Abbreviations and Acronyms

ADU	ammonium diuranate
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ANSs	American National Standards
ASA	American Standards Association
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
AW	aqueous waste
[b]	barn
BWR	boiling water reactor
C	Celsius
CFR	Code of Federal Regulations
cm	centimeter
DG	Draft Guide
DOE	Department of Energy
DOT	Department of Transportation
ϵ	fast fission factor
EOC	Emergency Operations Center
EPA	Environmental Protection Agency

F	Fahrenheit
f	fraction critical
FCR	facility change request
FSAR	Facility Safety Analysis Review
g	gram
GDP	gaseous diffusion plant
GE	General Electric
h	height
HEPA	high efficiency particulate air
HEU	high enriched uranium
HF	hydrofluoric acid/hydrogen fluoride
ICPP	Idaho Chemical Processing Plant
ICRP	International Commission on Radiological Protection
in	inch
ISO	International Standards Organization
k_{eff}	effective multiplication factor
k_{∞}	infinite multiplication factor
kg	kilogram
IAEA	International Atomic Energy Agency
L	length
ℓ	liter
LCV	level control valve
LEU	low enriched uranium
LWR	light water reactor
m	meter

MeV	mega electron volts
MOU	Memorandum of Understanding
mm	millimeter
NaI(Tl)	sodium Iodide detectors, thallium activated
NCRP	National Council for Radiation Protection
NCS	nuclear criticality safety
NCSF	nuclear criticality safety function
NDA	nondestructive assay
NFCM	Nuclear Fuel and Components Manufacturing
NIST	National Institute of Standards and Technology
NMSS	Office for Nuclear Material Safety and Safeguards
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulation
OSHA	Occupational Safety and Health Administration
PDC	Professional Development Center
PORTS	Portsmouth
ppm	parts per million
psi	pounds per square inch
Pu	plutonium
PWR	pressurized water reactor
QA	quality assurance
QC	quality control
QT	quarantine tank
s	second
SAR	Safety Analysis Report

SER	Safety Evaluation Report
SNM	special nuclear material
SOP	standard operating procedure
SX	solvent extraction
Th	thorium
TLD	thermoluminescent dosimeter
TSR	Technical Safety Requirements
U	uranium
^{235}U	uranium-235
UCl_4	uranium tetrachloride
U_3O_8	triuranium octoxide (yellowcake)
UF_4	uranium tetrafluoride (green salt)
UF_6	uranium hexafluoride
UN	uranyl nitrate
UO_2	uranium dioxide (brown oxide or uraninite)
UO_2F_2	uranyl fluoride
UO_3	uranium trioxide (orange oxide)
UO_4	uranium tetroxide
UPS	uninterruptible power supply
URU	uranium recycle unit
US	United States
USASI	United States of America Standards Institute
USNRC	United States Nuclear Regulatory Commission
WTF	waste treatment facility
yr	year

Glossary

The definitions given below are of a restricted nature for the purposes of their standard.

absorption, neutron. 1. Reaction between a neutron and a nucleus in which the neutron disappears. Radioactive capture and fission are the primary mechanisms. 2. A neutron-induced reaction, including fission, in which the neutron disappears as a free particle.[1] The absorption cross section is designated σ_a.

alarm system, criticality accident. A system capable of sounding an audible alarm after detecting neutron or gamma radiation from a criticality accident.[4]

alpha particle. A helium-4 nucleus emitted during a nuclear transformation.[1]

area(s) of applicability. The ranges of material compositions and geometric arrangements within which the bias of a calculational method is established. Source: ANSI/ANS 8.1, 1983.

area of intersection. The area of the solution within an arm which intersects a plane tangent to the column at the point where the axis of the arm intersects the surface of the column.

areal density. 1. The total mass of fissionable material per unit area projected perpendicularly onto a plan. (For an infinite, uniform slab, it is the product of the slab thickness and the concentration of fissionable material within the slab.) Source: ANSI/ANS 8.1, 1983. 2. Mass of fissionable material per unit area. Used as a measure of subcriticality in the surface density hand-calculation method.

arm. Any pipe intersecting a column. Source: ANSI/ANS 8.9, 1987.

array. Any fixed configuration of fuel units maintained by mechanical devices. Source: ANSI/ANS 8.17, 1989.

beta particle. An electron of either positive or negative charge that has been emitted in a nuclear transformation.[1]

bias. A measure of the systematic disagreement between the results calculated by a method and experimental data. The uncertainty in the bias is a measure of both the precision of the calculations and the accuracy of the experimental data. Source: ANSI/ANS 8.1, 1983.

breeding. Process where a system with fissionable material produces more fissionable material as a result of fertile conversion than it uses to sustain the neutron chain reaction.

buckling, geometric. 1. A parameter developed in the diffusion-theory calculational method from geometric terms that serves as a measure of neutron leakage. (The formulation also is applied in the buckling-conversion hand-calculation method to compare critical configurations of different geometric shapes. 2. Algebraic expressions that relate critical dimensions of various simple shapes (sphere, cylinder, or cuboid) of cores of the same composition and similar

reflectors. For example, the known radius of a critical sphere may be used to obtain the radius and length of a corresponding critical cylinder. For an applied definition of buckling, see Ref. 4, pp. 7 and 8.

calculational method (method). The mathematical equations, approximations, assumptions, associated numerical parameters (e.g., cross sections), and calculational procedures which yield the calculated results. Source: ANSI/ANS 8.1, 1983.

capture, neutron. Neutron absorption not leading to fission or other neutron production. The capture cross section is designated σ_c.[4]

chain reaction, fission. A sequence of nuclear fission reactions in which fissions are induced by neutrons emerging from preceding fissions. Depending on whether the number of fissions directly induced by neutrons from one fission is on the average less than, equal to, or greater than unity, the chain reaction is convergent (subcritical), self-sustaining (critical), or divergent (supercritical).[1]

column. The pipe of largest diameter in a system of intersecting pipes.

conservative (calculation). A calculation of the multiplication factor of a system containing fissionable material in which assumptions have been incorporated to assure that the result represents an *over*prediction.

contingency. A possible but unlikely change in a condition important to the nuclear criticality safety of a fissile material activity such that its nuclear criticality safety is decreased.

control Raschig rings (control rings). Rings that are nondestructively tested for physical properties and remain in the solution except for short test periods. Source: ANSI/ANS 8.5, 1986.

controlled parameter. A parameter that is kept within specified limits. Source: ANSI/ANS 8.1, 1983. Note: ANSI/ANS 8.17, 1989, adds to the end of the statement: "and, when varied, influences the margin of subcriticality."

conversion. Process where a system with fissionable material produces new fissile material as a result of fertile conversion. (When the net conversion exceeds that which would be required to sustain the neutron chain reaction, the process is referred to as *breeding*.)

core. That part of a fissile system containing most or all of the fissile material, as distinguished from an external reflector.[4]

critical. Self-sustaining fission chain reaction. k_{eff} is unity for a critical system.

critical (criticality) accident. The release of energy as a result of accidentally producing a self-sustaining or divergent neutron chain reaction. Source: ANSI/ANS 8.1, 1983; ANSI/ANS 8.3, 1986; ANSI/ANS 8.6, 1983; and ANSI/ANS 8.20, 1991.

criticality safety. Protection from the consequences of a criticality accident, preferably by prevention of the accident.[2] Encompasses procedures, training, and other precautions in addition to physical protection.

criticality safety staff. Specialists skilled in the techniques of nuclear criticality safety assessment and familiar with plant operations while, to the extent practicable, administratively independent of process supervision. Source: ANSI/ANS 8.20, 1991.

criticality safety Standards. These Standards describe criticality control practices for which there is industry-wide consensus. Consensus is established through procedures of the American National Standards Institute. Chapter 4 of Ref. 4 lists and discusses existing and proposed criticality safety Standards and explains capitalization of the term.

cross section. A measure of the rate at which nuclear reactions will occur. (See also *macroscopic cross section, microscopic cross section.)*

cross section (σ), neutron. The proportionality factor that relates the rate of a specified reaction (such as capture or fission) to the product of the number of neutrons per second impinging normally onto a unit area of a thin target and the number of target nuclei per unit area. It may be considered a small area assigned to each target nucleus, usually expressed in barns (i.e, 10^{-24} cm^2).

decay heat. Heat generated by the decay of fission products following fission. Provides a long-term source of heat following shutdown of the fission chain reaction.

decay, radioactive. A spontaneous nuclear transformation in which particles or gamma radiation is emitted, in which x-radiation is emitted following orbital electron capture, or in which the nucleus undergoes spontaneous fission.[1]

delayed criticality. State of a fissile system such that $k_{eff} = 1$, the steady-state condition.[4]

delayed neutrons. Neutrons from nuclei produced by beta decay following fission. They follow fission by intervals of seconds to minutes.[4] See *prompt neutrons*.

delayed radiation. Radiation including beta particles, gamma rays, and neutrons emitted as a result of fission by decay of the fission products.

diffusion theory. A model for a neutron chain-reacting system that is based on the assumption that neutrons' behavior can be described by Fick's law of diffusion (developed to describe diffusion of a chemical constituent through a medium).

double contingency. 1. The philosophy requiring that process designs shall incorporate sufficient factors so that at least two unlikely, independent, and concurrent changes in process conditions must occur before a criticality accident is possible. 2. The **double contingency principle** set forth in Standard ANSI/ANS-8.1, states that "Process designs should, in general, incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible." The two changes are referred to as the double contingency.

effective multiplication factor (k_{eff}). The ratio of the total number of neutrons produced during a time interval (excluding neutrons produced by sources whose strengths are not a function of fission rate) to the total number of neutrons lost by absorption and leakage during the same interval. Source: ANSI/ANS 8.1, 1983.

environmental factors. Conditions of the environment, usually not directly related to the process, that may affect the margin of subcriticality of a system and that could be subject to change.

favorable geometry. 1. A geometric configuration whose leakage is sufficiently great that it is not possible to obtain a critical configuration of a specified material type. 2. Geometric constraint of fissile materials in which subcriticality is maintained under anticipated conditions. Examples are limited diameter of pipes, intended to contain fissile solution, or limited volumes of solution containers.[4]

fertile nucleus. A fissionable nucleus that is not fissile but that following neutron absorption, converts to a fissionable nucleus. Primary examples are ^{238}U, ^{232}Th, and ^{240}Pu, which convert to ^{239}Pu, ^{233}U, and ^{241}Pu, respectively.

fissile assembly (assembly). A system consisting of fissile material and other components that influence the reactivity. Source: ANSI/ANS 8.6, 1983.

fissile isotopes. Fissile isotopes are the subset of the fissionable isotopes that will sustain a fission-chain reaction using thermal neutrons. The important isotopes ^{233}U, ^{235}U, ^{239}Pu, and ^{241}Pu are fissile isotopes. Fissile isotopes in solution or in special mixtures can absorb thermal neutrons and sustain chain reactions with much smaller masses than those usually required for sustained fission; therefore, fissile isotopes pose a greater risk of an accidental criticality.

fissile material. A material, other than natural uranium, that is capable of sustaining a neutron chain reaction. Source: ANSI/ANS 8.7, 1975.

fissile system. A system containing ^{233}U, ^{235}U, or ^{239}Pu nuclei and capable of significant neutron multiplication.[4]

fission, nuclear. 1. Nuclear reaction in which a neutron and nucleus interact with the result that the nucleus splits into two or more parts. Fission reactions of interest here release net energy and produce neutrons that can participate in a sustained chain reaction.
2. Disintegration of a nucleus (usually Th, U, Pu, or heavier) into two (rarely more) masses of similar order of magnitude, accompanied by a large release of energy and the emission of neutrons.[1] Although some fissions take place spontaneously, neutron-induced fissions are designated σ_f, and v is the number of neutrons emitted per fission.

fissionable isotope. A fissionable isotope is any isotope capable of sustaining a neutron-induced fission-chain reaction, regardless of the neutron energy or speed necessary to induce and sustain the reaction. For practical NCS purposes, these isotopes are limited to ^{233}U, ^{235}U, ^{239}Pu, ^{241}Pu, ^{242m}Am, ^{243}Cm, ^{245}Cm, ^{247}Cm, ^{249}Cf, ^{251}Cf, ^{237}Np, ^{238}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, and ^{244}Cm. Although other isotopes of some of the above elements would sustain fission, the quantity for fission is so great and/or the mass available is so small as to make a nuclear-criticality accident incredible.

fissionable nucleus. A nucleus capable of fission by neutrons or some energy. Fissionable nuclei include ^{238}U, ^{240}Pu, and others with neutron-energy fission thresholds, in addition to those that are fissile.[4]

fuel rod. A long slender column of material containing fissile nuclides, normally encapsulated

by metallic tubing.

fuel unit. The fundamental item to be handled, stored, or transported. It may be an assembly of fuel rods, canned spent fuel, or consolidated fuel rods. Source: ANSI/ANS 8.17, 1989.

full reflector. A closely fitting, effectively infinite thickness of water, or its equivalent, surrounding the system of pipes.

gamma radiation. Short-wavelength electromagnetic radiation emitted in the process of nuclear transition or particle annihilation.[1]

hazard. A potential danger. "Potentially hazardous" is redundant. Note that a hazardous facility is not necessarily a high-risk facility. [4]

interaction. Process in which neutrons from individual fissioning units affect the chain reaction in neighboring units.

intermediate reflector. A neutron reflector that contributes reactivity to a column with intersecting arms not exceeding that reactivity corresponding to the presence of a concrete wall in contact with the column and arms in a 2-m-square room having 30-cm-thick concrete walls and floor.

k_c. The mean k_{eff} that results from the calculation of the benchmark criticality experiments using a particular calculational method. If the calculated k_{eff}s for the criticality experiments exhibit a trend with a parameter, then k_c shall be determined by extrapolation on the basis of a best fit to the calculated values. The criticality experiments used as benchmarks in computing k_c should have physical compositions, configurations, and nuclear characteristics (including reflectors) similar to those of the system being evaluated.

k_s. The calculated allowable maximum multiplication factor, k_{eff}, of the system being evaluated for all normal or credible abnormal conditions or events.

k_{eff}(effective multiplication factor). The ratio of neutron production rate to the sum of neutron absorption and leakage rates for a fission chain-reacting system. k_{eff} is unity for a critical system.

k_∞(infinite multiplication factor). The ratio of neutron production rate to the neutron absorption rate for a fission chain-reacting system. (By neglecting leakage, this multiplication factor is for an essentially infinite system. See also k_{eff}).

leakage. Transport of neutrons by their physical motion from one region to another or from a system as a whole.

macroscopic cross section. Probability per unit distance of neutron travel that a specified reaction will occur. The macroscopic cross section is the product of the **microscopic cross section** and the atom density. In turn, the product of macroscopic cross section and neutron flux is the reaction rate per unit volume.

microscopic cross section. Nuclear reaction rate per unit atom density per unit distance traveled by a neutron. In a given neutron flux, the microscopic cross section for each reaction

type is proportional to the rate at which the reaction will occur.

minimum accident of concern. The smallest accident a criticality alarm system is required to detect. Source: ANSI/ANS 8.3, 1986.

moderation. Slowing down of neutrons as a result of scattering reactions with light nuclei in material. Primary moderators are hydrogen, deuterium, beryllium, and carbon.

neutron. An elementary particle having no electric charge, a rest mass of 1.67495×10^{-24} g, and a mean life of about 10 minutes.[1]

neutron balance. Basic equation for the neutron population in a system which states that the rate of change of the neutron population is equal to the production rate minus the absorption rate minus the leakage rate.

neutron flux. Product of neutron density and speed (neut/cm^2-s). Also the intensity of a neutron beam onto a surface or the track length of neutron travel within a unit volume.

neutron multiplication (multiplication). Neutron multiplication signifies a neutron counting rate that is sensitive to reactivity change. This rate is often normalized to the counting rate that would result if there were no fissions. In other contexts, this term has a different meaning. Source: ANSI/ANS 8.6, 1983.

nonfavorable geometry. See favorable geometry.

nuclear criticality safety. 1. The prevention or termination of inadvertent nuclear chain reactions in nonreactor environments. 2. Art of avoiding a nuclear excursion. 3. The art and science of not building a nuclear reactor without shielding, coolant, and control. 4. Protection against the consequences of a nuclear excursion. 5. Protection against the consequences of an inadvertent nuclear chain reaction, preferably by prevention of the chain reaction.
6. Prevention or termination of inadvertent nuclear criticality, mitigation of consequences, and protection against injury or damage due to an accidental criticality. Source: Ron Knief, Nuclear Criticality Safety Theory and Practice, pages 3 - 4. Note: No. 3 is also from ANSI/ANS 8.1, 1983.

nuclear criticality safety. Protection against the consequences of an inadvertent nuclear chain reaction, preferably by prevention of the reaction. Source: ANSI/ANS 8.20, 1991.

partial reflector. A neutron reflector that contributes reactivity to a column with intersecting arms not exceeding that reactivity corresponding to the presence of a 2-m-square room having 30-cm-thick concrete walls and floor, in which the fissile material is more than 30 cm from any concrete surface.

poison, neutron. 1. A material added to a neutron chain reacting system for the explicit purpose of removing neutrons by absorption. Examples of poisons are boron, cadmium, and gadolinium. 2. A nonfissionable neutron absorber, generally used for criticality control.[4]

primary criticality control. A method of control upon which principal or sole dependence is placed for maintaining subcriticality. Source: ANSI/ANS 8.5, 1986.

process area. An area in which fissionable material is handled, stored, or processed. Source: ANSI/ANS 8.3, 1986.

prompt criticality. State of fissile system such that the prompt-neutron contribution to k_{eff} equals unity.[4]

prompt neutrons. Neutrons emitted immediately during the fission process.[4] See **delayed neutrons**.

prompt radiation. Gamma ray and neutron radiation emitted by the fission reaction at the time the reaction occurs. (This is in contrast to **delayed radiation** emitted subsequently by fission products.)

quadrant. The region on the surface of a section bounded by any two perpendicular planes intersecting along the axis of the section.

radiation. In the context of criticality safety, alpha particles, beta particles, gamma rays, neutrons, and combinations thereof.[4] See **alpha particle, beta particle, gamma radiation, and x-ray**.

Raschig ring (ring). A small, hollow, borosilicate-glass cylinder, having approximately equal length and diameter. Source: ANSI/ANS 8.5, 1986.

reaction rate. The rate at which a nuclear reaction occurs. The product of the **macroscopic cross section** and the **neutron flux** is the reaction rate per unit volume.

reactivity. 1. A quantity proportional to $(k_{eff}-1)/k_{eff}$, where k_{eff} is the effective neutron multiplication factor. The reactivity of a subcritical fissile assembly is a negative quantity indicating the degree of subcriticality. The reactivity of a critical assembly is zero. Source: ANSI/ANS 8.6, 1983. 2. A parameter of a fissile system that is proportional to $1 - 1/k_{eff}$. Thus, it is zero if the system is critical, positive if the system is supercritical, and negative if the system is subcritical.[4]

reactivity addition. A modification of a fissile assembly that results in a positive incremental change of reactivity. Source: ANSI/ANS 8.6, 1983.

reflection. The process in which neutrons that would otherwise leak from a material volume are returned as a result of scattering from a surrounding material.

reflector. Material outside the core of a fissile system capable of scattering back to the core some neutrons that would otherwise escape.[4]

resonance energy. A highly favored energy for a nuclear reaction corresponding to a quantum state of the nucleus. A resonance shows up as a sharp peak in an energy-independent nuclear **cross section** plot. The change in the effect of a resonance with system temperature can be an important consideration.

scattering. Reaction between a neutron and a nucleus in which the net result is a change in the neutron energy and direction of travel. In elastic scattering the total kinetic energy of the system is unchanged by the reaction. In inelastic scattering the total kinetic energy decreases

by exciting an energy state in the nucleus that subsequently emits gamma radiation.

secondary criticality control. A method of criticality control that supplements a primary criticality control and provides backup for the unlikely case where the primary control fails. Source: ANSI/ANS 8.5, 1986.

section. Any arbituary 0.5-m length of a column.

storage array (array). A regular arrangement of storage cells. Source: ANSI/ANS 8.7, 1975.

storage cell (cell). A volume having defined boundaries within which a storage unit is positioned. Source: ANSI/ANS 8.7, 1975.

storage unit (unit). A mass of fissile material considered as an entity. The material may be of any shape, and a unit may consist of separate pieces. Source: ANSI/ANS 8.7, 1975.

subcritical. A convergent fission chain reaction. k_{eff} is less than unity for a critical system.

subcritical limit (limit). The limiting value assigned to a controlled parameter that results in a subcritical system under specified conditions. The subcritical limit allows for uncertainties in the calculations and experimental data used in its derivation but not for contingencies (e.g., double-batching or failure of analytical techniques to yield accurate values). Source: ANSI/ANS 8.1, 1983.

supercritical. A divergent fission chain reaction. k_{eff} is greater than unity for a critical system.

training. Instruction that imparts knowledge and skills necessary for safe and efficient on-the-job performance. Source: ANSI/ANS 8.20, 1991.

uranium enrichment (enrichment). The weight percentage of ^{235}U in uranium, provided that percentage exceeds its natural value; if the reference is to enhanced ^{233}U content, "^{233}U enrichment" should be specified.[4]

validated computational technique. A calculational method that satisfies the requirements in American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1983[2]. A calculational method that has been tested, by comparison with experiment, to establish the reliability of results when the method is applied to conditions of interest. Source: ANSI/ANS 8.7, 1975.

x ray. Electromagnetic radiation of wavelength in the range 10^{-10} cm to 10^{-6} cm (Ref.3).

Resources of Glossary Development

1. *Glossary of Terms in Nuclear Science and Technology*, 1986 revision, prepared by ANS-9, the American Nuclear Society Standards Subcommittee on Nuclear Terminology and Units, Harry Alter, chairman, American Nuclear Society Publication, La Grange Park, IL.
   - ANSI/ANS 8.1, 1983.
   - ANSI/ANS 8.3, 1986.
   - ANSI/ANS 8.5, 1986.
   - ANSI/ANS 8.6, 1983.
   - ANSI/ANS 8.7, 1975.
   - ANSI/ANS 8.17, 1989.
   - ANSI/ANS 8.20, 1991.

2. *Nuclear Criticality Safety Theory and Practice*, Ronald A. Knief, American Nuclear Society, La Grange Park, IL (1985).

3. *University Physics*, 2nd Ed., F.W. Sears and M.W. Zemansky (Eds), Addison-Wesley, Reading, MA (1955).

4. “Glossary of Nuclear Criticality Terms,” Hugh C. Paxton, consultant, Group HSE-6, Los Alamos National Laboratory, Los Alamos, NM (October 1989).