



American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

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Secretariat
Institute of Electrical and Electronics Engineers, Inc.

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Abstract: This standard specifies the data format that shall be used for both required and optional data to be made available by radiation instruments for U.S. Homeland Security applications. The performance for these types of instruments is described in other standards, such as ANSI N42.32, ANSI N42.33, ANSI N42.34, ANSI N42.35, and ANSI N42.38.

Keywords: data format, DHS standards, homeland security, radiation detectors

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This introduction is not part of ANSI N42.42-2006, American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security.

This standard is the responsibility of the Accredited American Standards Committee on Radiation Instrumentation, N42. The standard was approved on N42 letter ballot of August–September 2006.

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American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security

1. Overview

1.1 Scope

This standard specifies the data format that shall be used for both required and optional data available at the output of radiation instruments for U.S. Homeland Security applications. The performance requirements for these types of instruments are described in other standards, such as ANSI N42.32¹, ANSI N42.33, ANSI N42.34, ANSI N42.35, and ANSI N42.38.

1.2 Purpose

The purpose of this standard is to facilitate manufacturer-independent transfer of information from radiation measurement instruments to a standard file format for use in U.S. Homeland Security applications. The goal is to enable interpretation of data without reference to manufacturers' documentation. It specifies the format of data provided by radiation instruments used for homeland security. The purpose of this data is for analysis and storage of the radiation measurements. The data may consist of raw or unprocessed data, analysis results, device parameters or settings, or other measurements needed or applicable to the further analysis or to verify the quality of the results produced by the instrument.

This standard does not address instrument control, data transmission protocols, or the physical media used for communications.

¹ The ANSI N42 publications included in this clause are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

2. Normative references

NOTE—Internet URLs are provided for convenience only; while accurate at the time of printing, these addresses may be changed by the information provider.²

This standard shall be used in conjunction with the following publications. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI N42.32, American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security.³

ANSI N42.33, American National Standard for Portable Radiation Detection Instrumentation for Homeland Security.

ANSI N42.34, American National Standard Performance Requirements for Hand-held Instruments for the Detection and Identification of Radionuclides.

ANSI N42.35, American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security.

ANSI N42.38, American National Standard Performance Criteria for Spectroscopy-Based Portal Monitors Used for Homeland Security.

EPSG Map Datum Codes.⁴

IETF RFC 1590, Media Type Registration Procedure, March 1994.⁵

IETF RFC 2045, Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies.

IETF RFC 3275, (Extensible Markup Language) XML-Signature Syntax and Processing.

ISO 8601, Data elements and interchange formats—Information Interchange—Representation of dates and times.⁶

ISO/IEC 10646-1, Information Technology—Universal Multiple-Octet Coded Character Set (UCS)—Part 1: Architecture and Basic Multilingual Plane.

NOTE—The Unicode Consortium's Unicode Standard 4.0 is equivalent to the ISO document.

ISO/IEC 11578, Information Technology—Open Systems Interconnect—Remote Procedure Call (RPC).

NOTE—W3C RFC 4122, A Universally Unique Identifier (UUID) URN Namespace, is an equivalent standard covering the format of the UUID.

² Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement this standard.

³ The ANSI N42 publications included in this clause are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁴ The Map Datum codes are contained in a database that may be downloaded from <http://www.epsg.org>.

⁵ Internet Engineering Task Force. <http://www.ietf.org/rfc.html>.

⁶ ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/ Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www ansi.org/>).

National Institute of Science and Technology (NIST) ANSI N42.42 XML Schema.⁷

Nomenclature of Inorganic Chemistry, Recommendations 1990, Blackwell Scientific Publications, 1990.

W3C Recommendation, Extensible Markup Language (XML) 1.0, Third Edition, 4 Feb 2004.⁸

W3C Recommendation, XML Schema Part 2: Datatypes, Second Edition, 28 Oct 2004.⁹

3. Definitions and acronyms

3.1 Definitions

The following definitions apply to this standard, which has been developed at the request of the U.S. Department of Homeland Security (DHS) for instruments to be used by DHS and emergency responders.

3.1.1 absolute efficiency: The ratio of the total count rate of pulses recorded by the detector to the number emitted by the source.

3.1.2 absolute full-energy efficiency: The ratio of the net count rate of pulses recorded by the detector in the full-energy peak to the number emitted by the source.

NOTE—Net count rate is the total count rate minus the continuum count rate.

3.1.3 absorbed dose: The energy imparted by ionizing radiation per unit mass of irradiated material.

NOTE—The units of absorbed dose are the rad and gray (Gy).

3.1.4 alarm: An audible, visual, or other signal activated when the instrument reading or response exceeds a preset value or falls outside of a preset range.

3.1.5 attribute: An XML (eXtensible Markup Language) “name-value” construct contained in an XML element start tag.

NOTE—See W3C Recommendation, Extensible Markup Language (XML) 1.0.

3.1.6 calibrate: To adjust and/or determine the response or reading of a device relative to a series of conventionally true values.

3.1.7 calibration: A set of operations under specified conditions that establishes the relationship between values indicated by a measuring instrument or measuring system and the conventionally true values of the quantity or variable being measured.

3.1.8 confidence indication: A measure provided by the instrument of the reliability assigned to the radiation source identification; higher values indicate a higher likelihood of the presence of the nuclide.

⁷ The ANSI N42.42 schema can be obtained from <http://physics.nist.gov/Divisions/Div846/Gp4/ANSIN4242/xml.html>.

⁸ The W3C RFC documents referred to in this clause are copyright of the World Wide Web Consortium (W3C®). This particular document is available from the W3C Web site at <http://www.w3.org/TR/2004/REC-xml-20040204>. More information about W3C can be found at <http://www.w3.org>.

⁹ Available at <http://www.w3.org/TR/2004/REC-xmlschema-2-20041028>.

3.1.9 covariance: A statistical measure used in computing the correlation coefficient between two variables; the covariance is the mean of $(x - \bar{x}) \cdot (y - \bar{y})$ over all pairs of values for the variables x and y , where $\bar{x}$ and $\bar{y}$ are the mean values of x and y .

3.1.10 data: A formalized representation of facts or concepts suitable for communication, interpretation, or processing by people or automated means.

NOTE—The term “data” is often used to refer to the information stored in the computer.

3.1.11 default: A computer setting or preference that a program designer or user can set, showing what he or she wants to have happen automatically in the event that no other action is deliberately chosen.

3.1.12 detector: A device or component designed to produce a quantifiable response to ionizing radiation normally measured electronically.

3.1.13 dose equivalent: The energy absorbed by tissue from ionizing radiation.

NOTE—The Sievert (Sv) and rem are the units of dose equivalent.

3.1.14 element: An XML construct consisting of a start tag contained in angle brackets, optional data, and an optional end tag. All XML documents must contain a single, unique tag pair to define the root element.

NOTE 1—All other elements (or parent elements) must be nested within the root element. All parent elements can have sub elements (or child elements). The child elements must be in pairs and correctly nested within their parent element.

NOTE 2—A detailed definition can be found in W3C Recommendation, Extensible Markup Language (XML) 1.0.

3.1.15 exposure rate: The measure of ionization produced in air by x- and gamma-ray radiation.

NOTE 1—The special unit of exposure rate is the Roentgen per hour, abbreviated in this standard as R/h.

NOTE 2—In this standard, the International System (SI) units Sievert (Sv) or Gray (Gy) follow in parentheses the Roentgen value R, though the two units are not physically equivalent.

3.1.16 gross counts: The total number of events detected by the instrument.

3.1.17 instrument: A complete system consisting of one or more assemblies designed to quantify one or more characteristics of ionizing radiation or radioactive material.

3.1.18 intrinsic full-energy peak efficiency: The ratio of gamma- or x-rays recorded in the full energy peak to those striking the detector.

3.1.19 intrinsic total efficiency: The ratio of gamma- or x-rays recorded to those striking the detector.

3.1.20 live time: The total time during a measurement that the system is available for the acquisition of events.

3.1.21 location: The geographic coordinates where a measurement is performed.

3.1.22 manufacturer: A person or company that manufactures hardware or software.

3.1.23 MIME type: Identifies the format of data; MIME types are maintained by the Internet Assigned Numbers Authority.¹⁰

3.1.24 monitoring: Means provided to continuously indicate the state or condition of a system or assembly.

NOTE—May also be used for the real time measurement of radioactivity or radiation levels.

3.1.25 multichannel analyzer (MCA): A device designed to measure the differential pulse height spectrum from a radiation detector.

3.1.26 multichannel scaler (MCS): A device designed to count pulses from a radiation detector without amplitude discrimination.

3.1.27: multipurpose Internet mail extension (MIME): Defines the encoding of non-text data, such as images and sound, in text format.

NOTE—MIME is a standard, RFC 1590 [see IETF RFC 1590].

3.1.28 precision: Degree of agreement of repeated measurements of the same parameter.

3.1.29 pulse height analyzer (PHA): A device designed to sort successive signal pulses from a radiation detector into parallel amplitude channels.

3.1.30: radiological dispersal device (RDD): An improvised device used to disperse radioactive material.

3.1.31 range: All values lying between the lower and upper detection limits.

3.1.32 reading: The indicated or displayed value of the instrument readout.

3.1.33 readout: The portion of the instrument that provides a visual display of the response of the instrument or the displayed value, with units, displayed and/or recorded by the instrument as a result of the instrument's response to some influence quantity.

3.1.34 real time: The duration (i.e., elapsed clock time) of the measurement.

3.1.35 response: Ratio of the instrument reading to the conventionally true value of the measured quantity.

3.1.36 response time: The time interval required for the instrument reading to change from 10% to 90% of the final reading or vice versa, following a step change in the radiation field at the detector.

3.1.37 software: Sets of instructions or data that tell a computer what to do.

NOTE—Software is often divided into two categories: system software, which includes the operating system (e.g., Windows 95¹¹, MacOS¹²) and all utilities that enable the computer to function; and applications software, which includes programs that perform specific tasks (e.g., word processors, spreadsheets, and databases).

¹⁰ See www.iana.org/assignments/media-types.

¹¹ Windows 95 is a registered trademark of Microsoft Corporation. This information is given for the convenience of users of this standard and does not constitute an endorsement of these products. Similar products may be used if they can be shown to lead to the same results.

¹² MacOS is a registered trademark of Apple Computer, Inc. This information is given for the convenience of users of this standard and does not constitute an endorsement of these products. Similar products may be used if they can be shown to lead to the same results.

3.1.38 tag: A piece of text that describes a unit of data, or element, in XML.

NOTE—The tag is distinguishable as markup, as opposed to data, because it is surrounded by angle brackets (< and >). For example, the element <name>My Name</name> has the start tag <name>, the end tag </name>, which enclose the data “My Name”. Tags are case sensitive; i.e., <Start> is not the same as <start>.

3.1.39 uncertainty: The estimated bounds of the deviation from the conventionally true value, generally expressed as a percent of the mean, ordinarily taken as the square root of the sum of the square of two components: 1) random errors that are evaluated by statistical means; and 2) systematic errors that are evaluated by other means.

3.1.40 UTF-8: UCS Transformation Format 8, which encodes a character in the repertoire of ISO/IEC 10646 using between 1 and 6 octets.

NOTE—See ISO/IEC 10646-1.

3.1.41 variance (σ^2): A measure of dispersion, which is the sum of the squared deviation of observations from their mean divided by one less than the number of observations.

$$\sigma^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

3.1.42 XML (eXtensible Markup Language): XML is a system and hardware-independent language for expressing data and its structure within an XML document.

NOTE 1—An XML document is a text object that contains the data together with markup that defines the structure of the data.

NOTE 2—See W3C Recommendation, Extensible Markup Language (XML) 1.0.

3.1.43 XML schema: Provides a means for defining the structure, content, and semantics of XML documents through XML itself.

NOTE—See W3C Recommendation, XML Schema Part 2: Datatypes, Second Edition.

3.2 Acronyms

IANA: Internet Assigned Numbers Authority

NOTE—IANA is responsible for the registration of globally unique internet domain names and namespaces.¹³

MCA: Multichannel Analyzer

MCS: Multichannel Scaler

MIME: Multipurpose Internet Mail Extension

NIST: National Institute of Standards and Technology

OSI: Open Systems Interconnection

NOTE—Defined by ITU-TS Recommendation X.200.

¹³ For more information on IANA, see <http://www.iana.org>.

PC: Personal computer

URI: Uniform Resource Identifier

NOTE—Defined by IETF RFC 2732.

URL: Uniform Resource Locator

NOTE—Defined by IETF RFC 2396.

UUID: Universally Unique Identifier

NOTE—The format of a UUID is described by ISO/IEC 11578.

W3C: World Wide Web Consortium

NOTE—Maintains the definition for XML and associated standards.

3.3 Standard word usage

In this document, the following word usage applies:

- The word “shall” signifies a mandatory requirement (where appropriate a qualifying statement is included to indicate that there may be an allowable exception).
- The word “should” signifies a recommended specification or method.
- The word “may” signifies an acceptable method or an example of good practice.

4. General

4.1 Goals for this standard

It is the intent of this standard to facilitate the use of radiation data with particular regard to homeland security, emergency response, and common data-sharing needs by achieving the following goals:

- a) Readability. Data should be in a format that can be easily accessed and understood by analysts without the need for proprietary software.
- b) Compatibility. Data should be in a format that is compatible with accepted international standards for data representation to the broadest extent possible.
- c) Extensibility. The data format should provide for unforeseen future needs and for as-yet unknown requirements particular to the specific needs of individual manufacturers of instrumentation.
- d) Impartiality. The data format should not favor any particular commercial interest by adopting a particular manufacturer’s practices.

4.2 Characteristics of the data format

With these goals in mind, the data format defined by this standard, henceforth referred to as the “ANSI N42.42 data format,” is based upon the XML specification (see W3C Recommendation, Extensible Markup Language (XML) 1.0). Specifically, this standard requires that all radiation data instruments shall comply with the data formats discussed in the following list:

- a) The data shall be rendered in an XML document in conformance to the W3C XML V1.0 standard [see W3C Recommendation, Extensible Markup Language (XML) 1.0 and W3C Recommendation, XML Schema Part 2, Datatypes, Second Edition]. In this standard, an XML document is considered identical to an XML file and the terms will be used synonymously.
- b) The data format is to be compatible with the master ANSI N42.42 schema maintained by NIST (see ANSI N42 schema and Annex A).
- c) Data authentication, when required, shall be provided via XML-Signature (see IETF RFC 3275).

NOTE—Data encryption is not addressed in this standard.

This standard has the general characteristics discussed in the following list:

- a) Radiation instrumentation information is expressed as a hierarchical structure of data items.
- b) These data items are formatted as XML elements and attributes [see W3C Recommendation, Extensible Markup Language (XML) 1.0].
- c) In order to allow the data to be accessed using simple text editors, only the UTF-8 (see ISO/IEC 10646-1) character encoding shall be used.
- d) The structure of the data is described by an XML Schema document (see ANSI N42.42 schema and Annex A). This schema defines the standard names for data elements and attributes, whether or not they are optional or required for each class of instrument, and the hierarchical relationships between them. The schema document will be updated in concert with a revision to this standard.
- e) For new types of radiation instruments, or radiation instruments not specifically addressed in this standard, the ANSI N42.42 data format shall be used to the extent possible. If additional data for those instruments is required, these shall be defined in the performance standard for that type of instrument via a namespace extending the ANSI N42.42 data format. A schema describing the new data in the new namespace shall be created and made available along with the ANSI N42.42 schema, found at the location defined in the ANSI N42.42 schema.
- f) If data elements or attributes are needed by a particular instrument that have not been defined in the ANSI N42.42 data format schema, then the manufacturer of the instrument shall use a unique namespace prefix for the elements and attributes not defined in the ANSI N42.42 data format schema; see the example fragment in Annex G. Custom elements and attributes shall not supplant use of standard elements and attributes.
- g) When data in this format is recorded in a file, the data filename extension shall be “N42,” either uppercase or lowercase, to allow for automated recognition.
- h) The standard allows values to be expressed in a variety of units. Use of SI units is encouraged.

- i) The standard gives implementers a great deal of flexibility in deciding what information is to be included or omitted. Implementers should be sensitive to the needs of the users of this information; in particular, providing sufficient raw measurement data to substantiate analysis results.

4.3 General description of the ANSI N42.42 data format

ANSI N42.42 supports several different types of instruments, each of which customarily have had different data reporting formats. Because this standard supports the requirements of all of these types of instruments, certain aspects of the standard require additional explanation.

Example annotated data files can be found in Annex B, Annex C, Annex D, Annex E, and Annex F:

- Annex B A “spectrometer”; the file contains only a spectrum and energy calibration and demonstrates the minimum required information.
- Annex C A “spectrometer”; more complex than the example in Annex B, the file contains a spectrum, its calibration, and the results of the analysis of that spectrum.
- Annex D A “gross count portal monitor”; the data is a series of seven count values representing a small monitor with two gamma and two neutron detectors.
- Annex E A “spectroscopic portal monitor.”
- Annex F A “radiation pager”; the data is a series of four count and dose rate readings.

Note that annotation (given in the form of XML comments) is not required in real instrument data files. Also, the examples are indented for readability; this is desirable in real files but not required.

These examples can be downloaded from the ANSI N42.42 Web site, which is found online at: <http://physics.nist.gov/N4242schema>.

4.3.1 General organization

The <N42InstrumentData> element is the parent element for all data in the file. It shall contain one or more <Measurement> elements, each of which represents a “measurement”; the definition of a “measurement” depends on the type of instrument. The <Measurement> element contains various child elements that describe the instrument, the data collected, and the results of the instrument’s analysis of the data:

- <InstrumentInformation> element: describes the instrument that performed the measurement.
- <MeasuredItemInformation> element: describes the item being measured.
- <Spectrum> element: produced by spectrometers, this element contains a PHA or MCS spectrum, the acquisition start and elapsed times, and calibration information. Multiple <Spectrum> elements may be used in a single parent <Measurement> element to represent multiple detectors or background spectra.
- <DetectorData> element: typically produced by portal monitors, this element contains a series of gross count and/or spectroscopic “samples” from one or more detectors, along with other information associated with each sample, such as sampling duration and monitor occupancy status. A series of monitor occupancies could be represented by multiple <DetectorData> elements in a single <Measurement> element; alternatively, each occupancy could be represented by a <Measurement> element containing a single <DetectorData> element.

- <CountDoseData> element: produced by radiation pagers or survey meters, this element contains a series of count rate, exposure, exposure rate, dose, and/or dose rate values.
- <AnalysisResults> element: this element represents the information presented to the operator by the instrument as a result of its analysis of the data. For spectrometers, this consists of the nuclides identified by the instrument and an indication of the confidence that they are present.

Figure 1 shows the organization of a simple spectrometer file, containing a single spectrum measurement, and all the information associated with that measurement:

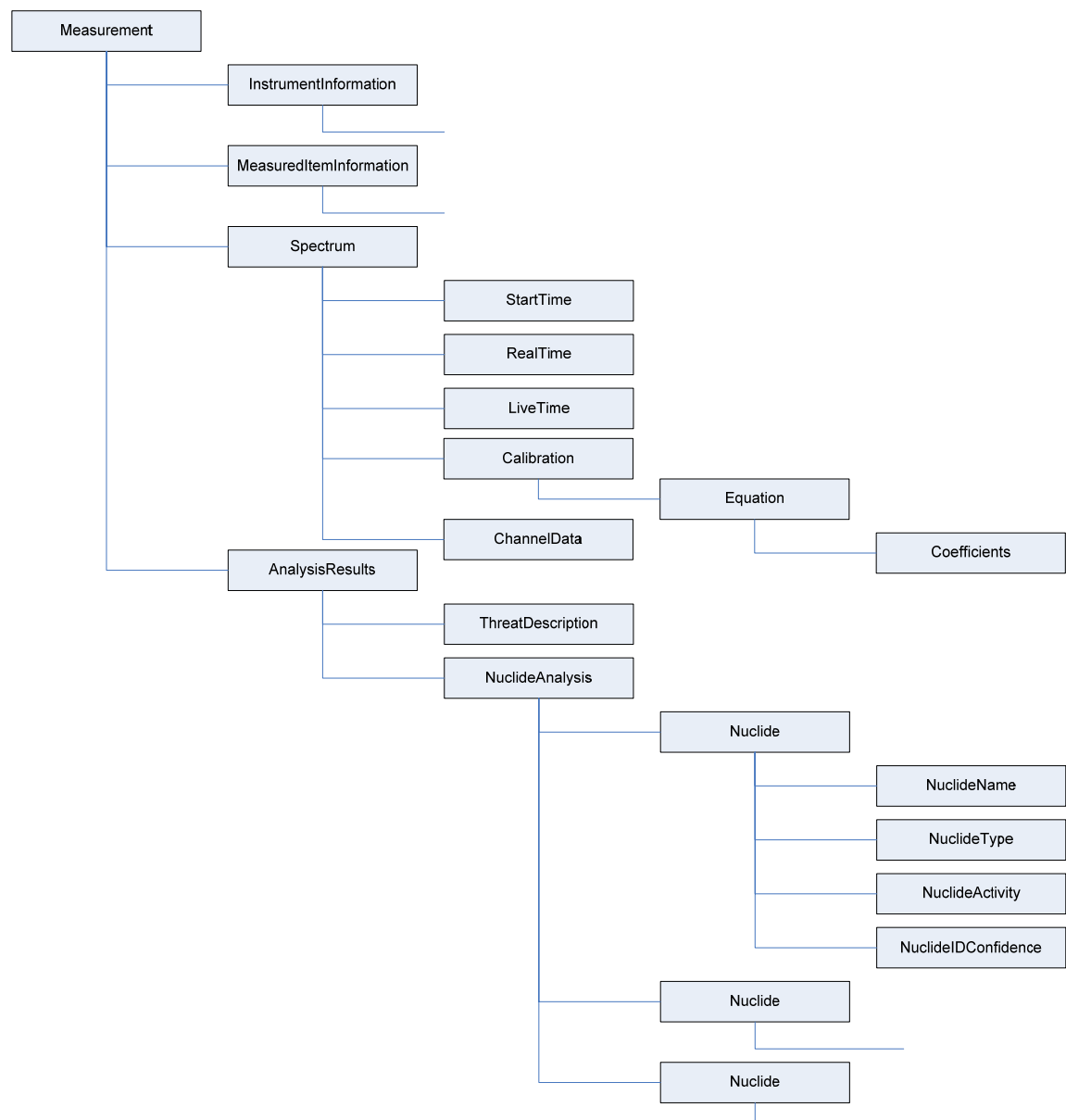


Figure 1—Organization of an N42 file containing a spectrum and analysis results

In Figure 1, <N42InstrumentData> (not shown) is the parent element; it contains a single <Measurement> element, which in turn contains:

- <InstrumentInformation>, which contains child elements (not shown) describing the instrument.
 - <MeasuredItemInformation>, which contains child elements (not shown) describing the item being measured.
 - <Spectrum>, which contains child elements describing the acquisition start and elapsed times, the spectrum (<ChannelData>), and the energy calibration (<Calibration>). Note that if there are multiple spectra in the file that share the same calibration, these spectra may reference a single <Calibration> element via the CalibrationIDs attribute; an example of this usage is given in the example file in Annex C.
 - <AnalysisResults>, which contains the results of the analysis of the spectrum:
 - <ThreatDescription>, which is the instrument’s “human-readable” conclusion as to the nature of the item; for example, “Possible RDD”.
 - <NuclideAnalysis>, which contains a series of <Nuclide> elements, each containing elements describing the analysis results for a nuclide of interest.

Multiple measurements are permitted in a single file, via multiple <Measurement> elements, and can be measurements for different classes of instruments.

5. Requirements

5.1 Data types and enumerations

5.1.1 Standard data types

Data type names, shown in *italics*, are taken from the XML Schema specification (see W3C Recommendation, XML Schema Part 2: Datatypes, Second Edition) and are summarized here for convenience. Note that case of literal values is significant.

- *boolean*: a true or false value (i.e., “0” or “false”, “1” or “true”).
- *dateTime*: a date and time, in ISO 8601 format; see ISO 8601. For example, November 3, 2004 8:36:04.3 AM CST is represented by “2004-11-03T14:36:04.3-06:00”. The seconds value can be represented to arbitrary precision; the precision used should be appropriate for the value being represented. If the time zone is known, then the time zone field (“-06:00”) shall be present. If the time zone is not known, then time zone field shall be omitted. If the time zone is not present, then it cannot be determined whether the value is UTC or local time.
- *decimal*: a real number represented by a series of numerals with an optional decimal point; for example, “123” or “123.456”. The precision used should be appropriate for the value being represented.
- *double*: a double-precision floating point number. Format without an exponent (for example, 123.456) or with an exponent (for example, 1.23456E02) can be used; the precision used should be appropriate for the value being represented.
- *duration*: a time duration in ISO 8601 format; see ISO 8601. For example, a 1 hour, 15 minute, 5.2 second time interval could be represented by “PT1H15M05.2S”, “PT75M5.2S”, or “PT4505.2S”. The precision of the seconds part of the value can be represented to arbitrary precision; the precision used should be appropriate for the value being represented.

- *enumeration*: a list of specific strings allowed for an element or attribute. Each enumeration is named and described in 5.1.3.
- *ID*: a string containing no whitespace or carriage control characters. An *ID* is used to uniquely identify elements in the XML file via the ID attribute. For example:

`<Example ID="Example1">example element value</Example>`

- *IDREF*: identical to the *ID* data type, an IDREF is a reference to a particular element identified by an *ID*. For example,

`<Ref Examples="Element1"/>`

- *IDREFS*: a *list* of IDREF values
- *list*: a finite-length series of space-separated values of an atomic data type
- *nonNegativeInteger*: an integer greater than or equal to zero
- *positiveInteger*: an integer greater than or equal to one
- *string*: a character (i.e., text) string

5.1.2 Derived data types

Data types specific to the ANSI N42.42 Schema are:

- *doubleUnc*: a *list* of *double* with length of 2, where the first item in the list is the value and the second is the 1-sigma absolute total uncertainty (i.e., including all sources of uncertainty) in the value. For example, an `<Activity>` element whose value is 1.2 ± 0.45 would be represented by

`<Activity>1.2 0.45</Activity>`

An uncertainty of 0 indicates that the uncertainty is unknown.

- *durationUnc*: a *list* of *duration* with length of 2, where the first item is the time interval value and the second is the 1-sigma total uncertainty in that value. For example, an `<Elapsed>` element whose value is 5 seconds $\pm$ 0.5 seconds would be represented by

`<Elapsed>PT5.0S PT0.5S</Elapsed>`

- *coordinates*: used to represent a geographic location; is a *list* of *decimal* with length of 2 or 3, where the first item is the latitude, the second is the longitude, and the optional third item is the height in meters relative to the applicable datum's ellipsoid. For latitudes, positive values correspond to Northern latitudes, and negative values to Southern; for longitudes, positive values are Eastern longitudes and negative Western. For example, a point 5.2 meters above the ellipsoid at "N42.123 W22.456" would be expressed as "42.123 -22.456 5.2".

5.1.3 Enumerations

Where the value of a *string* data type element or attribute has a restricted range of values, an enumeration data type is defined. All enumeration values are case sensitive.

- *enumInstrumentMode*: describes the operating mode of the instrument.
 - Used by: <InstrumentInformation> <Mode> element
 - Values:
 - “Measure”: normal measurement mode
 - “Calibrate”: calibration mode
 - “Test”: test or diagnostics mode
 - “Other”
- *enumSpectrumType*: indicates the collection mode of the spectrum.
 - Used by: <Spectrum> Type attribute
 - Values:
 - “PHA”: Pulse Height Analysis
 - “MCS”: Multi-Channel Scaling
 - “Other”
- *enumSourceType*: indicates the type of spectrum measurement.
 - Used by: <Spectrum> <SourceType> element
 - Values:
 - “Item”: measurement of an item
 - “Background”: measurement of environmental background
 - “Calibration”: measurement of a calibration source
 - “Other”
- *enumCalibrationType*: indicates the type of calibration represented by this <Calibration> element.
 - Used by: <Calibration> element
 - Values (see 5.2.35 for a description of each type of calibration):
 - “Energy”
 - “AbsoluteEfficiency”
 - “IntrinsicFullEnergyPeakEfficiency”
 - “IntrinsicTotalEfficiency”
 - “FWHM”
 - “CountstoDose”
 - “CountstoAbsorbedDose”
 - “CountstoExposure”
 - “Other”
- *enumEnergyUnits*: indicates the units in which energy is represented
 - Used by: various elements and attributes
 - Values:
 - “eV”
 - “keV”
 - “MeV”
- *enumFWHMUnits*: indicates the units in which FWHM is represented.
 - Used by: <Calibration> FWHMUnits attribute
 - Values:
 - “Energy”
 - “Channels”

- *enumEquationType*: indicates the functional form of the equation.
 - Used by: <Equation> Model attribute
 - Values (see 5.2.38 for a description of Equation models):
 - “Polynomial”
 - “Exponential”
 - “Pade”
 - “PolyLogarithmic”
 - “FullRangeFraction”
 - “Other”
- *enumActivityUnits*: indicates the units in which activity is represented.
 - Used by: various elements
 - Values:
 - “mBq”: milliBequerels
 - “Bq”: Becquerels
 - “kBq”: kiloBequerels
 - “MBq”: megaBequerels
 - “GBq”: gigaBequerels
 - “pCi”: picoCuries
 - “nCi”: nanoCuries
 - “uCi”: microCuries
 - “mCi”: milliCuries
 - “Ci”: Curies
 - “kCi”: kilocuries
 - “MCi”: megaCuries
- *enumGrossCountDetectorType*: used to indicate the general type of detector.
 - Used by: <GrossCountMeasurement> and <CountDoseData> DetectorType attribute
 - Values:
 - “Gamma”
 - “Neutron”
 - “Alpha”
 - “Beta”
 - “Other”
- *enumQualityStatus*: used to indicate data quality.
 - Used by: Quality attribute
 - Values:
 - “Good”: data quality is believed to be acceptable
 - “Bad”: data quality is known to be unacceptable
 - “Suspect”: data quality is unknown
 - “Missing”: data is missing
- *enumInstrumentTypes*: indicates the type of instrument.
 - Used by: <InstrumentType> element
 - Values:
 - “PortalMonitor”: instruments covered by ANSI N42.35
 - “SpecPortal”: instruments covered by ANSI N42.38
 - “RadionuclideIdentifier”: instruments covered by ANSI N42.34
 - “PersonalRadiationDetector”: instruments covered by ANSI N42.32
 - “SurveyMeter”: instruments covered by ANSI N42.33
 - “Spectrometer”: other instruments that produce spectra
 - “Other”

- *enumCountRateUnits*: the units in which a count rate may be expressed.
 - Used by: <CountRate> Units attribute
 - Values:
 - “CPS”: counts per second
 - “CPM”: counts per minute
- *EnumDoseUnits*: the units in which dose equivalent may be expressed.
 - Used by: <DoseRate> and <TotalDose>
 - Values:
 - “rem”
 - “mrem”
 - “urem”: μrem
 - “Sv”: Sievert
 - “mSv”
 - “uSv”: μSv
- *enumAbsorbedDoseUnits*: the units in which absorbed dose may be expressed.
 - Used by: <AbsorbedDoseRate> and <TotalAbsorbedDose>
 - Values:
 - “Gy”: Gray
 - “mGy”
 - “uGy”: μGy
 - “rad”
- *enumExposureUnits*: the units in which exposure may be expressed.
 - Used by: <ExposureRate> and <TotalExposure>
 - Values:
 - “C/kg”: coulomb per kilogram
 - “R”: Roentgen
 - “mR”
 - “uR”: μR
- *enumSpeedUnits*: the units in which speed may be expressed.
 - Used by <Speed> Units attribute
 - Values:
 - “mph”: miles per hour
 - “kph”: kilometers per hour
 - “m/s”: meters per second
 - “fps”: feet per second
- *enumDistanceUnits*: the units in which distance may be expressed.
 - Used by <ItemToDetectorDistance> Units attribute
 - Values:
 - “mm”: millimeters
 - “cm”: centimeters
 - “m”: meters
 - “km”: kilometers
 - “in”: inches
 - “ft”: feet
 - “mi”: miles

— *enumSpectrumCompressionType*: the algorithm with which spectrum channel data has been compressed.

- Used by <ChannelData> Compression attribute
- Values:
 - “None”: no compression
 - “CountedZeroes”: the data is compressed using the “CountedZeroes” algorithm

5.1.4 Nuclide name format recommendation

Radionuclide identifiers will create the <NuclideAnalysis> <Nuclide> <NuclideName> element, which is the name of a radioisotope or other radiation source. This section provides a format for these names; note that this standard permits the names of non-standard radiation sources to be defined by the XML file creator. Examples of standard nuclide names are “Ag-110m”, “Cs-137”, and “I-131” (per *Nomenclature of Inorganic Chemistry*); examples of non-standard nuclides or radiation sources are “Thorium”, “U-natural”, and “Attenuated Co-60”.

Element-Nucleons[Isomer]

where

- Element* is the IUPAC chemical element name (see *Nomenclature of Inorganic Chemistry*; note that the case of the IUPAC names shall be preserved)
- Nucleons* is the number of protons and neutrons for this isotope
- Isomer* is the metastable indicator. If the nuclide has a metastable state, the letter *m* follows *Nucleons*. If there is more than one metastable state, they are designated *m1*, *m2*, *m3*,...

5.2 ANSI N42.42 schema elements and attributes

The following sections describe the elements defined in the ANSI N42.42 schema. The following items are described for each element:

- a) Parent element(s)
- b) Possible child elements, given in the order in which they shall appear. Elements whose “Occurrences” (see below) includes “zero” can be omitted; however, when they are included they shall appear in the order given. Note that with the use of a custom namespace, arbitrary elements can be included after any standard elements; see the example in Annex G.
- c) Description of the meaning and use of the element.
- d) Data type of the element’s contents, if any.
- e) Element attributes. Attributes are required to be present unless noted as optional. Arbitrary attributes may be included with the use of a custom namespace.
- f) Number of times the element can occur in its parent. Options are:
 - 1) One: the element shall be present, and can occur only once.
 - 2) Zero or one: the element may or not be present; if it is present, it can occur only once.
 - 3) Zero or more: the element may or not be present; if it is present, it can occur any number of times.
 - 4) One or more: the element shall be present and may occur any number of times.

Refer to the examples in Annex B, Annex C, Annex D, Annex E, and Annex F for sample usage.

5.2.1 <N42InstrumentData>

- Parent: none
- Children: <Remark>, <Measurement>, <Calibration>
- Description: the top level entity in each file
- Element data type: none
- Attributes: none. Note that the XML file cannot be validated against the ANSI N42.42 schema unless namespaces are defined as shown in the examples in Annex C, Annex D, Annex E, and Annex F.
- Occurrences: one

5.2.2 <Remark>

- Parent: <N42InstrumentData>, <Measurement>, <Calibration>, <Spectrum>, <DetectorData>, <MeasuredItemInformation>, <CountDoseData>, <InstrumentInformation>, <QualityControl>, <MeasurementLocation>, <Equation>, <ArrayXY>, <PointXY>, <DetectorMeasurement>, <GrossCountMeasurement>, <SpectrumMeasurement>, <NuclideAnalysis>, <Nuclide>
- Children: none
- Description: general comments regarding the dataset
- Element data type: *string*
- Attributes: none
- Occurrences: zero or more

5.2.3 <Measurement>

- Parent: <N42InstrumentData>
- Children: <Remark>, <InstrumentInformation>, <MeasuredItemInformation>, <Spectrum>, <DetectorData>, <CountDoseData>, <AnalysisResults>
- Description: contains the data resulting from a measurement from a single instrument
- Element data type: none
- Attributes:
 - UUID (optional): data type *string*, a unique identifier for the measurement. The format of the UUID is defined in ISO/IEC 11578.
- Occurrences: one or more

5.2.4 <InstrumentInformation>

- Parent: <Measurement>
- Children: <Remark>, <InstrumentType>, <Manufacturer>, <InstrumentModel>, <InstrumentVersion>, <InstrumentID>, <ProbeType>, <InstrumentMode>, <QualityControl>
- Description: describes the instrument that collected the data
- Element data type: none

- Attributes: none
- Occurrences: zero or one

5.2.5 <InstrumentType>

- Parent: <InstrumentInformation>
- Children: none
- Description: the type of instrument
- Element data type: *enumInstrumentType*
- Attributes: none
- Occurrences: zero or one

5.2.6 <Manufacturer>

- Parent: <InstrumentInformation>
- Children: none
- Description: the name of the manufacturer of the instrument
- Element data type: *string*
- Attributes: none
- Occurrences: zero or one

5.2.7 <InstrumentModel>

- Parent: <InstrumentInformation>
- Children: none
- Description: the manufacturer's model number of the instrument. The information may include hardware and software version information.
- Element data type: *string*
- Attributes: none
- Occurrences: zero or one

5.2.8 <InstrumentVersion>

- Parent: <InstrumentInformation>
- Children: none
- Description: version information for the instrument. This information may include both hardware and software version information.
- Element data type: *string*
- Attributes: none
- Occurrences: zero or one

5.2.9 InstrumentID>

- Parent: <InstrumentInformation>
- Children: none
- Description: identification information for the specific instrument; i.e., serial number, asset tag number. The identification information shall be unique for a given manufacturer and model of instrument; if an instrument cannot generate a unique ID, then this field shall be omitted.
- Element data type: *string*
- Attributes: none
- Occurrences: zero or one

5.2.10 <ProbeType>

- Parent: <InstrumentInformation>
- Children: none
- Description: the description of the probe used to make the measurement
- Element data type: *string*
- Attributes: none
- Occurrences: zero or one

5.2.11 <InstrumentMode>

- Parent: <InstrumentInformation>
- Children: none
- Description: the operating mode of the instrument
- Element data type: enumeration *enumInstrumentMode*
- Attributes: none
- Occurrences: zero or one

5.2.12 <QualityControl>

- Parent: <InstrumentInformation>
- Children: <InspectionDate>, <InService>, <Remark>
- Description: describes the quality control status of the instrument; see child elements <InspectionDate> and <InService>.
- Element data type: none
- Attributes: none
- Occurrences: zero or one