which have relatively large thermal-neutron capture cross-sections.

DISCUSSION—Absorbers with the largest capture cross-sections are commonly known as neutron poisons. Some examples are boron, cadmium, gadolinium and lithium.

neutron moderators, *n*—materials which efficiently slow down neutrons. Materials containing large amounts of low atomic weight materials, such as hydrogen are highly moderating.

neutron multiplication, *n*—multiplication takes place when a neutron interaction yields more than one neutron as a product.

DISCUSSION—Induced fission is the primary mechanism for neutron multiplication, however (n, 2n) interactions are also multiplication events.

nondestructive assay, NDA, *n*—an analysis of an item in which the chemical and physical properties of that item and container remain essentially unaltered.

one pass assay, *n*—a gamma ray measurement in which the transmission and emission data are collected simultaneously.

passive assay, *n*—assay based on the observation of naturally occurring or spontaneous nuclear radiation(s).

passive mode, *n*—a technique used to determine the spontaneously-fissioning mass in the measured item through the detection of spontaneously emitted neutrons rather than neutrons induced by external interrogation sources.

peaked background, *n*—gamma rays of the assay energy, which originate in sources other than the item material being assayed.

point model, *n*—the mathematical model used to analyze measurements of radioactive items where the item is represented as a point source.

point source, *n*—source material confined to a volume whose dimensions are small compared with the distance between the source and detector.

pre-delay, *n*—the coincidence circuit has a time period immediately after a neutron has been detected during which signals are not accepted.

prompt neutrons, *n*—neutrons released within approximately 10^{-14} s of the fission.

rate-loss correction, *n*—a correction for count rate related losses that are used for some gamma-ray NDA techniques.

reals, R, *n*—detection of neutron pairs produced from the same fission event.

DISCUSSION—The reals terminology is often used in reference to coincidence counting, but it is the same as the doubles from multiplicity counting.

sample, *n*—a portion of a population or lot. In the context of NDA measurements, it may consist of measurements of items that are part of a larger group that could have been considered.

scrap, *n*—materials that contain sufficient quantities of radioactive material to be worthy of recovery.

screening, *n*—rapid, that is, short-count time, measurements at specific locations or with a moving gamma-ray detector (sometimes with a neutron probe) along an item to qualitatively identify the presence and rough distribution of radioactive material.

DISCUSSION—The information from the screening can be used to optimize the assay procedure for the item(s).

secular equilibrium, *n*—the state of equilibrium that exists when a series of daughter radioisotopes have constant activity levels determined by the parent activity rate.

self-attenuation, *n*—the attenuation of emitted radiation by the emitting material itself.

sensitivity, *n*—the capability of methodology or instrumentation to discriminate between items having differing concentrations or containing differing amounts of a radioactive material or no radioactive material.

singles, S, *n—in multiplicity counting*, the sum of all detected neutrons.

DISCUSSION—Equivalent to the totals from coincidence counting.

special nuclear material, *n*—plutonium, ^{233}U, uranium enriched in ^{235}U and any other materials defined as SNM under the Atomic Energy Act of 1954 as amended and DOE orders.

spontaneously-fissioning nuclei, *n*—those nuclei which do not require an external neutron source to undergo significant fission.

DISCUSSION—The most common isotopes are ^{238,240,242}Pu, ^{242,244}Cm, and ^{252}Cf.

total measurement uncertainty (TMU), *n*—an estimated parameter, either mass, activity, concentration, or fractional, used to quantify the overall confidence in the assay result at a prescribed level including all sources of precision and bias.

totals, T, *n—in coincidence counting*, the sum of all detected neutrons.

DISCUSSION—Equivalent to the singles from multiplicity counting.

traceability, *n*—relating individual measurements through an unbroken chain of calibrations to a national or international primary reference materials or to accepted values of fundamental physical constants.

transmission correction, *n*—an attenuation correction determined from a transmission measurement of the item being measured.

transmission source, *n*—a radioactive source external to the item being measured that is used to determine the attenuation of gamma rays of interest by the item.

transmission, *n*—the fraction of gamma rays that pass through the item without losing energy or changing direction.

transuranic waste, TRU waste, *n*—as defined in DOE Order 5820.2 and DOE Order 435.1, transuranic waste is radioactive waste containing alpha-emitting isotopes with atomic number greater than 92 and half-life greater than 20 years, and with activity concentrations greater than 100 nCi per gram of waste at the time of the measurement.

triples, T, *n*—the detection of three neutrons produced from the same fission event.

two pass assay, *n*—a measurement in which the emission data and the transmission data are collected in separate measurements of the item.

uncertainty, *n*—a qualitative term describing the inability of a measurement process to determine the correct value.

voxel, *n*—a volume element.

waste acceptance criteria, *n*—the set of requirements pertaining to a waste item that must be satisfied before it can be shipped to a designated facility or disposal site.

waste, *n*—items containing radioactive materials not currently considered useful or economically recoverable.

working standard, *n—in nondestructive assay (NDA)*, an item used to check the performance of an NDA instrument, not necessarily representative of the items to be assayed.

DISCUSSION—The selected or fabricated item must be handled in a manner to ensure its internal integrity so that deviations in its measured response can be attributed to the instrument.

4. Keywords

4.1 definitions, measurements, nondestructive assay; special nuclear material, instruments, terminology