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Standard Guide for Making Quality Nondestructive Assay Measurements[1]

This standard is issued under the fixed designation C1592/C1592M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is a compendium of Quality Measurement Practices for performing measurements of radioactive material using nondestructive assay (NDA) instruments. The primary purpose of the guide is to assist users in arriving at quality NDA results, that is, results that satisfy the end user's needs. This is accomplished by providing an acceptable and uniform basis for the collection, analysis, comparison, and application of data. The recommendations are not compulsory or prerequisites to achieving quality NDA measurements, but are considered contributory in most areas.

1.2 This guide applies to the use of NDA instrumentation for the measurement of nuclear materials by the observation of spontaneous or stimulated nuclear radiations, including photons, neutrons, or the flow of heat. Recommended calibration, operating, and assurance methods represent guiding principles based on current NDA technology. The diversity of industry-wide nuclear materials measurement applications and instrumentation precludes discussion of specific measurement situations. As a result, compliance with practices recommended in this guide must be based on a thorough understanding of contributing variables and performance requirements of the specific measurement application.

1.3 Selection of the best instrument for a given measurement application and advice on the use of this instrument must be provided by a qualified NDA professional following guidance provided in Guide C1490. This guide is to be used as a reference, and to supplement the critical thinking, professional skill, expert judgment, and experimental test and verification needed to ensure that the instrumentation and methods have been properly implemented.

1.4 The intended audience for this guide includes but is not limited to Management, Auditor Support, NDA Qualified Instrument Operators, NDA Technical Specialists, and NDA Professionals.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1030 Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectrometry

C1133 Test Method for Nondestructive Assay of Special Nuclear Material in Low-Density Scrap and Waste by Segmented Passive Gamma-Ray Scanning

C1207 Test Method for Nondestructive Assay of Plutonium in Scrap and Waste by Passive Neutron Coincidence Counting

C1215 Guide for Preparing and Interpreting Precision and Bias Statements in Test Method Standards Used in the Nuclear Industry

C1221 Test Method for Nondestructive Analysis of Special Nuclear Materials in Homogeneous Solutions by Gamma-Ray Spectrometry

C1254 Test Method for Determination of Uranium in Mineral Acids by X-Ray Fluorescence

C1268 Test Method for Quantitative Determination of ^{241}Am in Plutonium by Gamma-Ray Spectrometry

C1316 Test Method for Nondestructive Assay of Nuclear Material in Scrap and Waste by Passive-Active Neutron Counting Using ^{252}Cf Shuffler

C1455 Test Method for Nondestructive Assay of Special Nuclear Material Holdup Using Gamma-Ray Spectroscopic Methods

C1458 Test Method for Nondestructive Assay of Plutonium, Tritium and ^{241}Am by Calorimetric Assay

C1490 Guide for the Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel

C1493 Test Method for Non-Destructive Assay of Nuclear Material in Waste by Passive and Active Neutron Counting Using a Differential Die-Away System

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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.

C1500 Test Method for Nondestructive Assay of Plutonium by Passive Neutron Multiplicity Counting
C1514 Test Method for Measurement of ^{235}U Fraction Using Enrichment Meter Principle
C1673 Terminology of C26.10 Nondestructive Assay Methods

3. Terminology

3.1 Definitions presented here are confined to those terms not defined in C1673, other common nuclear materials glossaries/references or whose use is specific to this application.

3.2 *Definitions:*

3.2.1 *differential die away technique (DDT), n*—also referred to as DDA, an NDA technique for characterizing the prompt neutrons from fissionable nuclides in scrap and waste using a neutron generator interrogation source.

3.2.2 *quality measurement practice, n*—an acceptable way to perform some operation associated with a specific measurement technique that is known or believed to influence the quality of a measurement (a way to perform some operation associated with a specific NDA technique in a manner that meets the quality requirements of a measurement).

3.2.3 *in-process material, n*—the nuclear material in a process stream, excluding holdup.

3.2.4 *passive neutron coincidence counting, n*—a technique used to measure the rate of coincident neutron emission in the assay item. The terminology refers specifically to shift-register electronics.

3.2.5 *Poisson assumption, n*—for counting measurements, it is assumed that the net counts in a fixed period of time follow a Poisson distribution. This assumption can be verified by comparing the observed standard deviation of a series of measurements on an item with the square root of the average number of counts. If the Poisson assumption is correct, these numbers should be equal within random error.

3.2.6 *procedure, n*—a set of systematic instructions for using a method of measurement or of the steps associated with the method.

3.2.7 *qualitative analysis, n*—an analysis or measurement in which some or all of the components of an item are determined.

3.2.8 *radioactive emissions, n*—alpha, beta, gamma-ray, x-ray, heat, and neutron emissions from spontaneous fission, induced fission, or delayed neutron emission following beta decay.

3.2.9 *replicate, n*—a counterpart of another measurement. It is the general case for which duplicate, consisting of two measurements, is the special case.

3.2.10 *segmented gamma scanner, n*—an NDA technique used to measure the gamma-ray emissions from low-density scrap and waste packaged in cylindrical containers. The technique involves independent measurements of the vertical segments of the container and may incorporate corrections for count rate losses and matrix attenuation.

3.2.11 *shift-register-based coincidence circuit, n*—an electronic circuit for determining totals *T*, Reals plus Accidentals (*R+A*), and accidentals (*A*) in a selected count time (*t*) during neutron counting.

3.2.12 *shuffler, n*—an NDA technique for characterizing the delayed neutrons from fissionable nuclides in scrap and waste using a ^{252}Cf interrogation source.

3.2.13 *standard:—*

3.2.13.1 *calibration standard, n*—an item sometimes physically and chemically similar to the items to be assayed, for which the mass of the nuclide(s) of interest and all properties to which the measurement technique is sensitive are known.

3.2.13.2 *working standard, n*—an item used to check the performance of an NDA instrument, nominally representative of the items to be assayed, and fabricated and handled to ensure its internal integrity so that deviations in its measured response can be attributed to the instrument.

3.2.14 *verification, n*—an evaluation of the critical item characteristics to ensure the collected characterization data represents the true characteristics of the sample population to an acceptable degree of accuracy and precision.

4. Significance and Use

4.1 NDA measurement practices aimed at achieving quality results are described in this guide. The application of the material provided in this guide should be determined on a case by case basis. Not all elements are required for all applications.

4.2 Nondestructive assay measurements are typically performed when the items measured or goals of the measurement program favor NDA over destructive analysis. NDA is typically favored when collecting a representative sample of the item is difficult or impractical (for example, scrap and waste items), personnel exposure would be significant, spread of contamination from sampling would occur, generation of secondary waste must be minimized, the weight and/or tare weight of the item cannot easily be determined (for example, in place process equipment), rapid turn around of the measurement results is needed, or the NDA measurement is significantly less expensive than the equivalent destructive analysis.

4.3 The principles provided in this guide should be used to determine which type of measurement is best suited to the measurement application. This determination involves consideration of the characteristics of the items to be measured, as well as the goals of the measurement program.

4.4 This guide applies to the suite of NDA instruments and measurement methods, many of which are described in detail in Refs (**1**) and (**2**).[3] A partial listing of measurement methods and applicable use references is provided in 5.6.1. It is incumbent upon the user to seek additional guidance within ASTM method-specific standards, as this guide does not take precedence. Additional information on specific methods is best found in technical meeting transactions, journals, commercial application notes, and NRC/DOE publications.

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.5 This guide may be applied to many situations spanning the range of nuclear materials from product through waste. Typical applications include: the measurement and characterization of transuranic wastes, low-level wastes, and mixed wastes; the determination of radioactivity below some regulatory threshold, estimated for non-detected radionuclides; the measurement of safeguarded nuclear materials; shipper receiver confirmation; confirmation of nuclear material inventory; support of nuclear criticality safety evaluations; measurement of holdup of special nuclear material in process systems; support of decontamination and decommissioning activities; and in-situ analyses of facilities, glove-boxes, hot cells, and the environment prior to and following demolition.

4.6 When applied to measurement of waste, this guide should be used in conjunction with a waste management plan that segregates the contents of assay items into material categories according to some or all of the following criteria: bulk density of the waste, chemical forms of the radioactive constituents and matrix, (α, n) neutron intensity, hydrogen (moderator) and absorber content, thickness of fissile mass(es), and the assay item container size and composition. Each matrix may require a different set of calibration standards and may have different mass calibration limits. The effect on the quality of the assay (that is, maximizing precision and minimizing bias) can significantly depend on the degree of adherence to this waste management plan.

4.7 This guide addresses elements of quality measurement practice such as; nuclear measurement instrumentation and its care; common hazards; facility readiness and requirements to support the NDA equipment; project scoping, requirements and objectives; assembly and deployment of the instrument; calibration and test; computational modeling to augment physical testing; measurement validation; preventive maintenance; and the measurement control program.

5. Quality Measurement Practice

5.1 *Introduction*—NDA measurements of nuclear material are performed to determine the relative or absolute abundance of one or more nuclides. Typically, such a determination is made by comparing the observed response of an unknown amount of material to the response of one or more known standards by means of a functional relationship established by calibration. NDA refers to the qualification and quantification of radionuclides using instrumentation capable of detecting a feature of the radioactive-decay process. These features include such radioactive emissions as alpha, beta, gamma-ray, x-ray, heat, and neutron emissions from spontaneous fission, induced fission, or delayed neutron emission following beta decay.

5.2 The primary goal of NDA measurements is to arrive at a quality result, that is, one that satisfies the user's measurement needs. Adequately analyzing problems and applying appropriate measurement techniques support this goal.

5.3 Each NDA technique has advantages and limitations that must be judged against the specific requirements of the intended applications. No single technique can satisfy all requirements. It is the responsibility of the user to consider the potential problems, and select the proper balance of measurement capability and desired precision and accuracy for the specific application.

5.4 The observed response of an NDA system shows sensitivity to a wide variety of factors that can bias the assay result. By careful selection of the measurement technique, attention to potential sources of error, implementation of operational procedures to control item categorization and packaging, operator training and instrument maintenance, supplemental measurements and calculations, and proper organization and evaluation of test data, the quality of assay results can be optimized.

5.5 Because performance requirements for NDA systems are application dependent, only general guidance for the selection of a system can be provided. If more than one technique can satisfy the specific measurement requirements, other considerations such as economics, ease of operation, and availability of instrumentation will ordinarily determine the choice of a system. The following parameters are among those that should be considered when selecting NDA measurement systems:

(a) The radionuclides to be measured, including the expected range of assays and interferences that may arise between radionuclides,

(b) The physical form (particle size, particle density, radioactive material distribution, etc.),

(c) The matrix (for example, pure product, oily waste, dry waste, degree of heterogeneity, average density, etc.),

(d) The container and packing material (for example, size, wall thickness, mass, wall material),

(e) Environmental conditions,

(f) Measurement quality objectives,

(g) The degree to which parameters affecting measurement results are known,

(h) Location(s) at which measurements are needed,

(i) Costs (instrument, set up, personnel, and operating costs),

(j) Availability of instrumentation,

(k) System maintenance requirements (reliability, stability, ruggedness, etc.),

(l) Training requirements,

(m) Ease of operation,

(n) Program schedule,

(o) Surface dose rate, and

(p) Item throughput.

5.6 NDA methods are often nuclide sensitive rather than element sensitive. Frequently the reaction of interest is possible in more than one species of nucleus present. Determination of the elemental content of an item from a measurement of radiations emitted by nuclide(s) of the elemental species and, in some cases, by their decay products requires knowledge of the relative radionuclide composition of the item assayed.

5.6.1 Many of the approaches to specific NDA measurement techniques are described by ASTM Standards as shown in Fig. 1. A listing of applicable ASTM and ANSI standards is provided in Section 7, Test Methods. Other standards may also be considered.

5.6.2 *Neutron Measurement Techniques*—Neutron techniques are based on the detection of neutrons, which are

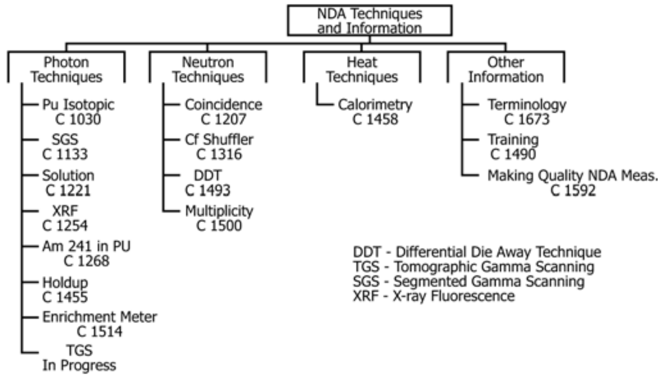

FIG. 1 NDA Techniques

emitted with various energies. Neutron energies are generally not measured. A passive neutron measurement is made when the neutrons measured are a result of spontaneous fission, self induced fission, or (α, *n*) reaction. Passive neutron assay systems are usually more effective for plutonium than for uranium, although applications for both exist. An active measurement is performed when the measured neutrons are the result of induced fission. The quantity of a particular nuclide may be obtained by measuring unusually low or high emission rates, distinctive time distributions, or markedly different energy spectra. To establish the quantity of radionuclide of interest from the directly observable neutron assay result(s) relative isotopic information is necessary. Important considerations include:

(a) Elements that initiate (α, *n*) interferences,

(b) Hydrogen content,

(c) Neutron moderation and absorption (poisons),

(d) Container wall effects,

(e) Influence of uranium on plutonium assay or of plutonium on uranium assay,

(f) Source self-shielding,

(g) Non-uniformity in source/matrix distribution as it relates to neutron moderation and absorption,

(h) Unexpected neutron-generating radionuclides,

(i) Chemical composition,

(j) System dead time,

(k) Item size (physical dimensions and amount of fissionable material),

(l) Measurement geometry,

(m) Background radiation (e.g., spallation neutrons),

(n) Density,

(o) Neutron multiplication.

(p) Delayed neutron emissions from fission or nuclear reactions, and

(q) (γ, n) emissions, perhaps resulting from (n, γ) reactions or gamma rays.

5.6.2.1 *Passive Neutron Counting:* The primary strengths of passive neutron counting are that it usually does not depend on the use of external sources of radiation and that passive neutrons are of sufficient energy to escape from most items without significant attenuation. The costs for passive neutron emission measurement programs are often considerably less than for other neutron measurement techniques. In addition, because external neutron sources are not required, risk of personnel exposure to radiation is generally lower for passive neutron assay. The primary disadvantages of passive neutron assay relative to other neutron assay methods are that counting rates are often lower and contaminants might contribute to the totals count rate resulting in a bias.

(1) Total neutron counting is most suitable if the material to be assayed is homogeneous with respect to all attributes affecting the measurement, if it contains little or well characterized (α, *n*) target material, and if the nuclide ratios are well known. When the measured items do not have all of these attributes, the user must be cautious with respect to sources of measurement uncertainty. The presence of (α, *n*) target material can result in a bias unless the relative amount of this material and its yield are well known and appropriate compensation is included in quantity estimates.

(2) Passive Coincidence-neutron counting is a viable technique for the measurement of ^{240}Pu effective mass or ^{238}U in low enriched uranium. Isotopic ratios are necessary to compute the grams of element. Coincidence neutron counting is less sensitive to many of the biases typical of total neutron counting (for example, the presence of [α, *n*] target material) because their effect is reduced. Spontaneous fission of ^{244}Cm and certain other nuclides interferes with the measurement of ^{240}Pu effective mass.

(3) Multiplicity counting is a viable assay technique for plutonium in cases where sufficient counting precision may be obtained for higher order coincidences. In principle, the technique does not require representative standards, but they are often used to provide corrections to assays. It provides improved accuracy over conventional coincidence counting in cases where the measured items are impure or heterogeneous and the multiplication and/or (α, *n*) yield are not known prior to the measurement. The precision is usually poorer because of lower count rates for the higher moments. It can be used to reduce the impact of cosmic ray background even when the count rates for the higher moments are low.

5.6.2.2 *Active neutron interrogation* is applicable when ^{235}U is present or when passive signals are weak. Selection of an appropriate interrogating-neutron spectrum is important. Active techniques are sometimes used when the uncertainty in the passive result is unacceptable. Costs may be significantly higher than for passive assay systems. In addition, the matrix in which the measured nuclides are contained is often an important consideration.

Thermal neutrons can be used for active neutron assay systems if they can adequately penetrate the item. The presence of thermal-neutron absorbers such as gadolinium (Gd) in light-water-reactor (LWR) fuel may preclude the use of a thermal spectrum. Thermal-neutron interrogation may be possible for small items with high moderation, for example, hydrogen (H) content (for example, solutions). Interrogation with thermal neutrons offers the advantage of higher detection sensitivity because of increased fission cross sections at low neutron energies in fissile material.

For the assay of uranium-bearing items of high density, interrogation by neutrons having energies greater than thermal is recommended. Interrogating-neutron spectra can originate from various sources such as spontaneous fission nuclides, neutron generators or accelerators.

A major problem in active neutron assay is differentiation between the interrogating radiation and the stimulated response radiation. Ideally, the detector should be insensitive to the interrogating radiation. Although total insensitivity is seldom achieved, the amount of interrogating radiation detected can be reduced by several techniques. These techniques include using an energy-biased detector, coincidence counting, timing, and shielding.

5.6.3 *Calorimetric Assay*—Applications of calorimetry to NDA refer to the measurement of heat flow from radioactive decay. Calorimetric assay typically provides assays with very good precision and low bias. It is most often used to assay plutonium plus ^{241}Am and tritium. Typical assay times range from 4 to 24 hours. Typically calorimeter chambers are 0.203 m [8 in.] diameter or less. To estimate the quantity of radionuclide of interest present, the effective specific power, or amount of heat generated per unit mass per unit time, must be determined from knowledge of the item's isotopic composition. For plutonium, this is typically accomplished using high-resolution gamma-ray spectrometry. Important considerations include:

(a) Heat-generating contaminants (e.g., chemical curing, biological decay, bacterial reaction, and radiolysis),

(b) Isotopic composition,

(c) Chemical reactions that produce or consume heat,

(d) Phase changes that produce or consume heat,

(e) Weight of the measured item (dependent on calorimeter design),

(f) Item position,

(g) Heat transfer characteristics of the item and its packaging, which might affect total measurement time and results, and

(h) Drift in Bridge Potential (or baseline power for servo-control method).

5.6.4 Photon techniques are based on the detection of gamma or x-rays that are emitted with discrete energies characteristic of specific nuclides. The intensity of photons of a specific energy is related to the quantity of a particular nuclide. The relative intensity of gamma rays from different radionuclides can be related to the relative abundance of those nuclides. There are a variety of detectors available, which generally span the range of efficiency and resolution from relatively high to low.

Important considerations include:

Lumping (self absorption),

Radial/axial non-uniformity of the radioactive source material in the item,

Matrix heterogeneity,

Non representative calibration standards,

Attenuation,

Low signal to noise ratio,

Signal distortion (e.g., tailing, pulse pileup),

Dead time correction,

Measurement geometry,

Item size (physical dimensions),

Container packaging and matrix attenuation,

Background radiation,

Interfering radiation, and

Decay of radioactive sources used to routinely test the stability/functionality of a measurement system, transmission sources, and rate-based correction sources.

5.6.4.1 *Isotopic Composition*—Gamma-ray spectrometry may be used to determine isotopic composition (Test Methods C1030, C1268). Isotopic composition from gamma ray spectrometry is often used to support both calorimetry (Test Method C1458) and neutron techniques (Test Methods C1207, C1493, C1500, and C1316), as well as for other applications.

5.6.4.2 *Quantitative Assay*—Gamma ray spectrometry is used for quantitative assay of specific nuclides in situations where attenuation by the container wall, by the item's matrix, and self attenuation by the radionuclides is not excessive, or can be accurately estimated. Estimates of attenuation are typically obtained from process knowledge, item density, transmission, or differential peak analysis.

5.7 Specific radionuclides may not be directly quantifiable by certain NDA measurement techniques in given situations. However, when the abundance of an unobservable radionuclide of interest is known (either from independent analysis or established correlation functions) relative to that of one or more radionuclides that can be directly measured, it is possible to infer its quantity. Subject matter experts must address the validity and accuracy of the estimate.

5.8 *Calibration*—Calibration provides a mathematical relationship to correlate detector response with characteristics of the measured item. Methods used for calibration are specific to the NDA measurement technique. In general, calibrations are performed in such a manner that overall calibration uncertainty is substantially lower than the target uncertainty for item measurements. The amount of effort expended on calibration should be associated with the quality objectives of the measurement results for items of unknown content (for example, a 0.1 % calibration uncertainty is not necessary for a measurement system that will produce results with 50 % total uncertainty). The data quality objectives are often, in turn, driven by regulatory, economic and ease of operation considerations. Some considerations that apply to calibration methods include:

(a) Determining the intrinsic system response,

(b) Assessing correction methods (for example neutron moderation, attenuation, absorption, geometry, self attenuation),

(c) Measuring instrument repeatability,

(d) Determining the sources and magnitude of bias, and
(e) Determining total calibration uncertainty.

5.8.1 Calibration Standards should be selected carefully. It is not always necessary for NDA calibration standards to bracket the anticipated system measurement range. The selected standards, however, should have characteristics that are the same as items to be measured with respect to parameters that affect the measurement results. Standards should be constructed so as to eliminate the possibility of a redistribution of the radionuclide content during use. Considerations for selection of calibration standards include:

(a) Standard type (element, state, etc.),
(b) Durability and stability under routine use,
(c) NDA measurement method,
(d) Container size,
(e) Matrix attenuation properties,
(f) Gamma self-attenuation properties,
(g) Emission rate for radiation of interest,
(h) Number of standards required,
(i) Replacement interval and accounting for standards with short half life, chemical instability, or pressure build up,
(j) Time-dependent isotopic composition,
(k) Uncertainty and traceability requirements,
(l) Neutron self shielding, and
(m) Availability, transportability, cost, handling and storage risks, and practicality.

5.8.1.1 Sometimes representative standards may not be available for calibration. In such cases calculated correction factors may be applied to generic calibration standards to allow for the difference(s). The calibration range may be extended by calculation for one or more parameters. Similarly calculation is often used to assess the uncertainty associated with the calibrations. The calculation may use established radiation transport codes that have been validated and verified for similar uses. The calculations should be documented sufficiently to allow replication. This should be performed by suitably qualified and experienced personnel and reviewed by a peer member. Examples include: ^{252}Cf can be used to simulate $^{240}Pu_{eff}$; modeling can correct results for SNM items for neutron self-multiplication and gamma-ray self shielding.

5.8.2 Total calibration uncertainty should be determined as a part of the calibration process. Calibration uncertainty is then included in propagated uncertainty as a bias. Uncertainty in standard values, uncertainty of calibration measurements because of counting statistics, uncertainty from fitting calibration curves, and other parameters affect the total calibration uncertainty.

5.8.3 Calibration validation may be performed to ensure that the calibration accurately reflects the response of the measurement instrumentation to radiation of interest. This can sometimes be conducted as a part of the measurement control program. Depending on regulatory requirements, the validation may be conducted using standards or process materials that are not traceable to a national measurement base, but whose radionuclide content is well known. Measured values for these items must agree within stated measurement uncertainty to validate the calibration. The validation requirements for a new measurement technique should be more rigorous than for a mature measurement method. Calibration validation typically includes measurement of actual process items. Parameters important to the assay method should, where practical, be varied to ensure that the calibration is valid over the range of expected values for each parameter.

5.8.4 Calibration activities need to be documented. Documentation should include sufficient information to reconstruct each calibration for each instrument. Documentation should include the calibration procedure, calibration measurement results, traceability of standards used, and other information deemed important to the calibration activities by measurement personnel.

5.9 *Operation:*

5.9.1 A measurement procedure is needed for each NDA technique. The measurement procedure should describe the steps required to perform measurements of items of unknown content. Operational procedures typically describe administrative responsibilities for staffing, oversight of measurements, and performance of measurements. Any safety precautions are usually noted in measurement procedures. Materials needed to conduct the measurements are listed. Procedures also are used to define item acceptance criteria (that is, describe the characteristics of items for which the technique is capable of providing accurate measurement results). Measurement control requirements and procedures for performing measurements in support of the measurement control program are also described. Reporting and data storage requirements are also typically included in measurement procedures. Developing a procedure for an analytical method is not an adequate substitute for expertise of the technical personnel involved.

5.9.2 Training of measurement personnel is required. The level of training needed is dependent upon the complexity of the measurement technique and the responsibilities of the personnel. Guide C1490 includes extensive guidance regarding training programs.

5.9.3 Training requirements often extend beyond measurement personnel. Obtaining the best results from NDA techniques require training of personnel who package items for measurement, install and maintain measurement instrumentation, perform instrument calibrations, perform measurements, and interpret measurement results.

5.9.4 Analysis of data obtained from NDA measurements is required to convert counting information to the desired results, typically mass or activity of radionuclides contained in each measured item. Depending on the assay technique used, the measurement instrumentation and software available, the result may be provided automatically or a significant amount of data processing by qualified professionals may be required.

5.9.5 Reviews of data analysis methods should be conducted by qualified professionals for all measurement techniques. Expert review software may be used to perform part of the review for individual items. Administrative reviews typically include checks to ensure that items are correctly identified, values have been correctly entered, measurement control has been properly established and verified, and that all applicable procedures have been followed. In addition, expert technical reviews are conducted to ensure the appropriateness of the assay technique for the items measured and to review the