Каталог приборов учета и контроля ядерных материалов

Material Control and Accounting Instrumentation Catalog

Третье издание
Third edition

All-Russian Research
Institute of Automatics (VNIIA)
Russia

Brookhaven National
Laboratory (BNL)
Department of Energy
USA

Всероссийский научно-
исследовательский институт
автоматики (ВНИИА)
Россия

Брукхэвенская национальная
лаборатория (БНЛ)
Департамент энергетики
США

2009

DISCLAIMER

CONTENTS

1 INTRODUCTION

In 1981 and 1985, two editions of a catalog of non-destructive nuclear measurement instrumentation, and material control and surveillance equipment, were published by Brookhaven National Laboratory (BNL) [1.1 and 1.2]. The last edition of the catalog [1.2] included one hundred and twenty-five entries covering a wide range of devices developed in the United States and abroad. Since then the devices described in it have undergone significant modifications, and new devices have been developed, and a new catalog has been created for specialists in the field of Material Control and Accounting (MC&A). The first edition of the MC&A Instrumentation Catalog covering two main categories, (1) nuclear materials non-destructive analysis (NDA) devices and (2) containment and surveillance was released in July 1998.

Shortly afterwards, a new effort had been initiated to expand the Catalog by including information on destructive analysis (DA) methodologies and equipment, and reference materials used in DA measurements. In the process of the DA Catalog expansion (second edition), several updates/additions to the information contained in the first edition of the Catalog were made. In particular:

- Introduction to the Catalog was augmented by general descriptions of various DA methodologies and equipment employed at the US and Russian nuclear complex facilities for assay of U and Pu materials: quantitative and isotopic measurements;
- Four new major device/method classes were added: Accounting (DA Methodology) and Accounting (DA Equipment), Accounting (Calibration Standard), Accounting (Mass/Volume Determination), and one class was renamed from Accounting to Accounting (NDA);
- New entries were added to “Device Type” and “Measurement Method” lists;
- Information on additional organizations/equipment suppliers was added;
- Layout of the printed page was slightly modified to reflect the specifics of the data structure related to measurement methodologies;
- Several modifications/corrections were made to the database program and the paper version of the Catalog.

Work under third edition of the the MC&A Instrumentation Catalog started in 2008. Most information has undergone a great modification against the second edition of the Catalog issued in 1999, since a lot of new instrumentation models were produced since then, and production of many obsolete models was stopped. The given Catalog includes in the first place the instruments and methods used at Russian facilities and produced in lots. New device types were added to the Catalog: optical emission spectrometer, pH-meter, weighting equipment.

Information presented is relevant to December 2009.

For more clearness the Catalog includes device images.

Some devices are listed with only one developer or supplier. This does not necessarily signify that there are no other developers or suppliers of those devices. The authors provide no assurance that the present Catalog includes an exhaustive enumeration of all developers or suppliers of MC&A equipment, nor completeness of devices within each class.

All data were entered in a database developed in MS ACCESS. The database was used for processing, viewing, and printing information throughout all stages of the Catalog preparation. Current electronic version is being sent to users together with version for printing (.pdf file). The electronic version will provide users with the opportunity to conduct fast and complex formalized searches (using a pre-determined list of keywords for making selections) as well as searches in free mode. The electronic database enables users to review data and print reports on selected devices in English or Russian.

Preparation and publishing of all editions of this Catalog was sponsored by the US DOE within the MPC&A US-Russia cooperative program. Technical work on the Russian side was performed by All-Russian Research Institute of Automatics (VNIIA, Moscow); Brookhaven National Laboratory (BNL) provided general project management and also contributed in the technical area. The Catalog is available on request to any organization involved in handling and processing of nuclear materials or development, manufacturing, and distribution of MC&A equipment.

REFERENCES

[1.1]. BNL-51450 Leslie G. Fishbone and Bernard Keisch, Safeguards Instrumentation: a Computer-Based Catalog. First Edition, 1981, Brookhaven National Laboratory, Upton, Long Island, New York 11973.
[1.2] BNL-51450 Clemens Auerbach, Safeguards Instrumentation: a Computer-Based Catalog, Second Edition. April 1985, Brookhaven National Laboratory, Upton, Long Island, New York 11973.

2.1 NON-DESTRUCTIVE ANALYSIS

2.1.1 GAMMA SPECTROMETRY

Most nuclear materials of concern in MC&A emit gamma rays and these can be used for NDA of the materials. Gamma rays have well defined energies which are characteristic of the isotopes emitting them. Determination of the gamma ray energies serves to identify the isotopic composition of the materials. When combined with a measurement of the intensities they can provide quantitative information on the amount of material that is present. Enriched uranium fuel, for example, has a strong 186 keV gamma ray associated with the alpha decay of U-235 and the U-235 enrichment can be determined by measuring the intensity of this gamma ray. Plutonium samples generally contain the isotopes Pu-238, Pu-239, Pu-240, Pu-241 and Pu-242 as well as decay products, which give rise to a highly complex mix of characteristic gamma ray energies. The date of discharge of irradiated fuel from a reactor can be verified by measuring the relative intensities of gamma rays associated with fission and activation products. The 662 keV gamma ray from Cs-137 is particularly important for this type of determination.

To detect gamma rays the radiation must interact with the detector to give up all or part of the photon energy. The basis of all gamma ray detector systems is the collection of this liberated electrical charge to produce a voltage pulse whose amplitude is proportional to the gamma ray energy. In a gamma ray spectrometer these pulses are sorted according to amplitude (energy) and counted using suitable electronics, such as a single- or multichannel analyzer. With a multichannel analyzer the gamma rays analyzed at different energies can be displayed or plotted to produce a gamma ray energy spectrum which provides detailed information on the measured material.

2.1.1.1 GAMMA DETECTORS

The gamma ray detectors most commonly used are either scintillators — usually activated sodium iodide (NaI) crystals — or solid state semiconductors — usually high purity germanium (Ge) or cadmium telluride (CdTe) crystals. The NaI detectors can be made large and generally have higher gamma detection efficiencies than Ge detectors. Their uses in MC&A applications include, for example, the verification of fresh U-235 fuel enrichment as well as the presence of spent fuel through detection of fission product gamma radiation. Their ability to distinguish between gamma rays of different energies, however, is relatively poor and of the three types of detectors they have the lowest energy resolution.

Germanium detectors have far superior energy resolution to NaI detectors and are better suited to the task of resolving complex gamma ray spectra and providing information about the isotopic content of materials. The Ge detectors used range in size from small planar types to large (80-90 cm3) coaxial detectors. A disadvantage of these detectors is that they must be operated at very low temperature, which is usually achieved by cooling with liquid nitrogen.

Standard CdTe detectors (and CdZnTe detectors) do not need cooling and of the three detectors they have the highest intrinsic detection efficiency. Recent progress in fabrication techniques has substantially improved CdTe resolution. Until 1997 the standard volumes available were relatively small (20 and 60 mm3). Nevertheless, their portability and small size made them especially suitable for use in confined spaces, such as in verification measurements of fresh fuel assemblies whose design permits insertion of the detector probe into the assembly interior, and of spent fuel bundles stored underwater in closely packed stacks. Much larger CdZnTe detectors have recently been fabricated with volumes of up to 1500 mm3, providing a substantial increase in detector efficiency.

2.1.2 NEUTRON COUNTING

There is a number of different types of neutron counting equipment using passive and active detector systems to determine the amount of fissile material.

Neutrons can be emitted from non-irradiated nuclear fuel in three ways:
- Spontaneous fission from fissile isotopes such as those of Pu,
- Induced fission from fissile isotopes (typically by means of a low energy neutron source), and
- Alpha particle induced reactions, (alpha , n), involving light elements such as oxygen and fluorine.

Fission neutrons in the first two categories are emitted in groups of two or more for each fission event. This signature is detected as a neutron coincidence. Nearly all the isotopes of U, Pu and other transuranium elements emit alpha particles. These interact with light elements present in compounds (e.g. oxides and fluorides) or as impurities (e.g. B, Be and Li) to form an undesirable neutron background. Neutron coincidence counting discriminates against this background by processing the neutron pulses to select correlated (in time) detection events and eliminating the (alpha ,n) background neutrons, which are emitted singly and thus are uncorrelated.

Passive detector systems determine the mass of Pu on the basis of the spontaneous fission of primarily its even-numbered isotopes (Pu-238, Pu-240 and Pu-242, with Pu-240 the dominant contributor). The major fissile isotope, Pu-239, has a typical abundance in fuel of 60-80%; yet, it contributes insignificantly to spontaneous fission. Isotopic abundance must be known or verified — typically by a high resolution gamma ray measurement. Using the isotopic abundance the coincident-neutron count rates can then be converted into a value for the total Pu mass in a sample. For uncontaminated samples, measurement accuracy is of the order of 1% or less.

The fissile isotope U-235 does not undergo sufficient spontaneous fission for practical passive detection. In this case an active system incorporating AmLi neutron sources is used to 'interrogate' the U-235 content by neutron induced fission. For low energy incident neutrons the U-238 in a sample contributes insignificantly to the measured coincident-neutron count rates even though U-235 may be enriched to only a few per cent (e.g. low enrichment fuels).

Neutron detectors employ various neutron capture reactions to function. The reactions produce energetic particles, which in turn ionize a gas and produce a charging pulse. The choice of detector (i.e. the capture material) is based mainly on the neutron detection sensitivity required and on the insensitivity to other radiation, e.g. gamma rays. Nearly all detectors have the highest sensitivity for low energy neutrons. Consequently, in many neutron detector systems the detectors are surrounded with a moderating material such as polyethylene to slow down the energetic neutrons to thermal energies.

2.1.2.1 GROSS NEUTRON COUNTING

Gross neutron counting refers to the sum of all neutrons detected. Here the neutron source cannot be characterized since coincidence requirements are not applied. The presence of significant numbers of neutrons is often a sufficient indication that fissile nuclear material is present. All the neutron coincidence detection systems (discussed below) give total neutron count rates as well as coincidence count rates.

2.1.2.2 NEUTRON COINCIDENCE COUNTING

Neutron coincidence counting has evolved into a very stable, reliable and accurate technique to determine Pu and U-235 content. Modern, well designed neutron coincidence systems are capable of reliably processing pulses over a very large range of input count rates (i.e. over more than six orders of magnitude). This stability is achieved by judicious selection and placement of amplifier electronics to minimize noise interference. These electronics boards, when located at the detector head, amplify and shape the pulses, apply lower level discrimination to (50 ns wide) logic pulses to the external pulse controller (the electronics controller).

Reliable coincidence counting is also due to a sophisticated pulse processing circuit (shift register electronics) in the external electronics controller. Pulses within a specified time period (normally set at 64 mks) of one another may be termed correlated (i.e. “coincident”) neutron pulses. This correlation time is associated with the slowing down of neutrons in the moderator. The shift register electronics keeps track of coincidences between pulses separated by about 1000 mks (accidentals) and coincidences in the first 64 mks (real coincidences plus accidentals) and subtracts the former to give the real coincidences. Other small corrections are also automatically applied.

PASSIVE DETECTOR SYSTEMS have one of two basic geometrical configurations: well detectors completely enclose the sample, and collar detectors encircle the sample (e.g. a fuel assembly). Well detectors have the preferred geometry since they have the capability of detecting all the neutrons emanating from the sample. Collar detectors are an alternative detector design that is appropriate when the sample becomes too large for placement inside a well detector. Whereas calibrated passive well detectors measure the total mass of Pu in a sample, collar detectors measure Pu mass per unit length of the fuel assembly. This linear density must then be multiplied by an effective length to give the total Pu mass in the assembly. There are many different passive detector systems, with their design features optimized for specific sample sizes, shapes or Pu mass ranges. About twenty such systems are currently used in nuclear safeguards.

ACTIVE DETECTOR SYSTEMS use neutron sources (typically AmLi) to interrogate the U-235 in the sample. Again, the well geometry is preferred but the collar geometry is the only practical solution when the sample is a fuel assembly. The full detector system includes the detector head, which detects the neutrons and houses the neutron source; the electronics controller, which powers the detector and determines the neutron coincidence rates; the portable computer for control and data analysis to determine U-235 content; and the printer for generating reports.

2.1.2.3 SPENT FUEL MEASUREMENT

NEUTRON EMISSION AND DETECTION. Spontaneous fission of Cm-242 and Cm-244 is the major source of neutrons emanating from spent fuel. These isotopes are produced in the nuclear reactor fuel assemblies through multiple neutron capture events. The fission products in the spent fuel produce an extremely high radiation background in which the neutrons must be detected. This high radiation environment determines the techniques that can be deployed for spent fuel verification. One approach is to choose a detector which is basically gamma ray insensitive. Another approach is to shield against the gamma rays but allow the neutrons to pass through the shield to the neutron detector. Spent fuel verification methods include not only neutron detection but also gamma ray and ultraviolet light (Cherenkov radiation) detection.

2.1.2.4 NEUTRON DETECTORS

Mechanisms for detecting neutrons in matter are based on indirect methods. The process of neutron detection begins when neutrons (neutral particles), interacting with various nuclei, initiate the release of one or more charged particles. The electrical signals produced by the charged particles can then be processed by the detection system.

Two basic type of neutron interactions with matter are available. First, the neutron can be scattered by a nucleus, transferring some of its kinetic energy to nucleus. If enough energy transferred, the recoiled nucleus ionizes the material surrounding the point of interaction. This mechanism is only efficient for neutrons interacting with light nuclei. Second, the neutron can cause a nuclear reaction. The products from these reactions, such as protons, alpha particles, gamma rays, and fission fragments, can initiate the detection process.

Detectors employing either the recoil or reactions mechanism can use solid, liquid, or gas-filled detection media. Although the choice of reactions is limited, the detecting media can be quite varied, leading to many options.

GAS-FILLED NEUTRON DETECTORS. He3 and BF3 Thermal-Neutron Detectors find many applications in passive and neutron assay because they are relatively stable, efficient, and gamma-insensitive. In the case of BF3, the gas is enriched in B10. Helium-3 is only about 1 ppm of natural helium, so it is usually obtained by separation from tritium produced in reactors. The detection efficiency for thermal neutrons is high, and the interaction probability for gamma rays is low. However, if the gamma dose is more than emitted by typical plutonium and uranium samples, the response of He3 and BF3 detectors will be affected.

He4 and CH4 fast neutron detectors rely on the recoil of light nuclei to ionize the gas in the tube. The interaction is elastic scattering of the neutron by light nucleus. Despite the apparent disadvantages of recoil-type detectors in terms of lower efficiency and stability, the detection process takes place without prior thermalization of the incident neutron. Thus the neutron is detected very rapidly and some information on its initial energy is preserved.

PLASTIC AND LIQUID (ORGANIC) SCINTILLATORS are often used for fast-neutron detection because of their fast response and modest costs. Fast response is particularly beneficial for coincidence counting applications where the ratio of real to accidental coincidence events can have a significant impact on the statistical precision of measurement. The major disadvantage of organic scintillators in nondestructive applications is their high gamma-ray sensitivity.

2.1.3 CALORIMETRIC ASSAY

Calorimetry is the quantitative measurement of heat. It measures the transfer of energy from one system to another caused by temperature differences. When applied to MC&A, calorimetry measures the rate of heat generation (power) from radionuclides. Radiometric calorimeters are designed to measure the power associated with alpha, beta, or gamma decay of radioactive materials.

Radiometric calorimeters operate on the principle that almost all of the energy associated with the decay of radioactive materials placed in the sample chamber is absorbed in the form of heat within the calorimeter. The radioactive decay of all uranium and plutonium isotopes generates heat, but only the plutonium isotopes, because of their shorter half-lives and thus higher specific activities, generate heat at a high enough rate (power) to be measured accurately. Most of the plutonium decay energy is released as alpha or beta particles and converted to heat energy through absorption. A small portion is carried away by neutrons and gamma rays, however this portion is generally less than 0.01% of the total decay energy.

Methods of calorimetry are now being applied with precision and accuracy in the passive nondestructive assay of nuclear materials, especially plutonium and tritium. The important features and advantages of calorimetric assay are listed below:

- The entire sample can be measured,
- The assay is independent of sample geometry (only equilibrium time is affected),
- The assay is independent of matrix material composition and distribution, including nominal moisture concentrations,
- The assay is independent of nuclear material distribution within the sample, including the effects of sample self-attenuation,
- Electric current and potential measurements are directly traceable to reference materials,
- Calorimetric assay is applicable to a wide range of material forms (including metals, alloys, oxides, fluorides, mixed oxides, waste, and scrap). Representative plutonium standards are not needed,
- Calorimetric assay is comparable to chemical assay in precision and accuracy provided that isotopic composition is well characterized,

- Calorimetric assay is a completely nondestructive assay procedure when coupled with high-resolution gamma-ray spectroscopy isotopic analysis.

An important disadvantage of calorimetric assay is that it is time consuming. In general the technique employs equipment which is less portable although more accurate than other nondestructive assay techniques applicable to nuclear material measurement. It can often provide accurate reference measurements for improving the calibration of other assay techniques such as neutron coincidence counting.

Calorimetric assay is most precise for materials with high plutonium concentrations such as powders, fuel pellets, and metals. Calorimeters are being used extensively for nuclear materials accountability and for shipper-receiver confirmatory measurements of plutonium. When applied to concentrated, homogeneous plutonium-bearing materials, calorimetry is comparable in accuracy to precision weighing and chemical analysis. For high-density scrap which has homogeneous isotopic composition, calorimetry plus gamma-ray spectroscopy can approach a precision and accuracy to within 1%.

2.1.4 K-EDGE DENSITOMETRY

The K-edge Densitometer is used to determine the Pu concentration in solutions. The system consists of a high resolution Ge detector, a multichannel analyzer and a portable computer. A Se-57/Co-57 source of low energy gamma rays is positioned for the gamma radiation to pass through the solution. The absorption of this radiation gives a sensitive measure of the Pu in its path.

REFERENCES

[2.1] Techniques and Equipment. International Nuclear Verification Series, No 1. International Atomic Energy Agency, Vienna, 1997

[2.2] Passive Nondestructive Assay of Nuclear Materials. Edited by Doug Reilly, Norbert Ensslin, and Hastings A. Smith, Jr., 1991

[2.3] Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle, Second Edition, Edited by Clement J. Rodden, Office of Information Services, U.S. Atomic Energy Commission, 1972

[2.4] Handbook of Nuclear Safeguards Measurement Methods, Edited by Donald R. Rogers,

2.2 DESTRUCTIVE ANALYSIS

Destructive Analysis measurement methodology descriptions presented in this section follow format and, to a large extent the text of [3.3] and [3.4]. The information taken from these publications was modified and condensed to fit the concise style of the Catalog. The reader is referred to these publications for details on the methodologies described below.

2.2.1 DETERMINATION OF URANIUM CONCENTRATION

2.2.1.1 GRAVIMETRY: THE IGNITION IMPURITY-CORRECTION METHOD

Scope of Application

The gravimetric method is applicable to the determination of uranium in pure product materials including uranium metal (but not powdered U metal because of the safety hazard), UF6, uranyl nitrate solution, UF4, and UO2. For accurate results, the total concentration of impurities should not exceed 500 microgram/g. Minimum 5-g samples are required to minimize weighting errors.

Summary

The ignition impurity-correction method is the most widely used gravimetric method for the determination of U in high-purity U compounds. In this method a weighed portion of the material is converted to U_3O_8 by ignition in air. The final weight of U_3O_8 is corrected for the non-volatile impurities present as determined by spectrometric analysis. The oxide impurities are usually considered to be present in their highest valency state.

High precision is easily attainable when rigidly controlled conditions of ignition and regular periodic checks of performance are maintained. Other advantages of the method are low operator time per determination, no need for dissolution of oxide samples, and simplicity of the laboratory equipment required.

Equipment
Balance, furnace, ignition crucibles.

Major Sources of Error
The principal sources of error are weighing errors resulting from the accuracy limits of the analytical balance, and nonstoichiometry of the U_3O_8 weighing form. Nonvolatile impurities must be determined (concentrations of impurities should not total more than 500 microgram/g for accurate results).

2.2.1.2 DAVIES-GRAY/NBL REDUCTION-OXIDATION TITROMETRY

Scope of Application
The Davies-Gray/NBL method using potentiometric end-point is applicable to a variety of U solutions containing nitric, sulfuric, and perchloric acids and to solutions containing several constituents that interfere in other high-precision U methods. Analyzed solutions may be derived from the dissolution of uranium oxide, uranium metal, uranium salts, uranium alloys, etc. The original Davies-Gray titration using a visual end-point is still occasionally used for the analysis of uranyl nitrate solution and uranium dioxide powder.

Summary
The original Davies-Gray method involved the reduction of U(VI) to U(IV) by ferrous ion in a concentrated phosphoric acid (H_3PO_4) solution containing sulfamic acid (NH_2SO_3H), oxidation of the excess (Fe(II) with nitric acid in the presence of Mo(VI) catalyst, dilution of the solution, and then titration of the U(IV) with potassium dichromate ($K_2Cr_2O_7$) to a visual end-point. Barium diphenylamine sulfonate was used as the indicator. The original method suffered from a sluggish end-point. At NBL this method was improved by the addition of a small amount of V(IV) to the solution before titration to accelerate the attainment of equilibrium. This modification made possible the use of potentiometric detection of the end-point and adaptation to automatic titration equipment.

The principal steps are:
- Sampling
- Dissolution
- Pretreatment to remove interferences, if required
- Reduction of U(VI) to U(IV) with Fe(II) in phosphoric-sulfamic (H_3PO_4-NH_2SO_3H) acid medium
- Destruction of excess of Fe(II) by Molybdate-catalyzed nitrate oxidation
- Dilution of sample with 1M H_2SO_4 and titration of U(IV) to U(VI), in the presence of vanadium catalyst, to a potentiometric (Pt-calomel) equivalence point.

Equipment
Balance, pH meter, Reference electrode (calomel), platinum indicator electrode, burette with bulb reservoir.

Major Sources of Error

- Accuracy uncertainty of the analytical balance
- Uncertainty in the assay of the potassium dichromate
- Change in titer of the standard potassium dichromate solution
- Malfunctioning of the platinum indicator electrode
- Inadequate operator techniques.

There are various techniques to remove nearly all interfering elements from the samples.

2.2.1.3 COMPLEXOMETRIC METHODS

Scope of Application
The complexometric determination of uranium is applicable to a variety of samples provided that interfering elements have been removed or selectively complexed. Such samples are generally relatively pure product solutions. Methods can be based on complex formation with either U(VI) or U(IV). Sample size ranges from 0.01 to 50 mg of contained uranium.

Summary
Reagents that form stable complexes can be used in titrimetric analysis if a suitable end point indicator is available. The complexing agent can be used alone, provided it either forms or removes a colored product, thereby providing a self-indicating end point. An end point indicator is used if the complexing agent does not meet the above conditions. The indicator must be a dye that forms a colored complex with a slightly lower stability constant than the compound being titrated. The most commonly used compleximetric titrant for Th, Pu, and U is disodium salt of (ethylenedinitrilo)tetraacetic acid (Na2C10H14O8N2*H2O) which is often referred to as disodium EDTA or just EDTA: it provides sharp end points.

The disodium salt of (ethylenedinitrilo)tetraacetic acid (EDTA) is probably the most commonly used complexometric titrant for Th, Pu, and U. Relatively strong complexes are formed, resulting in sharp end points. The propensity of EDTA to form complexes with many elements in the periodic chart constitutes a major problem in the use of this reagent. However, by careful selection of parameters, such as pH and indicator, and by selective complexing or total separation of potential interferences, EDTA titrations can be used for determination of uranium.

Generally, compleximetric titrations do not offer advantage over oxidation-reduction methods for determining U, and do not provide equivalent precision (typically, relative standard deviations of 1% or less may be achieved). Due to simplicity and relatively low cost of the equipment required, compleximetric methods are suitable for process control at the production line, rather than in the analytical lab.

Equipment
Standard analytical lab equipment. Depending on the methods, simple spectrophotometer-titration assembly, fiber optic probes, high-frequency oscillators may be used.

Major Sources of Error
Those are typical for titrimetric methods:
- Pipetting and/or weighing errors
- End point detection errors
- Inadequate pretreatment.

2.2.1.4 CONTROLLED-POTENTIAL COULOMETRY

Scope of Application
This method is applicable to a wide variety of U materials, ranging from relatively pure U solutions to various kinds of alloys and irradiated nuclear fuels. Controlled-potential coulometry is especially

well suited to the analysis of irradiated material, because only a few milligrams are required for a determination. Also, analysis can be done remotely, because only the coulometric cell needs to be inside the glovebox or hot cell. The electronics can be outside and some distance away.

Summary

Controlled-potential coulometry (CPC) may be regarded as a special kind of redox (oxidation-reduction) titration in which electric current is used as the titrant. In comparison with most redox titrations, coulometry has the advantage of high precision with small amounts of U (2 to 10 mg per determination) and is relatively free from interferences. In analysis by CPC, the species to be determined is quantitatively electrolyzed at an electrode whose potential is maintained at such a value that unwanted electrode reactions are precluded. Therefore, conditions must be precisely controlled so that all the current passing through the coulometric cell produces the desired electrochemical reaction; i.e., the current efficiency is 100%. The potential of the working electrode is controlled by means of a potentiostat. The electrolysis is then terminated. From the quantity of electricity required by the reac-tion (measured by means of a current/time integrator), the amount of the substanse being determined can be calculated.

The amount of U present can also be calculated from calibration of the instrument obtained by the analysis of standard solutions (chemical calibration).

Equipment

In CPC, the substance determined is electrolyzed at a working elec-trode, the potential of which is controlled or maintained constant during the electrolysis by means of a potentiostat, and the current is integrated by means of an electronic integrator or coulometer. A typical experimental arrangement for this is as follows: the counter elec-trode is placed in a separate cell compartment connected to the sample solution through a semipermeable separator to prevent reversal of the desired working-electrode reaction. The solution is stirred vigorously to effect a rapid electrolysis. The time for a normal electrolysis is 15 min.

Major Sources of Error

- Uncertainty in the value of the standard used for instrument calibration
- Accuracy uncertainty of the analytical balance
- Inadequate removal of oxygen and other impurities such as carbonaceous material from the cell before and during the electrochemical steps
- Malfunctioning reference electrode causing a shift in the actual control potential
- Inadequate operator techniques.

2.2.1.5 CONTROLLED-CURRENT COULOMETRY

Scope of Application

This method is applicable to a wide variety of U materials, ranging from relatively pure U solutions to various kinds of alloys and irradiated nuclear fuels. It is especially well suited to the analysis of irradiated material, because only a few milligrams are required for a determination. Also, analysis can be done remotely, because only the coulometric cell needs to be inside the glovebox or hot cell. The electronics can be outside and some distance away.

Summary

The Titrimetric Method described in section 3.2.1.2 has previously been demonstrated to be a very accurate and rugged method, capable of handling many sample types without bias. In that procedure, all uranium present is reduced to U(IV) and is titrated with potassium dichromate to U(VI). However, hexavalent chromium compounds are known human carcinogens; thus when chromium containing materials are combined with radioactive materials they form a US Resource Conservation and Recovery Act (RCRA) mixed waste*. It became extremely difficult, within the current US regulatory environment, to dispose of the waste materials generated by titrations (those involving

Cr(VI) or other RCRA hazardous constituents). The method described in this section presents an alternative procedure providing precision and bias comparable to the Davies-Gray/NBL Reduction-Oxidation Titration.

The development of a constant current coulometric titration [C.G. Goldbeck and M.W. Lerner, "Titrimetric Determination of Uranium with Electrogenerated Vanadium (V)," Analytical Chemistry, 44, 594, 1972] offered the advantages of elimination of the preparation, standardization, and storage of a standard titrant (such as dichromate). This method [P.V. Croatto, P.B. Mason, K.D. Johnson, I.W. Frank, "Determination of Uranium by Constant Current Coulometry," NBL Publication, 1996] has been used at NBL for uranium samples and standards containing 10-40 mg U with accuracy of ?0.05% and precision of 0.1% of Relative Standard Deviation (RSD) or better using a modified manual coulometric method. Other advantages of the method were the simplicity of the electrical circuit and of the method for measuring the total current and generation time, the suitability for automation, and the short titration times. An automated constant current coulometer offers the additional benefits of increased sample output with decreased manpower per sample, minimizing operator error, greater precision in control of current pulses, more thorough monitoring of system parameters, and better diagnostics.

Equipment
a) Apparatus electrolysis cell with a remote magnetic stirrer and the end point detection system; a nitrogen gas delivery system is used to blanket the solution in a non-oxidizing atmosphere and reduce air oxidation in the titration solution
b) Coulometer system including such components as constant current generator, multimeter, switches (current relay and multiplexer), universal counter, and pulse generator
c) Instrument control software integrating programs for calibration, blank, and sample measurements.

Major Sources of Error
(Same as in the previous method)

2.2.1.6 SPECTROPHOTOMETRY

Scope of Application
Spectrophotometric procedures may be applied to the determination of U in a variety of materials such as dissolver solutions, waste solutions, and product streams. Spectrophotometric methods have also been applied to the determination of the U content of U metal and U oxide, after dissolution of the solid.

Direct spectrophotometric methods are usually applied to the determination of larger concentrations of U in solution or to samples in which U is a major constituent. Methods covering the concentration range from 20 to 200 g/L have been developed. The precision of direct methods is generally poorer than 0.5% RSD, often 1% to 2%. Differential spectrophotometric methods were developed to improve the preci-sion so that the RSD of the measurements would decrease to a level of 0.1% to 0.5% or less. The increased precision is achieved by an appropriate expansion of the scale used for the measurement of light inten-sities. Scale expansion can be made by placing cuvettes containing solu-tions of suitable known concentrations in the cell compartment of the instrument, and adjusting the transmission (or absorbance) scale with them. In the "transmittance ratio method," the unknown solution is compared with a known solution of slightly lower concentration. In the "ultimate precision method," two reference solutions are needed; one is more concentrated than the unknown solution, the other is less concentrated. Differential spectrophotometry can yield an accuracy and precision comparable to those obtained with titrimetric methods.

The direct determination of U in nitric acid solution has been used for inline process control of solutions containing high concentrations of U. By measuring the absorbance at both 416 and 426 nm, it was possible to apply a correction for variations in the nitric acid contents. For 0.5 to 5M nitric acid solutions, the calculated RSD of the U concentration was 5.4%. For 0.02 to 0.5M nitric acid solutions the calculated RSD of the U concentration was approximately 3%. This preci-sion is not adequate for accountability or safeguards purposes but is quite satisfactory for process control. Browning of the optical components may be a problem with process streams containing fission products.

Chromogenic methods are used for the determination of microgram or milligram quantities of U. Chromogenic methods involve complexing the element of interest, in this case, U, with complexing agents to form colored complexes that are more readily measured by spectrophotometric methods. RSDs are generally between 0.3% and 10%.

Summary
The spectrophotometric determination of U is based on absorption of light of a specific wavelength by U compounds or complexes in solution. The fraction of incident light that is absorbed is proportional to the concentration of the absorbing species.

There are a number of chromogens that react with U to form colored complexes. These complexes generally have high molar absorptivities and are suitable for the determination of low concentrations of U. Since Th, Pu, and many other cations may form colored complexes with the chromogens that react with U, a separation is normally required.

Equipment
Direct or differential methods require a high-precision recording spectrophotometer with variable slit widths and temperature-controlled sample chamber. A dual beam instrument is preferred for differential methods. The band-pass should be 1 nm or less. Digital readout is desirable. Wavelength accuracy should be within 0.3 nm, and wavelength reproducibility within 0.1 nm. Photometric accuracy and reproducibility should be 0.15% between 1 and 2 absorbancy units (as defined by Beer's law). The wavelength range required will depend on the analyses to be performed with the instrument.
For many chromogenic methods, a nonrecording spectrophotometer with 10 nm (or less) resolution is adequate.

Major Sources of Error
Sources of error in spectrophotometric methods include:
- volumetric errors, such as in pipetting, dilution, or making solutions up to a specified volume,
- incomplete separation of U,
- presence of other oxidation states besides the one desired,
- failure to set the spectrophotometer to the absorption band maximum,
- differences in composition between standards and samples.

Temperature control to 0.2°C is required for direct and differential spectrophotometry.

2.2.1.7 FLUOROMETRY

Scope of Application
The fluorometric method is used for determination of trace quantities of uranium in aqueous or organic solutions resulting from the processing of irradiated reactor fuels, and in other nuclear waste solutions.

Summary
The fluorescence of U has been made the basis of a highly sensitive and specific method for its determination. Uranyl salts fused in sodium fluoride exhibit a characteristic yellow-green fluorescence when exited by ultraviolet light. The fluorescence spectrum consists of four bands, of which the most intense is at 555 nm. The waivelength of most efficient exitation is at 365 nm. The detection limit for U in a flux containing greater than 90% sodium fluoride is estimated to be about

10-7 mg. In such a flux, no other elements have been found to give a detectable fluorescence under the specified conditions of exitation and measurement of fluorescence. The intensity of the fluorescence for trace amounts of U is directly proportional to the amount present.

The method employs a preliminary extraction to remove interfering impurities, followed with a NaF fusion. The laser fluorometric and standard addition methods do not require the preliminary treatment.

Equipment
- Fluorometer (wavelength of 365 nm, measures the fluorescence at 555 nm; capable of detecting 0.5 ng U). The laser fluorometer for the direct analysis of solutions uses a low-power sealed nitrogen laser emitting at 337 nm. The detec-tion limit was found to be 0.005 ng U. The instrument can measure U solution concentrations from 0.05 ng/g to 50,000 ng/g.
- Blast burner, muffle furnace, tube furnace, or induction heater capable of 950°C temperature,
- Blender for blending flux,
- Pelletizer, syringe-type, to deliver the appropriate amount of flux,
- Platinum dishes,
- Optical pyrometer, for determining the fusion temperature of the flux.

Major Sources of Error
The fluorescence in fused or sintered pellets is influenced by a number of factors:
- composition of the flux, weight of flux,
- pellet thickness,
- fusion time and temperature,
- cooling time,
- reflectivity of the dish,
- time elapsed between fusion and measurement.

Because the method is used for the determination of micro quantities of U, the presence of small quantities of that element in the ingredients of the flux and in other reagents can lead to serious errors. Each batch of flux and all reagents must be checked to ensure that if any U is present the quantity in a reagent blank is very much smaller than the quantities to be measured in samples.

2.2.2 DETERMINATION OF URANIUM ISOTOPIC ABUNDANCE

2.2.2.1 THERMAL IONIZATION MASS SPECTROMETRY

Scope of Application
This method is applicable to a variety of physical and chemical forms of U ranging from high-purity UO2 to spent fuel dissolver solutions. However, spent fuel dissolver solutions are more commonly analyzed by isotope dilution mass spectrometry because the U concentration as well as the U isotopic abundances are desired. The sample to be analyzed contains the high purity U fraction separated from solutions prepared by dissolu-tion of U oxides, U metal and alloys, mixed U/Pu oxides, and such samples as nuclear fuels clad with Al, stainless steel, or Zircaloy. The method can also be applied to ash and scrap material measurements. The method is applicable to a quantity of U in the range of 10-8 to 10-5 g per determination, depending on the sensitivity of the instrument.

Summary
This method is applicable to the isotopic analysis of U in many U-compounds and alloys after dissolution and chemical treatment to obtain purified U fractions.

The purified U fraction is diluted and an aliquot is evaporated on the mass spectrometer filament. A current is passed through to form an adherent U oxide, preferably the yellow U trioxide, and to remove acid, water, and some organic matter. The filament assembly is placed within the ion source of the mass spectrometer and outgassed. The filament(s) then are heated following a carefully selected heating pattern to vaporize and ionize U. The singly charged metal ions produced by this thermal ionization are accelerated and focused with an electrostatic ion lens into the mass-analyzer section. The total ion beam is separated according to the mass-to-charge ratio (m/e) of the ions. By an appropriate variation of the magnetic field(s) and/or the accelerating potential, the separated ion beams are sequentially focused on the detector, which is either a Faraday cup, an electron multiplier, or a photomultiplier detector. The detector current or pulses are further amplified and recorded as a function of the mass on a stripchart recorder or by a digital recording system. The peak currents (intensities) at each isotopic mass are measured, and the average isotopic ratios are calculated with reference to the 238U or 235U peak inten-sity.

With an automated scan capability, a sample-introduction lock, high-speed pumping system, and digital data acquisition and reduction, two operators can process up to 16 samples per day, although 7 to 9 samples per day (or per shift) is more realistic.

Equipment

Mass Spectrometer

The major components of a mass spectrometer system required for this procedure are as follows:

- Ion source
- Mass analyzer
- Vacuum system with differential pumping of ion-source chamber and analyzer
- Detection system including an electron multiplier primary detector with stable current gain
- Data logging system.

Mass Spectrometer Accessories

(1) Filament material of high-purity, electron beam zone-refined rhenium, tungsten, or tantalum
(2) Filament-forming jig
(3) Filament assemblies (hats)
(4) Spot welder
(5) Filament-loading unit
(6) Filament bakeout chamber
(7) Optical pyrometer

Major Sources of Error

- Source Discrimination (or Source Fractionation)

Thermally produced ions of the lighter isotopes are vaporized and ionized preferentially with respect to the heavier isotopes of the same ele-ment. Fractionation is a complex, time-dependent phenomenon. A reproducible analytical procedure must be strictly followed. Such a pro-cedure will keep under control such factors as filament temperature, fila-ment loading, acidity of the sample, chemical form and oxidation state of the element, sample mounting procedure, outgassing procedure, and heating pattern and temperature.

- Ion-Optical Discrimination

The ion lens and the magnetic sector mass analyzer are not perfect. As a result, the ion path from the exit slit of the ion source to the entry slit of the ion collector/detector is not exactly the same for all ions of a given m/e. To minimize this effect, a high accelerating potential and a large ion-transmission coefficient are desirable. It is necessary to reproduce the spectrometer operating conditions for sample and standard, or for successive filament loadings of the same sample. This includes the mechanical alignment of the filament assembly in the ion source, focus of the ion lens, scanning mode, and scanning rate.

- Electron-Multiplier Discrimination and Nonlinearities in the Ion-Current Amplification and Recording System

Corrections for source, ion-optical, and electron multiplier discriminations have been combined with establishing the mass discrimination factor. This factor is determined using U Certified Reference Materials.

2.2.2.2 GAS-IONIZATION MASS SPECTROMETRY

Scope of Application

Gas-ionization mass spectrometry is particularly useful for determin-ing the isotopic composition of U in uranium hexafluoride (UF6) since no chemical treatment other than purification is required prior to the analysis. The technique is most often employed at enrichment facilities. Gas-ionization mass spectrometry can be used for the analysis of any U compound that can be converted to UF6; however, surface-ionization mass spectrometry is generally preferred for other compounds.

The gas-ionization technique requires a large sample and, therefore, is less than satisfactory for the analysis of materials that are highly radioactive or of limited availability. When a wide range of enrichments is to be determined, it is advisable to have a number of instruments, each dedicated to a narrow band of enrichments.

Summary

There are three different gas-ionization methods: (1) the double-standard interpolative method (or, simply, the double-standard method), (2) the single-standard method, and (3) the absolute method. For all three methods, samples (and standards, if used) are converted to UF6 , if necessary. The UF6 gas is admitted to the ionizing source of the mass spectrometer through an adjustable leak. The ions that are produced in the source are accelerated through a magnetic field, where they are separated by their mass into monoisotopic ion beams. By varying the magnetic field, each ion beam can be selectively introduced through a slit onto a receiver plate, where it produces a current in proportion to its strength. The voltage produced by the ion currents in the electrometer grid resistor is detected as a peak (isotope) by the peak reader. The relative abundances of the isotopes are calculated from the peak data.

The particular method to be used is dependent on the determination desired and, to some extent, the preference of the facility. The double-standard and single-standard techniques are principally applied to the determination of 235U, although they can be used, with suitable standards, for the determination of other isotopes. The absolute technique is par-ticularly adapted to the determination of two or more isotopes with a single spectrum scan.

The double-standard technique permits direct determination of a single isotope through the measured mole ratio of the isotope to two bracketing enrichment standards, namely, two standards whose 235U contents bracket that of the unknown. The single-standard technique uses the isotopic relation between the sample and a suitable standard to determine the abundance of the isotope of interest. At high enrichments (greater than about 70 mole percent), the determination of 235U abundance is obtained by difference. In the absolute technique, the ion spectrum is magnetically scanned, and the peak (isotope) data are used to calculate the various isotopic abundances.

A third method, the Absolute Method is applicable to the determination of the isotopic concen-trations of two components (e.g., 238U and 235U) and multicomponents (e.g., 238U, 236U, 235U, and 234U) using a single mass spectrometer. This method is primarily applicable to materials having concentrations of 235U greater than 70 weight percent. Although the method can be used as an ab-solute method, daily analysis of reference standards is strongly recommended.

Equipment

Similar mass spectrometers can be used for these methods with some procedure-dependent differences.

Major Sources of Error

- Nonrepresentative sample and/or subsample
- Inadequate purification of the sample and standards
- Different treatment of sample and standards during preparation and analysis

- Operator error, such as
(a) Mistakes in operation of inlet-system valves that lead to mix-ing of samples and standards
(b) Improper focusing of the ion beam
c) Timing inaccuracies in the introduction period of the sample and standards (double-standard method).

REFERENCES

23.1] Techniques and Equipment. International Nuclear Verification Series, No 1. International Atomic Energy Agency, Vienna, 1997
[2.2] Passive Nondestructive Assay of Nuclear Materials. Edited by Doug Reilly, Norbert Ensslin, and Hastings A. Smith, Jr., 1991
[2.3] Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle, Second Edition, Edited by Clement J. Rodden, Office of Information Services, U.S. Atomic Energy Commission, 1972
[2.4] Handbook of Nuclear Safeguards Measurement Methods, Edited by Donald R. Rogers, NUREG/CR-2078, MLM-2855, September 1983

Destructive Analysis measurement methodology descriptions presented in this section follow format and, to a large extent the text of [2.3] and [2.4]. The information taken from these publications was modified and condensed to fit the concise style of the Catalog. The reader is referred to these publications for details on the methodologies described below.

2.2.3 DETERMINATION OF PLUTONIUM CONCENTRATION

2.2.3.1 GRAVIMETRY: THE IGNITION IMPURITY-CORRECTION METHOD

Scope of Application
The gravimetric method is applicable to the determination of Pu in pure materials, such as plutonium oxalate, plutonium oxide, plutonium metal, and plutonium nitrate solutions. The method has been applied prin-cipally to low-fired plutonium oxide produced by the thermal decomposi-tion of plutonium oxalate.

Summary
The main principles of this method are similar to those for Uranium (see 3.2.1.1). The gravimetric determination of Pu as PuO2 by ignition at 1200°C or higher shares the disadvantages of the gravimetric determination of U and possesses some of its own. From a safeguards point of view, the objec-tion can be raised that the method is nonspecific for Pu. As with the gravimetric method for U, it is applicable only to high-purity compounds, such as product material. The final weight of PuO2 must be corrected for the nonvolatile impurities as determined by separate analysis.

For the gravimetric method to produce accurate results, the final weighing form (PuO2) must have a stoichiometry that is well known and reproducible with high precision.

The disadvantages of this method are the following: controversy concerning the ignition temperature and time required to obtain stoichiometric PuO2, the handling difficulties associated with Pu-containing powders, and the dif-ficulty of dissolving the high-fired plutonium oxide for recovery purposes.

The advantages of this method are the following: high precision is easily attained on a routine basis when rigidly controlled conditions of ig-nition and regular periodic checks of performance are maintained, actual operator time per determination is low, only simple laboratory equipment is required, and solid samples do not require dissolution.

Equipment
Analytical balance, furnace, glovebox.

Major Sources of Error
Nonvolatile impurities must be separately determined and a correction applied to the weight of PuO_2 obtained in the gravimetric measurement. Concentrations of impurities (e.g., Fe) should not total more than 500 microgram/g.

2.2.3.2 REDOX TITROMETRY

Scope of Application
The potentiometric and amperometric titration methods for the deter-mination of Pu are most commonly used for the analysis of final product materials. Redox (oxidation-reduction) titrimetric techniques have been applied to both the sequential determination of Pu and U and the determination of Pu in the presence of U.

Summary
Redox titrimetric methods for Pu are based on either the Pu(VI)-Pu(IV) couple or the Pu(III)-Pu(IV) couple. In the first case, all of the Pu is oxidized to the hexavalent state by a suitable oxidizing agent, usually AgO or Ce(IV). The Pu(VI) is then titrated with a standard Fe(II) solu-tion. Usually, an excess of Fe(II) is added, and the excess is back-titrated with a standard solution of Ce(IV) or dichromate.

In the second case, all of the Pu is reduced to the trivalent state by a powerful reducing agent. The trivalent Pu is titrated with either Ce(IV) or dichromate.

Uranium and plutonium can be determined by titrimetric methods based on redox reactions. Such methods are probably the most precise and accurate methods available for nonirradiated materials and generally use electrometric end point detection.

Titrimetric redox procedures are categorized by the method used for detection of the end point potentiometric or amperometric (spectrophometric end point detection is also used). These methods are capable of providing relative standard deviations of less than 0.1%.

In potentiometric titrations, the end point is found by measuring the oxidizing (or reducing) potential of the solution as the titration proceeds. This is accomplished by measuring the voltage developed between two electrodes immersed in the titrated solution. One of the electrodes, designated as the reference electrode, is unaffected by changes in the solu-tion. The other (indicating) electrode is an inert, usually noble-metal electrode that is responsive to the oxidation-reduction potential of the solution. The voltage is measured by means of a high-input-impedance in-strument so that negligible current will be drawn from the electrodes or solution. When the potential of the solution is monitored continuously during the addition of the titrant solution, it is found that there is a large change in potential (200 to 400 mV) in the vicinity of the end point. The exact end point can be located by constructing a titration curve of poten-tial versus volume of titrant; by mathematical processing of these data; or, if the change in potential is sharp enough, by titrating and stopping the ad-dition of titrant when the large excursion in potential occurs ("dead-stop" technique). Because the change in potential is the critical measurement, the sharpness of the end point is the limiting factor influencing the ac-curacy of the potentiometric titration.

In amperometric titrations, the end point is found by measuring the current generated by the reaction of an electroactive species in the solution as the titrant is added. This is accomplished with an indicator-reference electrode pair or a pair of indicator electrodes. In the single-indicator elec-trode method, a potential is applied to the indicator electrode that will make one species (reactant, titrant, or product) electroactive. The poten-tial is held constant with respect to the reference electrode during the titra-tion, and the current that flows through the system is measured with a precision dc picoammeter as a function of the volume of titrant added. In the dual indicator electrode method, the potential difference between the two electrodes remains constant during the titration and the current changes are, again, measured as a function of the added titrant. The exact end point of the titration can be obtained graphically from a plot of the current versus volume of titrant, by mathematical processing of the data, or by "dead-stop" techniques where the current flow at the end point is zero or close to zero. The exactness with which the end point of the titra-tion can be determined is the limiting factor with regard to the accuracy of amperometric titrations. The potential used in the titration can be selected so that the limiting current for either the reactant, titrant, or product is be-ing measured, depending on which yields the sharpest end point.

Equipment
The redox titrimetric methods require some special instruments in ad-dition to common laboratory apparatus such as analytical balances, volumetric or weight burettes, microburettes, and glassware. Commercial titration apparatus is available along with accessories:
- Amperometric end point methods.
(a) Precision microammeter or picoammeter
(b) Regulated constant potential supply with precision millivolt meter
- Potentiometric end point methods.
(a) Constant current source
(b) Precision millivolt meter; high-performance pH meter with millivolt indication is adequate

Major Sources of Error
- Uncertainty in the value of the standards used for titrant stan-dardization
- Accuracy uncertainty of the analytical balance
- Change in titer of a standard solution
- Inadequate operator technique.

Interference can be caused by ions that undergo the same set of redox reactions as the Pu ions. Such elements will increase the apparent Pu con-tent of the sample. If the interference is quantitative, as is usual with Fe in procedures using the Pu(III)-Pu(IV) couple, an appropriate correction can be made by determination of the Fe content.

2.2.3.3 COMPLEXOMETRIC METHODS

Scope of Application
Complexometric titrations can be applied to most Pu-containing materials that can be put into solution. Interferences must often be re-moved before titration unless highly pure solutions are analyzed.

Summary
Reagents that form stable complexes with Pu can be used in titrimetric analysis if a suitable end point indicator is available. If the reagent either forms or removes a colored complex (or compound), the color change can be used for end point determination. Alternatively, the end point indicator may be a dye that forms a colored complex with a somewhat lower stability constant than the compound being titrated.

The most commonly used complexometric titrant for Pu (as well as Th and U) is the disodium salt of (ethylenedinitrilo)tetraacetic acid (EDTA). Since strong complexes are formed, sharp end points can be ob-tained. Major drawback: EDTA forms complexes with many elements. By careful selection of pH and in-dicator and selectively complexing potential interferences, the problems resulting from the lack of specificity of the reagent can often be overcome.

From the MC&A viewpoint the lack of specificity of the complexometric procedures is a serious problem. For example, if a Th-containing solution is substituted for the Pu sample or is added to a Pu sample, the substitution would not be detected and the analytical result would overstate the Pu content. Because of this, it is strongly recommended that a Pu-specific separation step be added to the procedure to remove such in-terferences. Alternatively, methods that do not suffer from these in-terferences can be used.

All oxidation states of Pu form 1:1 complexes with EDTA. Potentially, this fact eliminates the need for a valency-conditioning step, provided a suitable end point indicator is available. The sample pretreatment should ensure that all the Pu in the sample is in the same oxidation state; complexometric titrations involve either trivalent or tetravalent Pu.

Equipment
Standard analytical laboratory ap-paratus.

Major Sources of Error
Sources of error in the complexometric procedures are those common to titrimetric analysis:
- pipetting and/or weighing errors,
- end point detec-tion errors,
- inadequate pretreatment.

2.2.3.4 CONTROLLED-POTENTIAL COULOMETRY

Scope of Application
Controlled-potential coulometry has been applied to a wide variety of Pu materials, ranging from relatively pure Pu solutions to high-fired ox-ides, carbides, and nitrides and irradiated nuclear fuels. Platinum or gold mesh electrodes or mercury pools have been used as working elec-trodes. In general, samples containing 5 to 15 mg of Pu per determination are used.

Controlled-potential coulometry is especially well suited to the analysis of irradiated material, since only a few milligrams are required for a determination. Furthermore, the method lends itself to remote opera-tions, since only the coulometric cell needs to be inside the glovebox or hot cell.

Summary
In CPC, the substance determined is electrolyzed at a working elec-trode, the potential of which is controlled or maintained constant during the electrolysis by means of a potentiostat, and the current is integrated by means of an electronic integrator or coulometer. In a typical arrangement, the counter elec-trode is placed in a separate cell compartment connected to the sample solution through a semipermeable separator to prevent reversal of the desired working-electrode reaction. The solution is stirred vigorously to effect a rapid electrolysis. The time for a normal electrolysis is 15 minutes.

Controlled-potential coulometry (CPC) may be regarded as a special kind of redox titration in which electric current is used as the titrant. In comparison with most redox titrations, coulometry achieves high precision with 5- to 15-mg quantities of Pu in the presence of large amounts of U, Al, and nitrate. As a result, the technique has been widely applied to the determination of Pu in irradiated nuclear fuel solutions as well as in unirradiated materials.

In analysis by CPC, the species to be determined is quantitatively electrolyzed at an electrode whose potential is maintained at such a value that unwanted electrode reactions are precluded. The potential of the working electrode is controlled by means of a potentiostat.

In a normal electrolysis, the current decreases exponentially as the reaction proceeds, until a background current is attained. The electrolysis is then terminated. From the quantity of electricity required by the reac-tion (measured by means of a current/time integrator), the amount of the substance being determined can be calculated, using the Faraday's Law.

Equipment

Potentiostat, integrator, digital voltmeter, and electrolysis cell comprise the major parts of the apparatus.

Major Sources of Error

- Uncertainty in the value of the standard used for measurement calibration
- Accuracy uncertainty of the analytical balance
- Inadequate removal of oxygen from the cell before and during the electrochemical steps
- A malfunctioning reference electrode causing a shift in the actual control potential
- Inadequate operator techniques.

2.2.3.5 SPECTROPHOTOMETRY

Scope of Application

Spectrophotometric procedures may be applied to the determination of Pu in a variety of materials, such as dissolver solutions, waste solutions, and product streams. Spectrophotometric methods have also been applied to the determination of the Pu content of Pu metal and Pu oxide, after dissolution of the solid.

Direct spectrophotometric methods are usually applied to the deter-mination of high concentrations of Pu in solution, or to samples in which Pu is a major constituent. The precision of direct methods is generally lower than 0.5% RSD, and often 1% to 2%. Differential spectrophotometric methods have higher precision, so that the relative standard deviation of the measurements can be 0.1% or less. The increased precision is achieved by an appropriate expansion of the scale used for the measurement of light intensities. Scale expansion can be made by placing cuvettes containing solutions of suitable concentrations in the cell compartment of the instrument and adjusting the transmission (or absorbance) scale with them. In the "transmittance ratio method" the unknown solution is com-pared with a known solution of slightly, lower concentration. In the "ultimate precision method" two reference solutions are needed; one is more concentrated than the unknown solution, the other is less concen-trated. Differential spectrophotometry can yield an accuracy and precision comparable to those obtained with titrimetric methods. The technique may be valuable for the determination of Pu in dissolver solutions and product streams.

Chromogenic methods (see “Summary” section below) are used for the determination of microgram quantities of Pu. Relative standard deviations generally fall in the 0.5% to 2% range. Solutions containing fission products or other interfering ions require a Pu separation prior to spectrophotometry. The tetrapropylammonium nitrate automated method can be used for sequential determina-tion of U and Pu.

Summary

The spectrophotometric determination of Pu is based on the absorp-tion of light of a specific wavelength by Pu compounds or complexes in solution. The fraction of incident light that is absorbed is proportional to the concentration of the absorbing species. Aqueous acid solutions of Pu may contain the element in the trivalent, quadrivalent, or hexavalent forms, or, less commonly, in the quinquivalent form. Each of the individual oxidation states of Pu has a characteristic absorption spectrum, consisting mostly of narrow bands.

If Pu is to be determined by spectrophotometry of an absorption band of an individual state, the temperature and acid concentration must be reproducibly controlled. This applies especially if the Pu concentration is to be calculated from the molar absorptivity. However, control of sol-vent and temperature is necessary also if standards are prepared and a calibration curve is constructed.

Determinations of Pu by use of a characteristic absorption band of an oxidation state is referred to as "direct determination." Because the molar absorptivities of these absorption bands are generally low, direct determinations are primarily for higher concentrations of Pu or samples where Pu is a major constituent.

There are a number of chromogens that react with Pu to form colored complexes. These complexes generally have high molar absorptivities and are suitable for the determination of low concentrations of Pu. Use of a chromogenic method generally requires that all the Pu be in the same ap-propriate oxidation state. Since Th, U, and many other cations may form colored complexes with the chromogens that react with Pu, a separation is normally required. Nuclear methods, such as alpha or gamma-ray spec-troscopy, may be preferable for the determination of Pu in solution at low concentrations.

Equipment

Direct or differential methods require a high-precision recording spectrophotometer with double monochrometer, a band-bass of 1 nm or less, variable slit width, and temperature-controlled sample chamber (con-trol within 0.2°C is required for differential methods). A dual-beam in-strument is preferred for differential methods. Digital readout is desirable. Wavelength accuracy should be within 0.3 nm, and wavelength reproducibility within 0.1 nm. Photometric accuracy and reproducibility should be 0.15% between 1 and 2 absorbancy units. The wavelength range required will depend on the analyses to be performed with the instrument. If analyses are done with the 831 nm band of Pu(VI), the range of the spectrophotometer should extend to 950 or 1000 nm.

For many chromogenic methods (but not the tetrapropylammonium method), a nonrecording spectrophotometer with 10 nm (or less) band-pass is adequate. Digital readout, rather than meter readout, is desirable.

Major Sources of Error

- Volumetric errors, such as in pipetting, dilution, or making solutions up to a specified volume
- Incomplete separation or improper oxidation state of Pu
- Presence of other oxidation states besides the one desired
- Failure to set the spectrophotometer to the absorption band maximum
- Differences in composition between standards and samples.

Temperature control to 0.2°C is required for direct and differential spectrophotometry.

2.2.3.6 PLUTONIUM(III) DIODE-ARRAY SPECTROPHOTOMETRY

Scope of Application

This method is used for the determination of total plutonium as plutonium(Ill) in nitrate and chloride solutions. The technique is applicable to solutions of plutonium dioxide powders and pellets, nuclear grade mixed oxides, plutonium metal, and plutonium nitrate solutions (solid samples are dissolved). The applicable concentration range for plutonium sample solutions is 10-200 g Pu/L.

Summary

In a diode array spectrophotometric measurement, the substance being determined absorbs light at frequencies characteristic of that substance. The amount of light absorbed at each wavelength is directly proportional to the concentration of the species of interest. The absorption is a function of the oxidation state and the complexation obtained in the solution matrix selected for measurement. Beer's Law permits quantifying the species of interest relative to a traceable standard when both solutions are measured under the same conditions. The array of photosensitive diodes permits the (virtually) simultaneous collection of spectral information over the entire range of the instrument, for example, 190-820 nm (or any selected portion of the range). An entire absorption spectrum can be obtained in 0.1 s; however, optimum precision is obtained from multiple spectra collected over a 4-s period.

Reduction to plutonium(III) is accomplished by the addition of a measured quantity of reductant solution to the sample aliquant.
- For nitrate solutions, ferrous sulfamate is the recommended reductant. Aliquants (1 mL or less) of the sample solution are diluted with 10 mL of a ferrous reductant/matrix solution to 1 g Pu/L and measured.
- For chloride solutions, ascorbic acid is the recommended reductant. Aliquants of the sample solution, each containing 50-100 mg of plutonium, are diluted with 2 mL of zirconium solution to complex fluoride ions, 2 mL ascorbic acid reductant solution, and 1.0 M HCl to a total volume of 25 mL yielding 2-4 g Pu/L solutions for measurement.

Plutonium concentration is determined from light absorption measurements taken on the sample solution in the blue-green region from 516 to 640 nm where a broad doublet band is observed. Spectral quantifying software capable of fitting the sample spectrum with spectral information from standard solutions is used to calculate the plutonium concentration. Both commercially available and custom-designed spectral fitting software has been used for plutonium measurements.

Equipment
- Diode Array Spectrophotometer with wavelength range 190-820 nm
- Analytical Balance with readability of 0.1 mg
- Solution Density Meter with readability of 0.1 mg/mL
- Adjustable, Fixed-volume Pipetters calibrated to deliver the desired range of volumes for sample and matrix-reductant solutions.

Major Sources of Error (Interferences)
- materials that absorb light in the region of the plutonium absorption
- undissolved solids that cause light scattering
- strong oxidizing or complexing agents that prevent complete reduction of the plutonium to the plutonium(III) oxidation state
- anions that shift the spectrum.

2.2.3.7 ALPHA COUNTING

Scope of Application
This method is applicable to radioactive solutions that require shielding and remote handling and can be used as a procedure for the determination of Pu in irradiated fuel dissolver solutions and in the determination of Pu in waste solutions, provided the specific activity of the Pu is known. If the specific activity must be determined solely for this method, other methods, such as isotope dilution mass spectrometry, should be considered. It has been supplanted for dissolver solution analysis by the isotope dilution mass spectrometry method. Alpha emitters such as Am, Cm, U, and Np interfere, and, if their amounts are not known or cannot be determined, they must be separated from Pu.

Summary
For the direct method (no separation), an aliquot of the sample is mounted on a counting disk and the gross alpha activity is determined. Interfering alpha emission is determined and the appropriate adjustments are made. Alternatively, interfering alpha emitters can be removed. Plutonium is reduced to Pu(III) with hydroxylamine hydrochloride, and then quan-titatively oxidized to Pu(IV) with sodium nitrate. Pu(IV) is extracted from 0.5- to 1.5M nitric acid solution into 0.5M thenoyltrifluoroacetone (TTA) in xylene. The organic phase is separated from the aqueous phase and washed with 0.5M HNO_3. An aliquot of the organic phase is evaporated on a counting disk, and the activity is determined by alpha counting. If significant amounts of Zr or Fe are present, Pu is stripped from the organic phase with 10M HNO_3, and the activity of the aqueous phase is determined by alpha counting.

Other alpha emitters, such as U, Am, Cm, and Th do not extract into TTA-xylene from 1M acid. Neptunium is not extracted if it is oxidized to the (V) state. Zirconium and Fe do extract, but remain in the organic phase when the Pu is stripped with 10M HNO3.

Equipment
Alpha Counter. A number of different types are satisfactory. Desired criteria are stability of the electronic system, capacity to handle high count rates reliably, and tolerance of high beta activity. An alpha counter that employs a silicon surface barrier detector would consist of (1) an evacuable light-tight chamber in which the detector and the counting plate on its support can be mounted, (2) detector bias supply, (3) preamplifier, (4) amplifier with discriminator or single-channel analyzer, and (5) counter and timer.

Major Sources of Error
- The counting statistics,
- Nonquantitative recovery of the Pu from extraction procedure,
- Self-absorption that occurs if the sample to be evaporated on the counting plate contains nonvolatile impurities that prevent ob-taining a "weightless" source. In this case, more accurate results may be obtained by back-extraction of the organic phase with 10M nitric acid and electroplating Pu from the aqueous phase on-to the counting plate. Vacuum sublimation from a hot filament may also be used.

Known interferences in the method are free sulfate, phosphate, fluoride, and oxalate ions. Free sulfuric acid should be main-tained at less than 0.1 M. Any fluoride ion present in samples must be complexed with aluminum nitrate before Pu is extracted from aqueous nitric acid solutions. To prevent polymer formation, any dilutions of the sample should be made with at least 1M HNO3.

2.2.4 DETERMINATION OF PLUTONIUM ISOTOPIC ABUNDANCE

2.2.4.1 THERMAL IONIZATION MASS SPECTROMETRY

Scope of Application
This method is applicable to a variety of physical and chemical forms of Pu ranging from high-purity plutonium dioxide to spent fuel dissolver solutions. The solution to be ana-lyzed contains the high-purity Pu fraction separated from the dissolution of Pu metal and alloys, Pu oxide, mixed U-Pu oxides, and fabricated Pu-containing nuclear fuels. However, spent fuel dissolver solutions are more commonly analyzed by isotope dilution mass spectrometry since the Pu concentration together with the Pu isotopic abundances is desired.

The resin-bead technique described in the “Summary” section below is especially useful for the isotopic analysis of Pu and U in highly radioactive spent fuel solu-tions. The technique is recommended for situations in which samples must be shipped for some distance. The beads can be packaged and shipped without the need for shielding. The resin-bead technique requires 20 to 30 h of equilibration of the solution with the resin.

If the abundance of 238Pu is less than 0.7%, alpha spectrometry is fre-quently used for the determination of that isotope.

Summary
In general, mass spectrometry is applicable to the isotopic analysis of Pu in a variety of forms and in mixtures with U. The sample must be dissolved in a suitable acid medium and chemically treated to obtain a purified Pu fraction. The separation of U and Am from Pu is especially important, since 238U and 241Am are mass interferences. The purified Pu fraction (after dilution, if necessary) is used for mass spectrometry. The separation should be used on Pu standards, as well as samples, to remove Am and other decay products.

An aliquot of the Pu fraction is evaporated on the mass spectrometer filament. A current is passed through to form adherent Pu oxide, and to remove acid, water, and some organic matter. The filament assembly is placed within the ion source of the mass spectrometer and outgassed. The filament(s) are heated following a carefully selected heating pattern to vaporize and ionize Pu. The singly charged metal ions produced by this thermal ionization are accelerated and focused with an electrostatic ion lens into the mass-analyzer section. The total ion beam is separated ac-cording to the mass-to-charge ratio of the ions (m/e). By an appropriate variation of the magnetic field(s) or the accelerating potential or both, the separated ion beams are sequentially focused on the detector, which is either a Faraday cup, an electron multiplier, or a photomultiplier detector. The detector current or pulses are further amplified and recorded as a function of the mass on a stripchart recorder or by a digital recording system. The peak currents (intensities) at each isotopic mass are measured, and the average isotopic ratios are calculated with reference to the 239Pu peak intensity.

There are variations of this procedure, in which Pu and U are separated together and are sequentially analyzed by increasing the filament temperature. In the "resin bead method," developed at Oak Ridge National Laboratory, Pu and U are ad-sorbed on anion exchange resin beads. A single resin bead is loaded into the mass spectrometer. Plutonium and U are analyzed sequentially at different filament temperatures. The normal temperature for Pu analysis is 1450°C to 1500°C. At the completion of the Pu analysis, the temperature is slowly raised to burn off excess Pu. Since U vaporizes at the same time, in order to avoid fractionation of U, care must be taken that this step does not take more than 15 min. Uranium is then analyzed at 1700°C to 1800°C.

Equipment

Mass Spectrometer

A typical thermal-ionization spectrometer would have a 30.5-cm (12-in.) radius of curvature, 60° or 90° sector, and single or double focusing. Minimum specifications for such a mass spectrometer are as follows:

- Ion source
- Mass analyzer
- Vacuum system with differential pumping of ion source chamber and analyzer
- Detection System including an electron multiplier primary detector with stable current gain
- Data logging system.

Mass Spectrometer Accessories

(1) Filament material, high-purity, electron beam zone-refined rhenium, tungsten, or tantalum
(2) Filament-forming jig
(3) Filament assemblies (hats)
(4) Spot welder
(5) Filament-loading unit
(6) Filament bakeout chamber, capable of heating to 2000°C under vacuum of less than 1 x 10-6 torr for outgassing of filament
(7) Optical pyrometer, range to at least 2500°C.

Other Equipment

(1) Ion-exchange columns: 4- to 6-mm inside diameter, 4- to 6-cm long with drip tip at the bottom and 2- to 3-mL reservoir on top.
(2) Quartz distillation apparatus for distilling water and acids.
(3) Perchloric acid scrubber. The anion-exchange separation pro-cedure calls for oxidation of Pu to Pu(VI) with perchloric acid. It has been shown that a highly efficient per-chloric acid fume system permits one to work safely with perchloric acid in gloveboxes.

Major Sources of Error

- Source Discrimination (or Source Fractionation)

Thermally produced ions of the lighter isotopes are vaporized and ionized preferentially with respect to the heavier isotopes of the same ele-ment. Fractionation is a complex, time-dependent

phenomenon. A reproducible analytical procedure must be strictly followed. Such a pro-cedure will keep under control such factors as filament temperature, fila-ment loading, acidity of the sample, chemical form and oxidation state of the element, sample mounting procedure, outgassing procedure, and heating pattern and temperature.
- Ion-Optical Discrimination
The ion lens and the magnetic sector mass analyzer are not perfect. As a result, the ion path from the exit slit of the ion source to the entry slit of the ion collector/detector is not exactly the same for all ions of a given m/e. To minimize this effect, a high accelerating potential and a large ion-transmission coefficient are desirable. It is necessary to reproduce the spectrometer operating conditions for sample and standard, or for successive filament loadings of the same sample.
- Electron-Multiplier Discrimination and Nonlinearities in the Ion-Current Amplification and Recording System.

Corrections for source, ion-optical, and electron multiplier discriminations have been combined with establishing the mass discrimination factor. This factor is determined using U Certified Reference Materials. It is recommended that the mass discrimination factor be verified by also analyzing one of the Pu isotopic standards.

2.2.4.2 ALPHA SPECTROMETRY

Scope of Application
This method is applicable to Pu-bearing materials that have a 238Pu abundance that is too low for precise mass spectrometric measurement, or to situations in which there is a significant interference from 238U. Precise measurement of the 238Pu abundance is essential for calorimetric measurements of total Pu since 238Pu contributes a large fraction of the heat. Alpha spectrometry is appropriate for the determination of 238Pu isotopic abundances from 0.01 to 0.7 weight percent.

It is frequently desirable to determine the isotopic abundance of 238Pu by a method other than mass spectrometry, especially for samples where 238Pu content is too low for precise mass spec-trometric measurement, or where there is interference from 238U either as background in the mass spectrometer or as contamination of the sample. Mass spectrometry should be used for the measurement of higher abundances, but it also can be used for 238Pu abundances as low as 0.1 weight percent, depending on the mass spectrometer, the amount of sample used, and the degree of decontamination from 238U achieved by the preliminary chemical separation. Alpha spectrometry is particularly suited for the determination of 238Pu because of the high specific alpha activity of that isotope relative to the other alpha-active Pu isotopes.

Summary
A portion of a suitable dissolution of the Pu-bearing material is diluted with 1M nitric acid. An aliquot of the dilute solution is extracted with an equal volume of 0.5M TTA in xylene. An aliquot of the organic phase is evaporated on a counting disk. Alternatively, the Pu fraction may be separated and purified by an ion-exchange procedure. In that case, an aliquot of the purified Pu fraction is evaporated on a counting disk. Preparation of a "weightless" uniformly distributed sample is essential to optimal performance. The presence of inert residue can lead to alpha ab-sorption and a degraded alpha spectrum. The recommended procedure in-volving plating of an organic phase extractant and subsequent flaming of the counting plate has provided good results. The alpha spectrum in the 5 to 6-MeV region is measured, using a silicon surface-barrier detector with associated electronics and a multichannel pulse-height analyzer. The total counts in the 238Pu and (239Pu + 240Pu) peaks are obtained and corrected for background. The 238Pu abundance is calculated from the ratio of the alpha activity due to 238Pu to the total alpha activity, and the abundance of 239Pu and 240Pu determined by mass spectrometry on a separate por-tion of the sample. A single determination requires only a few minutes for source preparation (beginning with a purified Pu fraction) and approx-imately 10 min of counting time.

Equipment

Alpha Spectrometer

This spectrometer will consist of the following components:

(1) Silicon surface barrier detector, with an active area of 100 mm2, 100 mkm depletion depth, and a resolution of 20 keV or less FWHM (for 241Am, 5.486 MeV alphas) is suitable. A detector with a rear microdot connector should be specified

(2) Evacuable light-tight chamber in which the detector and the counting plate on its support can be mounted

(3) Preamplifier, and charge-sensitive field effect transistor (FET)

(4) Detector bias supply, 0 to 1000 V, continuously variable, well regulated and stable

(5) Main spectroscopy amplifier, low noise, with variable shaping constants and baseline restoration

(6) Biased amplifier and pulse stretcher, with continuously adjustable post gain and automatic pileup rejection

(7) Multichannel pulse-height analyzer.

Counting Disks

Counting disks of highly polished Pt or Ta, 25 mm diameter by 0.051 mm (1" in diameter by 0.002"), are suggested. Platinum is preferred. Make a 4-mm diameter depression in the center with a fire-polished glass rod or the round end of a small test tube. Microscope cover slides (25 by 25 by 0.12 mm) have been recommended. These slides have a smooth polish and are inexpensive and disposable; however, they require care in handling and flaming. An infrared heat lamp and disposable micropipets are also required equipment.

Major Sources of Error

- The counting statistics
- Mass spectrometric determination of the 239Pu and 240Pu abun-dances
- Uncertainties in the half-lives of the Pu isotopes
- Thick or nonuniform deposits on counting disks.

2.2.5 SIMULTANEOUS DETERMINATION OF URANIUM AND PLUTONIUM

2.2.5.1 ISOTOPE DILUTION MASS SPECTROMETRY

Scope of Application

Isotope dilution mass spectrometry is applicable to the determination of U and Pu concentrations in solutions that result from the dissolution of nuclear reactor fuels. The technique is an adaptation of the mass spec-trometric methods for the determination of isotopic abundances that per-mit measurement of the elemental concentrations. As a result, the techni-que also provides isotopic abundance data.

The technique is applicable to dissolver solutions of nuclear fuels con-taining Pu, Al, Zr, or stainless steel. The technique is also applicable to process streams and waste tank solutions. The sample size required for mass spectrometric analysis is 10-9 to 10-6 g of Pu and 10-8 to 10-5 g of U, depending on the sensitivity of the instrument. However, it is recom-mended that aliquots containing at least 1.5 x 10-4 g of U be carried through the chemical separation. The resin-bead technique is especially useful for the determination of Pu and U in highly radioactive spent fuel solutions. This technique is recommended for situations in which samples must be shipped from one laboratory to another some distance away. The beads can be packaged and shipped without the need for shielding.

Summary

Isotope dilution mass spectrometry (IDMS) involves addition of a measured quantity of a highly enriched isotope to an aliquot of the sample. The isotope must either not be present or is present only at small relative levels in the sample. The added element of known isotopic composition is termed the "spike." After chemical and isotopic equilibration, the quantities of the isotopes in the sample are measured relative to the added isotope by mass spectrometry. From the change in the isotopic ratios of the sample caused by the spike, the elemen-tal content of the sample may be calculated.

The basic steps in an IDMS procedure are as follows:
(1) Obtain and prepare a representative and accurate aliquot of the sample
(2) Add accurately known amounts of the spike isotopes to the sam-ple aliquot
(3) Achieve identical chemical states of the isotopes and isotopic equilibrium between the sample and the spike prior to any chemical separations
(4) Separate the U and Pu from each other and from fission products and Am
(5) Carry out the mass spectrometric analysis and subsequent calcula-tions.

For fuels containing natural U, enriched U-235, and Pu, the conven-tionally used spike isotopes are U-233 and Pu-242. With increasing burnup of the fuel and the consequent increased formation of Pu-242 in the fuel specimen, this isotope becomes less desirable as a spike. If the abundance of Pu-242 in the fuel is 5% to 10%, Pu-242 can still be used as a spike isotope, but an unspiked sample must, of course, be analyzed to correct the amount of Pu-242 originally present. A preferable spike isotope in this case is Pu-244. For fuels containing U-233, the suggested spike isotope is U-236.

The preparation of the sample, including separations, requires about 2 man-hours. Many ion-exchange columns can be operated in parallel to increase sample throughput. Filament preparation, preliminary outgassing in a separate vacuum system, loading the filament, inserting the filament into the mass spectrometer, and obtaining the spectra require about 1 h. The elapsed time may be as high as 4 h if pumping speeds or filament outgassing rates in the instrument are slow. The measurement of recorder charts and manual data reduction requires another I to 2 h. If computer-ized data acquisition and reduction are available, this time is reduced to a few minutes.

Equipment
The sample preparation steps in IDMS require no special laboratory equipment other than an analytical balance, disposable ion-exchange columns, and perchloric acid scrubber. The mass spectrometer and associated equipment are described in the sections on isotopic analysis by surface-ionization mass spectrometry (3.2.2.1 and 3.2.4.1).

Major Sources of Error
- Uncertainty in the accuracy of the semimicro analytical balance used for weighing the initial sample, subsequent dilutions, and spike aliquots
- Uncertainty in the assay of the spike solutions
- Failure to obtain chemical and isotopic equilibrium of sample and spike
- Failure to obtain adequate separation of Pu and U
- Failure to remove organic impurities from the Pu and U fractions.

2.2.5.2 X-RAY FLUORESCENCE SPECTROMETRY

Scope of Application
XRF spectrometry is used for the analysis of unirradiated materials, such as U and Pu alloys, oxide and carbide fuels, and various types of solutions including irradiated fuel solutions (up to 1000 Ci/L prior to dilution). In general, methods have covered the con-centration range of 0.003 to 10 g U or Pu/L, and a precision of 1% RSD or better was attained at the 1-g/L level. Solutions have either been analyzed directly (after dilution, if necessary), or a small volume of the diluted solution was mixed with an in-ternal standard solution and an aliquot of the mixture deposited on filter paper. Precisions and accuracies of 1% or better were attained in most of the procedures.

X-ray fluorescence spectrometry (XRF) has been applied to the deter-mination of actinide elements for nearly 30 years. With improvements in the instrumentation, XRF has been used for the analysis of increasingly complex samples. Most of the early applications were for the determina-tion of U in solutions or fusions prepared from U alloys or unirradiated oxide fuel. Subsequently, the technique was extended to the determination of Pu and U, of various ratios, in solution or in unirradiated MOX fuel pellets. Most recently, much work has been done on the determination of Pu and U in highly radioactive reprocessing plant samples.

Summary

In X-ray fluorescence spectrometry, atoms within the sample are ex-cited through bombardment with a beam of energetic particles or elec-tromagnetic radiation, such as X-rays, gamma rays, electrons, or protons. The excited atoms emit characteristic secondary X-rays that are indicative of the chemical elements present in the sample and of their relative concen-trations. If means are provided for resolving, detecting, and counting the secondary X-rays, a qualitative and quantitative determination of the elements in the sample can be made. Two general types of spectrometers for resolving and detecting X-rays are in use: wavelength-dispersive and energy-dispersive spectrometers.

Wavelength-dispersive systems offer high resolution, but low efficiencies, so that X-ray tubes are required for excitation. Wavelength-dispersive systems excel at quantitative analysis, because of the com-parative freedom from interference by incoherently scattered primary radiation. This is especially important in the analysis of liquids. Signal-to-background ratios are high; most of the detected radiation is useful signal. The high resolution of wavelength-dispersive spectrometers is an asset in the analysis of spent fuel solutions where there is a potential for in-terference from fission product radiations.

Energy-dispersive systems are more efficient but have poorer resolu-tion at energies below 20 keV. The high efficiency is often an asset in measurements of "cold" solutions when radioisotopic excitation sources are used. Qualitative analysis is more rapid with an energy-dispersive spec-trometer. However, energy-dispersive systems have the disadvantage that the detector and PHA must process every photon that strikes the detector. This leads to low signal-to-background ratios, and a lower count-rate tolerance than with wavelength-dispersive spectrometers. In energy-dispersive systems, only about 10% of the total counts represent useful signal.

For U and Pu measurements, X-ray lines in the K, L, or M series may be used. The main considerations in selecting a line are its intensity above background and freedom from interference from adjacent lines.

Equipment

Wavelength-dispersive and energy-dispersive XRF spectrometers. The wavelength-dispersive instruments con-sist of a high-voltage generator (usually 60 to 100 kV, 50 to 60 mA) and X-ray tube, a crystal spectrometer with precision goniometer, a detector and high-voltage power supply (usually 2 to 3 kV), preamplifier, linear amplifier, single-channel pulse-height analyzer, scaler and timer, ratemeter, and stripchart recorder.

The energy-dispersive instruments consist of an X-ray tube and generator or power supply; a semiconductor detector and cryostat; preamplifier; linear amplifier; various other modules for peak-shaping, baseline restoration, and dead-time correction; a multichannel pulse-height analyzer, and a computer.

Major Sources of Error

- Statistical counting error depends only on the total accumulated count
- Instrumental errors include variations or drift in the X-ray tube potential and current, drift in detector potential, changes in crystal interplanar spacing due to temperature changes, coincidence (dead-time) losses in the detector and electronic circuitry, shift and distortion of pulse-height distributions, and instability or drift in the electronic circuity
- Operational errors consist of nonreproducibility in settings of instru-ment conditions
- Errors may also be incurred in estimating the concentration from the calibration curve.

REFERENCES

[2.1] Techniques and Equipment. International Nuclear Verification Series, No 1. International Atomic Energy Agency, Vienna, 1997
[2.2] Passive Nondestructive Assay of Nuclear Materials. Edited by Doug Reilly, Norbert Ensslin, and Hastings A. Smith, Jr., 1991
[2.3] Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle, Second Edition, Edited by Clement J. Rodden, Office of Information Services, U.S. Atomic Energy Commission, 1972
[2.4] Handbook of Nuclear Safeguards Measurement Methods, Edited by Donald R. Rogers, NUREG/CR-2078, MLM-2855, September 1983

2.3 CONTAINMENT AND SURVEILLANCE

Containment and surveillance (C/S) techniques are extensively deployed now owing to their flexibility and cost effectiveness. The main C/S means are radiation monitors, optical surveillance and sealing systems.

2.3.1 RADIATION MONITORS

Radiation monitors are located at the periphery of nuclear-material and radioactive-contamination control areas to detect accidental or covert removal of radioactive materials. Two types of radiation monitors are in use today: contamination monitors and nuclear material monitors. Contamination monitors detect contamination on the surface of the person or an object where the radiation comes from an extended area viewed without intervening absorbers. Nuclear-material monitors must be able to detect small, possibly shielded quantities of nuclear material that may be hidden.

Nuclear-material monitors have to meet requirements to search each person, package, or vehicle leaving a nuclear-material access area. Contamination monitors meet radiation safety standards for monitoring persons leaving a radioactive-contamination area. In both cases, visual or manual searches may be ineffective, but radiation monitors sense radiation emitted by materials and can conduct unobtrusive, sensitive, and efficient searches. The monitors provide timely notice of contamination or diversion before the controlled material can leave an access are.

Diversion monitors are either automatic portal monitors or hand-held monitors. The versatile hand-held monitor has many applications, including contamination monitoring. Their effectiveness depends on the operator making a thorough scan. In contrast, portal monitors are fully automatic.

2.3.1.1 DETECTORS FOR RADIATION MONITORS

Radiation monitors use different types of radiation detection depending on whether they are designed to detect contamination or diverted nuclear material. Gas proportional counters are most appropriate for detecting the radiation from contamination, and scintillators are most appropriate for detecting the penetrating radiation from diverted material.

Plastic scintillation detectors are solid organic scintillators that contain fluorescent compounds dissolved in the polymer solute. These materials have low density and low atomic number so they lack strong photoelectric absorption. They detect gamma rays by detecting Compton recoil electrons, and they detect neutrons by detecting recoil protons. These detectors do not display full-energy peaks; they display a continuous spectrum from the Compton edge down to zero energy. Although organic scintillators are poor energy spectrometers and have low intrinsic detection efficiency, they make excellent large-area, low-cost radiation counters. Their low cost results from the use of inexpensive materials and simple packaging; NaI crystals, on the other hand, are expensive to grow and to protect from moisture and thermal shock.

2.3.2 OPTICAL SURVEILLANCE SYSTEMS

Optical surveillance is most effective in storage areas (such as spent fuel storage ponds) with relatively few activities that could be interpreted as the removal of nuclear material. A typical application would consist of two or more cameras positioned to completely cover the storage area. The field of view of the cameras is such that any movement of items that might constitute the removal of nuclear material is easily identified. This means that items have to be sufficiently large in the field of view to be identified and that one or more images have to be recorded during the movement. The image recording may be set at a periodic frequency (significantly shorter than the fastest removal time) or the motion (i.e. scene change) may trigger the recording. Optical surveillance is intrinsically an unattended operation that may be enhanced by the remote transmission of image data or system operation data (i.e. the status of the surveillance system).

Optical surveillance equipment has undergone a transition from analog video systems to digital surveillance systems. Digital surveillance systems were essentially mandated by the strong commercial industrial trend in the manufacture of low cost digital components providing significantly improved system performance.

2.3.3 SEALING SYSTEMS

Seals are typically applied to individual items containing nuclear material. A seal can help to indicate that material was neither introduced into nor removed from a container and, at the same time, provides a unique identity for the sealed container. Unattended monitoring equipment is often also sealed. Most seals are usually applied for extended periods of time. These seals may be either single-use seals that are replaced when checked or seals that are verifiable in situ, i.e. they can be checked for integrity and identity in the field. If the seals are in situ verifiable then the verification activity must be efficient (to limit radiation exposure to the inspector) and extremely reliable. The in situ verification activity must consist of checking the item containment as well as the seal and the method of its attachment to the item.

A sealing system comprises the containment (container) enclosing the nuclear material, the means of applying the seal (e.g. a metal wire) and the seal itself. All three components must be examined in order to verify that the sealing system has fulfilled its function of ensuring continuity of knowledge of the identity and integrity of the nuclear material concerned. There are single-use seals: metallic and adhesive seals; in situ verifiable seals: fiber optic, ultrasonic, electronic seals.

2.4 UNATTENDED AND REMOTE MONITORING

The use of unattended instrument systems has always been a requirement for MC&A. Optical surveillance systems, for example, are inherently unattended systems since their prime function is to survey an area over extended periods of time. Contemporary unattended monitoring systems employing radiation detection sensors are increasingly being used to detect the flow of nuclear material past key points in the facility process area. For complex nuclear facilities where the plant is automated (remotely operated), unattended assay and monitoring techniques are an integral part of a practicable MC&A implementation approach.

Unattended use necessitates that special considerations be included in the instrumental system design if the system is to be reliable and cost effective in providing credible, independent data. This means that the system must operate without failure over extended periods, including times when the facility power supply is interrupted. The unit should operate automatically and periodically record and transmit its status. If data are to be sent over unsecured transmission pathways then the data must be authenticated. And if data are to be shipped off-site then they must be encrypted to meet the requirements of the facility and the State for confidentiality of information. Because of the stringent design considerations unattended and remote monitoring equipment typically has to be flexible, modular and highly reliable.

In summary, the primary advantages of unattended and remote verification techniques are:
- Reduced inspection efforts,
- Reduced radiation exposure of inspectors,
- Reduced level of intrusiveness in the operation of nuclear facilities.

3. STRUCTURE OF DETAILED DEVICE INFORMATION

This section describes the structure of the device information presented in Catalog ("device" in the context of this section can refer to any MC&A instrument, software, or methodology). The description of each device follows a fixed structure emulating the structure of the previous catalog developed by Brookhaven National Laboratory [1.1 and 1.2]: the description is divided into two parts, as described below.

The first part contains the main qualitative device characteristics important for MC&A specialists:

DEVICE/METHOD NAME
MODEL
SUPPLIER
USE CATEGORY
DEVICE/METHOD TYPE
MEASUREMENT METHOD
MEASURED PROPERTIES
NUCLEAR MATERIAL(S)
PHYSICAL FORM(S) OF NM
STATUS
PORTABILITY
EVIRONMENT OF USE
DEVELOPER
MANUFACTURER

Below are brief descriptions of these characteristics.

DEVICE/METHOD NAME
As a rule, the device/method name is unique and is supplied by the device/method developer or manufacturer.

MODEL
The device's model names are unique for each device and are supplied by the developer or manufacturer.

SUPPLIER
Name of the supplier of the device/method. Short name of the supplier is provided.

USE CATEGORY
Six MC&A categories: Accounting (DA Equipment), Accounting (DA Methodology), Accounting (Mass/Volume Determination), Accounting (NDA), Accounting (Reference Material), and Containment and Surveillance.

DEVICE/METHOD TYPE
Corresponding lists of device/methodology types for the six Use Categories are shown below.

Accounting (DA Equipment):
- Alpha Spectrometer
- Coulometer
- Chromatograph
- Mass Spectrometer
- Optical Emission Spectrometer
- pH-meter
- Software
- Spectrophotometer

Titrimeter

Accounting (DA Methodology):
- Alpha Counting
- Alpha Spectrometry
- Analytical Chemistry
- Coulometry
- Extraction Chromatograpgy
- Gravimetry
- Isotopic Dilution
- Mass Spectrometry
- Optical Emission Spectroscopy
- Spectrophotometry
- Titration
- Total Activity Measurements

Accounting (Mass/Volume Determination):
- Weighting Equipment
- Volume Meter

Accounting (NDA):
- Calorimeter
- Densitometer
- Detector
- Equipment Component
- Identifier
- Measurement System
- Multichannel Analyzer
- Neutron Counter
- Software
- Spectrometer
- Waste Measurement System
- XRF System

Accounting (Reference Material):
- Certified Reference Material

Containment and Surveillance:
- Hand-held Monitor
- Portal Monitor
- Seal
- Software
- Video Surveillance System

As follows from these lists, two DEVICE/METHOD TYPE names may belong to two USE CATEGORIES - Detectors and Software types in Accounting (NDA) and Containment and Surveillance categories - while being functionally different in each case.

MEASUREMENT METHOD
- Access Control
- Alpha
- Alpha Counting
- Alpha Spectrometry
- Analytical Chemistry

Beta
Calorimetry
Conductivity measurement
Coulometry
Densitometry
Extraction chromatography
Flow Rate Measurement
Gamma
Gamma spectrometry
Gravimetry
Liquid Level Measurement
Mass Spectrometry
Neutron
Neutron coincidence counting
Neutron multiplicity counting
Optical Emission Spectrometry
Spectrophotometry
Titration
Video Surveillance
Weighing
X-ray
X-ray spectrometry
XRF

MEASURED PROPERTIES
This entry shows physical characteristics determined by the device/method that can be used for the purposes of accounting and control.
Absorbed Dose Rate
Density
Effective Isotope Mass
Element Concentration
Element Mass
Isotopic Composition
Radiation Intensity
Video Image
Volume
Weight

Note: entries in the "Device/Method Type" and "Measurement Method" fields are the same for USE CATEGORY "Accounting (DA Methodology)".

NUCLEAR MATERIAL
This entry shows the nuclear material type characterized by this device/method. This information is presented in a free format.

PHYSICAL FORM(S) OF NM
Physical forms of nuclear materials such as gas, fusion cake, metal, hold up, ore, powder, scrap, solution, and nuclear waste are shown in this entry.

STATUS
Status of device can be one of the following: experimental sample, limited production, one-of-a-kind, prototype, and serial production.

PORTABILITY

Devices can be hand-held, portable, or stationary.
- hand-held: light devices
- portable: devices that may have significant weight or size but are easily relocated and setup
- stationary: devices designed to be permanently installed

ENVIRONMENT OF USE
Environment of Use has three categories:
- laboratory
- industrial
- field

DEVELOPER
The name of the company that developed the device/method.

MANUFACTURER
The name of the company that manufactures this device.

The second part entitled, DESCRIPTION consists of the following sections:

PURPOSE
DESCRIPTION
COMPONENTS
SPECIFICATIONS
SOFTWARE
ADDITIONAL INFORMATION
REFERENCES

The contents of these sections are presented in free format.

4 USER GUIDE FOR ELECTRONIC VERSION

Installation

The MC&A Instrumentation Catalog database was prepared using MS ACCESS™, Microsoft Office 2003. The database is distributed on a CD containing the database file, "MCA Catalog 3_0 Distribution.mde" and folder "Pictures".

WARNING: When copying the data base to the hard drive, .mde file and "Pictures" folder should be copyied in the same folder.

User Interface

The user interface has three major screens: MAIN, SEARCH, and MISCELLANEOUS. The MAIN screen opens automatically when the database is loaded. This screen has three buttons: "Open Database", "Miscellaneous", and "Exit". Pressing any of the first two buttons leads the user to corresponding screens; pressing the "Exit" button closes the database and exits MS ACCESS.

Note. The MAIN screen has pictures of the American and Russian flags; the user can click on the pictures to choose either English or Russian for the MAIN and MISCELLANEOUS screens.

The "Open Database" button opens the SEARCH screen designed to interrogate the database and print the search reports. The "Miscellaneous" button opens a menu screen providing the user with miscellaneous information such as companies, instrumentation descriptions, etc. (see below). The "Exit" button closes both the database and MS ACCESS.

SEARCH Screen

This screen is reached by pressing "Open Database" button on the main screen.

The database search can be performed by using from one to seven search key words or expressions entered in the three green, two blue and two yellow fields. The green fields are used for a free entry of the search key words or expressions in the selected language; the entire record for each device is searched for the second and third (green) entries. Identifier search should be used in combination with other fields to narrow the search results; used alone, this search may along with the sought record, select those containing similar combinations of digits. Four remaining fields allow the user to do searches by Use Category, Type, Method, and Supplier, respectively. Once the key words/expressions are selected, pressing the button with binoculars will conduct the requested search (leaving all the search fields empty will show the entire database). It is recommended to exercise care when search is requested using a combination of Type and Method fields (yellow): some of the combinations may be mutually exclusive.

The user can request results of the searches to be arranged according to one of the three sorting orders indicated on the SEARCH screen.

After search is completed, pressing the buttons on the left of each record in the resulting window will show and print the Catalog page corresponding to the selected device. The entire group of devices identified by the search can be reviewed by pressing the "glasses" button, or directly printed by pressing the "printer" button located at the top of the window. Listing of selected devices can be viewed or printed by pressing a blue "list" button. Note that clicking on the cell showing the name of the supplier will open a report page with information on that particular company.

The working language for searches and printed reports is selected by pressing one of the two buttons located at the top of the screen.

From the SEARCH screen, the user can print the entire Catalog with three options for sorting. To do that, a search with empty fields for the search keywords is performed with the selected sorting order.

MISCELLANEOUS Screen

This screen contains buttons allowing to view the following information in both languages:

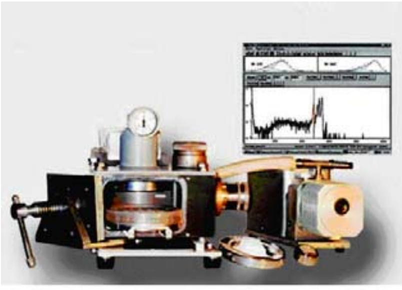
- Introduction
- Non-Destructive Analysis
- Destructive – U
- Destructive – Pu
- Containment and Surveillance
- User's Guide
- Companies. A list of companies' names will be shown in a form of a table. The user can view/print information for a particular company or for all companies
- STOP (return to the main screen).

Accounting (DA Equipment): Alpha Spectrometer

1

Stationary alpha-spectrometer

MODEL: СКС-07(09)П-А



SUPPLIER: **Green Star**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Alpha Spectrometer
METHOD: Alpha Spectrometry
Passive
MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM: Solution (any form converted to solution)
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Green Star
MANUFACTURER: Green Star

PURPOSE

The device is designed for the alpha-particles energy distribution measurements. The spectrometer can be used for:
- nuclear material control;
- process control at plant radiochemical laboratories

DESCRIPTION

The operation is based on conversion in the sensitive volume of the detector of the alpha-particle energy to electrical pulses of proportional amplitude produced; this is followed by pulse counting and the analysis using an amplitude-pulse analyzer.

COMPONENTS

- personal computer;
- single-plate processor of pulse signals of SBS series installed into personal computer;
- vacuum chamber equipped by vacuum pump;
- semiconductor silicon ion-implanted detectors with the sensitive surface area of up to 3000 mm² and with capacity of up to 3000 pF;
- software.

SPECIFICATIONS

Minimum activity of alpha-nuclides measured in radioactive samples with large area (10-30 sm²) of active spot	0.01 Bq
Autonomous behavior, that is without continues pumping air from the vacuum chamber	during 8-24 hours

SOFTWARE

It is provided with software controlling the spectra acquisition and processing in automatic and interactive modes.

ADDITIONAL INFORMATION

Stationary alpha-spectrometer СКС-07(09)П-А is put in the RF Register

REFERENCES

http://www.greenstar.ru/

Accounting (DA Equipment): Alpha Spectrometer

2

Multi channel alpha-spectrometer

MODEL: СЭАМ-1К

SUPPLIER: **IFTP**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Alpha Spectrometer
METHOD: Alpha Spectrometry
Passive
MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM: Solution (any form converted to solution)
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: IFTP
MANUFACTURER: IFTP

Four-channel СЭАМ-1К

PURPOSE

The device is designed for the alpha-particles energy distribution measurements. The spectrometer can be used for:
- nuclear material control;
- process control at plant radiochemical laboratories

DESCRIPTION

The operation is based on conversion in the sensitive volume of the detector of the alpha-particle energy to electrical pulses of proportional amplitude produced; this is followed by pulse counting and the analysis using an amplitude-pulse analyzer.
Advantages:
• Independent measurement to 4 samples simultaneously.
• Possibility of effective decontamination.
• Possibility of measurement of samples analyzed during long time without continues pumping air from the vacuum chamber.
• Possibility to carry on measurements of low active samples on minimum “detector-sample” distance.

COMPONENTS

It is possible to deliver one- two-, three, or four-channel spectrometer.
Components of four-channel spectrometer:
• Four independent spectrometric measurement tracts made in NIM construction system, which has the following units:
  - Vacuum chamber
  - Silicon detector
  - Preliminary amplifier
  - Forming amplifier
  - Power supply of detector
  - Control unite with micro-processor
  - Vacuum indicator
• Two plates of two-input ADC in IBM PC constructive form.
• Personal computer
• Vacuum pamper

SPECIFICATIONS

Region of detected energy	4-8 MeV
Energy resolution	from 12 to 75 keV
Sensitive area of detector	from 20 to 2000 mm^2

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.iftp.ru

Accounting (DA Equipment): Alpha Spectrometer

3

Alpha Spectrometer

MODEL: CEA-2K

SUPPLIER:	**IFTP**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Alpha Spectrometer
METHOD:	Alpha Spectrometry Passive
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	IFTP
MANUFACTURER:	IFTP

PURPOSE

The device is designed for the alpha-particles energy distribution measurements and qualitative and quantitative analysis of water and nitric solutions containing the alpha radiating nuclides.

DESCRIPTION

The operation is based on conversion in the sensitive volume of the detector of the alpha-particle energy to electrical pulses of proportional amplitude produced; this is followed by pulse counting and the analysis using an amplitude-pulse analyzer.

COMPONENTS

- Alpha-radiation detection unit
- Processor of pulse signals like SBS
- Generator of test pulses
- Personal computer

SPECIFICATIONS

Sensitive of detection	no less than 3E-4 Bq^-1 ×cm³ • s^-1
Absolute energy resolution of spectrometer on line of 5156,7 keV from sample solution of radionuclide Pu-239	no more than 60 keV

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.iftp.ru

Accounting (DA Equipment): Alpha Spectrometer

4

Integrated alpha spectrometer

MODEL: Alpha Analyst

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Alpha Spectrometer
METHOD:	Alpha Spectrometry Passive
MEASURED PROPERTIES:	Alpha spectra
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Alpha spectrometer is designed for simultaneous measurement of several samples

DESCRIPTION

Alpha Analyst is a fully software controlled alpha spectrometer connected to computer with standard network adapter and vacuum system. To begin operation, it is only required to install detectors in chambers, connect spectrometer to the pump or vacuum line and to the control computer with Genie-2000 software installed.

COMPONENTS

Each spectrometer module contains:
- two chambers of low background stainless steel with detectors (PIPS detectors of Series A are recommended),
- amplifiers,
- ADC,
- power supply,
- test pulse generator,
- vacuum valves control system.

Minimal number of inputs for desktop device - 2, maximal - 12.
Up to 4 devices can be combined in single compartment of industrial standard, the systems with large number of inputs can be made by connecting several compartments to local network.
Desktop device case houses common power supply unit and interface. Device is connected to control computer via ETHERNET (50Ω coax cable).
Auxiliary equipment:
- bar code scanner,
- single port filter with cartridge,
- mixed alpha standard,
- flanged adapter

SPECIFICATIONS

(for twin alpha spectrometer with PIPS 450-20AM detector)

Vacuum chambers	8.26×6.03×6.35 cm
Maximum sample size	up to 51 mm diameter
Sample to detector spacing	1 to 45 mm in increments of 4 mm
Maximum detector size	1200 mm²
Vacuum range	0 to >26.7 kPa (0 to >200 millimeter of mercury)
Bias supply	from 0 to 100 V, in increments of 1V
Test pulse generator frequency	40.96 MHz
Measurement range	from 0 to 10 MeV
Energy resolution	<20 keV for sample-to-detector spacing equal detector diameter
Detector efficiency	>25% for sample-to-detector spacing of less than 10 mm
Background	<1 count/hour for energy above 3 MeV
Power (selectable from)	nominal 100, 120, 230, 240 V, 47-63 Hz
Operating temperature	from 0 to 50 ˚C
Relative humidity	up to 95%, non-condensing
Overall size	52.1×43.8×65.4 cm (desktop device)
Weight	63.5 kg (for 7200-12 model with six twin alpha spectrometric modules)

SOFTWARE

Operation with Alpha Analyst requires the AASW-2K software package including:

ADDITIONAL INFORMATION

model (multi-input version)
- Genie-2000 software for measurement quality assurance of S505 model
- Genie-2000 software for interactive peak fitting of S509 model

- Genie-2000 software for alpha spectra analysis of S509 model
- Alpha Analyst management software of S570 model

Installation, calibration, personnel training services are provided at purchase

REFERENCES

http://www.canberra.com

Accounting (DA Equipment): Alpha Spectrometer

Alpha spectrometer

MODEL: 7401

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Alpha Spectrometer
METHOD:	Alpha Spectrometry Passive
MEASURED PROPERTIES:	Alpha spectra
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Spectrometer is designed for operation in NIM standard systems

DESCRIPTION

7401 Module is single-input alpha spectrometer able to be connected to any multichannel analyzer with built-in ADC. Due to the built-in low level discriminator and scaler the module can be used without analyzer for measurements in radiometric mode. Module can be supplied with additional block of sample counting plate bias supply in order to reduce the background. PIPS detectors of A Series are recommended for use with Canberra 7401 Modules.

COMPONENTS

7401 Module includes:
- vacuum chamber,
- preamplifier,
- amplifier,
- detector bias supply
- test pulse generator
- discriminator
- built-in counter/timer
- digital display

SPECIFICATIONS

Measured sample size	diameter of up to 51 mm
Reproducible sample to detector spacing	1 to 49 mm, in increments of 4 mm
Maximal detector size	1200 mm²
Operating temperature	from 0 to 50 ˚C
Overall size	6.86 × 22.12 cm
Weight	2.5 kg (net); 3.3 kg (gross)
Vacuum chamber	8.16×6.03×6.5 cm (height, width, depth)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (DA Equipment): Alpha Spectrometer

6

Alpha Spectroscopy Workstation

MODEL: Octête-PLUS

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Alpha Spectrometer
METHOD:	Alpha Spectrometry Passive
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Measurement of alpha emitting samples

DESCRIPTION

Octete-PLUS provides fully integrated control for eight internal alpha spectrometers plus an additional eight external spectrometers — including direct, transparent support for the TC-256, 7401, and 7404 spectrometers, as well as those from other manufacturers.

COMPONENTS

The OctetePLUS contains eight identical alpha spectroscopy channels with an eight-input multichannel buffer. Each alpha spectroscopy channel includes:
- vacuum chamber with independent vacuum gauge,
- variable detector bias supply (switchable positive or negative),
- preamplifier,
- shaping amplifier with adjustable gain,
- test pulse generator with variable amplitude,
- leakage current monitor.
- BU-017-450-100 ULTRA™ Series detector with Am-241 point source

The OctetePLUS may be either rack mounted or left in the tabletop mounting enclosure in which it is supplied.

SPECIFICATIONS

Maximum sample size	51 mm (2.030 in.)
Maximum sample-to-detector spacing	44 mm, in increments of 4 mm
Maximum detector size	1200 mm^2
Vacuum control	from 10 mTorr to 30 Torr
Energy resolution	≤20 keV (FWHM) with a detector-to-source spacing equal to the detector diameter
Detector efficiency	≥25% for detector-to-source spacing of less than 10 mm
Background	≤1 count/hour, above 3 MeV

SOFTWARE

Acquisition, analysis, and QA control from the world's most complete, Windows-platform 32-bit software, AlphaVision-32.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (DA Equipment): Alpha Spectrometer

7

Alpha Spectrometer

MODEL: SOLOIST

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Alpha Spectrometer
METHOD:	Alpha Spectrometry Passive
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

The SOLOIST is an integrated spectrometer for measuring low-activity samples that decay by alpha-particle emission.

DESCRIPTION

COMPONENTS

Consists of NIM-standard double-width module that includes:
- vacuum chamber,
- sample changer,
- ULTRA-AS detector (active area - 300, 450, 600, 900, or 1200 mm^2),
- bias supply,
- preamplifier,
- amplifiers,
- calibration pulser

SPECIFICATIONS

Maximum sample size	51 mm (2.030 in.)
Maximum sample-to-detector spacing	44 mm
Maximum detector size	1200 mm^2
Energy ranges:	
biased amplifier (ENERGY) output	3 to 8 MeV, 4 to 7 MeV, 3 to 5 MeV, 4 to 6 MeV, 5 to 7 MeV, and 6 to 8 MeV
linear amplifier output (LIN AMP OUT)	0 to 10 MeV
Integral nonlinearity	<±0.1% of full scale in each energy range
Energy resolution	<20 kev
Detector efficiency	>25% for a detector-to-source spacing <10 mm and a Am-241 point source
Background	<24 counts in 24 hours above 3 MeV
Weight:	
net	2.4 kg (5.2 lb)
shipping	3.3 kg (7.3 lb)
Dimensions:	NIM-standard, doublewidth module 6.90 x 22.13 cm (2.70 x 8.714 in.) front panel per DOE/ER-0457T

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (DA Equipment): Coulometer

8

Coulometric installation

MODEL: ПИК-200

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Coulometer
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

The coulometer is designed for the selective determination of the main material components in different conditions. This can be used for MC&A applications for the accurate determination of the actinides content

DESCRIPTION

COMPONENTS

- Potentiostat
- Support ShL-08
- Magnetic Stir MM-02 (with 2 activators)
- Service unit MS-08
- Multimeter HP34401A
- Counter HP 53131A
- Personal Computer
- Electrolytic cell
- Cables (a set)
- Software CPCLab 2004
- Documentation (Guide for user. Guide for operator. Method of control testing for PIK-200. Passport.)

SPECIFICATIONS

Electrolytic cell:

area of platinum grid electrodes	100 cm^2
working volume	20 ml
resistance between a working and auxiliary electrodes in a 1 N mineral acids solution	no more than 30 Ohm
maximum current at working electrode	1 A
time constant	50 sec

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля Каталог 2005, ПО «Маяк»/Catalog of equipment, “Mayak”

Accounting (DA Equipment): Mass Spectrometer

9

Specialized mass-spectrometer for isotopic analysis of uranium hexafluoride

MODEL: МТИ-350Г

SUPPLIER: **UEIP**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Mass Spectrometer
METHOD: Mass Spectrometry
MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U
PHYSICAL FORM(S) OF NM: Gas(Any form converted to UF6 gas)
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: UEIP
MANUFACTURER: UEIP

PURPOSE

Mass-spectrometer MTI-350G is created for automatic control of isotopic content of uranium hexafluoride.

DESCRIPTION

Mass- spectrometer MTI-350G is created for automatic control of isotopic content of uranium hexafluoride.
Precision measurement of uranium isotopic content is carried on automatically and in correspondence with indigenous and international standards.

COMPONENTS

SPECIFICATIONS

```
Relative standard deviation for single measurement of isotopic content of uranium
hexafluoride is no more than:
       ±0,02% for uranium-235 content in range of 1 to 5%
       ±1,0% for U-234, U-236 content in range of 0.005 to 0.05%
```

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №23457-02

REFERENCES

UEIP advertising material/Рекламный проспект ФГУП «УЭХК»

Accounting (DA Equipment): Mass Spectrometer

10

High Resolution Multi Collector ICP-MS

MODEL: Nu Plasma 1700

SUPPLIER: **Nu Instruments Ltd**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Mass Spectrometer
METHOD: ICP Mass Spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Nu Instruments Ltd
MANUFACTURER: Nu Instruments Ltd

PURPOSE

The instrument was developed for isotope ratio measurements with high resolution.

DESCRIPTION

The instrument has been designed with a high dispersion and large geometry to provide a no compromise high resolution capability whilst still maintaining flat top peaks for high precision measurements with minimal loss in sensitivity.

COMPONENTS

• a single 750-mm radius, 70-degree magnet, combined with a 943-mm radius, 70-degree ESA, to provide a double focusing arrangement
• sixteen Faraday detectors; ten incorporated in a fixed central array and three each to the low and high mass side which are adjustable from outside the vacuum housing permitting simultaneous recording of ion beams of high dispersion
• Multiple Ion-Counting System with optional High Abundance Sensitivity Filter
• independent computer controlled adjustable slits positioned in front of all detectors, allow movement in width and central position providing perfect alignment of the peaks of interest
• fully adjustable source defining slit and selectable alpha slit allow maximum transmission for desired resolution
• Failsafe Vacuum System, using three turbo molecular pumps and five ion pumps for vacuum integrity

SPECIFICATIONS

SOFTWARE

Multi-tasking Windows based software with instrument tune-up, full system monitoring, analysis programs, flexible data

ADDITIONAL INFORMATION

REFERENCES

http://www.nu-ins.com

Accounting (DA Equipment): Mass Spectrometer

11

Glow Discharge Mass Spectrometer

MODEL: Finnigan ELEMENT GD

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Mass Spectrometer
METHOD:	ICP Mass Spectrometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solids
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Finnigan
MANUFACTURER:	Thermo Scientific

PURPOSE

The Finnigan ELEMENT GD is designed for the direct analysis of conductive materials. Almost all elements present in a solid sample, including carbon, oxygen and nitrogen can be detected and routinely quantified. Many elements can be analyzed down to the ppt (parts per trillion) range

DESCRIPTION

The Finnigan ELEMENT GD is a combination of a glow discharge ion source with a high resolution mass spectrometer. The sample itself is placed in a vacuum chamber, completely eliminating any risk of leak between the sample and the GD cell. The sample holder can quickly and easily be removed from the ion source, simply unloaded and re-loaded, and repositioned for the next measurement. Opening and closing of the ion source manifold is fully automatic.
A glow discharge occurs when a potential difference is applied between two electrodes in a cell filled with gas (in most cases Ar) at reduced pressure. In a configuration for elemental analysis the sample acts as the cathode, and its surface is sputtered by impacting gas ions. The sputtered neutral atoms are ionized downstream in the plasma.

COMPONENTS

- Glow Discharge ion source
- double focusing mass spectrometer/analyzer
- magnitude automatic detection system:
  - dual mode secondary electron multiplier (SEM)
  - Faraday collector

SPECIFICATIONS

Sensitivity (peak height, total ion current)	>1E+10 cps, 1.6E-9 A for copper in medium resulution (R ≥ 4000)
Dark Noise	< 0.2 cps
Dynamic Range	>1E+12 linear with automatic cross calibration
Minimum integration times:	
counting mode	0.1 ms
analog mode	1 ms
Faraday mode	1 ms
Mass Resolution (3 fixed resolutions)	≥ 300; ≥ 4.000; ≥ 10.000
Resolution Switching Times	< 1 s
Mass Stability	25 ppm / 8 hour
Scan Speed (magnetic)	< 150 ms from m/z 7 to 238 to 7
Scan Speed (electric)	1 ms/jump, independent of mass range
Power	3-phase, 230/400 V ± 10 %, 50/60 Hz fused 32 A per phase
Power Consumption	max. 8 kVA
Operating temperature	18 to 24 °C (64 - 75 °F)
Humidity	50 - 60 %, non-condensing, non-corrosive

SOFTWARE

The software is based upon that used in the Finnigan ELEMENT High Resolution ICP-MS, using Microsoft Windows XP

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/finnigan

Accounting (DA Equipment): Mass Spectrometer

12

High Resolution Multicollector Mass Spectrometer

MODEL: Finnigan TRITON

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Mass Spectrometer
METHOD:	Thermal ionization mass spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, impurities
PHYSICAL FORM(S) OF NM:	Solids
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Finnigan
MANUFACTURER:	Thermo Scientific

PURPOSE

The Finnigan TRITON is desifned for precisive isotope ratio measurements on solid samples. Typical applications are dating of geological samples as well as control of isotopic compositions of nuclear materials.

DESCRIPTION

Spectrometer uses a thermal ionization source and variable multicollector platform which can be configured with Faraday detectors and/or miniaturized ion counting detectors for smallest sample sizes.
The TRITON is the first system built on Thermo Electron's new multicollector platform. The second member of the product family is the Finnigan NEPTUNE, a multicollector ICP-MS.

COMPONENTS

- thermal ionization source
- multicollector containing up to 9 Faraday detectors and/or 8 miniaturized ion counting detectors
- metal sealed vacuum system

SPECIFICATIONS

Mass Resolution (10% valley)	>450
Mass Range	3 to 310
Acceleration voltage	10 kV for positive and negative ions
Abundance sensitivity (U-238 ± 1 u)	<2 ppm in the focal plane of the mass analyzer, < 20 ppb on RPQ channel
Simultaneous collector mass range	17 %, i.e. Li-6 and Li-7
Amplifier noise	< 0.2 fA rms @ 4s integration time
Inter-channel calibration stability	< 10 ppm within 24 h, < 1 ppm with virtual amplifier mode
Basic system specification	5 ppm external reproducibility for Nd and Sr

SOFTWARE

The Finnigan TRITON software package contain following program modules:

ADDITIONAL INFORMATION nd select cup configurations

• Method editor to set up user-defined measurement procedures
• On-line and off-line data evaluation packages including statistical capabilities and display of the results in spreadsheet or graphical form
• Sequence editor for automatic, unattended acquisition and evaluation of samples including sample/standard bracketing and blank substraction
• Automated report generation of analytical results
The software allows the data system to be easily connected to a network, enabling data transfer and remote control of the instrument.

REFERENCES

http://www.thermo.com/finnigan

Accounting (DA Equipment): Mass Spectrometer

13

High Resolution Multicollector Mass Spectrometer

MODEL: Neptune

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Mass Spectrometer
METHOD:	ICP Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, impurities
PHYSICAL FORM(S) OF NM:	Solids
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Finnigan
MANUFACTURER:	Thermo Scientific

PURPOSE

Mass spectrometer performs precision isotope ratio measurements.

DESCRIPTION

The system incorporates the features of the TRITON analyzer and the the ELEMENT2 plasma interface, which provide the basis for powerful MC-ICP-MS.

COMPONENTS

- inductively coupled plasma source with double focusing
- multicollector
- metal sealed vacuum system

SPECIFICATIONS

SOFTWARE

The Finnigan NEPTUNE software package includes following program modules:

ADDITIONAL INFORMATION nd select cup configurations

• Method editor to set up user-defined measurement procedures
• On-line and off-line data evaluation packages including statistical capabilities and display of the results in spreadsheet or graphical form
• Sequence editor for automatic, unattended acquisition and evaluation of samples including sample/standard bracketing and blank substraction
• Automated report generation of analytical results

The software allows the data system to be easily connected to a network, enabling data transfer and remote control of the instrument.

REFERENCES

http://www.thermo.com/finnigan

Accounting (DA Equipment): Optical Emission Spectrometer

14

Multi-channel emission spectra analyzer

MODEL: МАЭС-10

SUPPLIER: **VMK-Optoelectronika, Ltd.**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Optical Emission Spectrometer
METHOD: Optical Emission Spectrometry

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Any form
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: VMK-Optoelectronika, Ltd.
MANUFACTURER: VMK-Optoelectronika, Ltd.

PURPOSE

The installation measures intensivity of spectral lines and calculates concentration of analyzed materials.

DESCRIPTION

Multi-channel emission spectra analyzers, МАЭС-10 allows to analyze a lot of examples with high precisions.

COMPONENTS

SPECIFICATIONS

Spectral region of sensitivity	from 160 to 1100 nmeter
Relative standard deviation for output signal	0.1%
Relative standard deviation for spectral line	3%

SOFTWARE

Software “ATOM” provides atomic emission analysis, processes spectra, calculates graduate curves in any coordinates, aduate curves, results of analysis and intermediate experimental data. Users-analysts can simultaneously have information regarding macro components of investigated matter as well as about element content at clarcs level, ss well as to perform scintillation analysis which can provides information regarding form in which element is presented in the sample.

ADDITIONAL INFORMATION

RF Register, №21013-01

REFERENCES

http://www.vmk.ru/

Accounting (DA Equipment): pH-meter

15

Portable pH-meter

MODEL: pH-410

SUPPLIER: **Aquilon, SPC**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: pH-meter
METHOD: Conductivity measurement

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Solution
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Aquilon, SPC
MANUFACTURER: Aquilon, SPC

PURPOSE

PH- meter is created to measure the activity of hydrogen ions (pH), oxidized-reduced potential (Eh) and temperature in solutions, drinking water, food products and raw products, background object and industry systems of monitoring technological processes.

DESCRIPTION

The device is based on direct dependence of electrical conductivity of solution (electric current in constant electrical field, created of electrodes of the device) from concentration of dissolved compounds.

COMPONENTS

SPECIFICATIONS

Range of measurement of pH, units of pH	from 0 to 14
Discrepancy of measurement of pH, units of pH	0.01
Range of measurement of voltage, mV	from -1999 to +1999
Discrepancy of measurement of voltage, mV:	
in range from 0 to ± 999,9	0.1
in range from ± 1000 to ± 1999	1
Range of measurement of temperature, °C	от -10 до 100
Discrepancy of measurement of temperature, °C	0.1
Limit of permissible main absolute error of:	
measurement of pH, units of pH	0.01
measurement of voltage, mV	1
measurement of temperature, °C	2
Mass, g	320
Overall size, mm	183x84x55

SOFTWARE

ADDITIONAL INFORMATION

Put in the RF Register

REFERENCES

http://www.aquilab.ru

Accounting (DA Equipment): pH-meter

16

Microprocessor-based pH-meter – ions meter

MODEL: И-500

SUPPLIER:	**Aquilon, SPC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	pH-meter
METHOD:	Conductivity measurement
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Aquilon, SPC
MANUFACTURER:	Aquilon, SPC

PURPOSE

Microprocessor-based pH-meter – ions meter И-500 is created to measure the activity of hydrogen ions (pH), oxidized-reduced potential (Eh), concentration (activity) of ions: F-, Br -, Cl -, I -, NO3-, S2-, K+, Na+, Ag+, NH4+, Ca2+ and other, as well as for potentialmetric titration when the device is equipped with additional units.

DESCRIPTION

The device is based on direct dependence of electrical conductivity of solution (electric current in constant electrical field, created of electrodes of the device) from concentration of dissolved compounds.

COMPONENTS

SPECIFICATIONS

Range of measurement of pH, units of pH	from -0,5 to 14
Range of measurement of voltage, mV	from -2000 to +2000
Range of measurement of concentration in solution	from 3E-8 to 5E-1 Mol/l
Limit of permissible main absolute error of:	
measurement of pH, units of pH	0.01
measurement of voltage, mV	0.7
measurement of concentration	2 - for ions with valency of 1 5 -for ions with valency of 2

SOFTWARE

ADDITIONAL INFORMATION

Put in to RF Register

REFERENCES

http://www.aquilab.ru

Accounting (DA Equipment): pH-meter, ionometer, conductometer

17

Instruments for electrochemical measurements

MODEL: Seven

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	pH-meter, ionometer, conductometer
METHOD:	potentiometry, conductometry
MEASURED PROPERTIES:	pH, concentration, specific electroconductivity, concentration of dissolved oxygen
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

Combined meters of Seven series are intended for measuring pH, specific electroconductivity, concentration of dissolved oxygen, and concentration of ions in different liquids with simultaneous temperature measurement.

DESCRIPTION

The operational principles of instruments for pH and ion concentration is based on measurement of potentials from sensing devices (electrodes). Measurement of specific electroconductivity (SEC) is based on resistance measurement between the electrodes of sensing device (SEC sensor). Measurement of dissolved oxygen concentration is based on measurement of current intensity within electrochemical cell of the sensing device (sensor). Instrument consists of secondary and primary (sensing device) transducers. Secondary transducer is a microprocessor unit with LCD and membrane keyboard. Depending on modification, the instrument operates from four AA batteries or accumulators, or network adapter. Microprocessor software controls the instrument operation including calibration, concentration indication in different units, diagnosts instrument status, its electrode system condition, sensor and batteries condition. Signal can be received both from temperature converter built-in sensing device, and autonomous temperature gage. Software allows for temperature compensation of pH measurement results, reduction of SEC measurement results to +20 or +25 ˚C, and temperature and barometric correction of dissolved oxygen concentration measurement results. Instruments and be connected to PC, printer and other external devices with RS232 (standard) or USB (optional) interfaces. Communication TTL module allows to connect the automated sample changer Rondolino.
Additional electrodes and sensors allows for instrument use in different conditions and for wide sample range.

COMPONENTS

SPECIFICATIONS

pH measurement range	-2.000 … 19.999
Conducticity measurement range	0.01 µrOhm/cm … 1000 mrOhm/cm
Ion concentration measurement range	1x10^-7 to 1x10^0 mole/l
Dissolved oxygen concentration measurement range	0.00 … 99.00 mg/l
Temperature measurement range	-5.0 … 130.0 ˚C

SOFTWARE

Special LabX pH software for operation with all instruments of Seven series controls the instruments via RS232, USB, or IR- …nMulti instruments. It allows for simultaneous measurement and data transfer from one or two SevenMulti channels, data export to EXEL, and printing the measurement results according to GLP.

ADDITIONAL INFORMATION

REFERENCES

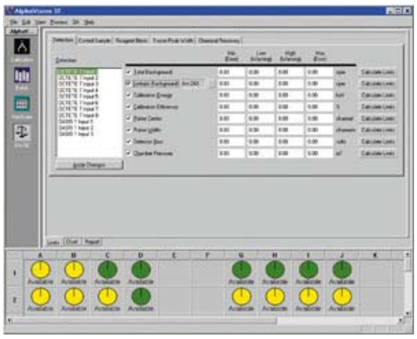
http://www.mtrus.com

Accounting (DA Equipment): Software

18

Alpha Spectroscopy Data Management and Analysis Software AlphaVision®-32

MODEL: A36-B32 V5.3



SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Software
METHOD:	Alpha Spectrometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu, T
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

AlphaVision-32 V5.3 is an analysis software for alpha spectroscopy in the "production environment".

DESCRIPTION

AlphaVision-32 V5.3 provides the following built-in analysis capabilities:
• Region-of-Interest (ROI) or peak search and fit spectrum analysis
• Interactive or "production" analysis modes
• Internal or external tracers; No-tracer analyses
• Sample and tracer decay corrections
• Tracer contamination correction
• Background analyses with blank subtraction option
• Choice of Flexible Detection Limit Formalisms
• Detector quality control analyses
• Process quality control analyses
• User defined sample analyses
• Flexible Calibrations with Calibration Explorer for easy review

The region-of-interest (ROI) analysis technique is the primary method for spectrum analysis when the peak locations and shapes are well-known and reproducible. This analysis technique provides integration of counts between a start and end channel and includes user options for background count subtraction and peak location (calibration) adjustment based on tracer peak location and width. ROI’s may be specified in energy or in channels.

AlphaVision-32 V5.3 offers a choice of peak search and fit algorithms. The methods enable deconvolution and analysis of complex spectra with accuracy and reliability. There are two peak search algorithms to choose from: Mariscotti 2nd Derivative and Top-Hat Correlation. In addition, a library-driven peak fit technique adds user (library) provided nuclide information to assist in the most complex deconvolutions.

Interactive Spectral Analysis mode allows an easy way to modify regions of interest and update analysis results.

Once the peak area has been determined, either via ROI analysis or as a result of the peak search (library search) techniques, the sample activity is calculated using one of two methods: Absolute Analysis (With the detector efficiency known, the sample activity is calculated directly from the analyte peak areas, with no correction for an internal tracer. Manual chemical recovery values, (i.e., from an external tracer), can be added by the user) or Relative or "Tracer" Analysis (Using the relative analysis technique, the sample results are modified by the ratio of tracer activity found to the tracer activity added. This calculation is performed concurrently with the analysis and is completely automatic. Chemical recovery values can be tracked by the built-in QA features, and tracer contaminants which may affect analyte results can be automatically subtracted during the analysis. Tracer analysis options include Internal or External (non-alpha-emitting) tracers, corrections for tracer contamination and tracer decay. Multiple dilution options are provided to allow for flexibility when tracer and sample are mixed and in what way. (aliquot or total)).

AlphaVision-32 V5.3 includes the capability for Minimum Detectable Activity (MDA) and Critical Level (Lc) calculations using (user selectable) background or batch blank options. The user can select a default ANSI N13.30 equation or choose the general Currie equation for estimating the detection limits.

AlphaVision-32 V5.3 provides energy and efficiency calibrations, based upon calibration standards. The calibration process may be done interactively (a manual calibration), or automated according to user needs.

COMPONENTS

SPECIFICATIONS

Number of detectors controlled	up to 256 detectors
MCB supported	any ORTEC MCB (Recommended MCB's include: 920-8, 920-16, 920E, OCTÊTE-PC, and OCTÊTE-Plus); alpha chambers 576A, 676, AlphaKing, Soloist, TC256, Canberra 7401/7404, Oxford Oasis
Operating system	Windows 2000 or XP

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (DA Equipment): Spectrophotometer

19

Spectrophotometer

MODEL: СФ-2000

SUPPLIER:	**Spectr**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Spectrophotometer
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Liquid samples
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Spectr
MANUFACTURER:	Spectr

PURPOSE

Spectrophotometer is used for the determination of atomic and molecular concentration. For MC&A applications it is utilized for U or Pu content measurement in a variety of nuclear materials.

DESCRIPTION

Spectrophotometer СФ-2000 is indended for substitution of obsolete models of СФ (СФ-26, СФ-46) or Specord increasing working efficiency because of automation analysis of till 9 samples per one click of button.
This device operation is based on the measurement of ultraviolet and visible light absorption by atoms or molecules.

COMPONENTS

SPECIFICATIONS

Spectral measurement range, nm	200-1000
Minimum permissible spectral interval, nm in spectral range:	
from 200 to 390 nm	1.0
from 390 to 1100 nm	4.0
Error of setting wavelengths, nm: in spectral range:	
from 200 to 390 nm	±0.4
from 390 to 1100 nm	±1.6

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №18212-00

REFERENCES

http: //www.okb-spectr.spb.ru

Accounting (DA Equipment): Spectrophotometer

20

Spectrophotometer

MODEL: СФ-56

SUPPLIER:	**Spectr**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Spectrophotometer
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Liquid samples
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Spectr
MANUFACTURER:	Spectr

PURPOSE

Spectrophotometer is used for the determination of atomic and molecular concentration. For MC&A applications it is utilized for U or Pu content measurement in a variety of nuclear materials.

DESCRIPTION

Spectrophotometer СФ-56 is constructed based on classic scheme of scanning, permits fulfill unitary and multiple scanning specified parts of spectrum. The device has large dynamic measurement range, high accuracy and precision of results, is simple and friendly for user in operation. Spectrophotometer СФ-56 can be equipped by attachments of mirror reflection (model ПЗО) and diffusion reflection (model ПДО-6).
Automated cavity section permit to install simultaneously to 5 investigated samples with length from 10 to 50 mm.

COMPONENTS

SPECIFICATIONS

Spectral measurement range, nm	190-1100
Main absolute error of measured transmitting efficiencies in range of 400-750 nm, for transmitting efficiencies of 30 - 100%	±0.5%

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №12862-91

REFERENCES

http: //www.okb-spectr.spb.ru

Accounting (DA Equipment): Spectrophotometer

21

Spectrophotometer

MODEL: СФ-103

SUPPLIER:	**Aquilon, SPC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Spectrophotometer
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Liquid samples
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Aquilon, SPC
MANUFACTURER:	Aquilon, SPC

PURPOSE

Spectrophotometer is used for the determination of atomic and molecular concentration. For MC&A applications it is utilized for U or Pu content measurement in a variety of nuclear materials.

DESCRIPTION

Spectrophotometer СФ-103 – single-beam scanning spectrophotometer with expended spectral range in ultra-violet and visual area of wave lengths, with auto sampler for 8 cavities.

COMPONENTS

SPECIFICATIONS

Spectral range of wave lengths, nm	190-1100
Step of setting wave length, nm	0.1
Accuracy of setting wave length in the total range, nm	±1
Width of selected spectral interval, nm	5

SOFTWARE

ADDITIONAL INFORMATION

Spectrophotometer СФ-103 is put in the RF Register.

REFERENCES

http://www.aquilab.ru

Accounting (DA Equipment): Spectrophotometer

22

Spectrophotometer

MODEL: СФ-201

SUPPLIER:	**Aquilon, SPC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Spectrophotometer
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Liquid samples
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Aquilon, SPC
MANUFACTURER:	Aquilon, SPC

PURPOSE

Spectrophotometer is used for the determination of atomic and molecular concentration. For MC&A applications it is utilized for U or Pu content measurement in a variety of nuclear materials.

DESCRIPTION

Spectrophotometer СФ-201 – scanning spectrophotometer of extended precision with spectral range in ultra-violet and visual areas of wavelengths.
Measurement results are kept in memory of spectrophotometer, external computer or in flashcard. Control can be managed using keyboard of the device, computer mouse, computer including network.

COMPONENTS

SPECIFICATIONS

Spectral range of wave lengths, nm	190-1100
Step of setting wave length, nm	0.1
Accuracy of setting wave length in the total range, nm	±1
Width of selected spectral interval, nm	5

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.aquilab.ru

Accounting (DA Equipment): Spectrophotometer

23

Atomic-absorption spectrophotometer

MODEL: АНАЛИТИК 2000

SUPPLIER: **UEMP**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Spectrophotometer
METHOD: Spectrophotometry

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Liquid samples
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: UEMP
MANUFACTURER: UEMP

PURPOSE

Spectrophotometer is used for the determination of atomic and molecular concentration. For MC&A applications it is utilized for U or Pu content measurement in a variety of nuclear materials.

DESCRIPTION

The device is created for qualitative determination of metal content in solutions or in other samples preliminary converted in solution. Spectrophotometers is a one-beam device having the mirror optics with proof from aggressive medium and scanning monochromator .

COMPONENTS

SPECIFICATIONS

Monochromator focal distance	260 mm
Working wave length range	from 195 to 600 nm

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.uemz.ru

Accounting (DA Equipment): Titrimeter

24

Coulometric Titrimeter

MODEL: ЭКСПЕРТ-006

SUPPLIER:	**Econics-Expert, Ltd.**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Titrimeter
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Econics-Expert, Ltd.
MANUFACTURER:	Econics-Expert, Ltd.

PURPOSE

Universal high precision coulometer for wide area of chemical-analytical tasks for determination of mass of substance, contained in solution in form of ions, complex compounds, neutral molecules and other electro active compounds.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

```
Limits of main permissible error of the analyzer used
 complex pH-electrode as an indicating electrode                    ± 2,0%
```

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №23192-02

REFERENCES

http://www.ionomer.ru

Accounting (DA Equipment): Titrimeter

25

Fisher Titrimeter

MODEL: Эксперт-007

SUPPLIER:	**Econics-Expert, Ltd.**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Titrimeter
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Econics-Expert, Ltd.
MANUFACTURER:	Econics-Expert, Ltd.

PURPOSE

Coulometric Fisher Titrimeter “Эксперт-007” is created for quantitative determination of water mass contained in liquids, gases and solid substances, by GOST 24614-81 and Attachments to this GOST.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Ranges of titrating current	50 mA and 5 mA
Ranges of water detection	100 mg and 10 mg
Reduced relative error	± 2%

SOFTWARE

ADDITIONAL INFORMATION

RF Register, № 24170-02

REFERENCES

http://www.ionomer.ru

Accounting (DA Equipment): Titrimeter

26

Titrator

MODEL: АТП-01

SUPPLIER:	**Aquilon, SPC**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Titrimeter
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Aquilon, SPC
MANUFACTURER:	Aquilon, SPC

PURPOSE

The device is intended for laboratories with average throughput and used for implementation of different methods of titration.

DESCRIPTION

Titrimeter АТП-01 – universal semiautomatic complex consisting of functionally combined numeric burette АТП-1Д, ions meter И-500 and software of gathering and processing experimental data «Titrate-1.1».
Delivery of titrant is made by rotating handle of the titrator. Data automatically are transferred though ions meter to computer (RS-232 port). Numeric burette can be used separately for standard photometric titrations, and ions meter – as an ions meter-pH-meters.

COMPONENTS

SPECIFICATIONS

Measurement ranges:	
voltage, mV	from -2000 to 2000
magnitude pH(pX), units of pH(pX)	from -20 to 20
temperature,°C	from 0 to 100
Main absolute error of measurement:	
voltage, mV	1.0
magnitude pH (pX) for univalent and bivalent ions correspondingly, units of pH(pX)	0.01; 0.02
temperature, °C	1.0

SOFTWARE

Titrator АТП-01 uses software «Titrate-1.1» for measurement data acquisition and processing .

ADDITIONAL INFORMATION

Put in the RF Register

REFERENCES

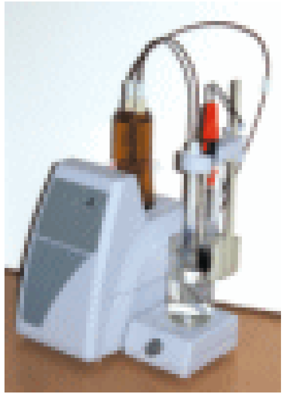
http://www.aquilab.ru

Accounting (DA Equipment): Titrimeter

27

Titrimeter

MODEL: АТП-02



SUPPLIER: **Aquilon, SPC**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Titrimeter
METHOD: Titration

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Any form converted to solution
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Aquilon, SPC
MANUFACTURER: Aquilon, SPC

PURPOSE

DESCRIPTION

Titrimeter APT-02 – fully automatic high accuracy potentialmetric titrator.
The device provides continuous and discrete delivery of titrant (range from 0,1 to 36 ml/minutes – for volume of dosing unit of 20 ml; and from 0,25 to 90 ml/minutes – for volume of dosing unit of 50ml), automatic changing velocity of delivery in accordance with arriving to point of equivalence or a specified point and so on.
The device permits to use the following methods of titration:

- general method of potentiometric titration;
- acid-base titration;
- titration by precipitation method;
- titration by complex creation method and other.

COMPONENTS

SPECIFICATIONS

Measurement ranges:	
voltage, mV	from -2000 to 2000
magnitude pH(pX), units of pH(pX)	from -20 to 20
temperature,°C	from 0 to 100
Main absolute error of measurement:	
voltage, mV	1.0
magnitude pH (pX) for univalent and bivalent ions correspondingly, units of pH(pX)	0.01; 0.02
temperature, °C	1.0

SOFTWARE

Titrator control is performed with software «Titrate-6.0», including software «Исследователь» (Researcher) and «Анализатор

ADDITIONAL INFORMATION ng

- choice of titration method and specifying regime of titration;
- registration and processing of titration curves;
- forming, editing and keeping of techniques (including GOST techniques), protocols and reports of measurements;
- developing new techniques of titration.

Put in the RF Register

REFERENCES

http://www.aquilab.ru

Accounting (DA Equipment): Titrimeter

28

Karl Fisher Titrators

MODEL: Compact: C30, V30

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Titrimeter
METHOD:	Fisher Titration
MEASURED PROPERTIES:	Water Concentration for evaluation in dry substance
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

Left - C30 model, Right - V30 model

PURPOSE

Water Fisher Titirarors of Titration Compact series, C30 and V30, are designed for measuring the weight fraction of water in liwuids, gases and solids.

DESCRIPTION

Device stores 8 standard adopted METTLER TOLEDO methods. In case there are titrants, sensors or pumps available, the METTLER TOLEDO methods can be used for analysis without any modifications. When requiring, these methods can be modified using the special method editor to adapt them to specific user demands.

Titrators include the main unit, the unit of reagent supply or generation and discharge. For coulometric titrator the sample is introduced by syringe or with evaporator for solid samples. In volumetric titrator the sample is poured in titration cell, can be introduced through the evaporator, and the gas sample can be introduced through the tube for gas supply. Main unit controls titration process, selects the titration method, displays the results, stores the information and transfers the information to printer or computer, controls the external devices.

Titrator is controlled via color touch screen that allows for displaying the messages in Russian.

Titrators have a built-in memory. The data stored can be displayed, recorded on USB stick or sent to PC. Analytical balances, drying oven DO308, automated sample changer Stromboli can be connected to titrator via cable junction.

COMPONENTS

C30 (V30) includes:
- titrator with titration cell and electrode
- generating electrode (integrated burette drive and 5 ml burette - for V30)
- magnetic stirrer
- Solvent Kit module for reagent changing
- touch-sensitive terminal for manipulating in Russian
- built-in USB or RS232 interface
- TTL interface for control of external devices

All other necessary components (autosampers, pumps) can by supplied by order.

SPECIFICATIONS

	C series	V series
Measurement range, mg	0.01 - 5%	0.01 - 100%
Allowable relative error limits, %, in the range of:		
0.01 to 1 mg;	± 6.0	± 6.0
more than 1 mg;	± 3.0	± 3.0
Allowable STD limit of titration results, %	1.5	1.5
Burette capacity, ml	-	1, 5, 10, 20
Power supply, V	100-240 V~ ±10 %	100-240 V~ ±10 %
Frequency, Hz	50-60 Hz	50-60 Hz
Power, Wt	35	30
Overall dimensions, mm		
length	210	210
width	340	333
height	312	320
Weight, kg	3.3	4.2
Mean life time, years	10	10
Operating conditions:		
ambient temperature, ˚C	10 …30	5 …40
relative humidity range, %	20…80	20…80

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.mt.com, http://www.mtrus.com

Accounting (DA Equipment): Titrimeter

29

Titrator

MODEL: T90

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (DA Equipment)
DEVICE/METHOD TYPE:	Titrimeter
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

T90 Titrator is automatic titrator replacing T77 model. Among others it performs redox titrations, complexometric titrations, photometric titrations, conductivity titration, pH, ion selective and conductivity measurements, two phase titration, etc.

DESCRIPTION

Over thirty commonly used and well-proven methods are stored as METTLER TOLEDO methods in the instrument. If the resources such as titrants, sensors, or pumps are available, you can use the METTLER TOLEDO methods for analyses just as they are. If desired, you can easily modify these methods using the well-designed method editor so that they can be optimally integrated in your processes.
You can save not only individual methods but also complete sample series as templates. It is even possible to combine different sample series to form a Series Sequence, which is also stored as a Short Cut on the Home Screen. Analyses that consist of several methods and series can be started with one single click. The “if…then” logical conditions allow the instrument to decide how the analysis should proceed. For example, does acid or base have to be added first to satisfy the initial pH conditions? Up to seven additional dosing units ensure that all the necessary resources are available at any time.
Together with the Rondo 60 sample changer, the Titration Excellence line provides very efficient system solutions.
Result buffer allows for method or series-overlapping calculations and synchronization of parallel analyses.

COMPONENTS

T90 consisting of:
- titrator with pH board,
- integrated burette drive,
- magnetic stirrer

All other components needed (control unit, titration stand, etc.) can be ordered as modules

SPECIFICATIONS

Measurement range (potentiometric sensors)	2000 mV
Resolution	0.1 mV
Error limit	0.2 mV
Burette resolution	1/20000 of burette volume
Overall size	210 x 246 x 250 mm (w x d x h)
Weight	4.3 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.mt.com, http://www.mtrus.com

Accounting (DA Equipment): Chromatograph

30

Chromatograph

MODEL: Кристалл 5000

SUPPLIER: **TsvetChrom Ltd.**
USE CATEGORY: Accounting (DA Equipment)
DEVICE/METHOD TYPE: Chromatograph
METHOD: Extraction chromatography

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Solution
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: TsvetChrom Ltd.
MANUFACTURER: TsvetChrom Ltd.

PURPOSE

DESCRIPTION

The device:
- can work with two different types of chromatographic columns: capillary and nozzle;
- used four-channel detecting with automatic distribution of elute flow between detectors;
- can use the full set of detectors;
- works automatically from input of sample, monitoring working parameters – to full processing obtaining information and results of analysis in form of documents;
- has perfect control system.

COMPONENTS

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.tsvet.com

Accounting (DA Methodology): Spectrophotometry

31

ASTM C1307-95: Standard Test Method for Plutonium Assay by Plutonium(III) Diode Array Spectrophotometry

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Plutonium dioxide powders and pellets, nuclear grade mixed oxides, plutonium metal, and plutonium nitrate solutions (solution for assay)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	ASTM

PURPOSE

This test method is used for the determination of total plutonium as Pu(III) in nitrate and chloride solutions. The technique is applicable to solutions of plutonium dioxide powders and pellets, nuclear grade mixed oxides, plutonium metal, and plutonium nitrate solutions (solid samples are dissolved). The applicable concentration range for plutonium sample solutions is 10-200 g Pu/L. This methodology was developed by WSRC.

DESCRIPTION

1. In a diode array spectrophotometric measurement, the substance being determined absorbs light at frequencies characteristic of that substance. The amount of light absorbed at each wavelength is directly proportional to the concentration of the species of interest. The absorption is a function of the oxidation state and the complexation obtained in the solution matrix selected for measurement. Beer's Law permits quantifying the species of interest relative to a traceable standard when both solutions are measured under the same conditions. The array of photosensitive diodes permits the near simultaneous collection of spectral information over the entire range of the instrument, for example, 190-820 nm (or any selected portion of the range). An entire absorption spectrum can be obtained in 0.1 s; however, optimum precision is obtained from multiple spectra collected over a 4-s period.
2. Reduction to plutonium(III) is accomplished by the addition of a measured quantity of reductant solution to the sample aliquant.
2.1 For nitrate solutions, ferrous sulfamate is the recommended reductant. Aliquants (1 mL or less) of the sample solution are diluted with 10 mL of a ferrous reductant/matrix solution to 1 g Pu/L. and measured.
2.2 For chloride solutions, ascorbic acid is the recommended reductant. Aliquants of the sample solution, each containing 50-100 mg of plutonium, are diluted with 2 mL of zirconium solution to complex fluoride ions, 2 mL ascorbic acid reductant solution, and 1.0 M HCl to a total volume of 25 mL yielding 2-4 g Pu/L solutions for measurement.
3. Plutonium concentration is determined from light absorption measurements taken on the sample solution in the blue-green region from 516 to 640 nm where a broad doublet band is observed. Spectral quantifying software capable of fitting the sample spectrum with spectral information from standard solutions is used to calculate the plutonium concentration.
Interferences:
- materials that absorb light in the region of the plutonium absorption
- undissolved solids that cause light scattering
- strong oxidizing or complexing agents that prevent complete reduction of the plutonium to the plutonium(III) oxidation state
- anions that shift the spectrum.

COMPONENTS

Apparatus:
- Diode Array Spectrophotometer (wavelength range 190-820 nm; wavelength accuracy +2 nm; wavelength reproducibility ±0.05 nm; full dynamic range 0.0022 to 3.3)
- Analytical Balance (readability of 0.1 mg)
- Solution Density Meter (readability of 0.1 mg/mL; precision of 0.3 mg/mL)
- Adjustable, Fixed-Volume Pipettes calibrated to deliver the desired range of volumes for sample and matrix-reductant solutions

SPECIFICATIONS

RSD for different matrices	0.15% to 0.20%

SOFTWARE

Both commercially available and custom-designed spectral fitting software have been developed for plutonium

ADDITIONAL INFORMATION

ocedure are responsible for selecting or customizing, or both, the spectral fitting (and instrument control) software that best meets their individual measurement methodology and needs. Software selection will dictate many of the procedural specifics not included in this procedure. The software package selected should include a feature that indicates the quality of spectral fit, thereby providing information on the measurement reliability and the presence

REFERENCES

1. ASTM C1307-95: Standard Test Method for Plutonium Assay by Plutonium(III) Diode Array Spectrophotometry, November 1995.

Accounting (DA Methodology): Coulometry

32

ASTM C1165-90: Standard Test Method for Determining Plutonium by Controlled-Potential Coulometry

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Solution (U, Pu mixture; Pu metal, oxide, etc.)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

This method is used to ascertain whether or not materials meet specifications for plutonium content or plutonium assay, or both. This standard is based on Los Alamos National Laboratory (LANL) techniques.
The determination of milligram quantities of plutonium in unirradiated uranium-plutonium mixed oxide (U/Pu ratio from 0.1 to 10). This method is also applicable to Pu metal, Pu oxide, U-Pu mixed carbide, various plutonium compounds including fluoride and chloride salts and plutonium solutions. Recommended amount of Pu per aliquant is 5 to 10 mg. Precision worsens for aliquants containing less than 5 mg. For amounts exceeding 10 mg, elapsed time of electrolysis becomes impractically large.

DESCRIPTION

Analyte reacts at an electrode having a maintained potential that precludes reactions of as many impurity components as is feasible. In electrolysis, current decreases exponentially as the reaction proceeds until a selected background current is reached. The quantity of analyte reacted is calculable by Faraday's law. A chemical calibration of the coulometer is necessary for accurate results.

Steps:
- obtain reproducible blank measurements on each individual Pt electrode
- initial reduction of Pu and impurity ions in a 0.5M H2SO4 electrolyte at a Pt working electrode maintained at +0.310 V versus a saturated calomel electrode (SCE)
- Pu oxidation to Pu(IV) at a potential of +0.670 V
- calculation of Pu quantity from the number of coulombs required for oxidation according to Faraday's law.

Interferences:
- metal ions that oxidize or reduce at the potential of +0.670 V used for the oxidation of Pu(III) to Pu(IV),
- organic matter,
- anions that complex plutonium,
- oxygen.

COMPONENTS

- Controlled-Potential Coulometer: a potentiostat having stable potential control at approximately 200 mA and 20 V and integrator-capable of 0.05% reproducibility. The linearity of the integrator should be better than 0.1% for the selected range.
- Cell Assembly consisting of: titration cell, counter (Pt) electrode, working (Pt) electrode, reference saturated calomel electrode (SCE), high-silica tubes, stirrer, TFE-fluorocarbon cap, gas inlet.
- Timer or stopwatch for measuring electrolysis times (measurements in seconds).

SPECIFICATIONS

Recommended amount of Pu per aliquant	5 to 10 mg
Estimated repeatability RSD for single aliquant measurement	0.1%
Estimated reproducibility RSD	0.15%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1165-90 (Reapproved 1995): Standard Test Method for Determining Plutonium by Controlled-Potential Coulometry in H2SO4 at a Platinum Working Electrode

Accounting (DA Methodology): XRF

33

ASTM C1254-93: Standard Test Method for Determination of Uranium in Mineral Acids by X-Ray Fluorescence

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	XRF
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solutions
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)
MANUFACTURER:	ASTM

PURPOSE

This test method is valid for aqueous solutions containing 2 to 20 g uranium/L as presented to the spectrometer. Higher concentration may be covered by appropriate dilution. Either wavelength-dispersive or energy-dispersive X-Ray fluorescence systems may be used provided the software accompanying the system is able to accommodate the use of internal standards.

DESCRIPTION

This test method requires the use of an appropriate internal standard (usually either yttrium or strontium). Solution samples containing 2 g/L uranium to 20 g/L uranium and the internal standard are placed in a liquid sample holder of an X-ray spectrometer and exposed to an X-Ray beam capable of exciting the uranium L-alpha emission line and the appropriate emission line for the internal standard (usually the K-alpha line). The intensities generated are measured by an appropriate detector. The intensity ratio values obtained from these data are used to calibrate the X-Ray analyzer.
Measurement Procedure:
- Sample Preparation
   - shake the sample, and pipette an appropriate aliquot into a tared 50-mL volumetric flask
   - obtain the gross weight of the sample and flask
   - add 2 mL of the internal standard solution; dilute to volume with water and mix thoroughly
- Counting the Sample
   - set the X-ray spectrometer according to specifications
   - shake each flask to mix thoroughly and fill the liquid sample cup with the recommended amount of liquid for the instrument in use
   - following manufacturer's instrumental instructions, obtain intensities for the uranium L-alpha line and the internal standard line
   - calculate the uranium concentration in the flask using the appropriate equation.

Precision and Bias:
There is no readily available certified material (uranium dissolved in mineral acid) to test this method. Therefore, a solution of NBL CRM-114 (U_3O_8) was prepared by dissolving approximately 50 g (weighed to the nearest 0.1 mg) and transferring to a tared 1000-mL volumetric flask. This solution was diluted to volume with water, mixed thoroughly and weighed. Aliquots of this solution were prepared by five different technicians and analyzed on two different X-Ray spectrometers over a four-month period. The average of thirty determinations was 0.03923 g uranium per gram solution with a relative standard deviation of 0.53 %. Using the t-test for bias there is no significant bias shown for these data.

COMPONENTS

Apparatus
- X-Ray Spectrometer (this test method is valid for either energy-dispersive or wavelength-dispersive systems)
- Sample Cups
- Solution Dispenser (the dispenser for the internal standard solution should be capable of reproducibly dispensing the internal standard to a level of 0.5 % relative standard deviation of the volume dispensed).

SPECIFICATIONS

```
Recommended sample concentration of U               2 g/L to 20 g/L
SRD for 0.04 g of U/g of solution
                           measurement              0.53%
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1254-93: Standard Test Method for Determination of Uranium in Mineral Acids by X-Ray Fluorescence, February 1994.

Accounting (DA Methodology): Mass Spectrometry

34

ASTM C1380-97: Standard Test Method for Determination of Uranium Content and Isotopic Composition by IDMS

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Element Concentration, Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solid (oxide)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

Determination of the uranium concentration in uranium oxides by isotope dilution mass spectrometry (IDMS). The isotopic composition of the oxide is measured simultaneously.

DESCRIPTION

For the measurement, a representative and accurately measured aliquant of the sample is prepared. Sample weight should be around 0.35 - 0.45 g. Smaller or larger aliquants of the sample may be used. However, the sample size should be sufficient to obtain a representative sample of the material and the ratio of the measured U-233 to major uranium isotope in the material must be >0.02. It is recommended that the samples are prepared in duplicate.

A known quantity of U-233 ("spike") is added to an aliquant of the sample. The sample aliquant and spike are taken to dryness, redissolved in dilute nitric acid, and loaded on a filament for analysis in a thermal ionization mass spectrometer. After measurement of the isotopic ratios in the spiked sample, the uranium content and isotopic composition of the sample are calculated.

COMPONENTS

Apparatus:
- TI MS configured with Faraday cup detectors, an automated operating system, preconditioning unit, and filament loading assembly
- balance, analytical, with five-place range
- automatic pipette, liquid dispenser, and other chemical lab accessories

CRMs:
- NBL CRM 129 (uranium oxide)
- NBL CRM 114 or equivalent (elemental uranium metal)
- NBL CRM 111-A or equivalent (U-233 spike assay and isotopic standard)

SPECIFICATIONS

Recommended sample weight	0.35 - 0.45 g
Filament sample load for TIMS	4 microliters
Average SRD for total U	0.4%
Average SRD for U-235	0.7%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1380-97: Standard Test Method for Determination of Uranium Content and Isotopic Composition by Isotope Dilution Mass Spectrometry, May 1998.

Accounting (DA Methodology): Optical Emission Spectroscopy

35

ASTM E402-95: Standard Test Method for Spectrographic Analysis of Uranium Oxide (U3O8) by Gallium Oxide-Carrier Technique

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Optical Emission Spectroscopy
METHOD:	Optical Emission Spectroscopy
MEASURED PROPERTIES:	Impurity Elements Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Any uranium material convertible to U3O8
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

This test method covers the semiquantitative spectrographic analysis of high-purity U3O8 for 32 elements with combined concentration range of less than 0.5% (quantitative analyses of boron, chromium, iron, magnesium, manganese, nickel, and other impurities can be performed using densitometric methods).
The test method can be applied to those samples of uranium and uranium compounds, or both, which can be converted to the black oxide (U3O8) and which are of approximately 99.5 % purity or better.

DESCRIPTION

Main operational steps:
- the as-received sample is ignited to U3O8 (it is important that the sample be in the same physical oxide form as are the comparison standards)
- the sample is mixed with pure gallium sesquioxide (Ga203) in the ratio of 98 parts U3O8 to 2 parts Ga2O3
- if densitometric determinations are desired, the Ga2O3 used in the mixture contains 1% chromium or 1% cobalt by weight
- the chromium or cobalt is used as an internal standard element in the spectrochemical analysis
- the U3O8-Ga2O3 mixture is placed in a special cupped electrode and excited in a d-c arc. Varying amounts of impurities either in vapor form or as solid particles are carried up into the arc stream, along with the vaporized Ga203, for excitation
- the spectrum is recorded on a photographic plate and the selected lines are either visually compared with standard plates or photometrically measured and compared with synthetically prepared standards according to standard spectrochemical procedures
- standards can be synthesized by adding the impurity elements to purified U308 and homogenizing.

COMPONENTS

Apparatus:
1. Sample Preparation Equipment:
1.1 Sample-Carrier Mixers, either a highly polished agate mortar and pestle, or a clean plastic capsule with a plastic ball and a mechanical mixer
2. Balances, torsion type, with capacities up to 1000 mg, capable of weighing +/- 0.1 mg accurately. When samples are hand ground it may be necessary to have a balance capacity of 2.500 g
3. Muffle Furnace, capable of 1000° C
4. Excitation Source, capable of providing a 14-A d-c arc (short-circuit)
5. Excitation Stand, conventional type with adjustable water cooled electrode holders
6. Spectrograph, grating, providing preexposure and exposure timers, wavelength coverage from 2250 to 8650 A, a reciprocal linear dispersion of at least 5 A/mm and sufficient resolving power to separate cadmium 2288.02 A, from arsenic 2288.12 A
7. Photographic Processing Equipment, to provide developing, fixing, washing, and drying operations
8. Comparator-Microphotometer, as a comparator to provide sufficient magnification and facility to compare spectral line densities of the sample and a reference standard plate or film; as a microphotometer having a precision of +/- 1.0% or better for transmittance values between 5 and 90%
9. PC for transposing percent transmission values into intensity or density values

SPECIFICATIONS

Impurities analyzed:

Sb, Be, Cl, Co, Pb, Ni, K, Na	1 - 200 ppm
Al, Fe, Si	5 - 200 ppm
As, Ba, Cs, F, V, Zn	10 - 200 ppm
Li, Mg, Cu	0.5 - 100 ppm
Bi, Ge, Au, In, Mn, Rb, Sn	1 - 100 ppm
Mo	2 - 100 ppm
Ta	5 - 100 ppm
Ag	0.1 - 50 ppm
Cd	0.1 - 10 ppm
B	0.2 - 10 ppm

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM E402-95: Standard Test Method for Spectrographic Analysis of Uranium Oxide (U_3O_8) by Gallium Oxide-Carrier Technique, March 1995.

Accounting (DA Methodology): Alpha Counting

36

Total Alpha Counting for Plutonium

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Alpha Counting
METHOD:	Alpha Counting
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

This method is applicable for the determination of Pu for a wide range of dissolvable plutonium materials (including waste solutions of high- or low-radioactivity levels) for mass and isotopics measurements in irradiated fuel, specifically for radioactive solutions that require shielding and remote handling.

In general, this method is a very rugged (not very sensitive to impurities, except for alpha emitters); at WSRC it is used for process control, products specification, waste characterization, accountability, and nuclear safety.

DESCRIPTION

Alpha emitters such as Am, Cm, U, and Np interfere, and, if their amounts are not known or cannot be determined, they must be separated from Pu.

Direct method (used when concentration of interfering alpha emitters is known):
- an aliquot of the sample is mounted on a counting disk and the gross alpha activity is determined
- interfering alpha emission is determined and the appropriate adjustments are made.

Method with separation (used when concentration of interfering alpha emitters is not known and chemical separation is required):
- used when interfering alpha emitters are present in the sample and can be removed. After their removal, follow the procedure of alpha counting.

COMPONENTS

Total Alpha
- Tennelec (Oxford) TC257 Spectrometer
- 1700 mm² Oxford IPC detectors
- Tennelec TC 550 Single Channel Analyzer
- GPIB 721 Scaler

SPECIFICATIONS

Duration of measurement (depends on rate; best: 30,000-40,000 counts per measurements, but less than 100,000)	4-10 minutes or less per measurement
Sample concentration range	<0.2 g Pu/L (<20 mCi Pu/L)
Sample weight mounted on plate	0.5 - 1000 nano-gramm Pu (0.05 - 100 nCi Pu)
Accuracy	5 - 25 % @ 95% CI as a function of sample matrix dilution and counting statistics

SOFTWARE

ADDITIONAL INFORMATION

This method can be also used for U-232 (0.6 dpm) provided long counting time is possible.

REFERENCES

1. Supplier/Developer Data - Информации поставщика/разработчика

Accounting (DA Methodology): Titration

37

ASTM C 1235-93a: Standard Test Method for Plutonium by Titanium(III)/Cerium(IV) Titration

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Metal (dissolved)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

This test method is designed to determine the plutonium content of plutonium metal and is applicable to the assay or purity determination of plutonium metal of 98% purity and higher. Uranium and iron are known interferences and must be determined separately. Their respective corrections must then be made to the assay value.
The recommended amount of plutonium determined in the titration is 210 to 240 mg
This method was developed for production support and has distinct advantages when a large number of samples are to be analyzed. It is largely automated, accomplishing a titration approximately every two minutes when optimizing step-wise operations.

DESCRIPTION

In a redox titration, as titrant is added, the change in concentration of the redox couple is monitored. This change in concentration of the redox couple can be monitored by measuring the potential difference between a platinum indicator electrode and a reference electrode (such as a saturated calomel electrode) in contact with the solution or by other equivalent methods of end point determination. The endpoint of the titration is usually chosen to be the point at which the rate of change of concentration of the redox couple is greatest per increment of titrant added. The concentration of analyte is calculated from the volume or mass of titrant added to reach the endpoint, concentration of the titrant, and the mass of the sample titrated.
In this method
- the plutonium in solution is reduced to Pu(III) with titanium (III) chloride,
- excess Ti(III) is destroyed with nitric acid and, finally,
- the reduced plutonium is oxidized to Pu(IV) with ceric titrant using ferrous indicator.

However, this adaptation substitutes a potentiometric endpoint for the indicator endpoint and employs commercial titration instrumentation.
Interferences:
Interferences are caused by any substance that can be reduced by titanium (III) chloride and, subsequently, oxidized by Ce(IV)during the titration. The only elements normally present in high-purity plutonium metal which interfere are iron and uranium. Corrections for these two interferences are based upon iron and uranium content determined by other methods and by stoichiometry of the titration reaction.

COMPONENTS

- Automated Titrator- An instrument capable of delivering titrant and recognizing the redox titration endpoint.(The Mettler DL40 Memotitrator with the DV910 10-mL polypropylene and glass burette with Mettler GA40 or GA-44 printer, available from Mettler Instrument Corp., Box 71, Hightstown, NJ 08520, has been found satisfactory).

Alternatively, a weight burette and millivolt meter could be used for manual titration.
- Combined Electrode or Endpoint Indicator - A combination platinum-calomel reference electrode or appropriate endpoint indicator. (The Mettler DM140 combination platinum ring with calomel reference electrode and 3N KCl filling solution, available from Mettler Instrument Corp., Box 71, Hightstown, NJ 08520, has been found satisfactory).
- Analytical Balance - A calibrated balance having a sensitivity of 0.01 mg for weighing plutonium samples.
- Bottle-Top Dispensers - A variety of fixed volume or adjustable dispensers for delivering reagents to the titration beaker.

SPECIFICATIONS

The recommended amount of plutonium determined in the titration	210 to 240 mg
Relative standard deviation for Pu	0.05%

SOFTWARE

ADDITIONAL INFORMATION

Variations of this method, such as manual titration with visual or photometric endpoint detection, or use of a weight burette would, no doubt, provide quality data, but at the expense of limiting sample throughput.

REFERENCES

1. ASTM C 1235-93a Standard Test Method for Plutonium by Tritium(III)/Cerium(IV) Titration

Accounting (DA Methodology): Mass Spectrometry

38

Inductively Coupled Plasma Mass Spectrometry

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Impurities in pure Pu and U materials
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

In general, this methodology is similar to Thermal Ionization Mass Spectrometer (TIMS). The methodology is very flexible, allows fast analysis, and is applicable to many elements. It is best for element concentration measurements, specifically for impurity analysis (without isotope dilution). Isotope ratio measurements made by this method are not as good as by TIMS and Gas Source mass spectrometers.
At LANL this methodology is in a developmental stage.

DESCRIPTION

COMPONENTS

Mass Spectrometer:
- there are many types of ICP instruments and their manufacturers: Micromass, Finnigan, VG Industries (PlasmaQuad II), and HP
- electron multipliers or Faraday detector.

SPECIFICATIONS

Sensitivity (depending on the element)	from 1 to 5 ppm

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Mass Spectrometry

39

Isotope Dilution Mass Spectrometry for Uranium

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Miscellaneous
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

IDMS methodology is used at LANL for uranium assay. In general, IDMS is applicable to any material that can be dissolved with no limit on concentration. The main advantages: applicable to wide variety of uranium samples and impurities, and uranium concentrations; produces minimal radioactive waste. Used in reprocessing industry (high impurity samples). This methodology provides highest precision analysis (radio-chemistry is less precise).

DESCRIPTION

Main steps:
- prepare an aliquant: add 200 mg of uranium sample into 50 ml of nitric acid; dilute (2-3 times) to obtain 10 microgram U/ml;
- add 10 micrograms of U-233 spike (known amount of U-233)
- separate uranium chemically using ion exchange
- use 100 nanograms to deposit on the filament
- measure ratio to 0.01% error (mass spectrometry part). Total error is 0.1% (impurities affect ionization).

Impurities:
Pu-238 is the main problem (interference with U-238); Pu must be removed chemically before measurements.
At LANL, a set of working "spikes" (10 micrograms of U each) are prepared in advance from the U-233 enriched material provided by ORNL; the NBS-960 standard (natural U) is used only for calibration. Note that spikes for U-233 containing materials must have different isotope composition than the measured sample.
Source of error:
- weighing
- cross-contamination of samples (environmental, cleanness of glassware)
- dilution (2-3 dilutions per sample).

COMPONENTS

- Mass spectrometer: Finnigan or Micromass Thermal Ionization Mass Spectrometer (preference: Thermal Ionization MS over high resolution instruments).
- Reference materials for MS calibration: Suite of isotopic standards produced by NBS is presently used at LANL. Currently, NBL became responsible for supply of these and new reference materials.

SPECIFICATIONS

```
Weight of uranium sample       200 mg
Weight of U-233 spike          10 mkg
Weight of aliquant
deposited on the filament      100 nanograms

Duration of measurement:
  per sample                   one hour
  per day                      10-12 measurements (average)
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer data - Информация от поставщика/разработчика

Accounting (DA Methodology): Mass Spectrometry

40

Thermal Ionization Mass Spectrometry for Plutonium and Uranium

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Element Concentration, Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Miscellaneous
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

At WSRS, this methodology is used for process control, accountability, nuclear safety, product specifications, and waste characterization (mostly work solutions and also can dissolve oxides and metals). Clean and radioactive solutions are analyzed. Within this methodology, they do both element (gram per gram) and isotopics measurements. Normal concentration range: U 0.1 g/L to 400 g/L, Pu > 0.1 g/L.

DESCRIPTION

WSRC follows the ASTM standard with some minor modifications.

- Sampling: manual sample preparation is used. Sample sizes are limited to 100 micrograms of U and 20 micrograms for Pu
- add spike (known amount of U-233 or Pu-244)
- separate U/Pu chemically using ion exchange
- samples are placed on the filament: 1 micrograms for U and 500 nano-grams for Pu
- measure isotopic ratio and perform U and Pu concentration calculations. For isotopic ratio, SRD is less than 0.1% of major ratio; for concentration it is 0.7%.

Each sample is bracketed by 2 standards.
For high activity solutions hot cells are used for sample processing and spiking.
The high speed ion exchange technique is unique in the WSRS methodology.
Impurities:
Uranium measurements: Pu-238 is the main problem (interference with U-238); Pu-238 must be removed chemically before measurements.
Plutonium measurements: U-238 and Am-241 are the main problem (interference with Pu-238 and Pu-241); U-238 and Am-241 must be removed chemically before measurements.
Source of error:

- weighing
- cross-contamination of samples (environmental, dirty glassware
- dilution.

COMPONENTS

- Mass Spectrometers: Two systems are used for both U and Pu: Finnigan MAT 260 (1978) and MAT 261 (1984 with modernized electronics and PC software) are used.
    - 90 degree magnetic sector field
    - 26.5 degree entrance and exit angle
    - resolution of 500 atom mass units
    - multicollector detection
    - 13 samples carousel
    - PC controlled
- Small Resin Columns (Image Molding, 4525 Kingston St, Denver Co, tel. 800-525-1875).
- WSRC is using NBL CRMs isotopic standards for uranium and plutonium; for concentration standards WSRS internal standards traceable to National Measurement Base are used.
- Ion-exchange resins used in the methodology are U/Pu/Np TEVA by Eichrome Industries, Inc., Chicago, Illinois, USA (IE columns are 1” high):
    - TEVA resin (Aliquot 336), 0.35 g per column
    - UTEVA resin (diamylamyl phosphonate), 0.35 g per column, (both 50-100 micron size)

SPECIFICATIONS

```
Concentration range:
        U                                 0.1 g/L to 400 g/L
        Pu                                > 0.1 g/L
SRD for:
        isotopic major ratio              less than 0.1%
        concentration                     0.7%
```

SOFTWARE

Finnigan Co. program modified by O'Hara Spectrometer Services, Pittsburgh, PA: interface with PC was modified, not the

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Titration

41

Uranium Davies-Gray Titration

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

This high accuracy and precision method is used for accountability measurements at WSRS.

DESCRIPTION

Standard methodology:
- U(6) to U(4) with Ferrous Sulfate
- U(4) to U(6) with Potassium Dichromate
- Weight titration monitored at a Pt indicator electrode

Steps:
- Sample weighed to 0.0001 gram
- Fumed with concentrated sulfuric acid
- Reagent addition are timed (to decrease an error)
- Weight titration with potassium dichromate using squeeze bottle with a fine removable tip
- Endpoint at the potential break measured with pH/mV meter

Standards used:
- Uranium working standards traceable to National Measurement Base;
- NBL CRM 112A Uranium Metal Standard (see this catalog; previously SRM 960)
- SRM 136e (Potassium Dichromate)
  - standard's weight: 60 g
  - certified use: oxidimetric value
  - stoichiometric purity: 99.984%

No bias corrections are performed.

COMPONENTS

- balance readable to 0.0001 g, 160 g capacity
- digital pH/mV meter
- Pt working electrode
- Squeeze bottle with elongated fine tip

SPECIFICATIONS

Sample size	10 g
U amount in aliquant per analysis	50 mg
Potential change at endpoint	70 mV
Precision(relative standard deviation)	
usual	< 0.2%
for good operator	< 0.1% (it is difficult to have an experience because analysis are made not frequently)
Bias (relative standard deviation)	< 0.05%

SOFTWARE

ADDITIONAL INFORMATION

For two tanks with solutions located at WSRS, twelve measurements per tank are made every year.

REFERENCES

1. Supplier/Developer Data (Gary P. Wills) - Информация от поставщика/разработчика (Gary P. Wills).

Accounting (DA Methodology): Spectrophotometry

42

Plutonium and Uranium Diode Array Spectrophotometry

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

This methodology was developed at WSRC. It is used at WSRC for assay of Pu and U solution samples.

DESCRIPTION

This methodology is based on measurement of the absorption spectrum in the region of 371-550 nm for U (500-700 nm for Pu) and calculating U or Pu concentration (g/L) by comparing it to the spectrum of a standard. Its major advantages are: speed (compared to conventional IDMS), and ease of sample preparation. Operated in glovebox.
Samples Preparation:
Size: typically 100 mkL (0.8% accuracy; variability (very important!) is 0.3%) of basic sample diluting into 5 ml of matrix solution. 100 mkL is used for all measurements, samples and standards. Note that variability is important, not accuracy.
Motorized pipettes (Rainin Corp., US – distributor, Gilson is the manufacturer, Germany; EDP+, EDP-2 models)
Major Sources of Error (factors affecting performance): dilution is the major source of error.
Interferences:
Cr has peak close to Pu peak (bias). WSRS make corrections for Cr: increasing resolution allows to separate the two peaks.
Bias correction factor is used for quality control; each measurement is bracketed by two blind standard measurements.
Certification of calibration is performed once each shift/each technician.

COMPONENTS

Apparatus:
- HP8452A Diode Array Spectrophotometer

WSRS custom modified system:
- Fiber optics remote cell for remote measurements (allows work with hot materials). Remote flow cell assembly is composed of two fiber optic cables and a fixed geometry, 4 cm flow cell
- Xenon lamp as a light source (not the standard HP setup). Xenon Lamp Source – 75 W ozone free, #L1994 by Hamamatsu Xenon lamp housing by Oriel, #66057. Lamp power supply 0.1% peak-to-peak stability, Hamamatsu #C4251

SPECIFICATIONS

```
Accuracy at 95% confidence interval:
                     Pu                      2%
                     U                       3%
```

SOFTWARE

PC program analyzing the spectrum compares the measured spectrum to the calibration spectrum to get the results in g/L

ADDITIONAL INFORMATION

sed: computerized procedure; software flags deviations from expected values.

REFERENCES

1. ASTM C1307-95: Standard Test Method for Plutonium Assay by Plutonium(III) Diode Array Spectrophotometry, November 1995.
2. Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Alpha Spectrometry

43

Plutonium Alpha Spectroscopy

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Alpha Spectrometry
METHOD:	Alpha Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Any form converted to solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

This method is applicable to Pu-bearing materials that have a Pu-238 abundance that is too low for precise mass spectrometric measurement, or to situations in which there is a significant interference from U-238. Precise measurement of the Pu-238 abundance is essential for calorimetric measurements of total Pu since Pu-238 contributes a large fraction of the heat. Alpha spectrometry is appropriate for the determination of Pu-238 isotopic abundances from 0.01 to 0.7 weight percent.

DESCRIPTION

- a portion of a suitable dissolution of the Pu-bearing material is diluted with 3M nitric acid
- an aliquot of the diluted sample is mounted directly on a counting dish and evaporated
- the alpha spectrum in the 5 to 6-MeV region is measured, using a silicon surface-barrier detector with associated electronics and a multichannel pulse-height analyzer
- the total counts in the Pu-238 and (Pu-239 + Pu-240) peaks are obtained and corrected for background
- the Pu-238 abundance is calculated from the ratio of the alpha activity due to Pu-238 to the total alpha activity, and the abundance of Pu-239 and Pu-240 determined by mass spectrometry on a separate portion of the sample.

COMPONENTS

Alpha PHA:
- Tennelec (Oxford) TC256 Spectrometer
- 450 mm² Canberra PIPS detectors
- Canberra's GENIE PC Spectroscopy System (Analog-Digital Converter, Amplitude-Impulse Multiplier)

SPECIFICATIONS

Duration of measurement (depends on rate; best: 30,000-40,000 counts per measurements, but less than 100,000)	4-10 minutes or less per measurement
Sample concentration range	<0.2 g Pu/L (<20 mCi Pu/L)
Sample weight mounted on plate	0.5 - 1000 nano-gramm Pu (0.05 - 100 nCi Pu)
Accuracy	5 - 25 % @ 95% CI as a function of sample matrix dilution, counting statistics

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информации поставщика/разработчика

Accounting (DA Methodology): Coulometry

44

Plutonium Coulometry

MODEL:

SUPPLIER:	**WSRC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Solution, pure Pu metal
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	WSRC
MANUFACTURER:	WSRC

PURPOSE

At WSRC this method is used for PUREX product solution analysis and characterization of pure plutonium standards (WSRC are the leaders in this methodology; they supply this systems to IAEA). This method is used for the assay of aliquants containing 5 to 15 mg plutonium.

DESCRIPTION

This method is based on the first principles – there is no need for Pu standards. Analyte reacts at an electrode having a constant potential that precludes reactions of as many impurity components as is feasible. In electrolysis, current decreases exponentially as the reaction proceeds until a selected background current is reached. The quantity of analyte reacted is calculable by Faradey's law.

Variations:

1. Sulfuric acid electrolyte at platinum working electrode (used for routine samples)
2. Nitric acid electrolysis at a gold working electrode (used for characterization of working pure plutonium standards)

Interferences:

- organic material remaining after fuming in sulfuric acid
- iron, neptunium (cannot be eliminated completely), gold, iridium, palladium, platinum, all - present at above trace levels, and
- high salt content samples

Anion exchange purification on BioRad AGMP-1 resin is used if interferences are present.

Electrode conditioning is performed periodically to eliminate background current under load (flame electrode and store it in nitric acid to control surface oxide coating).

COMPONENTS

Apparatus:

- WSRC custom-made coulometer including potentiostat and integrator modules
- commercially-available instrument controller and peripherals
- cell assembly (using gold and platinum electrodes and electro-conducting glass by EG&G Princeton Applied Research)

SPECIFICATIONS

Pu content per aliquant	5 to 15 mg (fumed dry in sulfuric acid)
Typical sample range	> 1 g Pu/L (>100mkCi Pu/L)
Accuracy	0.1%
Calibration temperature	15 - 30 ˚C
Pure measurement time per sample	15 minutes
Production rate	up to 4 aliquates per day including standard/blank measurements

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Coulometry

45

Determination of Plutonium Using Automated Controlled-Potential Coulometry

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu, Np (possible)
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

This method is used for the assay of aliquants containing 5 to 15 mg plutonium. This methodology does not require the use of Pu standards (except to verify the cell performance during coulometry).

DESCRIPTION

The controlled-potential coulometric determination of plutonium is based on electrolytic oxidation of Pu(III) to Pu(IV) in a reproducible matrix and on the accurate determination of the quantity of electricity required to perform the oxidation. Pu(IV) is electrolytically reduced to Pu(III) at a gold working electrode in 0.9 M HNO3. The Pu(III) is then electrolytically oxidized to Pu(IV) while integrating the current used and monitoring the cell current and voltage.
The controlled-potential adjustment technique was developed at NBL to reduce sample analysis time [2]. When 99 % Pu(III) has been oxidized to Pu(IV), the current in the cell reaches a low, predetermined cut-off level. The controlled-potential setting is then adjusted in gradual steps to the potential on the cell as indicated by a current reading of 2 microamps or less; system is allowed to equilibrate; and the solution redox potential is measured. Corrections for the Pu(IV) not reduced in the electrolytic reductions and for the Pu(III) not oxidized in the electrolytic oxidation are calculated by the Nernst equation. These corrections, together with subtraction of the electrolyte blank (determined prior to each sample analysis) and background current, are made to the total integrated current (coulombs) measured. The corrected value for the current necessary to oxidize all Pu(III) to Pu(IV) is then entered in the Faraday Equation used to calculate the equivalent amount of Pu present in the sample.
Prior to assay, plutonium materials are dissolved and aliquatted using approved NBL procedures. Aliquants must be purified by anion exchange unless they are of high-purity Pu metal which have been dissolved and reduced using high-purity reagents. Aliquants are fumed to dryness in H2SO4 after ion-exchange processing to stabilize the plutonium in the +4 or lower oxidation state.
Quantitative ion-exchange and proper cell operation are checked daily before use by assay of "blind" standards prepared from the primary standard Pu metal (NBL C-126 or equivalent).
Major source of errors:
Proper sample handling is required to avoid errors due to ion exchange purification. NBL’s ion exchange preparation procedure prior to coulometry has been shown to give full recovery of plutonium [3].
Other sources of errors are: working and counter electrode quality, stirring rates (optimized in an established methodology to minimize the error). The presence of gallium in samples can cause problems with sluggish response of the gold working electrode.

COMPONENTS

Apparatus (WSRC built a number of coulometers for Russia, Japan, and IAEA):
- Coulometer (NBL-designed) including software for controlling PC, TLF Automation Module, Power Supply Programmer, Potentiostats (TLF 1), Digital Integrator, Timer, Digital Voltmeter, Digital I/O Converter
- Cell (NBL-designed)

Reference Material:
- NBL C-126 or equivalent (primary standard Pu metal)

SPECIFICATIONS

Pu content per aliquant	5 to 15 mg
Systematic error of coulometer	0.01%
Total uncertainty	0.1% (combined bias)
Precision	+ 0.1% of the actual value

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL-SA-Pu(E)-1.1: Determination of Plutonium Using Automated Controlled-Potential Coulometry, P.V. Croatto and U.I. Narayanan (04/10/95).
2. M.K. Holland, J.R. Weiss, and C.E. Pietri, The New Brunswick Laboratory Controlled-Potential Coulometric Method for the

Determination of Plutonium, NBL-299, June 1981.
3. W. G. Mitchell, M. I. Spaletto, K. Lewis, M. D. Soriano, and M. M. Smith, Topical Report, NBL-323, The Effect of Ion-Exchange Purification on the Determination of Plutonium at the New Brunswick Laboratory, July 1990.

Accounting (DA Methodology): Mass Spectrometry

46

Determination of Isotopic Composition of Uranium by Thermal Ionization Mass Spectrometry

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

This method is used for the determination of the isotopic composition of uranium. Isotopic ratios are measured and calculations are performed to obtain the atom percent, weight percent, mole percent and atomic weight. The method may also be used to determine the elemental composition of a sample using a spike material with known parameters as described in NBL Procedure NBL-SA-U-Pu(E)-I. Samples may require pretreatment as described in NBL Procedures NBL-SP-U(I)-I and NBL-SP-U(I)-4.
This is a primary method of analysis (but only when used with very thorough procedures for calibration and when the highest standard materials are used. Certified Standards are used for bias corrections.)

DESCRIPTION

An aliquant, containing approximately 1 microgram U in a purified uranyl nitrate solution, is loaded onto a sample filament, dried, and oxidized. In the instrument source and under a high vacuum, the sample is ionized at high temperature and the resulting ions are accelerated, using a differential electric potential, through a magnetic field. The ions follow a curved path which is determined by the mass to charge ratio (m/z) of the ions, the accelerating potential, the magnetic field and the radius of curvature of the flight tube. Ions of a given isotope are focused onto a Faraday cup or Secondary Electron Multiplier (SEM) detector by adjusting the magnetic field. Ion currents for all specified isotopes are measured and isotopic ratios are calculated. The atom percent and weight percent of the uranium can then be calculated from the mass ratios.
Uranium samples must be chemically purified to assure reliable analysis by thermal ionization mass spectrometry. Impurities, especially alkali elements, tend to produce unstable ion emission and therefore alter observed ratios in an unpredictable manner. Organic contaminants or rhenium oxide layers on the filaments will adversely influence the sample analysis. Isobaric interferences, if not removed or accounted for in calculations, will bias the ratios. Uranium contained in reagents or glassware or filament-material may bias the observed ratios.
Instrument performance can be adversely affected by environmental changes in the laboratory, i.e., temperature and humidity, due to the sensitivity of the electronic equipment.
Purification of uranium is performed following [2]. A weighed aliquant of the dissolved sample material is dried and redissolved in 2.5 M nitric acid. The sample is transferred to a U/TEVAL Spec(TM) ion-exchange resin column. The column is rinsed with 2.5 M nitric acid to remove the impurities from the sample, but leaves the uranium on the column. The purified uranium is eluted from the column with 0.01 M nitric acid and the sample is evaporated to dryness.
Sources of error include isotope mass fractionation/mass bias effects, and isotopic bias in the instrument (standards are used for bias corrections).

COMPONENTS

Instruments:
- Finnigan Model MAT 261 mass spectrometers
- Finnigan Triton TI mass spectrometer multicollector
- variable Faraday cups
- RPQ Plus ion counter
- one secondary electron multiplier/ion counter
- computer and software.

Apparatus:
- a 13 or 21-position sample magazines with double rhenium filament assemblies for sample loadings

Reagents:
- liquid nitrogen

SPECIFICATIONS

```
Sample aliquant load on filament, U                     1 microgram
Relative uncertainties for U isotope weight in %:
   Weight % :                                           Error Limit %:
     1-15                                               <0.2
    30-40                                               <0.13
    93-95                                               <0.014
```

SOFTWARE

Slightly modified manufacturer's source code; Basic, C++. Results are exported into EXCEL for data reduction. Spreadsheets [illegible]g ISO are used.

ADDITIONAL INFORMATION

REFERENCES

1. Procedure: NBL-SA-U(I)-4: Determination of Isotopic Composition of Uranium by Thermal Ionization Mass Spectrometry (FINNIGAN MAT 261), April 14, 1998.
2. Procedure NBL-SP-U(I)-4: Purification of Uranium for Mass Spectrometric Analysis Using U/TEVALSpec(TM) Columns, Author: Iris W. Frank, 11/21/95

Accounting (DA Methodology): Mass Spectrometry

47

Inductively Coupled Plasma Mass Spectrometry

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Impurities in pure Pu and U materials
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

This methodology incorporates sample introduction into an argon plasma. The methodology is very flexible, allows fast analysis, and is applicable to many elements. It is best for element concentration measurements, specifically for impurity analysis (with or without isotope dilution). Isotope ratio measurements results obtained by this method are not as good as those obtained by TIMS and Gas Source mass spectrometry.

DESCRIPTION

Sample for analysis: solution aspirated into argon plasma. Ions are formed and measured by electron multipliers or Faraday detector.

COMPONENTS

Mass Spectrometer:
- there are many types of ICP instruments and their manufacturers. NBL uses the Micromass quadrupole mass spectrometer. The mass spectrometers are also manufactured by Finnigan, VG Industries (PlasmaQuad II), and HP
- electron multipliers or Faraday detector.

SPECIFICATIONS

Sensitivity (depending on the element)	from 1 to 5 ppm

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Optical Emission Spectroscopy

48

Optical Emission Spectroscopy

MODEL:

SUPPLIER:	**Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Optical Emission Spectroscopy
METHOD:	Optical Emission Spectroscopy
MEASURED PROPERTIES:	Impurity Elements Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Pure metal
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)
MANUFACTURER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)

PURPOSE

This method can be used for impurity analysis in high purity uranium materials: metals, oxides, solid fluorides, and liquids. Although this method is relatively simple and inexpensive, it is less advanced than the ICP MS methodology.
For MC&A purposes at Y-12, this method is used primarily for pure metals in gram-per-gram measurements using the difference calculations methodology developed at Y-12 (subtracting impurities from total).
Generally, the Davies-Gray titration is recommended by Y-12 for use in MC&A application.…

DESCRIPTION

Methodology similar to ASTM Standard E 402-95 (see present catalog) is followed at Y-12 (except that silver fluoride is used as carrier instead of gallium sesquioxide). 100% pure metal is assumed for difference calculations; all impurities are measured; carbon concentration is measured separately before subtraction calculations. There is no standard for this procedure.
Main steps are:
- metal is cleaned from U_3O_8
- cleaned metal is mixed with silver fluoride carrier, and loaded into electrodes
- measurements are performed using DC arc
- detection system uses a photo-plate
- manual measurement are performed by visual comparison of the photo-plate with the plate obtained from measurement of a standard
- working reference standards are prepared internally at Y-12

COMPONENTS

Apparatus:
- a unique 3 m spectrophotometer is used at Y-12. The "difference technique" may have to be replaced by Davies-Gray if the large radius device is not available: smaller radius devices (around 0.75 m) may not be appropriate (manufacturer: Jarrell Ash Corporation).

SPECIFICATIONS

Measurement rate	up to 20 samples (photoplates) in one day
Elements	33 elements are covered (C is measured by other method)
Accuracy	10 ± 5 ppm (RSD 0.0001%)
Comparative accuracy	0.0003 gram-per-gram average discrepancy between two methods: direct (Davies-Gray) and Y-12 difference method

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM E402-95: Standard Test Method for Spectrographic Analysis of Uranium Oxide (U_3O_8) by Gallium Oxide-Carrier Technique, March 1995.

Accounting (DA Methodology): Titration

49

Davies-Gray Uranium Potentiometric Titration in the Presence of Plutonium

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Uranium-plutonium mixed oxides, metals, MOX
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

Determination of uranium content in the presence of plutonium (up to 50%) in solution, metals, MOX. This method works with 25 - 30 mg samples that reduces waste. Good results are achieved for U concentration from 30% and up.

DESCRIPTION

The method used LANL follows uranium potentiometric titration described in ASTM C1204-91 presented in this catalog (see Reference below), but titrant is changed to Ceric sulfate.
NBL CRM is used for certification of working reference materials.
Automatic and manual titration are available.
Sources of error:
sampling,
weighing(presence of oxide surface introduces error, or moisture absorption);
manual manipulations (too rapid heating, splattering of solution)
To reduce the influence of these sources, duplicates of materials as two independent measurements are used.

COMPONENTS

- Automated titrators (Metrohm, Swiss, Brinkman-US distributor- high precision instrument) and manual titration.
- Burette- Polyethylene bottle, gross weight, or volumetric.
- pH Meter, with indicator (platinum has been found to be satisfactory) and reference (saturated calomel has been found to be satisfactory) electrodes.

SPECIFICATIONS

Recommended sample size	25-30 mg
Relative standard deviation	0.1%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C 1204-91 (Reapproved 1996) Standard Test Method for Uranium in the Presence of Plutonium by Iron(II) Reduction in Phosphoric Acid Followed by Chromium(VI)Titration

Accounting (DA Methodology): Titration

50

ASTM C 1204-91 (Reapproved 1996): Standard Test Method for Uranium in the Presence of Plutonium by Iron(II) Reduction in Phosporic Acid Followed by Chromium(VI) Titration

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution (Uranium-plutonium mixed oxide having a U/Pu ratio of 2.5 and greater)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

This test method covers unirradiated uranium-plutonium mixed oxide having a uranium to plutonium ratio of 2.5 and greater. This method determines 20 to 300 mg of uranium, is applicable to fast breeder reactor (FBR)-mixed oxides having a uranium to plutonium ratio of 2.5 and greater, is not subject to interference by most metallic impurity elements usually specified for FBR-mixed oxide fuel, and uses no special equipment.

DESCRIPTION

Sample preparation:
- Samples are prepared by dissolution techniques
- Aliquantes containing 20 to 300 mg of uranium are prepared by weight
- Sample is fumed to incipient dryness after the addition of sulfuric acid
- Sample is dissolved in dilute sulfuric acid prior to titration.

Sample assay:
- Uranium is reduced to U(IV) by excess ferrous Fe(II)) in concentrated phosphoric acid (H3PO4) containing sulfamic acid (NH2SO3H)
- The excess Fe(II) is selectively oxidized by nitric acid (HNO3) in the presence of Mo(VI) catalyst
- After the addition of V(IV), U(IV) is titrated with Cr(VI) to a potentiometric end point.

Interferences:
Interfering elements are not generally present in significant quantities in mixed uranium, plutonium oxide product material. However, elements that cause an error when present in milligram quantities are Ag, V, Pt, Ru, Os, I. ASTM C-1204-91 gives references where methods are presented for elimination of impurity interference.

Calculations include:
A. Buoyancy and Purity Corrections
B. Concentration Calculations for standard solutions of potassium dichromate and uranium are made using the buoyancy and purity corrected weights for the solids
C. Uranium Titration Factor
D. The Uranium content of the original sample by the following equation: U = TWR/FS
where:
U - milligrams uranium per gram sample,
T - titrant factor, mg uranium/g,
W - weight of potassium dichromate solution, g dichromate solution,
R - ratio of atomic weight of uranium in sample to atomic weight of CRM 112-A or its replacement,
F - factor for sample dilution, weight in grams of original sample initially dissolved per total grams of sample solution, and
S - weight of sample solution aliquant analyzed, g.

Reference materials:
The uranium titration factor and so the calibration of this method, is based on
- CRM 112-A (uranium reference material or its replacement, see this catalog) and
- SRM 136e (Potassium Dichromate)
  - stanrad's weight: 60 g
  - certified use: oxidimetric value
  - stoichiometric purity: 99.984%

COMPONENTS

- Automated titrators (Metrohm, Brinkman-US distributor- high precision instrument) and manual titration
- Burette: Polyethylene bottle, glass weight, or volumetric (NBL comment: the latter will not deliver the reproducibility stated)
- pH Meter, with indicator (platinum has been found to be satisfactory) and reference (saturated calomel has been found to be satisfactory) electrodes.

SPECIFICATIONS

U measured amount per aliquant having U/Pu ratio of 2.5 and greater	20-300 mg
Mean relative bias	0.072%
Reproducibility	0.066%

SOFTWARE

ADDITIONAL INFORMATION

The presence of larger amounts of plutonium (Pu) and thus lower uranium to plutonium ratios may give low analysis results for uranium (U), if the amount of plutonium together with uranium is sufficient to slow the reduction step and prevent complete reduction of the uranium in the allotted time.

Use of this method for lower uranium to plutonium ratios may be possible, especially when 20 to 50 mg quantities of uranium are being titrated rather than the 100 to 300 mg. Confirmation of that information should be obtained before this method is used for ratios of uranium to plutonium less than 2.5.

REFERENCES

1. ASTM C 1204-91 (Reapproved 1996): Standard Test Method for Uranium in the Presence of Plutonium by Iron(II) Reduction in Phosphoric Acid Followed by Chromium(VI)Titration

Accounting (DA Methodology): Mass Spectrometry

51

Isotope Dilution Mass Spectrometry for Plutonium

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Miscellaneous
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

IDMS used in LANL for plutonium assay. In general, IDMS is applicable to any material that can be dissolved with no limit on concentration. The main advantages: applicable to wide variety of plutonium samples and impurities, and plutonium concentrations; produces minimal radioactive waste. Used in reprocessing industry (high impurity samples). This methodology provides highest precision analysis (radio-chemistry is less precise).

DESCRIPTION

Main steps:
- prepare an aliquant: add 200 mg of plutonium sample into 10-12 M of HCl; use very rigorous methods to insure that all isotopes are in the same chemical form to insure good separation from Am-241
- add 2-5 microgram of Pu-244 spike (known amount of Pu-244, 97%; it is difficult to get 100% Pu)
- separate plutonium chemically using ion exchange
- use 100 nanograms to deposit on the filament
- measure ratio to 0.01% error (mass spectrometry part, total error is 0.1%: impurities affect ionization).

Duration of measurements: one hour per sample (on the average, 10-12 measurements per day).
Impurities:
U-238 is the main problem (interference with Pu-238); U-238 must be removed chemically before measurements.
At LANL, a set of working "spikes" are prepared from the Pu-244 isotopic standards. For Pu very few standards are available: NBL CRM 128 (Pu-242/Pu-239, 50/50%), and NBS 946, 947, 948.
Source of error:
- weighing
- cross-contamination of samples (environmental, cleanness of glassware)
- dilution (2-3 dilutions per sample).

COMPONENTS

- Mass spectrometer: Finnigan or Micromass Thermal Ionization Mass Spectrometer (preference: Thermal Ionization over high resolution instruments).
- Reference materials for MS calibration: Isotopic standards produced by NBS and NBL are presently used at LANL. Currently, NBL became responsible for supply of these and new reference materials.

SPECIFICATIONS

```
Weight of plutonium sample                         200 mg
Weight of Pu-244 spike                             2-5 micrograms
Weight of aliquant
deposited on the filament                          100 nanograms
Duration of measurement:
  per sample                                       one hour
  per day                                          10-12 measurements (average)
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer data - Информация от поставщика/разработчика

Accounting (DA Methodology): Coulometry

52

Plutonium Coulometry

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Pu/U oxides, nitrate solutions, Pu metal
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

Determination of plutonium in Pu and Pu-U oxides where Pu is the dominant element (preferably pure materials). Can tolerate up to 20% of U in the mixture. This method is used for verification of non-destructive assay.

DESCRIPTION

Nitrate solutions, Pu metals. +3 to +4 state, very selective for plutonium. Since total reading is the sum of Pu plus Fe, correction has to be made. Choice of dissolution techniques is critical.
Steps:
- start with 200 mg sample
- dissolve
- split in 5 mg portions into 50 ml cells
- fume to dryness in the presence of sulfuric acid, resulting in Pu sulfate
- add sulfuric acid and reduce Pu to +3
- oxidize to +4 and measure coulombs during this process under Ar blanket.
- in parallel measure coulons required to oxidize standard materials (CRM, NBL Cerium 126). Compare for calibration.

COMPONENTS

Apparatus:
- coulometer (commercial, from Princeton Applied Research / EG&G). Coulometer performance may be influenced by the electro-magnetic fields in the building
- cell (geometry of the cell is crucial: arrangement of electrodes, mixers, argon atmosphere – designed at LANL)

SPECIFICATIONS

Current	from 1 amp to 30 mk amps; down to level of milli-coulombs
Measurement duration	10-15 minutes
Accuracy	0.1 %

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1165-90 (Reapproved 1995): Standard Test Method for Determining Plutonium by Controlled-Potential Coulometry in H2SO4 at a Platinum Working Electrode

Accounting (DA Methodology): Spectrophotometry

53

Spectrophotometric Assay of Plutonium(III)

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Oxide
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

This method is designed by WSRC and is used for measuring Pu process oxides. Since this method is sensitive to impurities, it is applicable to well characterized streams only.

DESCRIPTION

This method is based on the characteristic light absorption by Pu(III). See the ASTM standard in this catalog for more details. The main steps of the methodology are:
- weigh a portion of oxide material and dissolve it in concentrated HCl
- heat the solution under pressure (several psi; controlled temperature of 130 deg. C) until full dissolution is achieved (about 1 - 2 hr); use hot plates commercially available
- transfer the sample into a calibrated flask
- reduce Pu in the sample to Pu(III)
- measure the spectrum photometrically, and compare it to the spectrum of a standard Pu solution
- calculate mass of Pu in the sample.

Since these procedures use volumetric measurements, the solution temperature becomes a factor and has to be taken into account.
Source of errors: initial weighing, instability of spectrum (30 second averaging is done), interferences. Impurities can distort the entire spectrum and lead to inconsistencies in results indicating presence of impurities.
Standard measurements are performed immediately following the sample measurements. Secondary standards (metal, not oxide) that are used are verified through coulometric measurements. Since these secondary standards are 100 mg Pu samples, using straight CRMs would not be economical.
Note that the control samples (as opposite to secondary standards) are made of oxide, and undergo all the procedures for measured sample.

COMPONENTS

- diode array spectrophotometer manufactured by HP (there are other brands). Visible range: 500-600 nano-meters. Extinction coefficient: 50.
- HP provides an interface PC board for data reduction and processing.

SPECIFICATIONS

Sample size	25 mL, 2 samples per measurement
Accuracy, RSD	0.2%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1307-95: Standard Test Method for Plutonium Assay by Plutonium(III) Diode Array Spectrophotometry, November 1995.
2. Supplier/Developer Data - Информация от поставщика/разработчика

Accounting (DA Methodology): Titration

54

Potentiometric Titration of Plutonium with Cerium(IV)

MODEL:

SUPPLIER:	**LANL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Metals
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	LANL

PURPOSE

Determination of the plutonium content. The method is applicable only for high purity metals. 250 mg weight portion is used for analysis.

DESCRIPTION

In general this technique looks like the potentiometric titration of plutonium described in ASTM C 1235-93a (see Reference below) presented in this catalog. But the first one is an old technique that was used at Rocky Flats. The LANL technique uses color-metric end point of titration, rather the potentiometric.
Steps:
- weigh portions of samples (around 250 mg) ;
- dissolve in HCl;
- add sulfuric acid, ferroin.

Semi-automated method of titration is used.

COMPONENTS

- Titrometer (Metrohm titration device) - semi-automated method.
- Probe color-meter connected to PC.

SPECIFICATIONS

The recommended size of samples	250 mg
Relative standard deviation for Pu	0.05%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C 1235-93a Standard Test Method for Plutonium by Cerium(III)/Cerium(IV) Titration

Accounting (DA Methodology): XRF

55

X-Ray Emission

MODEL:

SUPPLIER:	**Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	XRF
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Oxides, metals, solids
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)
MANUFACTURER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)

PURPOSE

This method is appropriate for any material that will fluorescence under X-rays. Solid materials and liquids are both covered (use platinum and graphite crucibles).
This method is suggested for low U concentrations (below 50%); however, the error is higher than in Davies-Gray method. Y-12 splits samples in two concentration groups: up to 50% - and uses X-Ray emission method (0.2% RSD), and over 50% uses Davies-Gray method (0.1% RSD).
Although this method can be used for irradiated materials (with shielding and special standards) it is not the Y-12 choice: NDA would be preferable.

DESCRIPTION

Y-12 follows the ASTM standard developed by their own analytical laboratory [2]. Isotopic analysis precedes these measurements. In this method, liquids are analyzed directly (Y-12 have standards). Metals, before dissolving are thoroughly cleaned: degreased and pickled in acids. For solids, fuse at 1100 deg. C with Li tetraborate for 2 hours in a crucible and cool down producing a glass pellet which is submitted for X-Ray analysis.
As a part of procedure, measured amount of internal standard is added, and uranium ratio is measured (internal standard can be yttrium or any other element which does not give any interference). Argon or helium is used as a cover gas for solutions; vacuum - for solids. No interferences are caused by matrix.
NBL standards are used for calibration of the instruments. Also, standard control samples are used regularly to check the measurements. Calibration is performed daily at the beginning of measurements. Every 10th measurement is a control sample measurement. Calibration is done using the special software provided with the spectrometer.

COMPONENTS

Apparatus:
- X-Ray Emission spectrometer (Bruker, Phillips, Applied Research Laboratories, etc.) working with inert gas or vacuum
- automatic sample changer
- minimum 60 kV X-Ray generator

SPECIFICATIONS

Mode of operation	unattended
Measurements rate	50-60 samples/day
U concentrations	<50%
RSD for U concentration <50%	0.2%

SOFTWARE

PC is used for collection and processing data, and for calculating isotopic corrections.

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информация от поставщика/разработчика
2. ASTM C1254-93: Standard Test Method for Determination of Uranium in Mineral Acids by X-Ray Fluorescence, February 1994.

Accounting (DA Methodology): Coulometry

56

Uranium Coulometry

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

The determination of uranium content for uranium samples and standards containing 10-40mg U with accuracies of +- 0.05% and precision of 0.1% (RSD) or better using a modified manual coulorimetric method [2,3]. This is an alternative method to NBL Titrimertic Method (Davies-Gray) which is very accurate and rugged but is using hexavalent chromium compounds which are environmentally undesirable.

DESCRIPTION

The automated version of the NBL constant current coulometer based on the work of Goldbeck and Lerner[4] .
Uranium samples in the range of 20-40 mg are prepared for coulometric determination using a 75% reagent volume scale-down of the NBL-Modified Davies and Gray sample preparation procedure. The uranium is reduced to U(IV) with ferrous sulfate in a concentrated phosphoric acid medium. Excess ferrous ion is removed by molybdate-catalyzed oxidation with nitric acid. The sample is diluted with a vanadyl solution which increases the rate of the titration reaction. U(IV) is titrated to U(VI) by constant current electrogeneration of V(V) at a gold working electrode. For this sample size range and for the proper current density of the 50 cm2 surface area of the gold electrode, a 150 mA current was chosen. Generation currents greater than 200 mA have caused anode gold surface oxidation due to high current density. Currents less than 100 mA have yielded longer titration times, increasing the risk of air-oxidation of vanadium.
The advantages of the method are the simplicity of the electrical circuit and of the method for measuring the total current and generation time, its suitability for automation, and the short titration times. An automated constant current coulometer offers the additional benefits of increased sample output with reduced labor spent per sample, minimization of operator error, greater precision in control of current pulses, more thorough monitoring of system parameters, and better diagnostics. Whereas previous coulometric systems were custom built, the NBL automated coulometer can be built in-house from readily available components which are then integrated and interfaced with a personal computer programmed in BASIC.

COMPONENTS

- Coulometer (EG&G PAR manufactures coulometers)
- Apparatus:
  - electrolysis cell
  - end point detection system:
    - reference electrode - (Fisher #13-639-79) miniature saturated calomel electrode
    - indicator electrode - 12 cm long coil of 16-guage Pt wire
  - electrode system:
    - cathode 10cm long coil of 16-gauge Pt wire
    - anode - 50 cm² gold mesh cylinder attached to two gold posts

SPECIFICATIONS

U content per aliquant	10-40 mg
Accuracy	0.05%
Precision	0.1%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. P.V. Croatto, P.B. Mason, K.D. Johnson, I.W. Frank, Determination of Uranium by Constant Current Coulometry. BNL Publication.
2. "Determination of Uranium Using Constant Current Coulometry," NBL Procedure NBL-SA-U(E)-3, NBL Procedures Manual, April 19, 1994.
3."Low Level Uranium Determination by Constant Current Coulometry," W. G. Mitchell and K. Lewis, NBL Special Publication 582 (1980).
4.C. G. Goldbeck and M. W. Lerner, Anal. Chem. 44, 594 (1972).

Accounting (DA Methodology): Mass Spectrometry

57

Thermal Ionization Mass Spectrometry

MODEL:

SUPPLIER:	**Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Oxides, metals
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)
MANUFACTURER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)

PURPOSE

Used at Y-12 for isotope ratio measurements of clean and radioactive solutions.

DESCRIPTION

Clean uranium sample is dissolved, loaded on a filament, placed under vacuum, heated to 1200 deg. C to ionize uranium. NBL U-500 50/50 standard is used (correction for bias is about 0.1%). VG Instruments spectrometer analyzes 16-20 samples at one time; Finnigan spectrometer analyzes 13 samples.
For gram per gram measurements: isotopic dilution by U-233 is used (NBL CRM 111A). Weighing is a crucial step: 0.5 gram of sample to dissolve in 40 mL of nitric acid. Take 0.5 grams of the solution and do a second dilution in 20 mL; then spike the solution with the amount of at least 5% of the major isotope content. Use NBL CRM 129 for oxides (natural U), and NBL CRM 116 (93%) for U metals.
System calibration is done infrequently. However, with each set of samples (set of 16-20) a standard measurement is performed. NBL verification standards are used for that purpose, and should match composition of the samples.
Same amount of uranium (10 micrograms) is used for all samples.

COMPONENTS

- Apparatus: Finnigan, Models MAT 262 and MAT 261 or VG Instruments (England), Model VG-354 (the latter is similar to MAT 262). Data on accuracy are given for VG-354. This equipment is not the latest.
- Reagents: Ion exchange resin (U/TEVA, small particle size) is supplied by EIChrom Industries, USA (approximately $6/g; 0.3 g per sample; it may be reusable, but not at ORNL).

In Russia CH3(C8H17)3N*NO3 is used for Pu – “toman”.

SPECIFICATIONS

TIMS filament sample load	10 microgram

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C1380-97: Standard Test Method for Determination of Uranium Content and Isotopic Composition by Isotope Dilution Mass Spectrometry, May 1998.

Accounting (DA Methodology): Titration

58

Modified Davies-Gray Potentiometric Titration of Uranium

MODEL:

SUPPLIER:	**Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Metal, alloys, oxide
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)
MANUFACTURER:	Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)

PURPOSE

Determination of uranium content in various materials: metal U and alloys, oxides. The method is free from interference for ORNL samples (Fe and Pu do not interfere). Magnesium chloride can interfere, but they removed by fuming with sulfuric acid. Ag and Sn can also interfere, but in ORNL samples they are not present.

DESCRIPTION

The major steps are:
- The sample is dissolved in mineral acid and fumed to near dryness in perchloric and/or sulfuric acid.
- The uranium salts are redissolved in dichromate-treated phosphoric acid.
- Hexavalent uranium is reduced to U(IV) by excess Fe(II) in concentrated phosphoric acid containing sulfamic acid.
- The excess Fe(II) is selectively oxidized with nitric acid using Mo(VI) as a catalyst.
- A weighed quantity of solid dichromate slightly greater than the equivalent amount for pure uranium metal is added, and the excess dichromate is back-titrated with Fe(II). Vanadyl sulfate is added to sharpen the end point.

Interferences:
Chloride, bromide, and iodide ions interfere, but can be removed by fuming with sulfuric acid. Molybdenum and manganese interfere in the presence of nitric acid, but up to 200 mg of each can be tolerated if the nitric acid is removed by fuming with sulfuric acid. Silver and Sn(II) interfere, but are rarely present in uranium samples.
Major Source of error: weighing (it should be very accurate), including air buoyancy correction (0.03%).
Reference materials: NBL CRM-129 is used daily.
Bias in this method is practically zero. Control measurements are done before and after the sample (typically 20 a day at Y-12 Plant) measurements.

COMPONENTS

Apparatus:
- Balance, analytical, 160-g capacity, with 40-g.
- Beakers, Pyrex, 150, 400, and 600 mL.
- Carboy, polyethylene, 4-L capacity.
- Electrode, silver/silver chloride and platinum (platinum needs to be removable for flaming).
- Flask, 500 mL, socket-joint, with fuming caps.
- Flasks, volumetric, 100, 500, 1000, and 2000 mL.
- Digital pH meter, millivolt scale, with 0.1-mV readability.
- Pipettes, volumetric, 10, 15, and 20 mL.
- Stirrer, for use with magnetic stirring bars, that reads and controls rpm.
- Stirring bar, Teflon, with no pivot ring. Same type of stirring bar must be used for samples, controls, and standards.
- Titration instrument that titrates to a potentiometric end point.
- Vials, plastic, approximately 50 mm tall by 10 mm diam, with snap-on caps.

Hotplates:
The custom built hotplate used for sample dissolution has a heating surface of 18 inches by 24 inches. The top of the hotplate heating surface is made of 0.5 inch inconel metal. There are six heating elements made of stainless steel and each heating element is a 1400 watt resistance type element. All elements are electrically connected in an attached 4 inches by 11.5 inches box. The hotplate is 5 inches high. There is a thermocouple inside the hotplate unit that provides feedback for temperature control. The control box is 5 inches by 9 inches by 10.5 inches and power is supplied from a 60 amperes circuit breaker, 220 AC volts.
Automated process is implemented. Metrohm automated Burettes (pulsed piston) are used. An automatic programmable device was designed at ORNL; it measures and dispenses all solutions in the process of measurements (Mayak and Luch, Russia have this device supplied by ORNL).

SPECIFICATIONS

Sample size	1 g
Relative standard deviation	
at 40% concentration of U	0.1%
at 100% concentration of U	0.05%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. R.B. Durham, MODIFIED DAVIES-GRAY POTENTIOMETRIC TITRATION OF URANIUM, Technical Procedure, Y/P65-3516, Rev. J, Lockheed Martin Energy Systems, Inc., September 17, 1998.

Accounting (DA Methodology): Titration

59

High Precision Titrimetric Method (Gravimetric Version)

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	`
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

Highly-precise assay of uranium-bearing materials for which an estimate of the uranium content is available. It can be used for analysis of uranium metal, UO2, UO3, U3O8, and UF6.

DESCRIPTION

- A sample containing 2.5-3.5 g uranium is dissolved in presence of phosphoric acid. (Samples as small as 1.0 g may be analyzed, but with some loss of precision).
- Uranium in solution is reduced to U(IV) by ferrous sulfate.
- The excess Fe(II) is destroyed by molybdate-catalyzed oxidation with nitric acid. The nitrous acid produced in this reaction, which with time would reduce Fe(III) to again form Fe(II), is destroyed by reduction with sulfamic acid.
- The sample is diluted with water, and vanadyl sulfate is added to increase the rate of the titration reaction.
- U(IV) is titrated with potassium dichromate by adding most of the potassium dichromate as an accurately-weighed solid, followed by final titration, by weight, with a standard potassium dichromate solution.

Potassium dichromate is added to the sample solution before sample reduction to oxidize the commonly-found impurity antimony to Sb(V), which does not interfere.

PROCEDURE:

- Sample preparation
- Assay procedure

CALCULATIONS:

A. Calculate the buoyancy-corrected weight of sample assayed.
B. Calculate the amount of solid potassium dichromate required to oxidize all of the U(IV) in the sample.
C. Calculate the amount of ferrous sulfate which must be added to reduce U(VI) to titratable U(IV).
D. Calculate the total weight of K2Cr2O7 used in titration.
E. Calculate sample uranium content.

Wt. % U = Wd,total/ (Wsbc x Fd) x 100%

where

Wd,total = total g K2Cr2O7 used in titration.
Fd = K2Cr2O7/uranium equivalence factor
Wsbc = buoyancy-corrected sample weight

STANDARD MATERIALS:

- NBL CRM 112-A, Uranium Metal Assay Standard
- NBL CRM 129, Uranium Oxide (U3O8) Assay Standard

COMPONENTS

Instruments:

- Balance, >= 3-g capacity, readable to 0.001 mg
- Balance, >= 30-g capacity, readable to 0.01 mg
- Balance, >= 160-g capacity, readable to 0.1 mg preferably with push button tarring capability.
- pH meter, capable of reading absolute mV, preferably with digital readout for easy readability.

Apparatus:

- Muffle furnace
- Magnetic stirrer.
- Magnetic stirring bars, Teflon-coated.
- Platinum wire electrode, 16-guage, 99.99% pure, about 35-cm long, coiled at one end.
- Reference electrode, saturated calomel.
- Polyethylene squeeze bottle, 125-mL capacity, fitted with a removable polyethylene tip drawn out to deliver drops of 3 to 7 mg (for use as weight burette).
- Pipets, 5-mL and 10-mL, graduated.
- Graduated cylinder, 100-mL.
- Beakers, 400-mL, tall form.
- Timer.

- Thermometer, digital or liquid in glass, calibrated, readable to 0.1° C.
- Barometer, mercury.
- Hydrometer, calibrated.
- Weighing dish, aluminum.
- Combination hot plate/magnetic stirrer.
- Steam bath in hood.
- Watch glass.

SPECIFICATIONS

Sample uranium content	2.5-3.5 g
Standard for the titrant standardization	NIST SRM 136e (*)
Reagent temperature must remain between	23 to 32 °C
Reproducibility of the method for a single analyst	<= 0.007%
Method bias	no detectable bias has been identified

(*) SRM 136e (Potassium Dichromate):

standard's weight:	60 g
certified use:	oxidimetric value
stoichiometric purity:	99.984%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL-SA-U(E) -2.2. Procedure. Determination of Uranium by the New Brunswick Laboratory High Precision Titrimetric Method - Gravimetric Version. Walter Nichiporuk. 07.20.95.

Accounting (DA Methodology): Titration

60

Titrimetric Method

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

Determination of the uranium content of samples from virtually every point in the nuclear fuel cycle. Plutonium does not interfere.

DESCRIPTION

- Uranium solutions are aliquanted into samples containing:
  >20mg U (Normal Level);
  8 to 20 mg U (Low Level);
  or 0.5 to 8 mg U (Low-Low Level).
- Interferences are removed by separation, oxidation and/or fuming, and samples are redissolved.
- The uranium is reduced to U(IV) with ferrous sulfate in a concentrated phosphoric acid medium.
- Excess ferrous ion is removed by molybdate-catalyzed oxidation with nitric acid.
- The sample is diluted with a vanadyl solution which improves the rate of titration reaction; U(IV) is titrated to U(VI) with potassium dichromate of appropriate strength

Potassium dichromate is added to the phosphoric acid to oxidize the commonly-found impurity antimony to Sb(V), which does not interfere. Sulfamic acid is used to remove nitrites which might interfere with uranium reduction and removes nitrites formed during oxidation with nitric acid.

While a single titration can be completed in ten minutes, elapsed time including sample preparation for single sample is usually 1-2 hours. Groups of 12-15 samples usually require two days.

PROCEDURE:
Sample Preparation
Blank Titration
Uranium Titration

CALCULATIONS:
mgU = (fn) (gTu - gTb)
where
gTb = g titrant used in blank titration
gTu = g titrant used in titration of uranium
fn = titrant equivalency factor for normal U

INTERFERENCES/LIMITATIONS:
Reagent temperature must remain between 23 ˚C and 31˚C for all reactions to proceed properly.

COMPONENTS

Equipment:
- Balance, readable to 0.0001g, preferably with push button tare capability.
- pH meter, capable of reading absolute mV.

Apparatus:
- Graduated cylinders, 100-mL.
- Pipettes, 5 and 10-mL
- Beakers, 400 -mL.
- Magnetic stirring bars.
- Magnetic stirrer.
- Timer.
- Indicating electrode. Pt wire (16-gauge, 99.99% pure) about 15 inches long, coiled at one end.
  Clean platinum electrodes used for sample titrations daily by flaming to a white heat and quenching in concentrated nitric acid. Electrodes previously used for extremely "dirty" samples may be cleaned by dipping in molten sodium bisulfate or a saturated solution of sodium bisulfate, then flaming.
- Reference electrode. Commercially available saturated calomel. Cracked bead or asbestos junctions are preferred.
- Polyethylene bottle, 125 mL capacity, fitted with a removable polyethylene tip drawn out to deliver drops not heavier than 5 mg.
- Thermometer.

SPECIFICATIONS

Standard for the titrant standardization	NBL CRM 112-A
Reagent temperature must remain between	23 to 32 ˚C
Single titration time	10 min
Analysis time including sample preparation time	1-2 hours
Time for 12-15 samples analysis	2 days
Relative standard deviation:	
Normal Level Samples (containing >20 mg)	< 0.10% (*)
Low Level Samples (8-20 mg)	< 0.13% (**)
Low Low Level Samples (< 8 mg)	< 0.36% (**)

(*) Potassium Dichromate, approx. 0.03N
(**) Potassium Dichromate, approx. 0.015N

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL-SA-U(E)-1 Procedure: Determination of Uranium by Ferrous Reduction in Phosphoric Acid and Titration with Dichromate (NBL Titrimetric Method), Iris W. Frank, November 21, 1995.

Accounting (DA Methodology): Mass Spectrometry

61

Analysis of Isotopic Content by Mass Spectrometric Method

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Miscellaneous
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

Mass spectrometry method is used for the determination of the uranium and plutonium isotopic compositions in different nuclear materials (metals and compounds).

DESCRIPTION

The analysis of the uranium and plutonium isotope content (metals and compounds) is performed by mass spectrometry method on a commercial thermal ionization mass spectrometers МИ-1201 and МИ-3306.
For the isotopic analysis of plutonium, a sample is stripped of americium using chromatography. (The presence of other actinides does not influence the results of mass spectrometric isotopic analysis of plutonium).
Samples prepared for analysis undergo the following preliminary processing:
1. Samples are converted to solution:
- metallic plutonium is dissolved in hydrochloric acid;
- plutonium dioxide is dissolved in mixture of concentrated nitric and hydrofluoric acids or hydrochloric and hydriodic acids;
- U, UO2, U3O8 is dissolved in nitric acid.
2. Sample solution is converted to nitrate form by evaporation in presence of concentrated nitric acid.
3. The solution containing 1-3 mg of U or Pu is placed on the evaporator of the ion source.
The mass spectrometric method is also used in the method of isotope dilution for determination of uranium and plutonium content in different materials and solutions. When the isotope dilution is performed, the known amount of measured element with the known isotopic composition different from the isotopic composition of the same element in the sample("spike") is added to the sample. The change of the isotopic composition is measured by mass spectrometer and the content of the measured element is calculated. U-233, U-235, U-238, Pu-242 are used as spikes.
The metrological support of this method is based on the State and Industry system of isotope uranium reference materials, which cover the entire system of isotope composition range.

COMPONENTS

SPECIFICATIONS

```
Isotopic sensitivity of the mass spectrometric method:
                  МИ-1201                                          5E-4 %
                  МИ-3306                                          2E-7 %

Error range (depends on device type and the isotopic content):
                  МИ-1201                                          0.008-0.2%
                  МИ-3306                                          0.005-0.01%
Relative error for the isotope dilution method                     1-1.5%
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контроля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Alpha Spectrometry, Total Activity Measurements

62

Radiometric and Alpha-Spectrometric Methods for Plutonium Determination Using Preliminary Plutonium Separation by Extraction/Chromatographic Methodology

MODEL:

SUPPLIER:	**MCC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Alpha Spectrometry, Total Activity Measurements
METHOD:	Alpha Spectrometry, Total Activity Measurements
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	High Level Liquid Wastes
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	MCC
MANUFACTURER:	MCC

PURPOSE

The methodology is used for the determination of plutonium in highly radioactive liquid waste by measuring total radiation and using alpha-spectrometry.

DESCRIPTION

Extraction chromatography separation of plutonium with methyltrioctylammonium nitrate allows the application of total radiation measurement methods and alpha-spectrometric methods for the determination of the plutonium content in highly radioactive solutions containing interfering impurities.

Steps:

- add nitric acid to an aliquot of the sample to a concentration of 1.5-2 M/l, enter Pu-238 spike (in case of alpha-spectrometry), stir, warm up to 70 deg. C, add 0.1 M/l $KMnO_4$ in order to convert Pu to Pu (VI) up to a steady raspberry color over 1-2 minutes;
- reduce Pu to Pu (III) with 0.5 M/l ferrous sulfamate, at first up to disappearance of the raspberry color, and then up to a concentration of 0.05M/l and hold for 2-3 minutes;
- oxidize Pu to Pu (IV) by adding saturated $KBrO_3$ solution, pouring along the test tube wall and stirring, in the same volume quantity as the added ferrous sulphamate solution, and hold for 2-3 minutes;
- dilute the solution with 1.5 M/l nitric acid solution such that the salt concentration in solution will not exceed 100 g/l, stir the solution and place 0.2-0.3 ml solution portions, washing the test tube 2-3 times with nitric acid, one by one to the prepared chromatography column (with 6 mm inner diameter, 1.2-1.3 g sorbent mass, 0.8-1.0 ml/min rate of flow). Extracted plutonium stays inside the column during this process, while uranium, americium, radionuclides and salt components go through the column;
- after filtration of the solution trough the column, the column is washed with 3 portions of 3-4 ml of 1.5 M/l nitric acid solution. If the analysis is performed on solutions stored for more then 5 years, the column is washed with 7M/l hydrochloric acid solution in order to extract Th-233 (after the second washing by nitric acid);
- plutonium is eluted with 0.3 or 0.03 % ammonium oxalate. The 0.3 % ammonium oxalate is applied if the following electrolyte extraction of plutonium on the target plates, the 0.03 % ammonium oxalate is applied in direct placement of eluate to target plates after fuming;
- in case where alpha spectrometry is used, the eluate is washed out of the test tube 2 or 3 times by 0.3% ammonium oxalate and transmitted to a cell for electrolytic extraction of plutonium. 1.5 ml of 1 M/l ammonium acetate is added to provide the optimum value of pH. Cathode is a polished steel (X18H10T) plate, anode is a platinum spiral. The current density is 0.1-0.3A, the electrolysis time is 15-20 minutes.

Main sources of error:

- aliquot preparation,
- radiation rate meter calibration,
- isotopic spike,
- estimation of the specific activity of plutonium.

COMPONENTS

SPECIFICATIONS

Content range of Pu:	
total radiation rate counting	0.3 - 30.0 mg/l(with the prior dilution of the sample the upper limit is increased)
alpha-spectrometric method	0.05 microgram/l - 10 mg/l (with the prior dilution of the sample the upper limit is increased)
Accuracy:	
total radiation rate counting	25%
alpha-spectrometric method	3%

SOFTWARE

ADDITIONAL INFORMATION

Metyltrioctylammonium nitrate is produced by the Hydrotsvetmet of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk.

REFERENCES

1. Аналитический контроль плутония в технологическом процессе радиохимического производства ГХК. (Analytical Plutonium Control at the MChC Radio-Chemical Facility.)

Accounting (DA Methodology): Spectrophotometry

63

Spectrophotometric Method for the Determination of Plutonium Concentration

MODEL:

SUPPLIER:	**MCC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	MCC
MANUFACTURER:	MCC

PURPOSE

The determination of plutonium in eluates.

DESCRIPTION

Determination of the Pu content is based on the optical density measurement of Pu(VI) in solution at a wavelength of 831 nm.
Steps:
- place a 0.5 – 2 ml aliquot of the sample in a volumetric flask (25-100 ml). Size and dilution factors of the aliquot are chosen based on the expected plutonium concentration in the sample in order to achieve the optimum range of measured optical density (0.3 – 0.6);
- add, pouring along the wall, 0.75 M/l nitric acid solution in the amount required to achieve a nitric acid concentration in the range of 0.6-1.0 M/l;
- add potassium dichromate solution(30g/l of potassium dichromate in a 0.75 M/l nitric acid) filling about 10% of the flask; warm the flask in boiling water for 15 minutes to convert Pu to Pu(VI) state; cool the solution to the temperature at wich the spectrophotometer calibration was made;
- add 0.75 M/l nitric acid to fill the volumetric flask to the "full" level marker. The measurement of the plutonium light absorption is performed at wavelengths of 815 and 845 nm, accounting for background solution absorbtion, and the values are then averaged.

The plutonium content is calculated using a calibration curve prepared using the plutonium standard solution measurements.
Main source of error:
- aliquot preparation;
- spectrophotometer calibration;
- optical density measurement.

COMPONENTS

Spectrophotometer СФ-46 (Russia).

SPECIFICATIONS

Accuracy of the plutonium determination	4%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Аналитический контроль плутония в технологическом процессе радиохимического производства ГХК. (Analytical Plutonium Control at the MChC Radio-Chemical Facility.)

Accounting (DA Methodology): Gravimetry, Spectrometry, Spectrophotometry

64

Determination of Plutonium Concentration in Plutonium Dioxide

MODEL:

SUPPLIER:	**MCC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Gravimetry, Spectrometry, Spectrophotometry
METHOD:	Gravimetry, Spectrometry, Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Powder
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	MCC
MANUFACTURER:	MCC

PURPOSE

The determination of plutonium content in plutonium dioxide.

DESCRIPTION

The determination of the plutonium content in plutonium dioxide is performed by subtraction from the stoichiometric content of plutonium (88.19%) of the following quantities: percentages of humidity and undercalcination, and of the total impurities content. The content of impurities, except for uranium, is determined by chemical-spectrometric methods. Then the calculation of total impurities content and of their oxides based on theoretical average conversion coefficients is performed. Uranium in plutonium dioxide is determined by the spectrometric method after its chromatographic extraction with trioctylamine. The determination of boron in performed in presence of mannitol to avoid losses during measurements. The values of humidity and undercalcination are determined by measuring the sample weight difference before and after the sample calcination in a platinum crucible at a temperature of 900 – 1000 ˚C over three hours.

Steps:

- plutonium dioxide samples prepared for the single and group impurity determinations are weighed to 0.0001g. Samples for the humidity and undercalcination determination are weighted first and are placed in the muffle furnace;
- remaining samples are transmitted to separate boxes and are dissolved in the mixture of the following acids: hydrochloric acid + hydriodic acid +nitric acid + hydrofluoric acid;
- after the dissolution of plutonium dioxide, measured impurities are extracted from plutonium in hydrochloride solutions with 30% solution of tributylphosphate in benzene; for uranium this is accomplished by the method of chromatography extraction in columns with trioctylamine impregnated on the granulated porous polytetrafluoroethylene;
- the content of uranium is determined by the spectrophotometric method using the color reaction with arsenazo;
- solutions with extracted impurities are fumed with nitric acid. Precipitation are dissolved in nitric acid solution, high purity graphite powder is added, the mixture is dried, and as a well mixed powder they are placed in graphite electrodes;
- burning electrodes in the arc of variable or direct current, emission spectra are obtained on photoplates with spectrographs. Simultaneously with the samples, spectra photographs of reference materials are also taken for comparison;
- Photoplates are processed and spectra are read using the automated system "Contrast - 3".

COMPONENTS

- Emission spectrographs:
    - СТЭ-1;
    - ДФС-8;
- Arc generator ИВС-28;
- Automated installation for reading spectrogram "Контраст-3" based on microphotometer МФ-2, developed by SKTB "Nauka", Krasnoyarsk;
- Spectrophotometer СФ-46.

SPECIFICATIONS

Accuracy of plutonium determination	0.5%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Аналитический контроль плутония в технологическом процессе радиохимического производства ГХК. (Analytical Plutonium Control at the MChC Radio-Chemical Facility.)

Accounting (DA Methodology): Alpha Spectrometry, Gamma Spectrometry

65

The Plutonium Isotopic Content Determination

MODEL:

SUPPLIER:	**MCC**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Alpha Spectrometry, Gamma Spectrometry
METHOD:	Alpha Spectrometry, Gamma Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Solutions
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	MCC
MANUFACTURER:	MCC

PURPOSE

This method is used for determination of isotopic composition of plutonium is used for calculation of the plutonium specific alpha-activity. The latter is required to calculate the plutonium content by using the total radiation rate counting and qualify control of the batches complectation of irradiated fuel on the isotopic content for reprocessing.

DESCRIPTION

Isotopic content of Pu-240 is determined by gamma spectrometry; isotopic content of Pu-238 is determined by alpha spectrometry.
Total alpha-activity of plutonium handled at the facility is caused by three isotopes: Pu-239, Pu-240, and Pu-238 (listed in decreasing order their contribution to total alpha activity).
Isotope activity ratio of Pu-240 and Pu-239 is calculated by comparing the ratio of their full energy absorption peak areas at 45,24 and 51,61 keV, respectively, with the ratio obtained from the measurement of plutonium isotopic content standards. Isotopic content of Pu-238 is calculated by comparing the peak area of Pu-238 with the peak area of Pu-239 + Pu-240. In this measurement, an alpha spectrometer with a silicon detector with resolution 60 keV or better is used.
Steps:
- an aliquot of the plutonium nitric acid solution, containing 220-250 mg of Pu, is measured by the gamma spectrometric method in order to determine the existence of americium which interferes with measured nuclides. If the americium interferes, americium is extracted using the ionoexchange method on the resin AV-17 (AB-17);
- concentrated nitric acid solution is added to yield concentration of 6.5-7 M/l ;
-Pu is stabilized in +4 oxidation state by heating the solution with sodium nitrate to 50-60 deg.C for 30-40 minutes;
- without cooling, the solution is poured on the AV-17 ionite column to separate americium and salt components (the working volume of the column is adjusted in order to extract 300-350 mg of Pu);
- the exchange column is washed with 5-6 column volume of a 7M/l nitric acid solution;
- the elution of plutonium is performed with 2-3 column volume of a 0.7M/l nitric acid solution. The eluate is stirred and it's plutonium content is determined by a the spectrometric method;
- the solution is fumed to 9.5-10.5 g/l Pu concentration and two 10.0 ml aliquots are sampled in measured teflon flasks. The same procedure of the americium separation and preparation to measurements is performed on Pu isotopic content standard;
- after the spectrophotometric determination of the plutonium content is finished, the aliquot of the solution purified from americium is diluted with 0.75 M/l nitric acid to a plutonium concentration of 0.5-1.0 mg/l;
- 0.05-0.15 ml of the solution is poured on the polished steel (X12H10T) plate by a capillary and spread uniformly on the plates surface. The plate is dried under a heat radiator lamp and sent for the alpha-spectrometric determination. .

COMPONENTS

Gamma-spectrometer:
- Analyzer AMA-03f (Russia) of "NOKIA" analyzer with a X-Ray semiconductor silicon detection unit with resolution no worse than 700 eV in the 40 – 60 keV ;

Alpha-spectrometer:
- IBM-PC;
- one board SBS-50 spectrometer (installed in PC);
- semiconductor detection unit -3000 mm2 silicon detector;
- vacuum pump NVR01-D (НВР01-Д);
- vacuum chamber VDR01-D (ВДЭ-А 1001);
- software for spectrum simulation and processing.

SPECIFICATIONS

Accuracy of the gamma-spectrometric method	±2%
Accuracy of determination of the specific activity of plutonium	±2%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Аналитический контроль плутония в технологическом процессе радиохимического производства ГХК. (Analytical Plutonium Control at the MChC Radio-Chemical Facility.)

Accounting (DA Methodology): Extraction chromatography, isotopic dilution, gamma-spectrometry

66

Determination of Np-237 Content by Methods of Extraction Chromatography, Isotopic Dilution, and Gamma-Spectrometry

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Extraction chromatography, isotopic dilution, gamma-spectrometry
METHOD:	Extraction chromatography, isotopic dilution, gamma-spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Np-237
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

This method is used for determination of neptunium content in concentrated plutonium solution.

DESCRIPTION

This method of determination of the Np-237 content in solutions is based on combining extraction chromatography, isotopic dilution and gamma spectrometry of Np-237 and Np-239 using a semiconductor gamma spectrometer. Trioctylamine is used as extractant and provides a high degree of purification of neptunium extracted from solutions containing uranium, plutonium, and gamma-emitting fission products. Np-239 is used as a spike which is in equilibrium with the mother radionuclide Am-243.

Steps:

1) Take 1-2 ml aliquot from the sample.
2) Add 2 ml of Am-234 (spike) and mix carefully.
3) For each ml of sample solution add 0.1 ml of ferrous (II) sulfamate solution, 0.1 ml of ascorbic acid and hold the mixture for 2-3 minutes.
4) Place the solution to a chromatographic column and filter at a rate of 1 ml/minute.
5) Wash the column with three portions of 3 ml of 1.5 M/l nitric acid after sample solution has passed through the column.
6) Elute neptunium with trioctylamine, with 0.3 M/l solution of $H_2C_2O_4$ in a cell made of special organic glass .

The content of Np-237 is determined by a gamma spectrometric method, detecting the 86.5 keV gamma-ray of Np-237 and 228.2 or 277.6 keV or (106,1 + 103.7) keV gamma-rays of Np-239 using high resolution gamma spectrometry. Calibration is performed with a control solution of known concentration of Np-237 being in equilibrium with Pa-233 and with a control solution of Am-243 being in equilibrium with Np-239. The control solutions are placed in cells similar to those cells used for the sample analysis; the measurements are performed in the same geometry.

There is a similar method using Np-237 as a spike instead of Np-239.

COMPONENTS

SPECIFICATIONS

Relative error of this method for Np-237 content range of 1-200 microgram in sample)at a confidence level of 0.95	30% - 6%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Gravimetry

67

Gravimetric Method for Uranium Determination

MODEL:

SUPPLIER: **VNIINM**
USE CATEGORY: Accounting (DA Methodology)
DEVICE/METHOD TYPE: Gravimetry
METHOD: Gravimetry
MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U
PHYSICAL FORM(S) OF NM: UNH
STATUS:
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: VNIINM
MANUFACTURER: VNIINM

PURPOSE

The method is used for the determination of uranium in UNH.

DESCRIPTION

The measurement of uranium content is based on:
- dissolving a sample in nitric acid;
- precipitation of uranium at pH of 2.25-2.50 in the form of uranyl EDTA complex, which is transformed to uranium peroxide by adding hydrogen peroxide and letting stead for 10-15 minutes;
- adding buffer solution which provides the optimum pH value for the quantitative precipitation of uranium within 15-20 minutes;
- ignition and weighing of the precipitate in the form of urano-uranic oxide (U3O8).

Operation steps:
Sample of uranyl nitrate hexahydrate containing 0.5 gram uranium is weighed with error of 0.0005 gram or less, put in flask. 10-20 ml (1 M) of nitric acid is added, then 20-40 ml of distilled water is added and the solution is heated to the boiling. Then the solution is dissolved in distilled water to 100 ml and at temperature below 40 degree C 5 ml diammonium salt of EDTA acid, 0.5 ml of blue tiomole solution and ammonia solution (1:6) are added until color changes from pink to orange. Precipitation of uranyl EDTA (light yellow color) takes place. Then 15-20 ml of peroxide hydrogen is added.
The solution above the precipitate becomes pink. After 10-15 minutes, 15 ml of buffer solution is added and after 15 minutes the solution is filtered through a double paper filter "white ribbon". The precipitate is washed by decantation (50-100 ml of washing solution). The washed precipitate with the filter is dried (possibly on the hot plate). The dried filter is placed inside a previously weighed crucible and placed in a muffle furnace at the temperature not exceeding 300 'C. The temperature is increased to 900-1000'C and the filter is kept there for one hour. Generated uranous-uranic oxide (U3O8) after cooling in the exciccator is weighed. Control measurements are performed on all steps along with the analysis.

COMPONENTS

SPECIFICATIONS

Relative error of the method	0.3%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Spectrophotometry

68

Spectrophotometric Method with Prior Extraction-Chromatography

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu, Np
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

The method is used for the determination of uranium and plutonium in refined materials and liquid waste.

DESCRIPTION

Aqueous and organic solutions of uranium, neptunium and plutonium have specific colors. This permits the determination of these elements and identification of their oxidation states.
Because of their low sensitivity and low selectivity spectrophotometric methods for the direct determination of uranium, neptunium and plutonium are used in general for the solution of special analytical tasks.
Spectrophotometric methods of the determination of uranium, neptunium, and plutonium based on production of sharply colored complexes with organic reagents became important for analytical purposes. Reagents such as arsenazo III and orange xylenol are used often. Since reagents from the arsenazo group also generate colored compounds with many elements in +4 and +6 oxidation states, a preliminary extraction of the measured element from the solution should be carried out to separate this element from interfering components and impurities. To provide the selective extraction and purification of uranium, neptunium and plutonium from analyzed solutions and materials chromatographic methods are used most often and in particular the method of the extraction chromatography with "solid extractants" (so called "twaks"- it is the Russian abbreviation of the words "solid extractants"). Twaks is a granule porous polymer impregnated by the extractant. Mass extractant content in twaks can be brought to high values greater then 50%.
The spectrophotometric determination of uranium (VI) using arsenazo (III) is carried out at pH 5.5. For this purposes:
- the aliquot of the analyzed solution (approximately 5 ml), containing from 5 to 50 micro gram of uranium, is put in a measured flask (25 ml);
- 15 ml of the acetate buffer, 5.5 pH contained EDTA (trilon B) is added in the flask;
- 1 ml of the saturate solution of sulphanilic acid and 2 ml of 0.1% aqueous solution of arsenazo (III) are added in the flask;
- distilled water is added to the flask up to mark (25 ml), the solution is mixed, and is left steading for 15-20 min, and after that
- the optical density is measured by a spectrophotometer at a wavelength of 650 nm in a dish with 60 mm length comparing with the solution of arsenazo (III). The content of uranium is obtained from a calibration chart.

For the determination of uranium in organic solutions uranium is reextracted by the acetate buffer solution including arsenaso (III). Optical density of the reextract is measured at two wavelengths: 750 nm and 650 nm correspondingly, comparing with eluate solution.

COMPONENTS

SPECIFICATIONS

```
For aqueous solution:
          sensitivity                  1 microgram
          relative error               10%
For organic solutions:
          relative error               5%
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Spectrophotometry

69

Injection-Spectrometric Method for Direct Determination of Uranium and Plutonium

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Spectrophotometry
METHOD:	Spectrophotometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

The method is used for the determination of uranium and plutonium in eluates of the I and II extraction cycles. Advantages of the method are: high speed of the analysis, no need for sample preparation, a small sample volume (a few tens of microliter), easy to automate.

DESCRIPTION

The method is based on the injection of a sample solution in the flow of the carrier (3M of nitric acid) followed by measurement of light absorption by uranium and plutonium at wavelengths of 416 nm and 563 nm, respectively.

The equipment consists of some units of liquid chromatograph "Цвет-306" produced in Russia.

Operation steps:

The carrier (3 M nitric acid) is brought through the installation with a volumetric rate of 5 ml/min at the valve switch position "sampling". The carrier goes by the loop-metering system and enters the analytical line. The loop-metering system is rinsed and filled with the analyzed solution. Then the valve is switched to the position "analysis", and the sample is pushed out by the carrier flow from the dosing loop into flowing cell of the spectrophotometer.

Optical density is measured at first at a wavelength of 416 nm, and then with the reintroduction of the sample - at a wavelength of 563. The time needed for the transition to the other wavelength and for setting a base line is not more than 5 minutes.

The concentration of uranium and plutonium in the analyzed solution is calculated using a calibration curve or a calibration coefficient derived by measuring solutions with the known content of the measured metals.

COMPONENTS

The installation consists of several components of the liquid chromatograph "Цвет-306" produced in Russia:

- liquid container for the dissolver-carrier,
- pump for feeding the carrier to the analytical line with the required speed (БПЖ-49),
- unit for introducing a sample - switching 6-position valve with the dosing loop (30 microliters). This unit has 2 stages: "sampling" and "analysis",
- spectrophotometer СФ-00 (Russia) consisting of
  - monochromator with spherical mirror (F=160 mm) and
  - diffraction grid, 1200 units/mm with a 15 long6 25 microliter flowing cell.

This spectrophotometer generates an electrical signal proportional to the intensity of the transmitted light , and

- logarithmic amplifier УЛ-02 for transforming signals from spectrophotometer to have output signals proportional to the optical density of solutions analyzed or to the concentration of metals defined in a range of 0.01 - 1.28 units of the optical density.

SPECIFICATIONS

For the installation:

noise at zero signal	≤0.005mV with the dry cell and at the signal division coefficient corresponding to position "8" for logarithmic amplifier УЛ-02
detection limit	5E-7 g/ml

For the method:

relative error	≤ 1%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Coulometry

70

Coulometric Method for Uranium and Plutonium Determination

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Coulometry
METHOD:	Coulometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

The determination of uranium and plutonium content in the following materials:
- nitric acid input solutions;
- eluate of the first and second extraction cycles;
- finished products in the form of plutonium dioxide and UNH.

DESCRIPTION

The controlled potential coulometric method (CPC) allows accurate analysis without prior extraction of measured components and can be made highly selective. The end point of the titration is reached when the current drops to its residual value.

One of the CPC method involves stepwise change of potential. In this method the potential of the oxidation state is not set at once, but is changed gradually, beginning with the original starting potential of starting valency forms. This approach allows decreased background currents and hence an increase of the sensitivity and accuracy of the determination of the uranium or plutonium content.

The analytical control is implemented step by step:
- a measured sample is placed in the electrolytic cell, and diluted with background electrolyte. The preliminary reduction of uranium and plutonium is performed by slowly changing potential from +0.5 to -0.17V and waiting until a residual current value of no more then 1 microamperes is attained.
- joint oxidation of uranium and plutonium is carried out by increasing slowly potential value up to +0.90V and waiting until a residual current value of 10 microamperes is attained.
- plutonium is reduced selectively by decreasing the potential value to +0.5V and waiting until a residual current value of 10 microamperes is attained.
- plutonium oxidation is implemented selectively by increasing the potential value up to 0.90V and waiting until a residual current value of 10 microamperes is attained.
- the duration of each step and integratedcurrents gone through the cell are measured and these data are used for calculation of final results by using some constants, parameters and results of blank measurements.

The electrochemical analysis and data processing of the method can be completely automated. It is possible to create a data archive and store it in a computerized MC&A system.

COMPONENTS

SPECIFICATIONS

Relative error of the method	0.3%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): Titration

71

Potentiometric Titration of Uranium by the Davies-Gray Method

MODEL:

SUPPLIER:	**VNIINM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Titration
METHOD:	Titration
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	VNIINM
MANUFACTURER:	VNIINM

PURPOSE

This method is used for determination of uranium in the following fuel reprocessing materials:
- input nitric acid solutions;
- solutions after the I and II cycles of extraction;
- end products in the form of uranyl nitrate hexahydrate.

DESCRIPTION

Uranium (VI) is reduced to uranium (IV) with ferrous (II). Excess of ferrous(II) is oxidized with nitric acid in presence of Mo(VI) as catalyst. Uranium (IV) is titrated with vanadyl sulfate used as indicator.
Steps:
1) Add 5 ml of 1.5 M/l solution of sulfamic acid and 40 ml of 80% phosphoric acid to the sample solution containing about 300 mg of uranium. Mix solution after addition of each reagent.
2) Add 5 ml 1 M/l solution of ferrous sulfate (II) and hold the sample for 0.5-1 minutes.
3) Wash the vessel walls with a 10 ml oxidizing mixture (solution of 8M/l nitric acid, 0.15 M/l sulfamic acid, and 0.4% ammonium molybdate).
4) Stir vigorously. After dark-brown color disappears (20-40 c), hold solution for 3 minutes.
5) Add 100 ml of water and 110-130 mg of vanadyl sulfate.
6) Begin titration immediately. That includes the following operations.
6.1) Place electrodes in the sample vessel.
6.2) Turn on the mixer and ion-current meter on a range of
«-1 - +4», if mercury sulfate reference electrode is used,
«+ 4 - + 9», if silver chloride reference electrode is used.
6.3) Quickly add a portion of approximately 90% of the estimated equivalent titrant volume with the burette switch.
6.4) Switch burette to low speed and outside control
6.5) Press buttons "START" and "ON" of the connector unit. The titration begins up to a given potential (70-160)mV if mercury sulfate electrode is used, and to 550-600 mV if silver chloride electrode is used.
6.6) The equivalent volume record from the burette panel when the light "END" appears.
Time between the moment when the sample is ready and the end of titration must not exceed 7 minutes.
Temperature of the titrant solution should be fixed. Value of the temperature is needed for calculation of the uranium mass fraction in the sample.

COMPONENTS

- Laboratory Titrator T-108 with ion-meter ЭВ-74 (produced in Russia).
- Platinum electrode ЭПВ-1 (Russia) used as indicator electrode;
- Mercury phosphate electrode (Hg/Hg2SO4) or silver chloride electrode, ЭВЛ-1М1 or ЭВЛ-1М3 (Russia) as the reference electrode (these electrodes have advantages when compared with calomel electrode because they provide a more distinct end point of titration)

SPECIFICATIONS

```
Relative error of the method          0.3% (Plutonium does not interfere)
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. В.Ф. Косицын, Н.Ф Мухортов, Ю.И. Коровин, В.С. Руденко, А.М. Петров. Методы контоля ядерных материалов, используемые на основном производстве радиохимического завода. ГНЦ РФ ВНИИНМ им. Академика А.А. Бочвара. Доклад на радиохимическом семинаре. Г. Обнинск, 2-6 ноября 1998г.

Accounting (DA Methodology): XRF

72

ASTM C1343-96: Standard Test Method for Determination of Low Concentrations of Uranium in Oils and Organic Liquids by X-Ray Fluorescence

MODEL:

SUPPLIER:	**ASTM**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	XRF
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Oils and organic liquids
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ASTM
MANUFACTURER:	ASTM

PURPOSE

This test method covers the steps necessary for the preparation and analysis by X-Ray fluorescence (XRF) of oils and organic solutions containing uranium. The procedure is valid for those solutions containing 20 to 2000 microgram uranium/mL as presented to the spectrometer. This test method requires the use of an appropriate internal standard.

DESCRIPTION

Solution standards containing 20 microgram uranium/mL to 2000 microgram uranium/mL and an internal standard are placed in a liquid sample holder of an X-Ray spectrometer and exposed to an X-Ray beam capable of exciting the uranium L-alpha emission line and the appropriate internal standard line. The intensities generated are measured by a detector. The intensity ratio values obtained from these data are used to calibrate the X-Ray analyzer. The samples are prepared with a similar matrix to fit the calibration range, and are measured using the same analytical parameters.
Either wavelength-dispersive or energy-dispersive XRF systems may be used, provided that the software accompanying the system is able to accommodate the use of internal standards.
Main Steps:
- Obtain the gross weight of the sample and flask. (This may be omitted if an answer on a weight basis is not desired.)
- Add 2 mL of the internal standard solution; dilute
to volume and mix thoroughly.
- Counting the Sample:
  - Set the X-Ray spectrometer.
  - If the analytical conditions are controlled by computer, start the computer
  - Shake each flask to mix thoroughly
  - Fill the liquid sample cup with the recommended amount of liquid for the instrument being used
  - Obtain intensities for the uranium L-alpha line and the internal standard line
  - Calculate the uranium concentration in the flask using the appropriate equation

The quadratic equation will have the form
$Y = CX^2 + BX + A$
where:
Y - concentration of uranium,
X - uranium/internal standard intensity ratio, and
A, B, C - coefficients of quadratic equation.
For self-absorption, the equation will have the form
$Y = (MX + B)(1 + aX/100)$
where:
Y - concentration of uranium,
X - uranium/internal standard intensity ratio,
M - slope of straight line,
B - intercept of straight line, and
a - self-absorption coefficient.
Note:"Additional factors, such as volume, weight, isotopic correction, and secondary dilutions, may be added to the equations to obtain correct results for the user's application.
There is no readily available certified material (uranium in organic liquids) for this test method. At ASTM test certification measurements, a solution of NBL CRM 129 (U_3O_8) was prepared by dissolving approximately 5.9 g (weighed to the nearest 0.1 mg). Thirty test samples of 5 mL each were prepared and analyzed by seven different technicians over an eight-month period (Bromine was used as the internal standard.).

COMPONENTS

Apparatus:
- X-ray Spectrometer
- Sample Cups:
  - Prepare liquid sample cups for the X-ray spectrometer as described by the manufacturer.

- Polyester, polyethylene, and polypropylene films are used as the film window for such cups.
- Solution Dispenser (Optional).

SPECIFICATIONS

```
RSD for a test solution of 0.010141 g U/g              0.8 %
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. ASTM C 1343-96: Standard Test Method for Determination of Low Concentrations of Uranium in Oils and Organic Liquids by X-Ray Fluorescence, September 1996.

Accounting (DA Methodology): Mass Spectrometry

73

Gas Source Mass Spectrometry

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (DA Methodology)
DEVICE/METHOD TYPE:	Mass Spectrometry
METHOD:	Mass Spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Gas (UF6; oxide and metals converted to UF6)
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

At NBL, this method is used to certify U-235 to U-238 certified reference materials (CRM).
Gas-ionization mass spectrometry is particularly useful for determining the isotopic composition of U in uranium hexafluoride (UF6) since no chemical treatment other than purification is required prior to the analysis. The technique is most often employed at enrichment facilities. Gas-ionization mass spectrometry can be used for the analysis of any U compound that can be converted to UF6; however, surface-ionization mass spectrometry is generally preferred for other compounds.
The gas-ionization technique requires a large sample and, therefore, is less than satisfactory for the analysis of materials that are of limited availability. In addition, the gas-ionization technique may be subject to a small memory effect. When a wide range of enrichments is to be determined, it is advisable to have a number of instruments, each dedicated to a narrow band of enrichments.
Theoretically, PuF6 can also be analyzed by this method.

DESCRIPTION

Sample materials have to be converted into UF6 for analysis. For details on this methodology see Introduction in this Catalog.

COMPONENTS

Gas Mass Spectrometer Finnigan MAT 281

SPECIFICATIONS

Sample size	0.1 g
Precision	0.01% to 0.1%
Purity requirements	High purity UF6

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Supplier/Developer Data - Информация от поставщика/разработчика
2. D. R. Rogers, Handbook of Nuclear Safeguards Measurement Methods, NUREG/CR-2078, September 1983

Accounting (Mass/Volume Determination): Weighting euqipment

Electronic crane scales

MODEL: ВК-10, ВК-5

SUPPLIER:	**Tenzo-M**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weighting euqipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight
NUCLEAR MATERIAL(S):	Any
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Tenzo-M
MANUFACTURER:	Tenzo-M

PURPOSE

Scales are used for weighing great packages (from 5 to 20 tones in depend of model).

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Rank of accuracy of scales on GOST 29329-92	middle (III)
Upper limit of weighing (ULW), tones (depending on model)	5, 10, 20
Error, less than, %	0.05 ULW
Range of working temperature, °C	from -30 to +40

SOFTWARE

ADDITIONAL INFORMATION

RF Register, № 18057-03, actives till 01.12.2008

REFERENCES

http://www.tenzo-m.ru/

Accounting (Mass/Volume Determination): Weighting equipment

75

Electronic platform scales

MODEL: ВП

SUPPLIER: **Tenzo-M**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weighting equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight
NUCLEAR MATERIAL(S): Any
PHYSICAL FORM(S) OF NM: Any
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Tenzo-M
MANUFACTURER: Tenzo-M

PURPOSE

Determination of item and package weights.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Upper limit of weighing (ULW)	from 500 to 25000kg
Rank of accuracy of scales on GOST 29329-92	middle (III)
Discrepancy	100 g (500 kg), 5 kg (25000 kg)
Range of working temperature, °C	10… +40*

____

* It is possible to manufacture scales with expanded range of working temperature (-30 … +40°C) on special booking.

SOFTWARE

ADDITIONAL INFORMATION

RF Register, № 21440-01

REFERENCES

http://www.tenzo-m.ru/

Accounting (Mass/Volume Determination): Weigthing equipment

76

Electronic platform scales

MODEL: ВПА

SUPPLIER:	**Tenzo-M**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight
NUCLEAR MATERIAL(S):	Any
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Tenzo-M
MANUFACTURER:	Tenzo-M

PURPOSE

Determination of item and package weights.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Upper limit of weighing (ULW)	from 5 to 500 kg
Rank of accuracy of scales on GOST 29329-92	middle (III)
Discrepancy	1 g (5 kg), 100 g (500 kg)
Range of working temperature, °C	-10… +40

SOFTWARE

ADDITIONAL INFORMATION

RF Register ,№ 21439-01

REFERENCES

http://www.tenzo-m.ru/

Accounting (Mass/Volume Determination): Weigthing equipment

Ramsey Impact Weighers

MODEL: DE10, DE20

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight
NUCLEAR MATERIAL(S):	Any
PHYSICAL FORM(S) OF NM:	Bulk solids
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

Weighers provide the continuous mass flow measurement in mechanical conveying systems without interrupting the flow of material.

DESCRIPTION

The weighers are designed to measure the force generated by the impact of flowing bulk solid material on a sensing plate. This force creates a mechanical deflection as it impacts the plate. This deflection is measured by a sensor and converted into an electrical signal. That signal is then processed by the Ramsey Micro-Tech 2106 or 3106 Electronic Controller, which displays the flow rate and total weight.

COMPONENTS

SPECIFICATIONS

	Ramsey DE 10 Impact Weighers	Ramsey DE 20 Impact Weighers
Measuring Range	(2.3 - 726 MTPH) 2.5 - 800 STPH	(0.2- 54.4 MTPH) 0.2- 60 STPH
Standard Temperature	+10 to +80°C (+50 to +180°F) (Lower and higher temperature configurations available)	+10 to +80°C (+50 to +180°F) (Lower and higher temperature configurations available)
Material Temperature	+10 to +180°C (+50 to +350°F)	+10 to +180°C (+50 to +350°F)
Approvals (optional)	FM approved, Class I and II, Div.1 and 2, Groups A-G, for use with Ramsey Micro-Tech 2106/3106 in safe area only	FM approved, Class I and II, Div.1 and 2, Groups A-G, for use with Ramsey Micro-Tech 2106/3106 in safe area only
Deflection Measurement	By linear variable differential transformer	By linear variable differential transformer
Weight Without Sensing Plate	61 kg (135 lb)	30 kg (66 lb)
Dust-proofing	Completely sealed from the sensing plate housing	Completely sealed from the sensing plate housing
Accuracy	Anywhere from 0.5% to 5% but most often will be 1% to 1.5%	

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.thermo.com/bulk-handling

Accounting (Mass/Volume Determination): Weigthing equipment

78

Precision laboratory balances

MODEL: Excellence XP/XS

SUPPLIER: **Mettler Toledo**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weigthing equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Mettler Toledo
MANUFACTURER: Mettler Toledo

PURPOSE

Precision balances are intended for weighting of different materials of 200 g to 64 kg weight with accuracy from 0.1 mg to 1 g (depending on capacity .

DESCRIPTION

Precision balances of professional (XP) and classical (XS) levels are equipped with function of automated calibration and linearization by two built-in weights. Dust and water proof and multi-level vibration filter allows for balances operation in rugged environment. Depending on the object size, the balances of S, M, or L-type are choosen.

Precision XP/XS balances allows for resolving the any tasks: starting from simple weighting to determination of expensive and dangerous material weight, complex formulation, counting of small parts, determination of sample weight within the heavy container, control of sample series weight tolerance, determination of liquid and solid density and others.

Precision balances allows for weighting the radioactive and toxic materials. Balances can be remotely controlled without touching the buttons.

COMPONENTS

- stainless steel weighting platform (with case for some models)
- terminal with touch graphical display and IR-sensors for remote control (for example, for opening/closing the weighting chamber doors)
- LabX software (optional) that connects the balances to computer and also other laboratory instrumentation (for example, titrator)

Instrumentatin integration in to the network provides reliable data storage and processing, and excludes the operator mistake when transfering the results to the paper or computer.

SPECIFICATIONS

XP Precision balances with S-platform:

Model	Capacity	Readability	Pan size
XP204S	210 g	0.1 mg	90 mm
XP404S	410 g	0.1 mg	90 mm
XP404S DeltaRange	80/410 g	0.1/1 mg	90 mm
XP203S	210 g	1 mg	127×127 mm
XP603S	610 g	1 mg	127×127 mm
XP603S DeltaRange	120/610 g	1/10 mg	127×127 mm
XP1203S	1210 g	1 mg	127×127 mm
XP2003S DeltaRange	500/2100 g	1/10 mg	127×127 mm
XP5003S DeltaRange	1000/5100 g	1/10 mg	127×127 mm
XP802S	810 g	10 mg	170×205 mm
XP1202S	1210 g	10 mg	170×205 mm
XP2002S	2100 g	10 mg	170×205 mm
XP4002S	4100 g	10 mg	170×205 mm
XP4002S DeltaRange	800/4100 g	10 mg/0.1 g	170×205 mm
XP6002S	6100 g	10 mg	170×205 mm
XP6002S DeltaRange	1200/6100 g	10 mg/0.1 g	170×205 mm
XP8002S	8100 g	10 mg	170×205 mm
XP10002S	10100 g	10 mg	170×205 mm
XP10002S DeltaRange	2000/10100 g	10 mg/0.1 g	170×205 mm
XP2001S	2100 g	0.1 g	190×223 mm
XP4001S	4100 g	0.1 g	190×223 mm
XP6001S	6100 g	0.1 g	190×223 mm
XP8001S	8100 g	0.1 g	190×223 mm
XP10001S	10100 g	0.1 g	190×223 mm

XP Precision balances with M-platform:

Model	Capacity	Readability	Pan size
XP6002M DeltaRange	810 g	10 mg/1 g	237×237 mm
XP12002M DeltaRange	1210 g	10 mg/1 g	237×237 mm
XP8001M	2100 g	0.1 g	237×237 mm
XP8001M DeltaRange	2100 g	10 mg/1 g	237×237 mm
XP12001M	4100 g	0.1 g	237×237 mm
XP16001M	6100 g	0.1 g	237×237 mm
XP16001M DeltaRange	6100 g	10 mg/1 g	237×237 mm
XP20001M	8100 g	0.1 g	237×237 mm
XP12000M	10100 g	1 g	237×237 mm
XP20000M	10100 g	1 g	237×237 mm

XP Precision balances with L-platform:

Model	Capacity	Readability	Pan size
XP8001L	8100 g	0.1 g	280×360 mm
XP16001L	16100 g	0.1 g	280×360 mm
XP32001L	32100 g	0.1 g	280×360 mm
XP32001L DeltaRange	6400/32100 g	0.1/1 g	280×360 mm
XP64001L	64100 g	0.1 g	280×360 mm
XP16000L	16100 g	1 g	280×360 mm
XP32000L	32100 g	1 g	280×360 mm
XP64000L	64100 g	1 g	280×360 mm

XS Precision balances with S-platform:

Model	Capacity	Readability	Pan size
XS203S	210 g	1 mg	127×127 mm
XS403S	410 g	1 mg	127×127 mm
XS603S	610 g	1 mg	127×127 mm
XS603S Delta Range	120/610 g	1/10 mg	127×127 mm
XS1003S	1010 g	1 mg	127×127 mm
XS802S	810 g	10 mg	170×205 mm
XS2002S	2100 g	10 mg	170×205 mm
XS4002S	4100 g	10 mg	170×205 mm
XS4002S DeltaRange	800/4100 g	10 mg/0.1 g	170×205 mm
XS6002S	6100 g	10 mg	170×205 mm
XS6002S DeltaRange	1200/6100 g	10 mg/0.1 g	170×205 mm
XS4001S	4100 g	0.1 g	190×223 mm
XP6001S	6100 g	0.1 g	190×223 mm
XP8001S	8100 g	0.1 g	190×223 mm

XS Precision balances with M- and L-platforms:

Model	Capacity	Readability	Pan size
XS6001M	6100 g	0.1 g	237×237 mm
XS6001M DeltaRange	1200/6100 g	0.1/1 g	237×237 mm
XS1001M	10100 g	0.1 g	237×237 mm
XS12001M DeltaRange	1200/6100 g	0.1/1 g	237×237 mm
XS16001M	16100 g	0.1 g	237×237 mm
XS10000M	10100 g	1 g	237×237 mm
XS16000M	16100 g	1 g	237×237 mm
XS8001L	8100 g	0.1 g	280×360 mm
XS16001L	16100 g	0.1 g	280×360 mm
XS32001L DeltaRange	1200/6100 g	0.1/1 g	280×360 mm
XS16000L	16100 g	1 g	280×360 mm
XS32000L	32100 g	1 g	280×360 mm

SOFTWARE

LabX balance software for data management, y control.

ADDITIONAL INFORMATION

An additional equipment and accessories designed by METTLER TOLEDO are used for tasks of weighting the complex, dangerous and toxic samples:

- nonmagnetic pans eliminating magnetic field effects in measurement results
- sets for determination of solids and liquids density
- printers for printing and minuting the results obtained

REFERENCES

www.mt.com, www.mtrus.com/precision

Accounting (Mass/Volume Determination): Weigthing equipment

79

Weights and Sets of Weights

MODEL:

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

The weights are designed for calibrating, verifying and testing the scales and balances.

DESCRIPTION

The weights and the weight standards of METTLER TOLEDO are made of high-quality nonmagnetic steel resistant to any kinds of atmosphere corrosion. According to internal requirements of METTLER TOLEDO company , the quality of weights material and their treatment are higher than the OIML R111 standard's reuqirements.

COMPONENTS

SPECIFICATIONS

	Individual weights	Sets of Weights
E1	1 mg - 50 kg	1 mg - 5 kg
E2	1 mg - 50 kg	1 mg - 5 kg
F1	1 mg - 50 kg	1 mg - 5 kg
F1 with fitting cavity	1 mg - 20 kg	1 mg - 5 kg
F2 with fitting cavity	1 mg - 20 kg	1 mg - 5 kg
	special weights 5 - 50 kg	
M1	special weights 5 - 50 kg	
M1 with fitting cavity	1 mg - 20 kg	1 mg - 5 kg
M1		
	special weights 5 - 50 kg	
M2	special weights 5 - 50 kg	
M3	special weights 5 - 50 kg	

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

/www.mtrus.com

Accounting (Mass/Volume Determination): Weigthing equipment

80

Ultra-micro and Micro- Balances

MODEL: XP/XS

SUPPLIER: **Mettler Toledo**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weigthing equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Mettler Toledo
MANUFACTURER: Mettler Toledo

PURPOSE

Ultra-micro and micro balances are designed for weighting the microscopic samples with highest accuracy.

DESCRIPTION

XP6U, XP2U, XP6, XS3DU ultra micro balances and XP6 microbalances allows for taking the weighted samples with extremely high precision of 0.1 µg. Weighting chamber has a minimal volume, and individual electronics unit doesn't distort the measurement results. They are recommended for verification the weights of high accuracy class.

XP26, XP26DR, XP56, XP56DR micro balances with capacity of 52 and 22 g are ideal for weighing the samples directly into the container.

ErgoClips attachments allows for taking the samples into flasks or vials.

COMPONENTS

- weighting chamber
- terminal with touch graphical display and IR-sensors for remote control (for example, for opening/closing the weighting chamber doors)
- LabX software (optional) that allows for balances communication with computer and also other laboratory instrumentation (for example, titrator)

Instrumentatin integration in to the network provides reliable data storage and processing, and excludes the operator mistake when transfering the results to the paper or computer.

SPECIFICATIONS

Model	Capacity	Readability	Cell stabilization time
XP6U	6.1 g	0.1 µg	~ 15 sec
XP2U	2.1 g	0.1 µg	~ 10 sec
XP6	6.1 g	1 µg	~ 8 sec
XS3DU	3 g/800 mg	10/1 µg	~ 10 sec
XP56	52 g	1 µg	~ 3.5 sec
XP56DR	52/11 g	10/2 µg	~ 2.5/3.5 sec
XP26	22 g	1 µg	~ 3.5 sec
XP26DR	22/5.1 g	10/2 µg	~ 2.5/3.5 sec

SOFTWARE

ADDITIONAL INFORMATION

For weighting of complex, dangerous, and toxic samples the auxilliary equipment and accessories developed by METTLER TOLEDO are used:
- tool kits for weighting the filters of 40 to 110 mm diameters
- antistatic tool kits for weighting the electrostatically charged samples
- tool kit for weighting the microsamples
- printers for printing and minuting the results obtained

REFERENCES

www.mtrus.com/micro

Accounting (Mass/Volume Determination): Weigthing equipment

81

Analytical laboratory balances

MODEL: Excellence XP/XS

XP205

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

Designed for weighting different materials with high accuracy (0.01 mg or 0.1 mg), as well as for determining the density of solids and liquids by method of hydrostatic weighting.

DESCRIPTION

Analytical balances of professional (XP) and classical (XS) levels are equipped with function of automated calibration and linearization by two built-in weights. The balance pan is made in form of grid - its small surface is resistant to air flows that allows for reducing the time of cell stabilization. The pan is fasten to the side wall of weighting chamber that excludes the fall of weighted samples inside the balance mechanism. Wind-proof case is easily removed for clean.

Analytical XP/XS balances allows for resolving the following tasks: taking the weighted samples directly into container, weighting the electrostatically charged samples, determination of liquid and solid density, formula weighting, display the weighting results in variious units.

Analytical balances allows for weighting the radioactive and toxic materials. Balances can be remotely controlled without touching the buttons - the weighting chamber is placed under draught or in the box, and the terminal is placed outside the dangerous zone.

COMPONENTS

- weighting chamber with SmartGrid grid pan and wind-proof case;
- terminal with touch graphical display and IR-sensors for remote control (for example, for opening/closing the weighting chamber doors);
- LabX software (optional) that allows for balances communication with computer and also other laboratory instrumentation (for example, titrator)

Instrumentatin integration into the network provides reliable data storage and processing, and also excludes the operator mistake when transfering the results to the paper or computer.

SPECIFICATIONS

Model	Capacity	Readability	Cell stabilization time
XP505	520 g	0.01 mg	~ 6 sec
XP205	220 g	0.01 mg	~ 6 sec
XP205DR	81/220 g	0.01/0.1 mg	~ 6 sec
XP105DR	31/120 g	0.01/0.1 mg	~ 6 sec
XP504	520 g	0.1 mg	~ 4 sec
XP504DR	101/520 g	0.1/1 mg	~ 4 sec
XP204	220 g	0.1 mg	~ 4 sec
XS205DU	81/220 g	0.01/0.1 mg	~ 3/2 sec
XS105DU	41/120 g	0.01/0.1 mg	~ 3/2 sec
XS204	220 g	0.1 mg	~ 2 sec
XS204DR	81/220 g	0.1/1 mg	~ 3/2 sec
XS104	120 g	0.1 mg	~ 2 sec
XS64	61 g	0.1 mg	~ 2 sec

SOFTWARE

ADDITIONAL INFORMATION

For weighting the complex, dangerous, and toxic samples the auxilliary equipment and accessories developed by METTLER TOLEDO are used:

- tool kits for weighting the filters of 40 to 110 mm diameters
- antistatic tool kits for weighting the electrostatically charged samples
- tool kits for determining the density of solids and liquids

- ErgoClips tools for easy taking the weighted samples directly in final container
- printers for printing and minuting the results obtained

REFERENCES

www.mtrus.com/analytical

Accounting (Mass/Volume Determination): Weigthing equipment

82

Self-contained Compact Industrial Scales 3kg… 35kg capacity

MODEL: BBK4xx

SUPPLIER: **Mettler Toledo**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weigthing equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight, density, volume, strength, number of pieces
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held, portable, table
ENVIRONMENT OF USE: Industrial
DEVELOPER: Mettler Toledo
MANUFACTURER: Mettler Toledo

PURPOSE

Scales are intended for different weighting operations with laboratory precision under industrial conditions, as well as for making the weight compositions, determining the volume, density, strength.

DESCRIPTION

Compact scales of BBK4xx series are based on MonoBloc electromagnetic weighting cell having the high wear resistance, overload and shock protection, and high performance.
MonoBloc ensures the high weighting accuracy for any object weight and high reliability during long-time operation. Besides, the scales with MonoBloc cell are more resistant to the temperature drift, that allows for their use in the wide temperature range with reliable results.

COMPONENTS

- strong cast aluminium body with a stainless steel weighting pan
- dust/water-proof keyboard
- built-in batteries (or power supply from the mains of 220V)

Additional equipment:
- PVC protective cover for the scale body,
- printer,
- second display,
- relay unit,
- bar code scanner,
- RS232/RS485/USB/Ethernet built-in interfaces.

SPECIFICATIONS

Model	Capacity, g	Readability, g	Platform (weighting pan) size, mm
BBK4x2 - 3 DXS	600/3100	0.01/0.1	165x165
BBK4x2 - 3 XS	3100	0.01	165x165
BBK4x2 - 6 DXS	1200/6100	0.01/0.1	165x165
BBK4x2 - 6 XS	6100	0.01	165x165
BBK4x2 - 6 DSM	1200/6100	0.1/1	200x240
BBK4x2 - 6 SM	6100	0.2	200x240
BBK4x2 - 15 DLA	3500/15100	0.1/1	240x350
BBK4x2 - 15LA	15100	0.5	240x350
BBK4x2 - 35 DLA	7000/35100	0.1/1	240x350
BBK4x2 - 35 LA	35100	0.1	240x350

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.mtrus.com

Accounting (Mass/Volume Determination): Weigthing equipment

83

High-precision platform scales
3kg… 20000kg capacity
MODEL: серия К (K line)

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing
MEASURED PROPERTIES:	Weight, density, volume, strength, number of pieces
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial, including explosive areas
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

High-precision weighting of smaples and supersize containers under industrial conditions, as well as making the weight compositions, determining the volume, density, strength.

DESCRIPTION

The platform scales of K series are based on the principle of electromagnetic compensation, that ensures the high precision of measurements, linearity and reproducibility of the results. Special leverage system and high-precision weighting cell of METTLER TOLEDO ensures the high precision (up to 300 000 calibration divisions) and reliability. All-metal body of the weighting cell is made of high quality stainless steel of IP66/IP67 protection class. Built-in calibration weight allows for verification of scale performance in any time. Scale embodiment - from colored, galvanized or stainless steel for different operation environments. Dust and water proof - up to IP67.

COMPONENTS

- scale frame with weighting cell and leverage system for scale capacilty of more than 32 kg
- receptacle (sample load platform)
- terminal with required set of functions and instruments - from simple displays (IND429) to free programmable industrial computers (ID30)

SPECIFICATIONS

Model	Capacity, kg	Readability, g	Platform size, mm
KA3s	3	0.01	200 x 200
KA6s	6	0.02	200 x 200
KA15s	15	0.1	350 x 280
KA32s	32	0.1	280 x 350
KB60	60	1	500 x 400
KCC150	150	1	600 x 800
KCC300	300	2	600 x 800
KC300	300	2	800 x 1000
KD600	600	10	1000 x 1250
KES1500	1500	20	1500 x 1500
KES3000	3000	50	1500 x 1500
KU10000	10000	200	by order
KU20000	20000	500	by order

SOFTWARE

Basic weighting functions or special software of any destination (is completed or developed according to the user's

ADDITIONAL INFORMATION

Wide communication capabilities for integration in any industrial information system (interfaces: RS422/485, Ethernet IP, Profibus DP, Aleen Bradley RIO, ControlNet, 4-20мА/0-10В), additional accessories and equipment.

REFERENCES

www.mtrus.com

Accounting (Mass/Volume Determination): Weigthing equipment

84

Weighting sensors and modules
121 g… 300 000 kg capacity

MODEL:

SUPPLIER:	**Mettler Toledo**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Weigthing equipment
METHOD:	Weighing, making the weight compositions, determining the volume, density, strength
MEASURED PROPERTIES:	Weight, density, volume, strength
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary, portable, mobile
ENVIRONMENT OF USE:	Industrial, including explosive areas
DEVELOPER:	Mettler Toledo
MANUFACTURER:	Mettler Toledo

PURPOSE

Weighting modules and sensors are the universal means for transformation of almost any construction to the scales. It can be the tank, bunker, mixer, apparatus, column, platform, conveyor, installation with manupulator. METTLER TOLEDO produces the weighting modules with capacity of 121 g to 300 tons and minimal readability of 0.01 mg.

DESCRIPTION

COMPONENTS

Modules embodimen can be selected on the base of operating conditions:
• sensor and mounting elements made of stainless steel with up to IP 68 protection class designed for installation in moist and corrosive environments;
• alloyed steel sensor, carbon steel mounting elements, IP 66/67 protection class are applied for installation in less aggressive environments.

Any Mettler Toledo's weighting terminal can be used as a weight display, signal processing device.
There is a possibility to connect the weighting modules to industrial automation systems via specialized transmitters-transformers to control the variable in time weighting processes
.

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.mtrus.com

Accounting (Mass/Volume Determination): Weigthing equipment

85

Automobile scales

MODEL: 7560-31-S, 7560-41-S

SUPPLIER: **Mettler Toledo**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weigthing equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Field
DEVELOPER: Mettler Toledo
MANUFACTURER: Mettler Toledo

PURPOSE

Weighting auto transport with containers.

DESCRIPTION

Thesse automobile scales use strain-gauge transducers with digital output.
Scales' "heart" is a patented weighting gauge DigiTOL with digital output. Analogous signal of resistive-strain measurement bridge is concerted to digital one within the gauge itself. Immediately after this the weight is corrected depending on the temperature pf resistive-strain layer (thermocompensation). Result obtained is transferred in digital form to weighting terminal through the cable. Weighting gauge is made of stainless steel using laser bonding and is filled with rare gas. To connect the cable the weighting gauges have bayonet connector made in accordance with military standards. Supporting elements of weighting gauge are covered with silicon nitride to reduce its wear-out. Shape of the bottom pivot excludes gauge rotation during operation, and spherical shape of top pivot prevents the cross-slide load. DigiTOL gauges are designed for operation within temperature range of—40°C to +45°C. Automatic temperature compensation allows to obtain the precise weight values over total temperature range. Weighting result is displayed at weighting terminal and can be printed or transmitted to computer database.

COMPONENTS

- loading platform
- Cougar weighting terminal with RS232/RS422 interface
- DigiTOL weighting gauges with digital output
- tool lit for gauges installation
- shielded stainless steel cable of 25 m length
- documentation

Size of loading platform, m	Number of loading platform modules	Number of weighting gauges
7,5 x 3,3	1	4
12,0 x 3,3	2	6
15,0 x 3,3	2	6
18,0 x 3,3	3	8
21,0 x 3,3	3	8
22,5 x 3,3	3	8
24 x 3,3	4	10

SPECIFICATIONS

Maximal weighting capacity	from 10 to 100 t
Readability	2 / 5 / 10 / 20 kg
Calculated lifetime	15 - 20 years
Operating temperature range of loading platform	from -40°C to +45°C
Relative humidity	up to 100%
Operating temperature range of weighting terminal	from -40°C to +45°C
Relative humidity	up to 95%, non condensing
Power supply	mains 220 Vac, 50 Hz
Power5 consumption	100 Wt
Calibration interval	1 year

SOFTWARE

ADDITIONAL INFORMATION

Certificate:- ISO9001
- Gosstandard (input into State Register)

Mettler Toledo ensures 7560-31-S and 7560-41-S scales warranty during 1 year, as well as post-warranty service in any place of NIS.

REFERENCES

http://www.mt.com

Accounting (Mass/Volume Determination): Weigthing equipment

86

Railway car scales

MODEL: 7260 series

SUPPLIER: **Mettler Toledo**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Weigthing equipment
METHOD: Weighing

MEASURED PROPERTIES: Weight
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Field
DEVELOPER: Mettler Toledo
MANUFACTURER: Mettler Toledo

PURPOSE

Weighting the containers in railway cars.

DESCRIPTION

Railway car scales can be delivered with a wide set of devices for displaying information proceeding from simple weight indicators to fully independent controllers that automatically weight the moving railway cars and transfer the information to computer network. When connecting the system of automatic identification, the data on railway car number, cargo shipper, cargo receiver, and containers within the car can be receiver and transmitted together with data in car weights.
Railway cars produced by Mettler Toledo can be distinguished by:
- method of weighting the cars;
- sizes and constructions of loading platform.

Methods of car weighting:
1. Static weighting. 7260S scale series. Static weighting, during which the motionless car as a whole is on the loading platform, is the most precise measurement method.
2. Weighting in motion. 7260M scale series. Scales for weighting trolley-be-trolley in motion. Total weight of the railway car is determined by summing the trolley weights.
3. Static weighting and weighting the car in motion on its full length. 7260SM scale series. Universal scales allows for both static weighting and weighting in motion process.

COMPONENTS

SPECIFICATIONS

Characteristic	Scale modification		
	7260S	7260M	7260SM
Method of weighting the cars (tank-wagons) and trains	Static, car-by-car	Static and in motion, trolley-by-trolley	In motion, car-by-car or element-by-element
Maximal weighting capacity, t	100, 150, 200		
Readability, kg	20, 50, 100		
Number of calibration points, ne	From 2000 to 5000 inclusive	-	From 2000 to 5000 inclusive
Minimal weighting capacity	20 e	1000 kg	20 e
Accuracy class for static weighting by GOST 29329	Medium	-	Medium
Accuracy class for weighting in motion of uncoupled and coupled cars and train by GOST 30414-96*	-	0.2/0.5/1.0/2.0	0.2/0.5
Speed of car motion during weighting, km/h	-	from 3 to 10	
Motion direction during weighting	-	Two-way or single-way traffic, at pull and push	
Number of modules in loading platform	from 2 to 7	from 1 to 3	from 2 to 7
Overall size of loading platform:			
length, m	from 3.8 to 24	from 1.5 to 4.5	from 3.8 to 24
width, m	from 2 to 3	from 2 to 3	from 2 to 3
Operating temperature range, °C:			
for loading platform	from -45 to +45		
for other devices	from −10 to +45		
Power supply characteristics:			
ac voltage, V	220 (from 187 to 242)		
frequency, Hz	50 ± 2		

power consumption, VA, no more that 300

*) Certain accuracy class for specific scale is guaranteed by manufacturer depending on the condition of local railway in the place of seal installation, as well as on condition and type of the railway cars to be weighted, and is established in maintenance documentation.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.mt.com

Accounting (Mass/Volume Determination): Level meter

87

Ultrasonic level meter

MODEL: «Взлет УР»

SUPPLIER: **Vzlet, JSC**
USE CATEGORY: Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE: Level meter
METHOD: Liquid Level Measurement (Ultrasonic)

MEASURED PROPERTIES: Volume
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Solution
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Vzlet, JSC
MANUFACTURER: Vzlet, JSC

PURPOSE

Ultrasonic level meter «Взлет УР» is created for measuring without contact levels of different liquid and bulk solids, including aggressive and highly explosive matters.This device can work also as a long meter and as a 8-channel level signaling device.

DESCRIPTION

These devices use non-contact acoustics measurement of distance to measured surface through gas substance (air). Calculation of flow rate (in a gutter flow rate meter) is run indirectly by recalculating a measured level of liquid in flaw passage to a value of flow rate based on specified flow rate characteristics. In this case the calculation of cumulative volume of liquid went through flow passage is run by integrating finding flow rate in time.

COMPONENTS

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

moscowoffice@vzljot.ru

Accounting (Mass/Volume Determination): Level Meter

88

Radar level meters

MODEL: УЛМ-11 и УЛМ-31

SUPPLIER:	**LIMACO**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Level Meter
METHOD:	Liquid Level Measurement (radar)
MEASURED PROPERTIES:	Volume
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution in processing tanks
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LIMACO
MANUFACTURER:	LIMACO

PURPOSE

These sensors are used for high precision non-invasive probing product level in tanks.

DESCRIPTION

Sensors of level are installed on the proof of tanks (one sensor for one tank) contained controlled product and measure level of fill tanks.

COMPONENTS

SPECIFICATIONS

Maximum measurement error	±1 mm
Performance of level senso	explosion-proof

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №16861-04

REFERENCES

http://www.limaco.ru/

Accounting (Mass/Volume Determination): Level meter

89

High frequency level meters

MODEL: УВВ

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Level meter
METHOD:	Liquid Level Measurement (Inductivity)

MEASURED PROPERTIES:	Volume
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

DESCRIPTION

Principle of working is based on transforming measured inductivity into frequency.
Probe devises from stainless steal allow measure a level of aggressive oxides, alkaline and salt mediums.

COMPONENTS

Measuring transducer УВВ-П and probe device УВМ-Д

SPECIFICATIONS

Range of measured level, L1, m	0-1.5 ... 8.0
Main error of measurement, % ,	less than: ±0.5 – on frequency output
Range of controlled temperature, °C	10-110

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Measurement and control instrumentation. Catalog 2005, PS “Mayak”/Средства измерения и контроля. Каталог 2005, ПО «Маяк»

Accounting (Mass/Volume Determination): Level meter

90

Tracking neutron level meter

MODEL: НСУ-2

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Level meter
METHOD:	Liquid Level Measurement (neutron)
MEASURED PROPERTIES:	Volume
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution (in processing tanks)
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

The level meter is designated for non-contact continuous automatic remote measurement of a level of aggressive foaming and crystallizable hydric medium in technological devices.

DESCRIPTION

The level meter is based on registration of neutrons radiated by source of fast neutrons and delayed by controlled medium and based on maintaining specified counting rate by watching system of the level meter. Delayed neutrons are registered by sensitive element or sensor.

COMPONENTS

SPECIFICATIONS

Upper levels of measurement, m	1.0; 1.6; 2.5; 4.0; 6.0
Main absolute error, mm	less than ±10
Range of controlled temperature, °C	from 10 to 140

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля.Каталог 2005, ПО «Маяк»/Measurement and control instrumentation. Catalog 2005, PS "Mayak"

Accounting (Mass/Volume Determination): Level Meter

91

Ultrasonic explosive-proofed level signaling devices

MODEL: СУВ

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Level Meter
METHOD:	Liquid Level Measurement (Ultrasonic)
MEASURED PROPERTIES:	Volume
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution in processing tanks
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

Control level of electroconductive and non-electroconductive liquid mediums including high aggressive and explosive medium in technologic apparatus and tanks.

DESCRIPTION

The device is based on measuring of frequency of generator resulted changing acoustic properties of medium surrounding sensitive element of sensor.

COMPONENTS

Transducer СУВ-П and two sensors СУВ-Д.

SPECIFICATIONS

Number of controlled level positions	2
Sensor is efficient when pressure in apparatus is, MPa	from 0.06 to 0.6
Overall size of sensor, mm:	
length	from 200 to 8000
diameter of dipping part	27
Area of switching, mm	less than ±6
Range of controlled temperature, °C	from - 5 to +115

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля. Каталог 2005, ПО «Маяк»/Measurement and control instrumentation. Catalog 2005, PS “Mayak”

Accounting (Mass/Volume Determination): Level Meter

92

Sensor of level signaling devices

MODEL: СУЭ-ДР

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Level Meter
METHOD:	Liquid Level Measurement (Ultrasonic)
MEASURED PROPERTIES:	Volume
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution in processing tanks
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

Specify existing electroconductive aggressive liquid in the specific point of level.

DESCRIPTION

The sensor is used in indicating units in systems of technological control at enterprises of atomic power engineering and industry.

COMPONENTS

The sensor includes: hermetic body, electrode insolated by teflon or chlorine vinyl tube, probe. Parts contacting with technological medium are constructed from materials of 12X18H10T (abbreviation in Russian Symbols) for nitric oxide mediums and 10X17H13M2T for alkaline mediums, alloy 46XHM (ЭП-630) or titanium for hydrochloric oxide mediums.

SPECIFICATIONS

```
Sensor is efficient when overpressure in apparatus, MPa,              to 0.6
Sensor is efficient when temperature of measuring medium, °C:
                with teflon insulation                                from 5 to 110
                chlorine vinyl insulation                             from 5 to 60
Overall size of sensor, mm:
                minimal length                                        240
                maximum length                                        40000
                maximal diameter                                      60
Mass, kg, less than                                                   10
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля. Каталог 2005, ПО «Маяк»/Measurement and control instrumentation. Catalog 2005, PS “Mayak”

Accounting (Mass/Volume Determination): Flow rate meter

93

Vibration carioles flow rate meter

MODEL: РВК-1

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (Mass/Volume Determination)
DEVICE/METHOD TYPE:	Flow rate meter
METHOD:	Flow Rate Measurement (vibraiton)
MEASURED PROPERTIES:	Flow Rate
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

Measurement of mass flow rate of different electroconductive and non-electroconductive liquid mediums including high aggressive solutions, pulps, emulsion and other liquids.

DESCRIPTION

The device is based on using Carioles forces resulted by interaction of controlled medium flow and angular rate of rang of sensitive element of fluid flow converter.

COMPONENTS

SPECIFICATIONS

Range of measurement, kg/hour I depend of sensor diameter	0 - 12.5 … 5000
Main error, %	less, than ± 1
Range of controlled temperature, °C	from 5 - to 80
Pressure of controlled medium, MPa	to 1.6

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля. Каталог 2005, ПО «Маяк»/Measurement and control instrumentation. Catalog 2005, PS “Mayak”

Accounting (NDA): Detector

94

Scintillation detection units

MODEL: БДЭА

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Alpha
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

Detection unit БДЭА is constructed to detect alpha-radiation.

DESCRIPTION

The detection unit converts energy of alpha-radiation absorbed by the sensitive area of the detector to electric pulses of proportional amplitude.

COMPONENTS

SPECIFICATIONS

Area of working surface	180 cm^2
Energy range	from 4 MeV to 12 MeV
Maximum statistical load	no more than 5E+4/s
Time of installing working regime	no more than 15 minutes
Time of continuous operation	no less than 24 hours

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Detector

95

Scintillation detection units

MODEL: БДБС

SUPPLIER: **Green Star**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: Beta

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Green Star
MANUFACTURER: Green Star

hosphich detector), Right-БДБС-ПЛ (scintillati

PURPOSE

Scintillation detection units БДБС are developed for detecting and spectrometry of beta-radiation.

DESCRIPTION

Scintillation detection units БДБС are issued of different geometry parameters with different detectors (scintillating plastic, paratephenil), «forswitch»-detectors.

COMPONENTS

SPECIFICATIONS

Amplitude resolution for gamma-ray of 624.2 keV of Cs-137	no more than 15 %
Working energy range	from 25 keV to 3500 keV
Integral nonlinearity of converting characteristic	no more than ±10%
Maximum statistical load	no more than 5E+5/s
Time of installing working regime	no more than 15 minutes
Time of continuous running	no less than 24 hours

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Detector

96

Scintillation detection units

MODEL: БДЭГ

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

ЭГ-62-3;БДЭГ-25(25)Н, БДЭГ-40(40)Н, БДЭI

PURPOSE

Scintillation units БДЭГ is developed for detecting and spectrometry of gamma-radiation.

DESCRIPTION

Scintillation detection units БДЭГ are issued of different geometry parameters with crystals of NaJ(Tl), CsJ(Tl), BGO and other.

COMPONENTS

SPECIFICATIONS

Working energy range	from 25 keV to 3500 keV
Integral nonlinearity of converting characteristic	no more than ±1%
Maximum statistical load	no more than 5E+5/s
Time of installing working regime	no more than 15 minutes
Time of continuous running	no less than 24 hours

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Detector

97

Scintillation detection units

MODEL: УДБТ-002/003

SUPPLIER: **Green Star**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: Beta

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Green Star
MANUFACTURER: Green Star

PURPOSE

DESCRIPTION

Scintillation units УДБТ (liquid scintillator) is developed based on principle of analyzing results with coincidence scheme used two photoelectric multipliers (PM). This construction of detection unit allow decrease noise at low energies.
Scintillation units УДБТ-002 is manufactured based on PM ФЭУ-184 of indigenous production.
Scintillation units УДБТ -003 is manufactured based on PM of Japanese production.

COMPONENTS

SPECIFICATIONS

	УДБТ-002	УДБТ-003
Efficiency of detection		
H-3	35%	60%
C-14	96%	98%
Sr+Y-90	99%	99%
Background		
H-3	0.7 pps	0.25 pps
C-14	1.5 pps	0.35 pps
Sr+Y-90	2.4 pps	0.5 pps

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Detector

98

Detection units

MODEL: БДЭР

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	X-ray
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

Detection units, БДЭР are constructed for detecting and spectrometry of X-rays.

DESCRIPTION

The detection units convert energy of X-rays swallowed by the sensitive area of the detector to electric pulses of proportional amplitude.
Detection units, БДЭР are manufactured based on detection p-i-n structures produced by AMPTEK (USA).
Detection units, БДЭР are issued of different geometry parameters with are of sensitive surface of 5 and 25 mm^2.

COMPONENTS

SPECIFICATIONS

Amplitude resolution for gamma-ray of 5,9 keV of Fe-55, is no more than:	170 eV for surface of 5 mm² 220 eV for surface of 25 mm²
Working energy range of photons	from 0.5 keV to 50 keV
Integral nonlinearity of converting characteristic	no more than ±0.25%
Maximum statistical load	no more than 5E+4/s
Time of installing working regime	no more than 15 minutes
Time of continuous running	no less than 24 hours
Operating temperature	from 10 °C to 40 °C

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

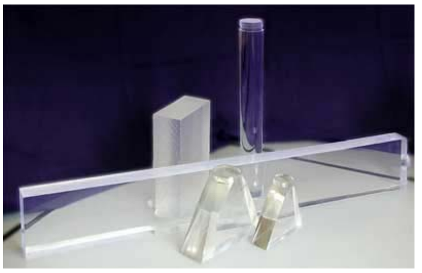
Accounting (NDA): Detector

99

Plastic scintillators

MODEL:

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Beta, gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	Aspect
MANUFACTURER:	Aspect



PURPOSE

Plastic scintillators are used for detecting different types of nuclear radiation.

DESCRIPTION

Plastic scintillators are made in different forms with polished surface and without containers.

COMPONENTS

SPECIFICATIONS

Scintillating efficiency related to anthracene stabdard, %	45 – 56
Specific weight	1.1 g/cm³
Time of highlighting	2 – 300 ns
Emission maximum	4100 A

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://aspect.dubna.ru

Accounting (NDA): Detector

100

Scintillation detection unit for gamma-radiation (with ADC)

MODEL: УДС-Г

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Creation of stationary and portable spectrometric systems for laboratory and industrial applications.

DESCRIPTION

Detection and conversion of gamma-radiation energy to electrical signals of corresponding amplitude; forming statistical distribution of amplitude depending on energy (forming spectrum); transferring spectra to computer for their visualization and processing.

COMPONENTS

- NaI(Tl) scintillator of 40x40 mm or 63x63 with photoelectronic multiplier
- Spectrometric amplifier
- Stabilization system based on a peak from light diode with function of thermo-compensation
- Source of high voltage for food of photoelectronic multiplier
- Spectrometric analogue digital converter
- Buffer storage and interface controller (RS232/485 or USB)

SPECIFICATIONS

Measurement energy range	0.05 – 3 MeV
Relative energy resolution at 662 keV (Cs-137)	
for Ø 40 x 40 crystal	no more than 8%
Integral non-linearity	no more than 1%
Number of ADC channels	992
Operating temperature range	from +5 to + 50 °C

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://aspect.dubna.ru

Accounting (NDA): Detector

101

Scintillation detection unit for beta-radiation

MODEL: БДС-Б

SUPPLIER: **Aspect**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: Beta

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Aspect
MANUFACTURER: Aspect

Left-БДС-Б; Right-БДС-Б-150

PURPOSE

Creation of spectrometric systems for laboratory and industrial applications (“Бета-1С” and “Бета-1С-150”).
Detectors are used in different areas of science and industry, where it is needed to carry on quality or quantity analysis of different example on content of beta-irradiating radionuclides

DESCRIPTION

Detection and conversion of beta-radiation energy to electrical signals of corresponding amplitudes for their processing.

COMPONENTS

Detectors and made on the base of "plastic scintillator - PEM" assembly and include:
- preamplifier, amplifier-shaper
- high voltage supply
- measuring circuit stabilization system on the base of special light diode with temperature correction function of conversion characteristic

SPECIFICATIONS

Measurement energy range	0.2 – 3 MeV
Energy resolution at peak of Cs-137 conversion electrons	no more than 15 %
Temperature instability	no more than 0.1 %/° C
Time instability for 24-hours continuous operation	no more than 1 %
Power supply	6 – 15 V
Power consumption	no more than 1.1 Watt
Operating temperature range	from 10 to 35 °C
Scintillator size	Ø 70 x 7 mm
Overall detector size	Ø90 x 250 mm
Detector weight	1.3 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://aspect.dubna.ru

Accounting (NDA): Detector

102

Scintillation detection unit for gamma-radiation

MODEL: БДС-Г

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

t-to-right: БДС-Г;БДС-Г100x100;БДС-Г150x1

PURPOSE

Creation of spectrometric systems for laboratory and industrial applications.

DESCRIPTION

Detection and conversion of gamma-radiation energy to electrical signals of corresponding amplitudes for their processing.

COMPONENTS

Detection units are made based on assembly of " NaI(Tl) scintillation crystal - photoelectronic multiplier.

SPECIFICATIONS

Type of detector	БДС-Г	БДС-Г 100x100	БДС-Г 150x100
Size of scintillator	63x63 mm	100x100 mm	150x100 mm
Relative energy resolution on gamma-line 662 кэВ (Cs-137)	≤ 8%	≤ 9.5%	≤ 10.5%
Weight	1.4 kg	6.5 kg	9.3 kg
Overall size	88x315 mm	125x375 mm	180x387 mm
Range	0.03 – 3 MeV		
Integral nonlinearity	≤ 1%		
Temperature instability	no more than 0.1%/° C		
Operating temperature range	from +10 to +35°C		
Power supply	6 – 15 V		
Power consumption	no more than 1.5 Watt		

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://aspect.dubna.ru

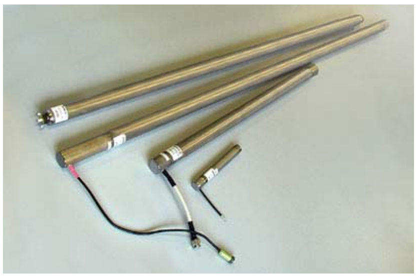
Accounting (NDA): Detector

103

Neutron counters

MODEL: CH

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect



PURPOSE

Detection of weak flow of thermal neutrons (to 10^-2 neutrons/cm²/s) and middle flow of thermal neutrons (to 10^3 neutrons/cm²/s).

DESCRIPTION

The counter run based on reaction of neutrons with gas of helium-3 filling a chamber: -n+3He = p+T+764 keV.

COMPONENTS

SPECIFICATIONS

Counter type	CH-01	CH-03	CH-04
Diameter (mm)	30	18	30
Detection efficiency for thermal neutrons (%) no less than *	50	70	60
Operating temperature range (°C)	± 50	± 50	± 50
Weight (kg) no more than	0.6	0.2	0.5

* For isotropic flow of thermal neutrons the detection efficiency increases when He-3 pressure rises.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://aspect.dubna.ru

Accounting (NDA): Detector

104

Detection units of X-rays and gamma-rays of planar type

MODEL: БДЕР-Г-7К

SUPPLIER:	**IFTP**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma, X-ray
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	IFTP
MANUFACTURER:	IFTP

PURPOSE

Detection units of X-rays and gamma-rays, БДЕР-Г-7К is constructed for detecting and spectrometry of X-ray and gamma-ray radiation.

DESCRIPTION

Units are used as a part of systems of non-destructive analysis in laboratories and industry conditions.

COMPONENTS

- Detector made from high purity germanium (HPGe) in cryostat of dipping type
- Preamplifier of signals PPD
- High voltage filter
- Sensor of existing liquid nitrogen in Dewar

SPECIFICATIONS

Working energy range	from 3 keV to 1333 keV
Square of sensitive surface	from 20 mm² to 2000 mm²
Energy resolution for Energy of 122 keV	from 480 eV to 900 eV
Energy resolution for Energy of 1333 keV for squares with sensitive surfaces of 1000, 1500 и 2000 mm²	from 1.7 keV to 2.0 keV

The detection units can be transported and storaged without liquid nitrogen.

SOFTWARE

ADDITIONAL INFORMATION

Certificate УЛКА.418257.002 ТУ

REFERENCES

www.iftp.ru

Accounting (NDA): Detector

105

Detection units of gamma-rays based on semi-conducted detectors made from high pure germanium

MODEL: БДЕГ-ОЧГ

SUPPLIER:	**IFTP**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	IFTP
MANUFACTURER:	IFTP

PURPOSE

Detection and spectrometry of gamma-radiation.

DESCRIPTION

Detection units of gamma-rays based on semi-conducted detectors made from high pure germanium, БДЕГ-ОЧГ, are developed for detection and spectrometry of gamma-radiation.
A set of connecting cables for connecting Coaxial detector made from (HPGe) with n+ diffusion and p+ ions implanted contacts.
The detection units can be transported and storaged without liquid nitrogen.

COMPONENTS

- Coaxial detector made from high purity germanium (HPGe) with p-type of conductivity
- Preamplifier with cooled head cascade
- Cryostat
- Dewar
- Set of connection cables

SPECIFICATIONS

```
Working energy range                                       from 40 keV to 10 MeV
Energy resolution for Energy of 122 keV                    from 800 eV to 1.2 keV
Energy resolution for Energy of 1333 keV                   from 1.7 keV to 2.1 keV
Efficiency of detection of gamma-rays
for energy of 1333 keV regarding to
3x3" NaJ(Tl) scintillator                                  from 10% to 60%
The detection units can be transported and storaged without liquid nitrogen.
```

SOFTWARE

ADDITIONAL INFORMATION

Certificate УЛКА.418257.006 ТУ

REFERENCES

www.iftp.ru

Accounting (NDA): Detector

106

Silicon detectors of alpha-radiation

MODEL: ПДПА-1К

SUPPLIER: **IFTP**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: Alpha

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory
DEVELOPER: IFTP
MANUFACTURER: IFTP

PURPOSE

Passivated implanted spectrometry silicon detectors of alpha-radiation ПДПА-1К are developed for working in spectrometers for quality and quantity analysis of different samples contained alpha-irradiated radio-nuclides.

DESCRIPTION

The detectors provide high resolution for alpha-spectrometry under room temperature.
The detectors have washable sensitive surface.

COMPONENTS

SPECIFICATIONS

Assurance maximum energy resolution for 5.15 Мэв (Pu-239):

Conditional name of detector	Group	Sensitive area, mm²	Energy resolution, keV
ПДПА-1К	A	20	12
	B	20	16
ПДПА-1К1	A	600	28
	B	600	35
ПДПА-1К2	A	1000	35
	B	1000	45
ПДПА-1К3	A	2000	55
	B	2000	75

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.iftp.ru

Accounting (NDA): Detector

107

Scintillation plastic detectors of ionization radiation

MODEL:

SUPPLIER:	**IFTP**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Beta, Gamma, Neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	IFTP
MANUFACTURER:	IFTP

PURPOSE

Scintillation plastic detectors of ionization radiation are developed for detecting neutrons, beta- and gamma-radiation.

DESCRIPTION

Detectors are used as a part of controlling equipment in atomic energy industry, production of radioactive materials and other areas. Detectors are solid luminescence solution of admixtures to polystyrene.

COMPONENTS

SPECIFICATIONS

Operaiton temperature	from -30 ˚C to +40 ˚C at relative humidity of 95%
Detectors remain stable and keep their parameters after influence of ambient temperature	from -40 ˚C to +50 ˚C and relative humidity of 98%
Tenure of explore	no less than 10 years

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.iftp.ru

Accounting (NDA): Detector

108

Detection unit

MODEL: БДИГ-31П2

SUPPLIER:	**SNIIP - Konvel**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	SNIIP - Konvel
MANUFACTURER:	SNIIP - Konvel

PURPOSE

Detection unit БДИГ-31П2 is developed for use in systems of nuclear materials control, non-proliferation control, systems of radiation control, in dozimetric equipment.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Working energy range	from 9 to 1250 keV
Working range of gamma-radiation exposure rate	from 10 to 10^3 mcR/hour
Sensitivity to radiation of isotope Cs-137	32.0 pps/(mcR/hour)±10%
Limit of permissible main error	no more than 25% for confidence probability of 0.95
Level of detector background	no more than 30pps
Temperature dependence of sensitivity	±1% for every 10 ˚C
Power supply	12.0 (+3.0 minus 1.0) d.c.V
Consumption current	no more than 75 mA
Time for establishing working regime	no more than 15 minutes
for negative temperatures	no more than 30 minutes
Instability of sensitivity	no more than 5% during 8 hours

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.convel.ru/

Accounting (NDA): Detector

109

Coaxial and Planar Safeguard Germanium Detectors

MODEL: SGD

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: Gamma

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

The detectors are designed to meet the demands of the applications software used for isotopic ratio determination (FRAM-LANL, MGA-LLNL, TRIFID-Rocky Flats Plant).

DESCRIPTION

SGD series detectors are compatible with ALL conventional MCA types, although optimum performance will be obtained when used with the ORTEC Digital Signal Processing Spectrometers such as DSPec and DSPec Plus.
SGD Planars are applied for safeguards accountancy measurements involving the verification of declared materials values, when the sample is usually presented in a pure form in a purpose-designed thin-walled container. This occurs with routine safeguards inspection programs, when a portable system is employed.
SGD GEM coaxial and semi-coaxial detectors are applied for samples in thick walled containers, or when significant matrix attenuation is present, and it may be necessary to use a higher energy region of the spectrum to perform the analysis.
The 5050 was developed as an optimum detector for use with PC/FRAM. The 6560 was developed for use in Tomographic Waste assay systems for fissile waste measurements. In general, coaxial detectors offer better high energy response than thinner planar detectors, a fact which makes them ideal for measurement of shielded sources.

The SGD-GEM-5050P4 is the "traditional" coaxial detector for use with PC/FRAM in a wide variety of cases, including the measurement of UF6 cylinders.
The SGD-GEM-5030P4 has a semi-planar geometry and can be used as a substitute for "telescope" detectors which have traditionally been used with the codes TRIFID and MGA in so-called "two-detector" mode.
The SGD-GEM-6560P4 has been produced specifically to provide a large-area detector, which meets the resolution requirements of the FRAM code, and has good high-energy efficiency and a large detection area.

COMPONENTS

The SGD Planar is supplied in a “classic” PopTop capsule. These capsules are compatible with all P4 type cryostats.

SPECIFICATIONS

SGD Planar Safeguards Detector:

Model No.	Active Diameter (mm)	Thickness (mm)	Warranted Resolution (eV) @122 keV @1 kcps	@50 kcps (1 µs)	Warranted FW.1M/FWHM @≤50 kcps	Warranted FW.02M/FWHM @≤50 kcps
SGD-16510P	16	15	510	560	1.87	2.50

SGD GEM Safeguards Detector:

Model No.	Active Diameter (mm)	Minimum Thickness (mm)	Nominal Relative Efficiency	Energy	Warranted Resolution (keV) @1 kcps (6µs)	@1 kcps (2µs)	@30 kcps (2µs)	Warranted FW.1M/FWHM <1kcps (6µs)	Warranted FW.02M/FWHM <1kcps (6µs)
SGD-GEM-3615P4	36	15	3	122keV 1.33MeV	575eV 1.65keV	600eV 1.75keV	630eV 2.00keV	1.9	2.6
SGD-GEM-5030P4	50	30	15	122keV 1.33MeV	625eV 1.70keV	675eV 1.85keV	725eV 2.05keV	1.9	2.6
SGD-GEM-5050P4	50	50	25	122keV 1.33MeV	750eV 1.75keV	870eV 1.95keV	880eV 2.10keV	1.9	2.6
SGD-GEM-6560P4	65	60	50	122keV 1.33MeV	800eV 1.80keV	925eV 2.05keV	950eV 2.15keV	1.9	2.6

SOFTWARE

ADDITIONAL INFORMATION

Besides ORTEC, the other companies also produce the wide range of similar detectors, for example, Canberra.

REFERENCES

www.ortec-online.com

Accounting (NDA): Detector

110

Submergible Photon Detector

MODEL: SPD-1

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

The ORTEC Submergible Photon Detector (SPD-1) is designed for nuclear fuel element scanning in storage pools.

DESCRIPTION

The particular system shown was designed for pool depths up to 30 feet. Polyvinyl chloride tubing is used to carry the electrical cables to and from the detector package and to vent the LN2 to the pool surface. A thin (30 mil) side window is provided in the stainless steel shroud to enable low energy photons (down to 50 keV) to enter the detector package.
The special compact LN2 dewar can be refilled at the surface of the pool without removing the waterproof shroud cover. The split-ring lead shield is provided behind the detector element to shield from contaminated water in the pool and also to provide negative buoyancy to the system.

COMPONENTS

The compact stainless steel shroud contains:
- HPGe coaxial detector element,
- cryogenic package,
- 20-liter LN2 dewar,
- LN2 level probe,
- preamplifier,
- H.V. filter,
- lead shield.

SPECIFICATIONS

Size	37-in. long and 12-in. diameter
Weight	100 lbs
Operating depth	30-foot
Operating time	approximately 12 to 14 days before LN2 refilling is required

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Detector

111

X-ray Silicon Detector with Peltie coolig element

MODEL: X-PIPS

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Detector
METHOD: XRF, gamma spectrometry

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

Detector is used for measuring X-ray spectra for X-ray spectrometry, X-ray fluorescent assay, densitometry, and other applications.

DESCRIPTION

X-PIPS detector is a spectrometric subsystem sensitive to X-ray and low energy gamma radiations.
Detector's preamplifier uses a clearing circuit with digital control, providing short recovering time. The signal of locking the clearing is provided for screening the false impulses caused by transient processes. Duration of output locking impulse can be set within the range of 10 to 650 µs.
X-PIPS detector can be supplied with built-in (silver) collimator to improve the peak/background ratio. At this the area of active detector surface is decreased down to 5 mm².

COMPONENTS

Detection block includes:
- silicon detector, 8 mm² active area, 0.5 mm thickness
- beryllium window of 25 µm thickness
- preamplifier with cleaning circuit
- high voltage source
- Peltie cooling element
- temperature controller

SPECIFICATIONS

Energy range	from 1 to 30 keV
Operating temperature	0 to 30˚C (standard), 0 to 50˚C (max)
Humidity	from 0 to 80%, non-condensing
Overall size	115 x 56 x 36 mm (without head)
Weight	0.35 kg

Energy resolution (for 5.9 keV at +10 to +30˚C):

Model	Active area (mm²)	Active thickness (µm)	Collimator	Peak/background	Energy resolution FWHM (eV) Typical RT/FT	Max 26.4/0.1µs	Min 5.6/0.1µs
SXP8-190-500	8	500	No	>600	185	<190	<220
SXP5C-190-500	5	500	Silver	>1100	180	<190	<220

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Detector

112

Helium-3 Neutron Detectors

MODEL:

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Detector
METHOD:	Neutron
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	Fissile materials
PHYSICAL FORM(S) OF NM:	any
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial, laboratory, field
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Passive or active non destructive analysis of nuclear material, surveillance of fissile material (Safeguard), entrance and exit control of nuclear sites, material assessment within nuclear sites, waste measurement for optimization of storage management, etc.

DESCRIPTION

The 25 and 50 mm diameter detectors are recommended for measurements of nuclear materials.
The 25 mm diameter Helium-3 neutron detectors can beused in various applications and offer high sensitivity to thermal neutrons (in low intensity neutron fluxes, for example in neutron scattering experiments or measurement of wastes) and a very good mechanical sturdiness (in severe environmental constraints, for example for measurement of spent fuel in reprocessing plants). Long 25 mm diameter detectors are used for the control of fissile material in nuclear fuel cycle factories (Safeguard measurements) and characterization of alpha emitters in waste barrels before storage.
The 50 mm diameter neutron detectors are recommended for ultrasensitive detection of fissile materials at the exit of the nuclear fuel cycle factories, borders and at the vicinity of harbours and airports. For example, these detectors allow to perform material assessments and thus efficiently participate to Safeguard actions. In the field of nuclear waste management, the estimation of very low quantities of alpha emitters allows for waste sorting before sending them to specialized storage sites (sea level or underground), with respect to the more and more stringent regulations aiming for storage cost optimization.
A heavy gas (generally Argon) may be added to Helium-3 to improve the measurement specifications at high count rates by using a fast amplifier. This add-on gas increases both operating high voltage and length of the high voltage plateau, improves the thermal peak resolution and decreases the wall effects; it also increases the sensitivity to gamma rays, and also lightly the background.

COMPONENTS

- stainless steel walls of 0,5 mm
- electrical output on HN female connector
- gas filling: 1-10 bars Helium-3 (possible addition of Argon)

SPECIFICATIONS

Model	Active length L (mm)	^{3}He pressure bars	^{3}He pressure cmHg	Sensitivity cps per n/(cm^2.s)	Capacity pF	Weight grams
25 mm diameter:						
65NH45	450	4	300	65	13	337
74NH49AS	495	5	375	74	13	353
105NH70	700	4	300	105	15	416
150NH100	1000	4	300	150	17	510
50 mm diameter:						
15NH5/5X	50	2	150	15	8	290
36NH10/5X	100	3	225	36	8	350
43NH10/5X	100	5	375	43	8	350
39NH9/5	88	5	375	39	8	350
133NH30/5	300	5	375	133	11	600
150NH50/5	500	2	150	150	12	800
205NH50/5	500	4	300	205	12	800
300NH1C/5	1000	2	150	300	15	1000
410NH1C/5	1000	4	300	410	15	1000

Operating characteristics:

	25 mm diameter			50 mm diameter			
	65NH45	74NH49AS	43NH10/5X	150NH50/5	205NH50/5	205NH50/5A	Unit

	105NH70	150NH100	39NH9/5 133NH30/5	300NH1C/5	410NH1C/5	410NH1C/5A	
Helium-3 pressure	4	5	5	2	4	4	bars
Mean high voltage (A~5 for 50mm, A□15 for 25mm))	950	1150	1500	1100	1250	1600	V
Ampl. broadening	±5	±5	± 10	± 10	± 10	± 10	%
Length of the HV plateau			400	400	400	500	V
Slope of the HV plateau	0.7	0.7	0.5	0.5	0.5	0.5	% per 100V
FWHM resolution	7	4	13	8	11	9	%
Background with shielding		10	10/30	40	60	100	c.h-1

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Identifier

113

Universal portable radiometer - spectrometer

MODEL: МКС-А03

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Identifier
METHOD:	Measuring alpha, beta, gamma, neutron radiation
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial, field
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

- Search and identification of radioactive sources (α, β , γ, n)
- Measurement of equivalent dose rate (γ, n)
- Measurement of flux density (α, β)
- Identification of radionuclides (γ)

DESCRIPTION

МКС-А03 is a hand-held device with self-contained power supply, display, and keypad, having built-in detectors: on the base of 40*40 mm NaI(Tl) or 38*38 mm LaBr3(Ce) , Geuger-Muller counter, He-3 neutron detector in polyethylene moderator, and external detectors: БДС-АБ2 alpha-beta detector , БДН-06-1 wide-wave range neutron detector (by order). МКС-А03L modification of the device (with increased resolution detector) provides more capabilities for identification of sources with complex radionuclide composition.

COMPONENTS

For МКС-А03-1, МКС-А03-2, МКС-А03-3, МКС-А03-4 models
- МКС-А03 radiometer unit
- МКС-А03L radiometer unit (radiometers in the base of LaBr3(Ce) are designated as МКС-А03L-1, МКС-А03L-2,and so on)
- Network adapter
- БДС-АБ2 unit (except for МКС-А03-3, МКС-А03-4)
- БДН-06М unit (radiometers euqipped with БДН-06М unit are designated as МКС-А03-1Н, МКС-А03-2Н and so on)
- Charging and calibrating device
- Case
- Set of maintenance documentation, CD with software

SPECIFICATIONS

Radiation type	Measured quantity	Measurement range	Energy range of measured radiation or nuclide	Basic error (%)
Gamma	EDR, µZv/h	0.1 – 10^2 10^2 – 10^4	0.05 – 3 MeV 0,05 – 3 МэВ	±20 ±30
Neutron (built-in detector)	EDR, µZv/h	1 – 10^3	Pu-Be source	±40
Neutron (БДН-06М detector)	EDR, µZv/h	1 – 10^4	10^-3 – 14 MeV	±30
Alpha	Flux density, cm^-2•min^-1	1...10 10 – 5x10^3	3 – 10 MeV 3 – 10 MeV	±40 ±20
Beta	Flux density, cm^-2•min^-1	2 – 2x10 2x10 – 5x10^3	0.3 – 3 MeV max. values of beta energies	±40 ±20

Memory capacilty	up to 1000 measured spectra
Measuring energy range for МКС-А03 (МКС-А03L)	0.03 – 3 MeV (0.03 – 1.6 MeV)
Relative energy resolution for МКС-А03 (МКС-А03L)	no more than 7.5% (3%)
Operating temperature range	from –20 to 50 °C
Overall size	280 mm x 130 mm x 181 mm
Weight (without external detectors)	3 kg

SOFTWARE

Built-in nuclide library recommended by IAEA with isotope classification by following types: special, medicine, industrial,

ADDITIONAL INFORMATION

«MKC Manager» service program, Program for spectra processing for PC by order.

REFERENCES

www.aspect.dubna.ru

Accounting (NDA): Identifier

114

Radioactive Isotope Identification Device

MODEL: 940 SAM

SUPPLIER: **BNC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Identifier
METHOD: Gamma/Neutron

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: any
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Field
DEVELOPER: BNC
MANUFACTURER: BNC

PURPOSE

Model 940 SAM is the isotope identifier designed as a hand-held instruments for the detection and identification of radionuclides used in the field of emergency response, radiation safety, passenger and freight monitoring, non-proliferation enforcement, environmental waste monitoring, unattended/remote monitoring, etc.

DESCRIPTION

Upon power-up, the unit goes through a quick self-test and immediately begins monitoring; even after a lengthy power-down, temperature stabilization guarantees accurate identification results within the first five minutes. In extreme environmental conditions manual recalibration is available.
Device provides nuclide identification, spectrum analysis, dose rate calculation (rem/Sv), total dose, audible search tool, data logging.
Device provides visual (on screen) and audio (internal speaker or optional headphones) alarms.

COMPONENTS

- detachable 2”x2” or 3”3” NaI, with or without neutron detector 6LiI, or optional LaBr detector
- digital signal-processing MCA
- 320x240 high brightness 32000-color 3.5” transflective LCD display
- 10/100 Ethernet port and CompactFlash reader with USB adapter
- 8 standard AA batteries
- 7-key custom keypad with one-thumb operation
- integral HV bisas supply
- optional modules: serial GPS receiver for spectral report mapping, wireless communications

SPECIFICATIONS

Energy range	18 keV – 3 MeV
Temperature range	-20 to 50˚C
Dimensions	12”L x 4”H x 5”W (excluding detector)
Weight	4.5 lbs. with 2” x 2” NaI detector and batteries

SOFTWARE

The software utility Reachback Defender allows for generating ANSI compliant spectral reports and downloadable. An [illegible]ility is included.

ADDITIONAL INFORMATION

The latest version of quantitative analysis package, Quantum Revealer, will allow users to perform a geoplotting of radiological data, mapping and surveying of facilities or logging complex data in real time on a local PC or over a network. Advanced features like peak deconvolution, geometry modeling and multi-source comparisons are quickly addressed also by the Quantum Revealer operator.
Library: standard N42.34 ANSI isotopes, ITRAP/IAEA list, medical, industrial, SNM, or user-defined lists

REFERENCES

www.berkeleynucleonics.com

Accounting (NDA): Identifier

115

HPGe-Based Portable Nuclide Identifier

MODEL: Detective, Detective-100

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Identifier
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	DU, NU, LEU, HEU, Weapons Grade (WG), Reactor Grade (RG) Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Reliable detection and identification of radionuclides with a minimum of false negatives and false positives.

DESCRIPTION

Detective is a "real time" identifier, it begins to identify immediately after the ID button is pressed. Identification takes place in some cases less than 1 second. "Suspected" nuclides are indicated if the statistical accuracy is not adequate; with more time, this tentative identification will often change from "suspected" to "found". This dynamic process is halted at any time by pressing STOP. During operation, operator may be provided with help messages. Detective can distinguish between "Highly enriched uranium", "Depleted uranium", "Low enriched uranium", "Natural uranium", "Elevated uranium concentration", and "Reactor Grade Pu", "Weapons Grade Pu". Operator can also display the actual radionuclide spectrum, and manipulate the screen display (e.g., vertical scale, zoom) like a conventional multichannel analyzer.
Both model Detective Portable Nuclide Identifiers provide the following functions:
SEARCH: Scanning mode for location of gamma-ray-emitting radioactive sources, with audio alert using an external ear piece.
IDENTIFY: identification and classification of gamma-emitting radionuclides such as: 232Th, 238U, 233U, 235U, 237Np, 239Pu, 252Cf
GAMMA DOSE RATE: Visual overrange indication and continuous audible alarm at dose rates >10,000 µSv/hr.

COMPONENTS

- ruggedized HPGe gamma-ray detector (50 mm diameter x 30 mm deep crystal – Detective, 65 mm diameter x 50 mm deep crystal – Detective-100)
- miniature, high-reliability mechanical cooler Hymatic SAX101-002
- Ge detector (below ~20 µSv/h) and compensated GM tube (above ~20 µSv/h) for dose rate measurement
- internal battery,
- digital spectrometer electronics with digital noise filter
- LCD display
- proprietary nuclide identification software (customized libraries for specific applications can be supplied by special order).

SPECIFICATIONS

Gamma dose rate range	from <0.05 µSv/h to >10000 µSvh
Maximum number of stored spectra	>40
Communications ports	USB 1.1
Internal battery life	>3 hours at 25°C
Temperature operation range	-15°C to +50°C
Relative humidity	<90% at 35°C, noncondensing
Maximum overall dimensions (including handle, Ge detector endcap and shock absorbers):	
Detective	37.3cm L x 16 cmW x 32cm H (14.7"L x 6.3"W x 12.6"H)
Detective-100	39.4cm L x 16.3cm W x 32cm H (15.5"L x 6.55"W x 12.6"H)
Weight:	
Detective	22.9 lb (10.39 kg)
Detective-100	23.3 lb (10.65 kg)

SOFTWARE

Detective/Detective-100 is fully supported by the latest versions of MAESTRO-32 MCA Emulator as well as the well-known ...ages such as GammaVision-32 for generalized HPGe spectrum analysis, PC/FRAM and MGAHI for Pu and U isotopic ratio analysis and ISOPlus for in-situ waste assay analysis.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

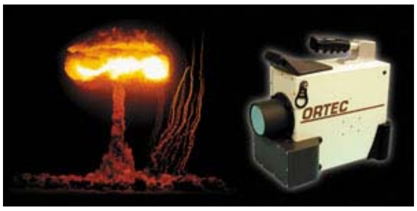
Accounting (NDA): Identifier

116

HPGe-Based Portable Nuclide Identifier

MODEL: Detective-EX, Detective- EX-100

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Identifier
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	DU, U-NAT, LEU, HEU, Weapons Grade (WG), Reactor Grade (RG) Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC



PURPOSE

Reliable detection and identification of radionuclides with a minimum of false negatives and false positives.

DESCRIPTION

Detective-EX is a "real time" identifier, that begins to identify immediately after the ID button is touched. "Suspected" nuclides are indicated if the statistical accuracy is not adequate; with more time, this tentative identification will often change from "suspected" to "found." This dynamic process is halted at any time by tapping STOP. The radionuclide gamma-ray spectrum may be displayed and manipulated (e.g., vertical scale, zoom) like a conventional multichannel analyzer.

Both model Detective-EX Portable Nuclide Identifiers provide the following functions:

SEARCH: Scanning mode for location of gamma-ray-emitting and neutron-emitting radioactive sources, with audio alert using an external ear piece.

IDENTIFY: Identification and classification of gamma-emitting radionuclides such as 232Th, 238U, 233U, 235U, 237Np, 239Pu, 252Cf

GAMMA DOSE RATE: Gamma dose rate is monitored and displayed at all times. Dose rate units may be chosen as µSv/hr or mR/hr.

NEUTRON COUNT RATE: Neutron count rate is displayed continuously.

COMPONENTS

- ruggedized HPGe gamma-ray detector
- miniature, high-reliability mechanical cooler
- internal compensated GM tube.
- internal battery
- 4 3He tubes (4" active length, 0.5" diameter, 20 atm He3 fill pressure).
- high density polyethylene moderator.
- digital spectrometer electronics with digital noise filter
- proprietary nuclide identification software (customized libraries for specific applications can be supplied by special order).

SPECIFICATIONS

Gamma dose rate range	from <0.05 µSv/h to >10000 µSv/h
Maximum number of stored spectra	>40, unlimited on removeable media (CF or SD)
Communications ports	1 Type I/Type II CF Card slot (3.3 V) 1 SD (Secure Digital) card slot (3.3 V) 1 USB connection for "ActiveSync" capability 1 USB connection for control of the MCA board 1 Audio headphone jack 1 External power connector for docking station power
Internal battery life	>3 hours at 25°C
Operation temperature range	0°C to 40°C
Relative humidity	<90% at 35°C, non-condensing
Maximum overall dimensions (including handle, Ge detector endcap and shock absorbers):	
Detective-EX	37.3 cm L x 18.3 cm W x 34.3 cm H (14.7" L x 7.2" W x 13.5" H)
Detective-EX-100	39.4 cm L x 18.3 cm W x 34.9 cm H (15.5" L x 7.2" W x 13.75" H)
Weight:	
Detective-EX	25.9 lb (11.75 kg)
Detective-EX-100	26.3 lb (12 kg)

SOFTWARE

Detective-EX/Detective-EX-100 is fully supported by the latest versions of MAESTRO-32 MCA Emulator as well as the well- y Packages such as GammaVision-32 for generalized HPGe spectrum analysis, PC/FRAM and MGAHI for Pu and U isotopic ratio analysis and ISOPlus for in-situ waste assay analysis.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Identifier

117

identiFINDER Spectrometer / Isotope Identifiers

MODEL: identiFINDER-NG, IdentiFINDER-U, IdentiFINDER-X*

SUPPLIER: **Thermo Scientific**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Identifier
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Doze rate, isotopic composition
NUCLEAR MATERIAL(S): U, Pu, Th
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial
DEVELOPER: Thermo Scientific
MANUFACTURER: Thermo Scientific

PURPOSE

Nuclide detecrion and identification, spectrum analysis, dose rate calculation, total dose display, source finding, and optional uranium enrichment calculation, Pu-U-Th-verification, determination of active length of fuel elements (X-versions).

DESCRIPTION

identiFINDER is a complete digital gamma spectroscopy and dose rate system, that is suited for homeland security, industrial, medical, nuclear power generation and nuclear fuel cycle applications. It finds the radioactive material, quantifies the radiological hazard, identifies the radioactive isotope, is suited for remote applications, advanced warning systems, hazardous environments and nuclear inventory monitoring.
identiFINDER-U version is waterproof to 10 m (33 ft) and used for underwater operation, waste monitoring, containment monitoring.
identiFINDER-X is integrated into a 4’ to 8’ telescoping pole for extended reach, and used for surveying large containers, waste monitoring, containment monitoring, leak identification, etc.
The operator can choose from 6 categories (Nuclear, Industrial, Medical, Customs, OSI and USER) of User Selectable Nuclide Library . All sub-libraries, except the OSI library can be edited by adding or deleting specific nuclides from the list.
Ten (10) reference spectra can be measured by the user and added to the predefined library spectra. Identification is done by a template-matching correlation procedure.

COMPONENTS

- 1.4 x 2” NaI detector,
- GM-tube (except for U-versions),
- 31 x 38 mm (1.2 x 1.5”) Nal (TI) (standard), CdZnTe (U,X-versions),
- 3He detector for neutron indication (optional),
- multi-channel analyzer,
- PMT preamplifier,
- spectroscopy amplifier,
- high voltage power supply,
- built-in 137Cs reference source (< 500 Bq/15 nCi),
- telescope tube (X-verions),
- memory with an integral scintillation detector.

SPECIFICATIONS

	identiFINDER	identiFINDER-U	identiFINDER-X
INL, top 99%:	<0.05%	>0.05%	>0.05%
DNL, top 99%:	<0.1%	>0.01%	>0.01%
Spectrum length:	1024 channels	1024 channels	1024 channels
Pileup rejection:	<100ns, pulse pair res.	400ns, pulse pair res.	400ns, pulse pair res.
Throughput rate:	>100,000 cps	>50,000 cps	>50,000 cps
Input rate:	>350,000 cps	>500,000 cps	>500,000 cps
Spectrum memory:	100 spectra at 1024 channels	60 spectra at 1024 channels	70 spectra at 1024 channels
Sensitivity:	>10,000 cps/mrem for 1.4x2”Nal(TI) detector	>500 cps/ µSv/h (>5 cps/µrem/h) for 30 x 38 mm (1.2 x 1.5”) Nal(TI) detector	
Dose-rate range:	10 nSv/h - 1 Sv/h (1 µrem/h - 100 rem/h)	10 nSv/h - 1 Sv/h (1 µrem/h - 100 rem/h)	
Dose range:	100 nSv - 1 Sv (10 µrem - 100 rem)	100 nSv - 1 Sv (10 µrem - 100 rem)	
Energy range:	NaI: 15 keV – 3 MeV; GM: 60 keV – 1.6 MeV	NaI: 20 keV – 3 MeV; GM: 60 keV – 1.5 MeV	

Temperature range:	-20 to 55°C (-4 to 122°F)	-15 to 55°C (4 to 131°F)	-15 to 55°C (4 to 131°F)
Protection:	water proof, dust tight	water proof to 10m(33') or 1 atm, dust tight	water, dust tight
Protection class:	IP 54	IP 65	IP 65
Drop test:	2' 8" on concrete		1 m (3.3') on concrete
Durability:		≥ ANSI Standard (10x50g over 18ms in 3 orthogonal axis)	
Dimensions:	9.8" x 3.7" x 3"	230 x 90 x 70 mm (9"x3.5"x2.75")	30 x 90 x 70 mm (9"x3.5"x2.75")
Weight:	1250g (2.75 lbs) with 1.4"x2" NaI and batteries	1340g (2.95 lbs) with 30mmx38mm (1.2"x1.5")NaI and batteries	2650 (5.8 lbs)
Length			min 1336 mm (4.4'), max 2356 mm (7.7')

SOFTWARE

Specialized SNM firmware, WinTMCA software (X-versions).

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): Identifier

118

Spectroscopic Personal Radiation Detector

MODEL: Interceptor

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Identifier
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

Device is designed for rapid detection and identification of radioactive materials.

DESCRIPTION

Device is a Spectroscopic Personal Radiation Detector (SPRD) combining the qualities of a Personal Radiation Detector (PRD) with isotope identifier capabilities (RIID). The Interceptor is operated through three easy-to-use buttons: on/off on top, select & execute on either side with informative display prompts shown in display footer.
Available in four versions with different options.

COMPONENTS

- high-efficiency large volume 0.3” x 0.3” x 0.15” (7 x 7 x 3.5 mm) CZT finder detectors;
- high resolution CZT identification detector;
- 3He neutron detector, 8 atm., 1/2” dia. x 2.6” (13 x 66 mm) at 1.2 cps/nv;
- 2048ch. DSP based MCA with energy compensation dose rate algorithm on Finder detectors;
- digital camera;
- voice recorder;
- Bluetooth;
- 64MB SD memory card;
- Li-Ion rechargeable batteries and 4 x AA battery pack.

SPECIFICATIONS

Energy range	25 KeV - 3 MeV
Sensitivity	1.5 cps/µR/h, 1.2 cps/nv
Operation temperature	from –4 to 122˚˚F (-20 to 50˚C) at up to 95%RH @ 95˚F
Dust-tight and waterproof	to IP 65
Shock protection	5 feet (1.5 m) drop onto concrete
Dimensions	4.4” x 2.4” x 1” (112 x 61 x 25 mm)
Weight	9.5 oz (270 g)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): Measurement System

119

Neutron & Gamma ray Under Water Coincidence Counters

MODEL: Series 2100

Model 2106

SUPPLIER: **ANTECH Corporation**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Measurement System
METHOD: Neutron, gamma

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): MOX
PHYSICAL FORM(S) OF NM: Fuel rod
STATUS:
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial
DEVELOPER: ANTECH Corporation
MANUFACTURER: ANTECH Corporation

PURPOSE

Underwater detectors are routinely used determine the radiation from reactor pond fuel rod assemblies whilst stored underwater.

DESCRIPTION

Two detector types are available:
FDET—Fork Detectors - Model 2104
The Fork Detectors are used to measure the neutron and gamma ray activity from spent fuel assemblies
UWCC—Under Water Coincidence Counters - Models 2106, 2108
The Under Water Coincidence Counters are used to measure neutron radiation activity from spent fuel or MOX fuel assemblies.
Each type of detector is available in either PWR or BWR configuration.

COMPONENTS

UWCC counter includes:
- 6/8 He-3 detectors 5”/11” active length variants
- 2 input/1 output OR Box
- polished stainless steel detector back plate and extension pipe (5x 2m, 2x 1m options)
- PDT210A dual AMPTEK preamp mounted in polyethylene holder

UWCC can be supplied as a system with AMSR 150, laptop PC and INCC32 software.
FDET counter includes:
- 4x 5” active length Fission Chambers
- 2x Ion Chambers
- tungsten shielded PDT210A dual AMTEK preamplifiers
- polished stainless steel detector back plate and detector pipes

SPECIFICATIONS

Detector efficiency	2-4% (typical)

SOFTWARE

INCC32

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Accounting (NDA): Measurement System

120

Glovebox Neutron/Gamma System

MODEL: JCC-15

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Measurement System
METHOD: Neutron coincidence counting, gamma spectrometry

MEASURED PROPERTIES: Element mass, isotopic composition
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial, laboratory
DEVELOPER: LANL
MANUFACTURER: Canberra

PURPOSE

This device is designed for high accuracy measurements of plutonium, reducing the need for destructive analysis. It mounts below the drywall of a glovebox and provides simultaneous neutron coincidence and gamma isotopic analysis.

DESCRIPTION

The Glovebox Neutron/Gamma System is a combination of a passive neutron coincidence counter and a gamma spectroscopy system that is placed around the drywall of the glove box of the On-Site Laboratory (OSL).
The design was modified to place a Low Energy Germanium (LEGe) detector inside the counter, close to the sample, to simultaneously measure the plutonium isotopic. Both the top and bottom plugs are made from graphite and polyethylene. The bottom plug was altered to fit around the LEGe detector and the cold finger, reflecting neutrons back into the counter and flattening the axial response. The system is mounted on a trolley to facilitate positioning the counter under the glove box.
The neutron counter was further modified by splitting the body into two parts to allow placement around the drywell.
The measured isotopics are used as input to the neutron coincidence software to convert the Pu-240-effective to total plutonium mass

COMPONENTS

- OSL Neutron Counter:
  - eighteen He-3 tubes, 39.4 x 2.5 cm (L x Dia), in two rings of nine tube each
  - NIM electronics
    - JAB-01 Amplifier/Discriminator board
    - high voltage junction box
    - LED indicators
- JSR-12 Neutron Coincidence analyzer
- Low Energy Germanium (LEGe) Detector
- data processor with software.
- top and bottom plugs both the made from graphite and polyethylene
- high density polyethylene moderator
- trolley

Connections between the OSL and the JSR-12 include:
- +5 V
- HV
- single ORed output signal.

SPECIFICATIONS

```
Detector efficiency             40%
Cavity dimension:
          drywell O.D.          5.1 cm
          sample volume         10 mL
Overall size                    74.9 cm x 74.9 cm x 30.7 cm (H x L x W)
Weight                          34 kg
```

SOFTWARE

The plutonium gamma-ray spectrum is very complex, with several multiplet structures. Software like MGA, which was tional Laboratory (LLNL), uses the integrals of these close lying peaks to calculate the isotopic composition of plutonium.

ADDITIONAL INFORMATION

Based on LANL design (INVS III).

REFERENCES

1. H. Wagner, et. al., Proceedings of the ESARDA Meeting, 1992.
2. M.C. Miller, H.O. Menlove, and P.A. Russo, A High Efficiency Neutron Coincidence Counter for Small Samples, Proceedings

of the Fourth International Conference on Facilities Operations - Safeguards Interface, Albuquerque, NM, September 1991, p. 420.
3. http://www.canberra.com

Accounting (NDA): Measurement System

121

Neutron and Gamma Unattended Plutonium Safeguards System

MODEL:

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Measurement System
METHOD:	Neutron coincidence counting, gamma spectrometry
MEASURED PROPERTIES:	Isotopic composition, isotopic effective, element mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Dioxide
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

This is a fully integrated system for unattended monitoring of PuO2 canisters and combines passive neutron measurement with gamma ray measurement for increased accuracy.

DESCRIPTION

The system utilizes intelligent front end acquisition devices for maximum data compression and redundancy incorporating sophisticated analysis of gamma spectra using MGA. The central CPU system is connected remotely, and is used for data analysis, storage and review. The secure architecture protects the system from unauthorized access.

The concept of unattended plutonium safeguards using NonDestructive Assay systems has been developed previously [1,2,3] and is implemented at several nuclear facilities. Typically these facilities have many different acquisition stations, with the following potential data sources at each one. The neutron data collected using passive neutron measurement systems, gamma-ray data collected using high-purity germanium detectors, and sensor information which might indicate item identity, position, direction of motion, etc. These acquisition stations might be located at the entrance to a processing plant so that incoming fuel can be assayed, near a common fuel storage area, at a location which corresponds to the end product of the plant, etc. Since the physical dimensions of the facility are in general quite large, one approach to unattended safeguards is to place one or two computer(s) at each acquisition station; two computers would be installed if redundancy was needed. Each computer would be responsible for acquisition control, data storage, data analysis and report generation at a particular acquisition station.

The drawback to this type of system is that the most convenient location for the computer might be in a potentially hostile and highly controlled area. In addition, integration of the results from all facility acquisition stations would be difficult given the large number of independent stations.

An alternate approach is possible within a facility that has a Local Area Network (LAN, e.g. a coaxial or fiber optic cable) that connects each of the acquisition stations.

COMPONENTS

The system consists of major subsystems:

- passive neutron/gamma measurement devices (several JCC-35 Neutron/Gamma Counters):
  - 18 He-3 tubes, 50.8 x 2.54 cm (L x Dia)
  - JSR-12 electronics
  - LEGe detectors
- Data Acquisition Subsystem (DAS) for combining and buffering neutron, gamma and sensor data:
  - DECstation 212LP personal computer
  - DEPCA Ethernet communications interface
  - AccuSpec gamma interface
- host computer for analysis, record keeping and reporting:
  - two VMS Digital Euqipment Corporation workstations

SPECIFICATIONS

```
Detector efficiency          15.4%
Cavity dimension             59.0 x 21.6 cm (H x Dia)
Overall size                 69.1 x 130.8 x 42.7 cm (H x L x W)
```

SOFTWARE

Unattended Event Manager Process (EMP) providing preliminary analysis (identifying and quantifying neutron objects, and lances from the gamma ray spectra) and MGA for high precision calculation of the relative isotopic abundances.

ADDITIONAL INFORMATION

REFERENCES

1. S.F. Klosterbuer, E.A. Kern, J.A. Painter, S. Takahashi, "Unattended Mode Operation of Specialized NDA Systems", 30th

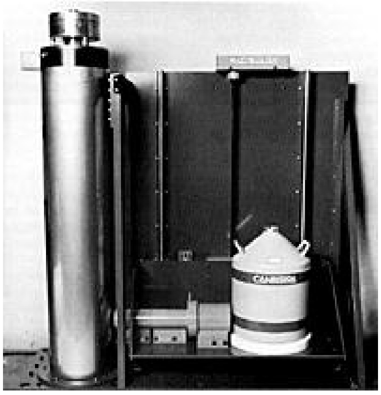
Annual INMM Conference, Orlando, Florida, USA, 1989.
2. B.G.R. Smith, J.D. Outram, M. Storey, "unattended Mode Monitoring of Passive Neutron Coincidence Detector Systems Using a Commercial Data Logger", 13th Annual ESARDA Symposium on Safeguards and Nuclear Material Management, Avignon, France, 1991.
3. B.G.R. Smith, P. Van Dyck, and P. DerBaix, "Unattended Mode Monitoring of High Resolution Gamma-Ray Spectra, 13th Annual ESARDA Symposium on Safeguards and Nuclear Material Management, Avignon, France, 1991, pp. 263-271.
4. http://www.canberra.com

Accounting (NDA): Measurement System

122

PuO2 Canister Verification System

MODEL:



SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Measurement System
METHOD:	Neutron coincidence counting, gamma spectrometry
MEASURED PROPERTIES:	Element mass, isotopic composition
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Dioxide
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

System is intended for high precise nondestructive plutonium assay in environment of plant laboratory.
It is designed for simultaneous passive neutron coincidence measurement and gamma isotopic measurement of canisters of PuO2.

DESCRIPTION

The PuO2 Canister Verification System is an integrated neutron/gamma safeguards system designed to measure, with a high standard of reliability, accuracy, and precision, the total plutonium mass for PuO2 samples. The system counts coincidence neutrons from the spontaneous fission of the even numbered isotopes of plutonium. In use, one to five cans of PuO2 stacked inside a stainless steel canister are positioned in the neutron counter on the load cell platform by the robotics mechanism. The weight of the canister is automatically displayed and verified against the shipper's declared weight by the operator.

COMPONENTS

Neutron system includes:
- Neutron Coincidence Counter with 12 3He detectors (divided into six groups of two)
- JAB-01 Amplifier/Discriminator circuit boards
- JSR-12 Neutron Coincidence Analyzer.
- "Telescope" Germanium detector with NIM electronics
- Computer

The exterior of the neutron counter is covered with 1 mm (0.039 in.) thick cadmium and 1 mm (0.039 in.) thick stainless steel.
Gamma System includes:
- "Telescope" Germanium (Ge) detector with lead shield /collimator consisting of LEGe detectors 300 mm2 x 10 mm thick and 12% coaxial type Ge detector

SPECIFICATIONS

Gate setting	32 µs
Die-away time	23 µs
Neutron detector efficiency	7.4%
Axial Response	± 1% over 127 cm
Mass loading	4.5 to 18 kg Pu
Overall size	182.2x178.1x80.3 cm (71.7x70.1x31.6 in.) H x L x W
Sample cavity size	164.6x18.3 cm (64.8x7.2 in.) H x Dia
He-3 tube size	157.5x2.5 cm (62x1 in.) L x Dia

SOFTWARE

MGA isotopics software (MGA code, which was developed at Lawrence Livermore National Laboratory), and Neutron

ADDITIONAL INFORMATION

REFERENCES

1. http://www.canberra.com
2. Ruhter, W.D. and Gunnink, R. (1992). Recent Improvements in Plutonium Gamma-Ray Analysis Using MGA. Report UCRLJC-109620. Livermore, California: Lawrence Livermore National Laboratory.

Accounting (NDA): Measurement System

123

Combined Tomographic Gamma Scanner (TGS) for 400 Litre Drums

MODEL: Model 3800

SUPPLIER:	**ANTECH, ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Measurement System
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Effective Isotope Mass
NUCLEAR MATERIAL(S):	Pu, U
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	LANL
MANUFACTURER:	ANTECH, ORTEC

PURPOSE

Determination of spatial distribution and quantity of U, Pu and other radionuclides using high resolution gamma spectroscopy, determination of isotope mass for a wide range of material and matrix types.

DESCRIPTION

The TGS uses transmission corrected, single photon emission computerized axial tomography to determine the spatial distribution and quantity of radio-nuclides using High Resolution Gamma-ray Spectroscopy (HRGS). The technique implements a sample translation axis in addition to vertical scanning and rotation axes.
A Se-75 transmission source allows the determination of a 3-D spatial map of the attenuation coefficient at any energy by interpolating between the gamma-ray peaks of Se-75 at several energies. Once the attenuation coefficient maps have been established for the sample, emission tomography is used to determine the distribution of selected radioisotopes within the sample. Two pass (transmission followed by emission) measurements are performed.

COMPONENTS

- germanium coaxial detector
- digital MCA based on ORTEC DSPEC Plus
- adjustable collimator (cans or drums)
- 30-200mCi Se-75 transmission source
- Cd-109 dead time source
- mobile operator control console

SPECIFICATIONS

Detector efficiency	50%
Measurement time	less than 1 hour
Accuracy	better than 10% for measurement of cans and 20% for matrices with average density 2g/cm³, better than 10% for metal scrap matrices
Spatial resolution for the emission image	about 6 cm for drums and 3 cm for cans
TGS Analysis	typically 4800 4k channel spectra for each measurement
Isotopic Analysis	one 8k emission spectrum
Overall instrument envelope	1835 mm long x 1512 mm wide x 1785 mm high
Sample drum and can size	variable (maximum 400 litre)
Weight	1200 kg
Dimensions	Pillar height 2.2 m, Base 1.8 m wide x 2.1 m deep

SOFTWARE

User friendly software runs under Windows NT4 and meets Nuclear Software QA requirements of NQA-1 (required for WIPP

ADDITIONAL INFORMATION

Isotopic ratio analysis of Pu is performed using PC/FRAM code.

REFERENCES

www.ortec-online.com

Accounting (NDA): Measurement System

124

Mobile Assay System

MODEL: ISO-CART

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Measurement System
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Effective Isotope Mass
NUCLEAR MATERIAL(S): Pu, U
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Field
DEVELOPER: ANTECH Corporation
MANUFACTURER: ORTEC

PURPOSE

In-situ assay of large containers, pipes, surfaces, etc.

DESCRIPTION

Cart-mounted mobile system for in-situ measurement of surfaces and objects that handles a wide variety of container sizes and densities. System provides simple point-source calibration, models geometry and matrix corrections. It also applicable to process holdup measurements of SNM

COMPONENTS

The hardware comprises a specially-designed cart which carries all the components:
- HPGe detector with 3.0-liter Gamma Gage dewar (7.0-liter multi-orientation dewar (MOD) is also available),
- shield and collimator,
- digiDART high performance multichannel analyzer,
- laptop computer.

Also included are:
- laser meter
- turntable for drums

SPECIFICATIONS

Throughput	over 100,000 processed pulses per second
Memory storage	23 16k spectra (614 at 512 resolution)
Typical counting time	from 15 to 30 minutes
Continuous operation time	about 9 hours

SOFTWARE

Program ISOTOPIC V. 3.0

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Measurement System

125

Radiation detection system

MODEL: FHT 1375 - grabSPEC

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Measurement System
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	Scrap
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

This spectroscopy-based radiation detection system is designed for monitoring scrap metal.

DESCRIPTION

FHT 1375-grabSPEC is an automatic radiation detection system for cranes and similar scrap handling systems equipped with grapples. The proven robust FHT 1375-grabSPEC can be mounted directly into the grapples of a crane. This results in minimum distance between scrap and detector, and therefore best detection sensitivity.

COMPONENTS

- user interface in the crane cabin
- wireless, radio controlled, shock resistant NaI detector (Ø 2” x 2” or Ø 4” x 2” in a ruggedized housing)
- nanoSPEC multi-channel analyzer
- ruggedized, but easy accessible battery case (dry lead battery, 6V/10Ah)
- battery charger including a 2nd battery to be charged in the cabin

SPECIFICATIONS

Energy range	60 keV to 3 MeV
Sensitivity	>2300 Ips/µSv/h with Ø3” x 2” NaI(Tl)
Response time	2 s
Detection sensitivity	shielded Cs-137 source with 30nSv/h dose rate in 1m distance (this is equivalent a unshielded 35kBq source) will be detected in a distance of 1,3 m with Ø3 x 2 NaI(Tl)- detector
Shock resistance	> 30 g (0.07 lb)
Operating temperature range	-20°C to +50°C (-4°F to 122°F)
Protection	water proof, dust tight (IP65)
Dimensions:	Ø200 mm x 300 mm height (8” x 12”)
control unit	205 x 100 x 62 mm (8 x 4 x 2.5”)
battery charger	125 x 75 x 65 mm (5 x 3 x 2.5”)
Weight:	27 kg (60 lbs)
control unit	1000 g (2.2 lb)

SOFTWARE

Operating system: Linux®

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): Calorimeter

126

High Sensitivity Large sample Tritium Calorimeter

MODEL: Model 350-375

SUPPLIER: **ANTECH Corporation**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Calorimeter
METHOD: Calorimetry

MEASURED PROPERTIES: Element mass
NUCLEAR MATERIAL(S): T
PHYSICAL FORM(S) OF NM: Any
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industria
DEVELOPER: ANTECH Corporation
MANUFACTURER: ANTECH Corporation

PURPOSE

The calorimeter determines the tritium mass and activity by measuring the total heat output resulting from the radioactive decay of tritium.

DESCRIPTION

The 350 series calorimeters determines the tritium mass in grams (g) and activity in units of Curies (Ci) or Becquerels (Bq) by measuring the total heat output resulting from the radioactive decay of tritium. The design has application to a wide range of measurement requirements. These include in-plant accountancy measurements, shipper - receiver difference measurements, the identification of empty transport containers and international safeguards measurements.
The calorimetry measurement method is independent of sample pressure, chemical composition and the presence of any other non-radioactive material, for example hydrogen, deuterium and helium. The measurement procedure is automated and requires almost no manual intervention, with the exception of loading and unloading the calorimeter. A calorimetric measurement of the tritium decay heat provides a direct measure of the total tritium activity or tritium mass based on precise electrical power measurement.

COMPONENTS

- true isothermal "air bath" element
- sample lifting device with fail safe hoist
- control console
- trolley

Two versions are available. Unit can be mounted on a single trolley or the control console and thermal element can be separated by up to 5 meters.

SPECIFICATIONS

Measurement range:	
Mass	10 g down to less than 10 mg
Activity	100 kCi (3.7 x E+15 Bq) down to 100 Ci (3.7 TBq)
Heat	5 mW to 20 Watts
Minimum power sensitivity	5 mW with 100% RSD
Measurement uncertainty	from better than 0.2 % at 50 kCi to between 5 % and 10 % below 1 kCi
Thermal power measurement accuracy	better than 1.0% over the operating range and better that 0.2% at 1.0 Watts power
Measurement time	from less than 2 hours to 4 - 5 hours
Weight	300 kg (trolley mounted version)

SOFTWARE

Software includes both end point power and equilibrium fitting software routines and decay correction for both tritium and

ADDITIONAL INFORMATION - Windows 2000 and is fully network compatible.

REFERENCES

www.antech-inc.com

Accounting (NDA): Calorimeter

127

Transportable Small Sample Calorimeter

MODEL: Series 601

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Calorimeter
METHOD:	Calorimetry
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	Pu, T
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

Designed for measurement of both plutonium and tritium. The accuracy and resolution of the instrument allow it to be used to replace destructive assay (DA) for small plutonium samples.

DESCRIPTION

The instrument employs a hybrid new technology using thermopiles and electrical resistance thermometry, and can operate in isothermal or heat flow mode. Highest measurement accuracy can be obtained by performing a differential measurement using the 'twin cells'.

COMPONENTS

- two sample chambers for temperature drift compensation
- automatic electrical calibration facility
- electric samples
- trolley

SPECIFICATIONS

Measurement times	some minutes
Sample power range	from 1 microwatt to 10 Watts
Measured power resolution	better than ± 1 microwatt
Absolute accuracy	better than ± 0.1%
Measurement chamber dimensions	5 cm x 10 cm (Diam. X H)
Overall dimensions	123 cm x 69 cm x 147 cm (L x W x H)
Weight	approximately 300 kg

SOFTWARE

The software includes both data acquisition and data analysis functions. Sample power end point predictions and equilibrium ecay correction for both Tritium and Plutonium samples. Measurement data is archived and may be analysed off-line.
Software operates under Windows NT4.

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Accounting (NDA): Calorimeter

128

High Sensitivity Large sample In-Line (Glove Box) Calorimeter

MODEL: SERIES 900

SUPPLIER: **ANTECH Corporation**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Calorimeter
METHOD: Calorimetry

MEASURED PROPERTIES: Element mass
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: ANTECH Corporation
MANUFACTURER: ANTECH Corporation

PURPOSE

Calorimeter is designed for measuring the plutonium bearing samples inside the glove box containment.

DESCRIPTION

In the standard configuration, the calorimeter is capable of measuring plutonium bearing samples which can be contained in a cylindrical canister with internal dimensions 186mm (7.30in) in diameter and 240mm (9.4in) high. The calorimeter has a variable sample power measurement range from below 0.025 to 15 watts. Variations to the standard design for different requirements and for special sample types or sample packaging can be accommodated. Smaller sample diameter custom systems achieve significantly better precision and accuracy at lower measurement powers (eg. <10mW).
Total mass of Pu is determined with error propagation when Pu isotopic data is provided on a file or 'on-line' from ANTECH Pu Gamma-ray Isotopic Measurement System.
Complete heat measurement performed inside glove box containment.

COMPONENTS

- sample well
- measurement chamber
- thermal element

SPECIFICATIONS

Measurement time	between 2-4 hours depending on sample
Power measurement accuracy	better than 0.5% over the operating range and better that 0.2% at 1.0 Watts power (7.5" diameter sample)
Measurement range	up to 15 Watts
Detection level	<5 mW
Operating temperature	from 20˚C to 30˚C

SOFTWARE

Automatic software algorithms are provided for equilibrium sample power prediction and measurement end point

ADDITIONAL INFORMATION

ic Plutonium and Americium decay correction.

REFERENCES

www.antech-inc.com

Accounting (NDA): Calorimeter

129

High Sensitivity Large Sample Calorimeter

MODEL: Series 200

SUPPLIER:	**ANTECH, ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Calorimeter
METHOD:	Calorimetry
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	ANTECH, ORTEC
MANUFACTURER:	ANTECH, ORTEC

PURPOSE

Calorimeter is used for international safeguards measurements, shipper-receiver difference measurements, in-plant accountancy measurements and anomaly resolution in passive neutron coincidence counting or segmented gamma-ray scanning. The instrument also has a role in replacing a proportion of destructive assay.

DESCRIPTION

Calorimeter performs an absolute measurement of sample thermal power and determine total mass of Pu with error propagation when Pu isotopic data is provided on a file or 'on-line' from ANTECH Pu Gamma-ray Isotopic Measurement System.

In the standard configuration, the calorimeter is capable of measuring plutonium bearing samples which can be contained in a cylindrical canister with internal dimensions 190.5 mm (7.70 in) in diameter and 355.6 mm (14.0 in) high. Variations to the standard design for different requirements and for special sample types or sample packaging can be accommodated. In particular the measurement chamber volume may be reduced or increased in size and measurement precision and measurement time may be optimised for a specific limited sample power range. Smaller sample diameter custom systems achieve significantly better precision and accuracy at lower measurement powers (e.g. <10 mW).

COMPONENTS

Two versions are available. Unit can be mounted on a single trolley or the control console and thermal element can be separated up to 10 meters.

SPECIFICATIONS

Thermal power measurement accuracy	better than 0.5% over the operating range and better that 0.2% at 1.0 Watts power (7.5" diam. sample)
Chamber operating temperature range	from 20 to 50°C
Measurement range	from 20 mW to 50 Watts (1mW to 15W for 275 model)
Measurement time	between 2-4 hours
Instrument dimension	123 cm x 69 cm x 147 cm (L x W x H), overall height of the removable hoist is 187 cm
Measurement chamber size	variable, 190.5 mm (7.70 in) in diameter and 355.6 mm (14.0 in) high (standard configuration)
Weight	approximately 300 kg (trolley mounted version)
Power consumption	300-600 watts 110/230 V AC

SOFTWARE

Windows based User Interface Software operating under NT4 or Windows 2000.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com
www.antech-inc.com

Accounting (NDA): Equipment Component

130

Neutron Time Correlation Analyser

MODEL: Series 1000

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Equipment Component
METHOD:	Neutron multiplicity counting
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

Neutron Time Correlation Analyzer (TCA) is designed for the measurement of Pu bearing waste and safeguards measurements of bulk Plutonium.

DESCRIPTION

The ANTECH Series 1000 Neutron Time Correlation Analyser (TCA) is a comprehensive implementation of multiplicity counting for passive neutron analysis of plutonium.
TCA allows to measure the effective number of neutron singlets and the effective number of correlated doublets in order to determine the spontaneous fission rate and hence the mass of the Pu (if the isotopic composition of the Pu in the sample is known). TCA is also able to measure the correlated triplets used in multiplicity analysis.
Single neutron pair and triple correlation neutron measurements can be performed simultaneously with the ANTECH Time Correlation Analyser. This is achieved using the two different and independent methods of measurement, the signal trigger and the periodic trigger operation modes. Data analysis is carried out for triple correlation using algorithms implemented in software and based on the interpretation model of Dr. W. Hage from JRC Ispra. For pair correlation (conventional coincidence counting), the passive coincidence counting software algorithms are implemented in the system.

COMPONENTS

SPECIFICATIONS

Count rate	maximum sustained input count rate between: 300 kHz to over 1 MHz
Pulse pair resolution	40 nsec
Recorded multiplicity	0 - 255
Measurement time	3 hours max

SOFTWARE

ADDITIONAL INFORMATION

The instrument has been developed by ANTECH in conjunction with and under licence from the Institute for Safety Technology of the Joint Research Centre Ispra of the CEC., for optimised neutron multiciplicity counting.

REFERENCES

www.antech-inc.com

Accounting (NDA): Equipment Component

131

Advanced Multiplicity Shift Register

MODEL: AMSR 150

SUPPLIER:	**ANTECH, ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Equipment Component
METHOD:	Neutron multiplicity counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	ANTECH, ORTEC

PURPOSE

The AMSR 150 Advanced Multiplicity Shift Register has been developed for neutron coincidence counting applications in Non-Destructive Assay (NDA) and Safeguards.
The AMSR 150 is suitable for use in mobile applications such as Safeguards inspections and in remote monitoring systems for unattended mode NDA.

DESCRIPTION

AMSR 150 counts single, double, and multiple coincidences. The information may be provided with a timestamp for authentication purposes.
AMSR 150 is backward compatible with the JSR-11, JSR-12, JSR-14, and PSR. Full compatibility with the latest version of the optional INCC Neutron Coincidence Counting program is therefore guaranteed.
Data from multiple runs may be processed and stored inside the instrument when the network is temporarily unavailable; data transmission may be encrypted and authenticated if required. An on-board, time-of-day clock is provided. The AMSR 150 is fully supported by the latest versions of the optional Los Alamos INCC and Multi-Instrument Collect (MIC) programs.

COMPONENTS

The Register among others includes :
- High contrast, back-lit LCD display
- The four-key, single-row KEYPAD
- PCMCIA card (Type 1 or Type 2) inserted in front-panel slot for removable flash memory storage
- Input pulse threshold discriminator
- Totals counter (36-bit synchronous)
- Reals plus Accidentals and Accidentals counters (48-bit synchronous)
- Multiplicity counter (256 channels, 32 bits per channel Reals-plus-Accidentals; 256 channels for Accidentals)

SPECIFICATIONS

Shift register frequency	4 MHz
Input pulse width	50 ns or greater
Pulse pair resolution	15 ns or less
Count time	1 to 9,900,000 seconds ±0.02%
Gate width	0.25 to 1023.75 µs ±0.02%; 1 to 512 µs from front panel
Pre-delay	0 to 1024 µs ±0.02%; 0 to 7.5 µs from front panel
Long delay	4.096 ms ±0.82 ms
High voltage	0 to 2000 V dc ±2%, ripple <10 mVptp, temperature <50 ppm/°C
Dimensions	25.7 W x 15.8 H x 37.8 cm D (10.1 W x 6.2 H x 14.9 in. D)
Weight	6.4 kg (14.1 lb)

SOFTWARE

Optional Software: Latest versions of INCC Neutron Coincidence Counting program and Multi-Instrument Collect Software

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com
www.antech-inc.com

Accounting (NDA): Equipment Component

132

Neutron Coincidence Electronic Analyzer

MODEL: JSR-12

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Equipment Component
METHOD: Neutron coincidence counting

MEASURED PROPERTIES: Effective Isotope Mass
NUCLEAR MATERIAL(S): Fissile
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

JSR-12 neutron coincidence analyzer is designed for separation of double coincidence events from the flow of random events and, finally, allows to determine the content of fissile material placed in detection unit.

DESCRIPTION

The JSR-12 Neutron Coincidence Analyzer separates coincidence neutron events from random neutron events, and thus provides a method of counting neutron signatures from spontaneously fissioning isotopes or induced fissions from fissile isotopes. At the conclusion of each counting interval (operator selected), the unit provides information on total counts, reals plus accidentals and accidentals as displayed on the front panel. Most significantly, it does this without substantial deadtime by a unique technique in which a new coincidence gate is started for each neutron event presented at the input.

COMPONENTS

The JSR-12 comes in two standard configurations: the standalone unit or a triple-width module, which uses the NIM standard physical configuration.
Unit includes:
- standard RS-232C serial port
- LCD alphanumeric display
- internal battery-backed time-of-day and day-of-year realtime clock
- automatic non-volatile storage for 3000 data runs
- internal burst pulser
- data RAM

SPECIFICATIONS

Power supply	110/220 V
Pulse pair resolution	20 ns
Clock speed	4 MHZ
Storage capacity	up to 3000 data runs
Measurement time	adjustable from 0.1 seconds to 9.9E+9 seconds
Operating temperature	15 to 35˚C
Operating relative humidity	up to 85%
Overall size	30.0 cm x 10.2 cm x 50.8 cm (NIM-10.2 x 19.3 x 26.7 cm)
Weight	5.4 kg (NIM – 2.6 kg)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Equipment Component

133

Neutron analysis shift register

MODEL: JSR-14

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Equipment Component
METHOD: Neutron coincidence counting

MEASURED PROPERTIES: Effective Isotope Mass
NUCLEAR MATERIAL(S): Fissile
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, industrial
DEVELOPER: LANL
MANUFACTURER: Canberra

PURPOSE

The JSR-14 is a data acquisition and analysis electronics package used in the measurement of plutonium and uranium (high and low enriched) materials. The added flexibility of coincidence and multiplicity counting ability, provides the user with analysis capability for a broad range of material configurations. These configurations include: Pu pellets, powder, solutions, Mixed Oxides, MOX fuel pellets, Pu fuel assemblies, HEU and LEU in metals, oxides, powders, fuel pellets and rods, as well as uranium hexaflouride (UF6) samples. The multiplicity analysis capability is very useful for measurement of scrap and other waste materials. The JSR-14 can also be used in various gross neutron counting applications.

DESCRIPTION

The JSR-14 Neutron Analysis Shift Register is a portable, fully computer controlled neutron analyzer that provides both neutron coincidence and multiplicity capability that is selectable through use of the provided setup software. The JSR-14 functions as a direct replacement of the Canberra JSR-12 Neutron Coincidence Analyzer and the 2150 Multiplicity Module. Neutron coincidence electronics used with all Canberra passive and active neutron counters.

COMPONENTS

- RS-232 serial interface
- battery-backed RAM
- ac charger/adapter
- shift register
- multiplicity and auxiliary scalers
- batteries

SPECIFICATIONS

Power	mains 110 to 220 V ac with battery in reserve or from batteries
Internal clock rate	4 MHz
Pulse pair resolution	50 ns
Data storage	last 3000 runs
Operating temperature	0 to 45˚C
Relative humidity	8 to 80%, non-condensing
Overall size	26.9 cm x 27.2 cm x 4.8 cm
Weight	3.2 kg with batteries

SOFTWARE

The JSR-14 comes with a neutron setup and acquisition software package that is based in Visual Basic and is compatible with

ADDITIONAL INFORMATION

erator to quickly define the operating modes, set up the counting parameters, and manually collect coincidence and multiplicity data. This software package displays the Reals plus Accidentals (R+A), Accidentals (A) and Totals (T) data during acquisition in real time for both coincidence and multiplicity modes. In multiplicity mode, the individual multiplicity channels are available for inspection after the acquisition is completed. All system configuration and hardware settings are stored in non-volatile memory, available in the event of power loss.

REFERENCES

http://www.canberra.com

Accounting (NDA): Equipment Component

134

Multiplicity counter

MODEL: 2150

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Equipment Component
METHOD:	Neutron multiplicity counting
MEASURED PROPERTIES:	Effective Isotope Mass
NUCLEAR MATERIAL(S):	Fissile
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The 2150 is used for multiplicity neutron counting. It is intended for use with passive thermal-neutron counters to determine the mass of fissile materials in safeguards and nuclear material.
The 2150 allows measurement of three quantities (total count rate, coincidence count rate and a higher order coincidence count rate).

DESCRIPTION

Since the mass of the material is proportional to the spontaneous fission rate, the mass can be determined. Multiple neutrons are emitted within a short time (i.e. coincident) of each other during the fission process. The number of these neutrons emitted in coincidence determines the multiplicity of the event.
The limitation of classical coincidence counting has been that only two independent quantities are measured (total counts and real coincidences). Corrections must be applied to get accurate assays, except when the material is pure metal or pure oxides, with the low Z material well characterized. The problem is that the characterization of the samples measured is often not well known. Both spontaneous and induced fissions contribute to the rate of the coincident neutrons from the sample. The induced fissions are caused by neutrons from outside the nucleus. The possible causes for these neutrons to be given off are a previous spontaneous or induced fission and alpha-neutron reactions if the sample contains low Z element impurities. The induced fission neutrons are classified as multiplication neutrons. The 2150 Multiplicity Counter can be used to determine the spontaneous fission rate from the measured neutron multiplicity distributions.

COMPONENTS

The 2150 is a single width NIM

SPECIFICATIONS

Clock rate	4MHz
Counting time	from 0.1 to 1.67E+6 s
Pulse pair resolution	20 ns
Data storage	internal histogram memory
Operating temperature	0 to 50 °C
Operating humidity	0-80% relative, noncondensing
Size	standard single width NIM module 3.43 x 22.12 cm
Net weight	0.9 kg
Shipping weight	1.8 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

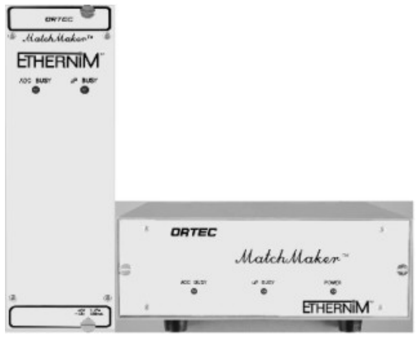
Accounting (NDA): Equipment Component

135

EtherNIM Acquisition Interface Module

MODEL: MatchMaker

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Equipment Component
METHOD:	Gamma Passive, active
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC



PURPOSE

MatchMaker is designed to interface a variety of commercial vendor's ADC'c into the ORTEC CONNECTIONS Software Environment, and to applications such as MAESTRO-32, GammaVision-32, ScintiVision-32, AlphaVision-32, Renaissance-32, MGA, Isotopic, and PC/FRAM.

DESCRIPTION

The ADC is connected directly to the NIM MatchMaker by ribbon cable (supplied), which then connects to the PC or PC network by the built-in Ethernet Interface. You can connect a virtually unlimited number of MatchMakers to one PC.
MatchMaker is available in two configurations:
The NIM "MatchMaker" in a 2-wide NIM module shares a bin with NIM ADCs.
The "MatchMaker-H" is a standalone, benchtop version for non-NIM installations. MatchMaker-H, mainspowered, may also be used with NIM ADCs if spare NIM slots are not available.
MatchMaker supports the following ADCs:
Canberra — Models 8075, 8077, 1510, 8701, 8706, 8713, 8715 (May be components in: CI Series 30/35 [external ADC option]; Series 85/90/95 [external ADC option]; S100.)
Canberra/Nuclear Data — 560, 570, and 580 Series (May be components in: Genie "AIM" systems [NOT ICB NIM]; Genie 9900; Accuspec "B"; μMCA module; ND62 [External ADC option, including top mount version]; ND65 series [external ADC option]; ND66/76 series; ND6600, ND6700, ND6680 Series.)
Silena — Models 7411, 7423 (May be components in Silena's Cicero; Varro; Livius; SIMCAS; NIM Series 8900; Memory Buffer 7328.)

COMPONENTS

SPECIFICATIONS

```
Memory                  up to 16384 channels are accessible depending on the ADC resolution.
                        Memory is nonvolatile, capacity 2^31-1 (2 billion) counts per channel.
______________________________________________________________________________________________
NIM Version             "MatchMaker"
___________________________________
Power Requirements      +12 V, 150 mA; +6 V, 1.25 A.
Dimensions              NIM-standard double width 6.90 x 22.13 cm (2.70 x 8.714 in.)
                        front panel per DOE/ER-0457T
Weight:
    Net                 2.25 kg (5 lb)
    Shipping            3.1 kg (7 lb)
______________________________________________________________________________________________
NON-NIM Version         "MatchMaker-H"
______________________________________
Power Requirements      AC voltage 90-260 V, 50-60 Hz;
                        115 V, 0.4 A; 230 V, 0.2 A.
Dimensions              11.4 x 22.3 x 29.2 cm (4.5 x 8.8 x 11.5 in.)
Power Supply Module     7.9 x 12.7 x 6.4 cm (3.1 x 5.0 x2.5 in.)
Weight:
    Net                 5 kg (11.1 lb)
    Shipping            6 kg (13.3 lb)
______________________________________________________________________________________________
```

SOFTWARE

MatchMaker applications software packages are 32-bit applications featuring full multitasking/multi-threading. They must be

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Concentration meter

136

Conductmetric concentration meters

MODEL:

SUPPLIER:	**Sibprompribor-Analyt**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Concentration meter
METHOD:	Conductivity measurement
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Sibprompribor-Analyt
MANUFACTURER:	Sibprompribor-Analyt

PURPOSE

Continuous determinating the concentrations of salts, alkalines, oxides in water solutions.

DESCRIPTION

Conductor meter for common industry applications is constructed for permanent control of conductivity of liquid mediums reduced to 25°C, and also used for measuring concentrations of salts, alkalines, oxides in water solutions when there is well-defined dependence of conductivity from concentration and temperature of these substances.

COMPONENTS

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №21065-01

REFERENCES

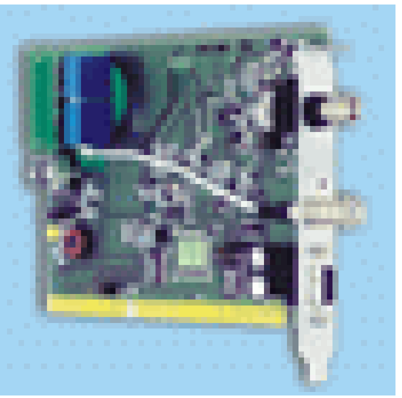
http://www.sibprompribor.ru

Accounting (NDA): Multichannel Analyzer

137

Fast acting one-plate spectrometer

MODEL: SBS-67



SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

Fast acting one-plate spectrometer created especially for applications which demand high throughput under high input loads.

DESCRIPTION

When scintillators based on NaI (TI) are used the device keeps its ability to work under loads to 2,5*10^6 pulses/second, Maximum throughput of 2*10^5 pulses/second is defined only by time of scintillator highlighting.

COMPONENTS

SPECIFICATIONS

Transformation time, micro seconds	0.85, double buffering
Integral non-linearity of spectrometric system, %	0.05% (0.02)
Differential non-linearity, %	1% (0.5)
Amplifier coefficient	2-512 or 20-5120 on order
Number of channel of transformation	4096, 2048, 1024,512, 256
Maximum input statistical load	1000000 pulses/second (2500000 with NaI(Tl))
Time resolution of imposition eliminator	150 ns

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

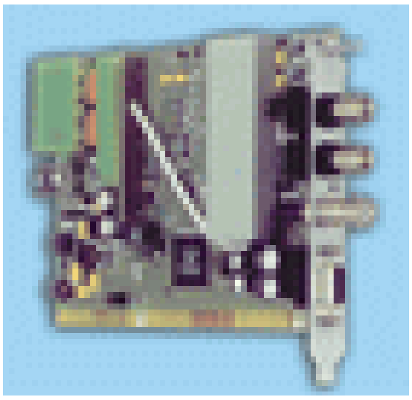
http://www.greenstar.ru/

Accounting (NDA): Multichannel Analyzer

138

"Public spectrometer", Universal no expensive one-plate spectrometer

MODEL: SBS-65



SUPPLIER: **Green Star**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Multichannel Analyzer
METHOD: Gamma

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu, Impurities
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, industrial
DEVELOPER: Green Star
MANUFACTURER: Green Star

PURPOSE

You can acquire only one plate in form-factor of IBM PC, incorporate it into your personal computer, hang a required detection unit and have high quality spectrometer just on you working table.

DESCRIPTION

The device has high throughput if it is equipped by specialized signal conditioners, that allow to work with high loads (more than 5x10^4 pulses/second) that applicable for measurements of nuclear materials by non-destructive analysis, activation measurements , and other.
This processor is created for work with ISA interface.

COMPONENTS

SPECIFICATIONS

Transformation time, micro seconds	1.8, double buffering
Integral non-linearity	0.025% (0.01)
Differential non-linearity	1% (0.5)
Amplifier coefficient	10-2500
Number of channel of transformation	8192, 4096, 2048, 1024, 512, 256
Maximum input statistical load	100000 pulses/second
Time resolution of imposition eliminator	400 ns

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

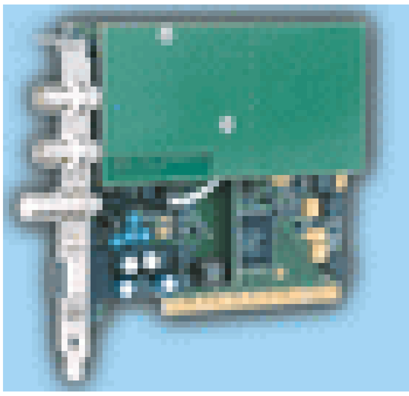
http://www.greenstar.ru/

Accounting (NDA): Multichannel Analyzer

139

Fast acting one-plate spectrometer

MODEL: SBS-70



SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

SBS-70 Processor of pulse signals was created especially for spectra measurement under high loads.

DESCRIPTION

The spectrometer differs from analogue units of more high throughput. After installation of processor of pulse signals SBS-70 into IBM compatible personal computer like Desktop or Notebook a user has got a modern spectrometer of nuclear radiation with highest metrological characteristics.

SBS-70 Processor provides compatible work with different types of detectors: scintillators (NaI(TI), CsI(TI), forswitch) , gasfilled detectors (proportional counters, ionization chambers) and semiconductor detectors (Ge, Si, CdTe).

COMPONENTS

SPECIFICATIONS

Transformation time, micro seconds	3.8, double buffering
Integral non-linearity,%	0.025 for 98% of amplitude region (0.005)
Differential non-linearity,%	0.25 for 98% of transformation channel region of (0.15)
Amplifier coefficient	from 5 to 1280 with discrepancy of 1/8000
Time resolution of imposition eliminator	600 ns
Number of channels	16K; 8K; 4K; 2K; 1K; 0.5K

SOFTWARE

Software provides quality and quantity spectra analysis (search of peaks, multiples decomposition, determination of are and pecification of energy value and other), determination of radionuclide activity for a number of popular measurement geometries, determination of specific volume, mass, and surface activities. In addition software for determination of uranium enrichment and plutonium isotopic analysis can be supplied for gamma-spectrometers with germanium detectors.

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Multichannel Analyzer

140

Digital Spectrum Analyzer

MODEL: DSA-2000

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Multichannel Analyzer
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial, laboratory
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The instrument is suitable for applications involving virtually all gamma, and most X-ray, detector types.

DESCRIPTION

The heart of the DSA-2000 is the Digital Signal Processor (DSP) subsystem.
Unlike conventional systems, which digitize the detector preamplifier signals at the end of the signal processing chain, the DSA-2000 digitizes the detector preamplifier signals at the front end of the signal processing chain. This approach eliminates significant amounts of analog circuitry at the front end of the instrument, resulting in increased stability, accuracy and reproducibility.
Digital signal processing allows filter algorithms and pulse shapes that are not realizable using conventional analog processing techniques. The result is a more efficient trapezoidal filter function which results in less processing time, less sensitivity to ballistic deficit, and superior resolution. With trapezoidal filtering the pulses can be processed more rapidly and accurately, so spectrum resolution is enhanced while throughput is increased.

COMPONENTS

- 16K channel digital signal processor,
- multi-range HVPS,
- 32k channel MCA memory,
- digital spectra stabilizer and
- Ethernet interface

SPECIFICATIONS

Integral nonlinearity	0.025% over 99.5% dynamic range
Differential non-linearity	1% over 99% range including integral nonlinearity effects
Pulse pair resolution	500 ns
Operating temperature	from 0 to +50 °C
Relative humidity	up to 80%, non-condensing
Power supply	90-259 V ac (47-63 Hz) in four user selectable ranges
Data memory	1-32K channels; 32 bits per channel, three day data retention when power is lost
Preset mode	Zone, Live or Real Time (computational presets are performed by the host computer)
Time resolution	0.01 s
Overall size	42.5 x 8.9 x 40.6 cm (16.75 x 3.5 x 16 in.)
Weight	8.5 kg (18.73 lb)

SOFTWARE

Analyzer works under Genie-2000 basic spectroscopy software.

ADDITIONAL INFORMATION

REFERENCES

1) Production Catalog and Reference Guide. Edition 11. Canberra Industries, Inc.,
2) http://www.canberra.com

Accounting (NDA): Multichannel Analyzer

141

Hand-held gamma spectrometer with digital signaling processor

MODEL: InSpector-1000

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Field
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Spectrometer is used for doze and count rate measurements, nuclide identification and activity measurements, as well as for spectra acquisition and analysis in the field.

DESCRIPTION

Operation modes:
– measurement and display of the doze and doze rate;
- radiation source search;
- nuclides identification;
- spectra acquisition and analysis

Shockproof design. It is able to sustain the drop from 1 m height to concrete floor (without detector).

COMPONENTS

- microtransmitter for signaling the count rate, doze rate, nuclide activity
- power supply /charger
– detectors:
  – buit-in Geiger counter (for large doze rates)
  - external intelligent detectors: NaI 1.5 x 1.5 inches (IPRON_1, model IN1KN_1), NaI 2 x 2 inches (IPRON_2, model IN1KN_2), NaI 3 x 3 inches (IPRON_3, model IN1KN_3).

SPECIFICATIONS

Doze measurement mode:	
doze rate range	10 nSv/h to 100 mSv/h
doze range	10 nSv to 10 Sv (1 µRem to 1000 Rem)
energy region:	
NaI	from 50 keV to 3 MeV,
Geiger counter	from 30 keV to 1.4 MeV
Spectrometric mode:	
energy region, NaI	from 50 keV to 3 MeV
throughput	> 50 000 counts/s
input count rate	> 500 000 counts/s
time preset	real or live time from 1 to 1000000 seconds or continuous counting
number of spectrum channels	up to 4096
spectra memory	up to 256 2048-channel spectra
user zones	up to 64 zones per file
Operation time	12 hours of continuous operation with fully charged battery (when display illumination is on, battery operation time decreases by 40%)
Power supply	12 V dc from universal power supply
Battery type	lithium-ion battery
Charging time	about three hours when device is off
Weight	1.8 kg with detector NaI 1.5 x 1.5 inches and battery
Dimensions	22 x 18 x 7 cm (L x W x H)
Operating temperature	from −10 to +50 ˚C
Relative humidity	up to 80%, non-condensing

SOFTWARE

Genie software (operates under Windows® 98/2000/XP) allows to:

ADDITIONAL INFORMATION

e thresholds/types of nuclides)
- create the sequences of automatic operation
- print spectra/results

- create reports
- perform efficiency calibration
- perform extended analysis (optionally)
- mathematical calibration by efficiency (optionally)

Auxiliary software (operates under Windows® 98/2000/XP) allows to:

- perform basic setup of device
- restrict access to mode/menu/parameters
- download new microprogram version

Additional software:

- gamma analysis program S501C
- quality assurance program S505C
- interactive peak fitting program S506
- mathematical calibration program (ISOCS) S573

REFERENCES

http://www.canberra.com

Accounting (NDA): Multichannel Analyzer

142

Portable digital multichannel analyzer

MODEL: InSpector-2000

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Evaluation of environment conditions, ensuring of nuclear safety, decontamination and decommissioning of the objects, technological process monitoring.

DESCRIPTION

InSpector-2000 is highly productive portable spectrometric working station based on digital signal processors (DSP). In conjunction with HPGe, NaI and Cd(Zn)Te detectors InSpector-2000 provide any task solution. It also is suitable for operation with temperature-stabilized NAID detectors.
InSpector- 2000 can operate both in pulse amplitude analysis (PAA) mode and multichannel counting (MCC) mode for applications that require measurement of depending on time quantity.

COMPONENTS

Analyzer includes:
- 16K-channel digital signal processor,
- spectrum stabilizer,
- universal HV power supply
- 16K-channel spectra memory
- accumulator battery SONY NP-F950 of high capacity

Analyzer is connected to computer via RS-232 and USB interfaces

SPECIFICATIONS

Operating temperature	0 to +50˚C
Humidity	up to 80%, non-condensing
Overall size	3.8 x 18.5 x 17.3 cm
Weight	1.3 kg including battery

SOFTWARE

Device operates under control of basic Genie-2000 software. Special version of this software is included in analyzer delivery

ADDITIONAL INFORMATION

Application programs:
- program for measuring objects of arbitrary form ISOCS
- program for measuring uranium enrichment IMCA
- program for measuring uranium and plutonium U/PU INSPECTOR
- program shell PROCOUNT-2000

REFERENCES

http://www.canberra.com

Accounting (NDA): Multichannel Analyzer

143

Universal MCA for scintillation spectrometry

MODEL: uniSpec

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

MCA is used in scintillation spectrometry.

DESCRIPTION

uniSpec is an integrated multichannel analyzer containing all units required for NaI(Tl) scintillation spectrometric system. All MCA's units are in single cylindrical body and powered from USB port. This simple design allows not to use NIM modules, PC-based MCA and external power sources. Standard technology of USB connection allows easily connect several detectors to one computer. To start spectra acquisition just connect uniSpec to free USB port and start Genie 2000 software.

COMPONENTS

uniSpec includes:
- high voltage supply (HVS),
- preamplifier supply block,
- amplifier-shaper,
- stabilizer,
- ADC (buit-in Wilkinson converter, 60 MHz),
- memory (2K channels),
- standard 14-pin connector (allows to adapt different scintillation detectors such as NaI(Tl),CsI(Tl), CsI(Na), BGO).

SPECIFICATIONS

Spectra size	1024 channels
Channel capacity	32 bits
Integral nonlinearity	<±0,05% over the top 99% of the range
Differential nonlinearity	<±0,5 over 99% of the range, including integral nonlinearity
Power	no more than 250 mA, through USB port
Temperature	from 0 °C to 50 °C
Humidity	up to 80%, non condensing
Overall size	58 x 53 mm
Weight	220 g

SOFTWARE

MCA is supported with following software:

ADDITIONAL INFORMATION

for multi-input systems
- S502C Basic spectroscopy software for single-input systems
- S504C Basic spectroscopy software for InSpector.

Basic spectroscopy software Genie 2000 is a comprehensive package for acquisition, processing and displaying data using personal computer. It provides independent support of several detectors, extensive network capabilities, and comprehensive set of batch procedures.

Batch procedure environment allows to create the user-oriented commands providing full automation of data measurement and analysis.

For specific applications Genie 2000 supports user environment for developing custom algorithms and interfaces. All basic functions of Genie 2000 are available as independent objects that can be run from the user's program.

Computer requirements: processor Pentium 233 with CD-ROM drive, operating system Windows NT 4.0, Windows 2000 or Windows XP, RAM no less than 64 Mb (Windows NT/2000) or 128 Mb (Windows XP), hard drive capacity not less than 100 Mb, color VGA display with resolution not worse than 800x600, 1024x768 is recommended.

REFERENCES

http://www.canberra.com

Accounting (NDA): Multichannel Analyzer

144

digiDART™

MODEL:

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Multichannel Analyzer
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Field
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

Instrument is designed for in-field spectroscopy.

DESCRIPTION

DigiDART can perform nuclide ID and activity calculations using internally stored calibration information, at the touch of a button, and all without the use of an attached PC. Everything is user controlled: the library for analysis, displayed peak labels, unit labels and calibration parameters. Activity is calculated for the list of up to 9 nuclides. The spectral data can be saved and later reanalyzed in more detail using a more sophisticated PC-based analysis package such as GammaVision-32.

COMPONENTS

- built-in backlit LCD display (240 x 160 pixel) and control keypad "SMART-1"
- detector interface module DIM
- support HPGe detectors and all other detectors using the DIM

SPECIFICATIONS

Maximum system throughput	>100,000 cps
Energy ranges:	
COAX	187 keV to 12 MeV
LO-AX	94 keV to 6 MeV
GLP/SLP	16.5 keV to 1 MeV
Iglet-X	8 keV to 500 keV
Integral nonlinearity	<±0.025%
Differential nonlinearity	<±1%
Memory	23 16k spectra in internal memory (614 at 512 resolution)
Battery life	>9 hours
Dimensions:	
DigiDART	8" x 5" x 3" (20 x 10 x 7.5 cm)
DIM	4.4" x 1.25" x 2.6 (W) [3" with handle]
Weight:	
DigiDART	<900 gm (1.9 lb)
DIM	<240 gm (0.5 lb)
Operating temperature range	-10 to 60°C, including LCD display

SOFTWARE

Setup and spectrum recovery requires a suitable version of MAESTRO-32 (supplied with DigiDART) or other ORTEC

ADDITIONAL INFORMATION

MAESTRO-32 will support the DigiDART on any PC that will run Windows with support for USB, currently Windows 98/2000/XP.

REFERENCES

www.ortec-online.com

Accounting (NDA): Multichannel Analyzer

145

14-Pin PMT Tube Base with Integrated Bias Supply, Preamplifier, and MCA (with Digital Signal Processing) for NaI Spectroscopy

MODEL: digiBASE™

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Multichannel Analyzer
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

The digiBASE is a 14-pin photomultiplier tube base for gamma-ray spectroscopy applications with NaI(Tl) scintillation detectors.

DESCRIPTION

The concept of the digiBASE combines a miniaturized preamplifier and detector high voltage (0 to +1200 V bias) with digital signal processing, multichannel analyzer, and special features for fine time resolution measurements — all contained in a low-power, lightweight, small-size tube base with a USB connection. The digiBASE features built-in gain and offset stabilization circuitry. Stabilization is performed by providing a reference peak in the spectrum, which the MCA can monitor, should drift be detected, the gain and offset of the system are adjusted automatically to correct for the drift! The stabilizer can correct for 10% of FSR error in offset and uses the full range of the Fine Gain to correct for gain errors.

COMPONENTS

- preamplifier;
- detector high voltage bias supply
- MCA

SPECIFICATIONS

Conversion gain	1024 channels
Coarse gain	gain settings of 1,3 and 9 (controlled by jumper)
Fine gain	0.4-1.2
Integral non-linearity	≤±0.05% over the top 99% of the range
Differential non-linearity	≤±1% over the top 99% of the range
Dead time accuracy	<5% error up to 50k cps input count rate
Detector voltage	0 to +1200 V dc in steps of 1.25 V under computer control
Offset drift	<50 ppm of Full-scale range per °C
Gain drift	<150 ppm per °C
Shaping time	Bipolar shaping adjustable under computer control from 0.75 to 2 µs in steps of 0.25 µs
Interface	Full-speed (12 Mbps) USB 1.1 Interface. The unit is powered from the USB cable
Power Requirements	<500 mA from USB connection
Ambient Operating Environment	-10 to 50°C at 0 to 80%; non-condensing humidity (Note: Unit will operate at -10°C, however, at power on, it should be at least 0°C for proper startup)
Dimensions	63 mm diameter x 80 mm length
Weight:	
Net (digiBASE only)	10 oz., 280 g
Shipping:	~ 5 lb., 2.27 kg

SOFTWARE

ORTEC's MAESTRO-32 advanced MCA software. MAESTRO-32 includes features for identifying peaks, editing libraries, and of Interest (ROI), performing energy calibrations, automating tasks via using simple "Job Streams", AND MORE

ADDITIONAL INFORMATION

ScintiVision or InterWinner (optional)
ScintiVision-32 offers all the features of the MAESTRO-32 MCA emulator, but adds the power of peak search and fit spectral analysis engines for more complex analysis needs for NaI gamma-ray spectra.

REFERENCES

www.ortec-online.com

Accounting (NDA): Multichannel Analyzer

146

Portable, Miniature MCA for Use with NaI(Tl), CZT, and Other Moderate-Resolution Detectors

MODEL: MicroNOMAD

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma Passive/active
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field, industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

MicroNOMAD is a hardware/software system to perform gamma spectroscopy. Can be used to collect large amounts of data in the field in a short time. If line powered, ideal for in-situ networks covering large areas.

DESCRIPTION

The accompanying software provides acquisition control, conventional MCA Emulation, and quantitative spectral analysis of data from NaI detectors. MicroNOMAD MCA can use the bar codes as a sample description for spectral data. This is valuable in survey work where a local bar code is often used to designate a measurement point. Many common bar code readers such as the Hewlett Packard “Smart Wand” types are supported; connection is made to the 9-pin D Serial connector.
MCA can store up to 63 512-channel spectra with bar codes, out in the field.

COMPONENTS

- quality amplifier,
- 2k ADC,
- digital stabilizer
- data memory

SPECIFICATIONS

Storage capacity	127 256-channel, 63 512-channel, 31 1024-channel or 15 2048-channel spectra with bar codes
Power supply	two sets of 4 AA alkakine batteries
Continuous time	> 8 hours of field operation
Integral nonlinearity	<0.1% over 98% dynamic range
Differential nonlinearity	<2% over 98% dynamic range
Overall size	7.1 cm x 7.1 cm x 21.3 cm
Weight	0.7 kg

SOFTWARE

ScintiVision-32, MAESTRO, HMS-III hold-up software, CZTU.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Multichannel Analyzer

147

MCA Plug-In Card and Software

MODEL: TRUMP, TRUMP-PCI-8k/2k

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

TRUMP and TRUMP-PCI

PURPOSE

TRUMP is a fully functional MCA-on-a-card for use with personal computers.

DESCRIPTION

TRUMP provides a <8 microsec ADC and data memory on a single plug-in card and is used in conjunction with MAESTRO-32 MCA Emulation program.

Two methods of dead time correction are available. Either Extended Live-Time correction according to the Gedcke-Hale method or Simple Live-Time correction with the clock turned off during the conversion time can be selected, using printed wiring board jumpers.

In addition to the Input signal, the TRUMP(TRUMP-PCI) Card accepts an ADC GATE input, a PUR pile-up rejection input, and BUSY input used by the live-time correction circuits.

Up to eight TRUMP (TRUMP-PCI) Cards can be controlled from the same computer under one copy of the MCA Emulator program with no overhead on the PC resources. During data acquisition the computer is entirely free to run other tasks.

COMPONENTS

Each TRUMP (TRUMP-PCI) ard consists of a single-slot plug-in card and MAESTRO-32 software.

The TRUMP hardware is comprised of an ADC, microprocessor, program memory, and dual-ported data memory.

The TRUMP-PCI hardware comprises an ADC, microprocessor with data and program memory, and PCI-Bus interface, on a single PCI format plug-in card.

SPECIFICATIONS

Maximal resolution:	
8k:	8192 channels, software selectable as 8192, 4096, 2048, 1024, and 512
2k:	2048 channels, software selectable as 2048, 1024, and 512
Dead time per event	8 µs, including memory transfer
Integral nonlinearity	≤±0.025% over the top 99% of the dynamic range
Differential nonlinearity	<±1% over the top 99% of the dynamic range
Gain instability	≤±50 ppm/°C
Data memory	8k channels of battery backed-up memory; 231−1 counts per channel (over 2 billion)
Power required	+5 V, 1 A
Dimensions	standard IBM full-slot card (TRUMP) or Standard full-slot PCI card (TRUMP-PCI)
Net weight	1.4 kg (3.1 lb)

SOFTWARE

MAESTRO-32 will run on any PC that supports Windows 98/2000/XP.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Multichannel Analyzer

148

Universal multichannel analyzer

MODEL: scintiSPEC

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Multichannel Analyzer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

DESCRIPTION

The scintiSPEC is a universal multi-channel analyzer based on the photomultiplier tube base, used for scintillation spectrometry and counting. It mounts directly on a scintillation detector's 14-pin PMT, and provides "Plug and Play" easy functionality via a PC USB port, with no external power required. It is compatible with all standard scintillation detectors with 14 pin sockets - NaI(Tl), CsI(Tl), CsI(Na), BGO, CdWO4, Plastic etc .

COMPONENTS

- photomultiplier tube base
- USB standard interface
- built-in LED

SPECIFICATIONS

Spectrum length	1024 Channels
Bits per channel	32
Operating mode	PHA, opt. MCS
Memory	2k Channels
Integral non-linearity	< ± 0.05 % of full scale over the top of 99 % of selected range
Differential non-linearity	< ± 0.5 % over the top of 99 % of the range including the effects of INL
Temperature	0 to 50 °C (32 to 122 °F)
Humidity	up to 80%, non condensing
Power requirements	max. 250 mA, through USB
Overall size	Ø 58 x 53 mm (Ø 2.3" x 2.1")
Weight	220 g (7.8 oz)

SOFTWARE

WinTMCA32 software package, includes basic spectroscopy software gamTMCA-N: optional quantitative gamma analysis

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): Neutron generator

149

Pulse Neutron Generators

MODEL: ИНГ-031, ИНГ-03, ИНГ-13, ИНГ-17, ИНГ-07, ИНГ-27

SUPPLIER: **VNIIA**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Neutron generator
METHOD: Neutron
Active
MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Industrial, laboratory
DEVELOPER: VNIIA
MANUFACTURER: VNIIA

PURPOSE

The generators can be used in different NM assay systems, including wastes.

DESCRIPTION

COMPONENTS

Vacuum tube based pulsed neutron generators (ИНГ-031, -03, -013):
- neutron emission unit and switching unit;
- power supply and control unit;
- up to 50 m long connecting cables.

Gas-filled tube based pulsed neutron generators (ИНГ-17, -07, -27):
- neutron emission unit (with alpha-detector for ИНГ-27);
- power supply and control unit;
- set of connecting cables.

SPECIFICATIONS

	ИНГ-031	ИНГ-03	ИНГ-013	ИНГ-17	ИНГ-07	ИНГ-27
Neutron energy						14 MeV
Neutron flux, neutron/sec	3E+10	1E+9	1E+10	5E+8	1E+9	1E+8(in 4π)
Neutron pulse width, μsec	0.8	0.8	0.8	20-100	20-100	
Frequency, Hz	1-100	1-15	1-100	400-10000	100-10000	
Operating life time, h	100	200	100	500	500	1000
Power consumption, W, no more than	700	90	500	60	200	40
Dimensions:						
neutron emission unit:						270x200x140
- diameter (mm)	130	130	130	70	190	
- length (mm)	950	950	1000	480	440	
power supply unit						200x300x120
Weight, kg:						
neutron emission unit						8
power supply uni						3
α-detector temporal resolution, nsec, not worse than						1
Number of alpha detector pixels						9 and more

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniia.ru

Accounting (NDA): Neutron Counter

150

Neutron coincidence counter

MODEL: CHC-02A

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting Active
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Determination of fissile material (plutonium and uranium isotopes) amounts contained in different samples and items by non-destructive assay method (without opening the shell or pack of item).

Instrument is used for measuring the nuclear material content in the items and production wastes for passportization and inventory accounting of products at the facilities involved in nuclear materials production, use and storage.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Measuring chamber dimensions:	
diameter	200 mm
height	200 mm
Detection efficiency for fission neutrons	25%
Maximally detected coincidence factor	16
Sensitivity to plutonium-240 in passive total counting mode	1 mg
Sensitivity to uranium-235 in active thermal neutron detection mode	1 g
Power supply	220 V
Overall size	1000 x 700 x700 mm
Weight	150 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Accounting (NDA): Neutron Counter

151

Passive neutron decommissioning piece monitor

MODEL: Model 2072

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

The ANTECH Model 2072 Decommissioning Piece Monitor is a high efficiency passive neutron counter designed for the measurement of plutonium contaminated size reduced pieces arising from the decommissioning of nuclear plant and equipment. The system can also be used to measure plutonium bearing material in storage containers.
Monitor can operate in conventional shift register (coincidence counting), multiplicity or totals neutron counting mode.
ANTECH Model 2072H is designed for horizontal operation.

DESCRIPTION

The operation of the instrument is based on passive neutron counting of the correlated neutrons arising from spontaneous fission of the even Pu nuclides, principally Pu-240. The measurement chamber can be installed outside of any Modular Containment System or similar exclusion zone. This can be adjacent to a convenient bagging port through which size reduced pieces are introduced for measurement. A closure plug is provided for the top of the measurement chamber.
Plant measured isotopic ratios can be used by the software in order to convert Pu-240 effective mass to total Pu mass. Alternatively a suitable germanium gamma-ray detector can be conveniently installed through the base polyethylene shield plug to interrogate the sample and determine the Pu isotopic ratios independently using PC-FRAM or other isotopic code.
Can be combined with a conventional high resolution gamma-ray system for the independent determination of Pu isotopic ratios.

COMPONENTS

- portable chamber
- 72 He-3 tubes (25mm diameter x 1metre length, 4 atmospheres fill pressure) arranged in two rows of 36 tubes
- high voltage junction box containing:
    - Amptek charge sensitive amplifier/discriminator circuit
    - electrical connections: high voltage, 5V supply, signal cables.
- polyethylene moderator
- AMSR 150 Neutron Coincidence / Multiplicity Counter or Time Correlation Analyser
- robust trolley
- stand-alone workstation containing:
    - counting electronics,
    - computer,
    - printer

SPECIFICATIONS

Measurement chamber dimensions	400mm x 671mm
Detection efficiency	~28%
Operating Voltage	~1650 volts
Minimum detection limit	between 10 - 50mg Pu-240 effective in coincidence (reals) mode equivalent to between ~0.2 and 1.0g total Pu (military grade)
Overall dimensions (including handle and frame)	110 cm long x 90 cm wide x 140 cm high
Weight	400 kg approx

SOFTWARE

INCC-32, PC/FRAM

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Accounting (NDA): Neutron Counter

152

Active Well Neutron Coincidence Counter

MODEL: JCC-51

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	U, Pu, Th
PHYSICAL FORM(S) OF NM:	Metal, oxides, alloys, fuel
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

This device is designed to make active neutron measurements on items such as bulk UO2 samples, high enrichment uranium metals, UAl alloy scraps, LWR fuel pellets and U-238/Th fuel materials.
Americium-Lithium (AmLi) neutron sources (one in the top plug and one in the bottom plug) induce fission in the uranium sample and the coincidence neutrons are counted. If the AmLi sources are removed, the counter can be operated in a passive mode to assay plutonium.

DESCRIPTION

The counter can be operated in two active modes: thermal mode and fast mode. Thermal mode is used for low enrichment material such as UO2 pellets, U3O8 powder and low content scrap (<50g U-235), high-enrichment material including U-235,Th and U-233,Th (HTGR fuels) and samples with large quantities of hydrogenous materials such as scrap with plastic bags, uranyl nitrate (few g/L to few hundred g/L) and plutonium solutions (few g/L to few hundred g/L). The fast mode is used for high-enrichment uranium metal. For thermal mode, the internal cadmium sleeve and cadmium in the end plugs are removed.
Detectors are arranged in two concentric rings to maximize efficiency. The tubes are divided into six groups of seven, and each group is wired together and connected to one JAB-01 channel.
For assay of large samples such as fuel rods or plates, the counter is turned on its side, the end plugs are removed and an MTR Insert (JWI-11) is positioned inside the counter. The cart is used to support the counter in the horizontal position.
The sample well height can be increased by removing one or both of the polyethylene discs in the top and bottom plugs. Enlarging the sample well will increase the absolute efficiency because the ends of the He-3 tubes are not as shielded, but decrease the precision because the random background from the AmLi source is increased.
A cadmium sleeve is wrapped around the outside of the counter to reduce the background and to reduce personnel exposure.

COMPONENTS

- forty-two He-3 tubes, D2.54 x 50.8 cm, embedded in the high-density polyethylene
- electrical connections:
    - +5 V
    - HV
    - single "ORed" output signal.
- fast Amptek electronics
- two AmLi neutron sources (JNS-01), 5x10^4 n/sec
- cart

JSR-12 Neutron Coincidence Analyzer, a computer and analysis software are required for neutron coincidence counting but are not included with the JCC-51.

SPECIFICATIONS

```
Detector efficiency        26% for small size samples
Sensitivity (U-235)        1 g in thermal mode
                           23 g in fast mode
Precision (U-235)          1.5%/20g in thermal mode
                           3.8%/200 g in fast mode
Cavity dimension           variable from D22.9 x 20.6 cm to D22.9 x 35.1 cm
Overall size               73.7 cm x 49.3 cm, H x Dia
Weight                     125 kg (including cart)
```

SOFTWARE

Canberra Neutron Assay Software

ADDITIONAL INFORMATION

REFERENCES

1) http://www.canberra.com
2) Menlove, H.O. Description and Operation Manual for the Active Well Coincidence Counter, Report LA-7823-M. Low Alamos,

New Mexico, Los Alamos National Laboratory, 1979.

Accounting (NDA): Neutron Counter

153

High Level Neutron Coincidence Counter

MODEL: JCC-31 (HLNC)

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Miscellaneous
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

The device is intended to assay plutonium samples including PuO2, mixed oxides (PuO2-UO2), metal carbides, fuel rods, fast critical assemblies, solution, scrap, and waste.

DESCRIPTION

The JCC-31 measures the Pu-240 effective mass in a sample by detecting coincidence neutrons from the spontaneous fission of plutonium. The effective mass of Pu-240 is the mass of Pu-240 which would emit the same number of spontaneous fission neutrons per second as the combined Pu-238, Pu-240 and Pu-242 in the sample.
A cadmium sleeve surrounds the sample cavity to prevent the re-entry of thermalized neutrons into the sample, which could induce fission in the sample and adversely affect the results. Outside the cadmium sleeve is a ring of high-density polyethylene with eighteen He-3 tubes placed in the polyethylene.
The tubes are arranged in a single ring around the sample with optimum spacing between the tubes for maximum counter efficiency for a transportable counter. The tubes are divided into six groups of three with each group wired together and connected to one JAB-01s are mounted inside a sealed junction box. LED indicator lights are places externally on the junction box to indicate proper operation of each JAB-01 channel. Electrical connections between the JCC-31 and the JSR-12 include +5 V, HV, and a single "ORed" output signal.
A cadmium sleeve wrapped around the outside of the JCC-31 provides radiation protection for personnel as well as background reduction.

COMPONENTS

-18 He-3 detectors in aluminum cladding
- fast Amptek electronics
- platform with rotary wheels
- one Cf-252 neutron source, 5 x 10^4 neutron/second strength for routine normalization measurement (optional)

A JSR-12 Neutron Coincidence Analyzer, a computer and analysis software are required for coincidence counting but are not included with the JCC-31.

SPECIFICATIONS

He-3 Active length x dia	50.8 x 2.54 cm
He-3 Detector efficiency	18%
Gate setting	64 microsec
Die-away time	50 microsec
Measurement range	1 g to 10 kg of Pu
Cavity dimensions	41 cm x 17.5 cm, H x Dia
Overall size	73.7 cm x 34 cm, H x Dia
Weight	34 kg

SOFTWARE

ADDITIONAL INFORMATION

Is based on a technology transfer from Los Alamos National laboratory(LANL)

REFERENCES

1) http://www.canberra.com
2) H.O. Menlove and M. Krick (1979). The High-Level Neutron Coincidence Counter (HLNCC): User's Manual. Report LA-7779-M. Los Alamos, New Mexico, Los Alamos National Laboratory.

Accounting (NDA): Neutron Counter

154

Inventory Sample Neutron Coincidence Counter

MODEL: JCC-12 (INVS)

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

The device is designed for passive neutron coincidence assay of Pu in the samples ranging from 0.1 to 500 g.

DESCRIPTION

The JCC-12 assays plutonium inventory samples by counting coincidence neutrons from the spontaneous fission of the even numbered isotopes of plutonium. The cylindrical-shaped sample holder accommodates various samples including liquids, powders and pellets. The sample cavity can be enlarged to 8.8 cm in diameter by removing the polyethylene sleeve around the aluminum sample carrier.

COMPONENTS

- 16 He-3 tubes (6 atm, 30.5x2.5(Dia) cm) in aluminum cladding embedded in the polyethylene
- junction box:
    - 4 groups (one for each of four detector groups) of JAB-01 Preamplifier/Amplifier/Discriminator circuit board.
- electrical connections:
    - +5 V,
    - HV,
    - ORed output signal.

A JSR-12 Neutron Coincidence Analyzer, computer, and analysis software are required for coincidence counting but not included with the device.

SPECIFICATIONS

Detector efficiency	35% with smallest sample configuration 29% with polyethylene sleeve removed
Measurement range	0.1 to 500 g Pu
Cavity dimension	14 cm x 5 cm (H x Dia)
Overall size	46.2 cm x 27.9 cm (H x Dia)
Weight	20.4 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

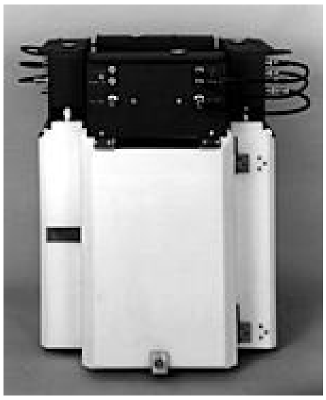
1) http://www.canberra.com
2) H.O. Menlove, et.al., Inventory Sample Coincidence Counter Manual, LANL Report LA-9544-M, Los Alamos, 1982

Accounting (NDA): Neutron Counter

155

Neutron Coincidence Collars

MODEL: JCC-71/JCC-72/JCC-73



SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Fuel assemblies
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

This devices are designed for neutron coincidence measurement of uranium in PWR (JCC-71/73), BWR and CANDU (JCC-71/72) fuel assemblies, or plutonium in MOX full assemblies.

DESCRIPTION

The Model JCC-71 Neutron Coincidence Collar is a passive/active neutron counter for the measurement of the U-235 content per unit length in fresh PWR, BWR and CANDU fuel in the passive mode. In the active mode, an AmLi source is required to interrogate the fuel, and coincidence counting of the induced fission neutrons from U-235 is performed. To measure the U-238 content, the AmLi source is removed, a fourth bank of He-3 detectors is added, and the counter is operated in a passive mode, counting the coincidence neutrons from spontaneous fission of U-238. The collar measures the U-235 and U-238 content along the axis of the assembly, not the enrichment. Since the U-235 content is of primary interest for safeguard purposes, only the active measurement is necessary. Pu-containing fuel rods are measured in the passive mode because of the high spontaneous fission rate.

For the passive mode, there are four counter banks composed of high-density polyethylene for moderation of the fission neutrons. If operated in the active mode, one bank of detectors is replaced with a polyethylene bank containing the AmLi interrogating source.

The Neutron Coincidence Collar (JCC-71) is designed to allow modification of the geometry to close-couple the detectors with the fuel type. For the smaller BWR fuel, the side detector banks are moved into the inner screw hole position. The fourth bank of tubes (passive mode) is hinged to facilitate placing the counter around fuel assemblies. For the active mode, the fourth side of the counter is a polyethylene moderator with a tungsten source bottle for the AmLi source. The AmLi neutrons are thermalized in the polyethylene and induce fission in the U-235. The average energy from the induced fission is higher than the moderated AmLi neutrons and gives fast neutron multiplication which allows the measurement to penetrate into the interior of the fuel assemblies. For HEU fuel, cadmium liners can be added to improve neutron penetrability.

The Neutron Coincidence Collar is designed to be insensitive to parameters such as open channels for control rods, enrichments, angular orientation of the fuel in the Collar, fuel pellet density, and any protective bagging. Cladding type (zinc alloy or stainless steel), different fuel pellet diameter, and neutron absorbers (Gd_2O_3) can affect the measurement.

COMPONENTS

- He-3 tubes:
  - JCC-71 (passive mode) - 24
  - JCC-71 (active mode) - 18
  - JCC-72 (active mode) - 16
  - JCC-73 (active mode) - 20
- passive fourth bank of 6 neutron detectors for JCC-72 and JCC-73 (ordered separately)
- AmLi source (ordered separately)
- fast Amptek electronics
- optional transport container
- Cf-252 neutron source for verifying proper operation (optional)

A JSR-12 Neutron Coincidence Analyzer, a computer and analysis software are required for coincidence counting but are not included with the JCC-71, 72 and 73.

SPECIFICATIONS

```
Required AmLi source strength:
   JCC-71                              5E+4 n/s
   JCC-72 and JCC-73                   1E+5 n/s
Tube active length                     33 cm x 2.54 cm (aluminum cladding), L x Dia
Efficiency:
   JCC-71 (passive PWR configuration)  11.5% ± 10%
   JCC-72 (active)                     13.5% ± 10%
   JCC-73 (active)                     12.5% ± 10%
Gate setting                           64 microsec
```

Sensitivity (JCC-71)	2.2 rods for iron substitution 2.8 rods for empty substitution
Cavity dimension	41.4 x 23.4 x 23.4 cm (for PWR assemblies) 41.4 x 16.5 x 23.4 cm (for BWR/CANDU assemblies)
Weight (JCC-71)	38 kg

SOFTWARE

ADDITIONAL INFORMATION

These devices are based upon technology transfer from the Los Alamos National Laboratory.
Since more neutron collars are being installed at facilities for measuring designated fuel types (BWR or PWR), the Neutron Coincidence Collar was redesigned by Los Alamos National Laboratory to make two separate counters: the JCC-72 for BWR and CANDU fuel assemblies and the JCC-73 for PWR fuel assemblies.

REFERENCES

1. H.A. Menlove, Description and Performance Characteristics for the Neutron Coincidence Collar for the Verification of Reactor Fuel Assemblies, LANL Report LA-8939-MS, Los Alamos, 1981
2. Edition Ten Product Catalog, Canberra Industries, Inc.
3. http://www.canberra.com

Accounting (NDA): Neutron Counter

156

Pu Scrap Multiplicity Counter

MODEL: PSMC-01

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Scrap MOX
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

The Plutonium Scrap Multiplicity Counter (PSMC) is a high efficiency neutron counter designed for measuring impure samples such as plutonium oxide and mixed-oxide (MOX) scrap materials.

DESCRIPTION

The PSMC design is optimized for multiplicity counting to include high efficiency in multiplicity counting, the triples rate is proportional to the efficiency cubed. PSMC has four rings of He-3 proportional detectors arranged to flatten the energy response, and graphite end plugs to flatten the axial response by reflecting neutrons back into the He-3 detection region. The deadtime is small because the counter has 19 amplifiers to reduce the deadtime.

The PSMC uses Canberra's 2150 multiplicity electronics module, which is an extension of the JSR-12 Neutron Coincidence Counter Electronics (NCCE) module. Where the JSR-12 simply sums the R+A and the A gates, the 2150 multiplicity distribution is used to determine the singles (S), doubles (D), and triples (T) rates which can be used to solve for three unknowns: the Pu-240-effective mass, sample multiplication, and the alpha value (the alpha value is the ratio of the uncorrelated to spontaneous fission neutron events).

COMPONENTS

- 80 He-3 proportional detectors
- graphite end plugs
- 19 amplifiers
- Canberra's 2150 multiplicity electronics module

SPECIFICATIONS

```
Efficiency             about 55%
Cavity dimentions      41cm x 20 cm (HxD)
Overall size           66 cm x 66 cm x 80 cm (LxWxH)
```

SOFTWARE

ADDITIONAL INFORMATION

The PSMC is a commercialized version of a multiplicity counter originally developed by Los Alamos National Laboratory.

REFERENCES

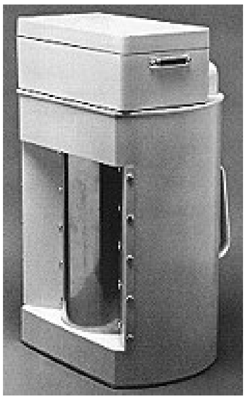
1. H.O. Menlove, et. Al., Plutonium Scrap Multiplicity Counter Operation Manual, Los Alamos National Laboratory Report LA-12479-M, January 1993.
2. D. Davidson and R. McElroy, Comparison of Neutron Coincidence and Multiplicity Counting Techniques for Safeguards, Proceedings of the 16th Annual Meeting of INMM Japan Chapter, December 7-8, 1995, Tokyo, page 163.
3. http://www.canberra.com

Accounting (NDA): Neutron Counter

157

Shielded Neutron Assay Probe

MODEL: JSP-12



SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Holdup
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

This device is a modification of JCC-71, designed specifically for detecting holdup of Pu or UF6.

DESCRIPTION

This device can be operated in a total neutron or coincident neutron mode. The probe has directional shielding. It is operated with Canberra's JHH-50 hand-held monitor.

COMPONENTS

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) Canberra Catalog, Edition 10.
2) http://www.canberra.com

Accounting (NDA): Neutron Counter

158

Inventory sample passive neutron coincidence counters

MODEL: JCC-13/14 (INVS)

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Liquids, powders and pellets
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

Counters of JCC-13 and JCC-14 models are intended for measuring plutonium amounts in the range of 0.1 to 500 g.

DESCRIPTION

The JCC-14 is designed to assay plutonium inventory samples inside a glovebox. It is an upgraded version of the JCC-12, and fits around the drywell of the glovebox. Samples are loaded into an aluminum carrier inside the glovebox and then lowered into the JCC-14 for counting. The JCC-13 which is a modification of the Los Alamos National Laboratory design, differs only in the sample diameter and the method of sample loading. The JCC-13 is slightly larger in diameter than the JCC-14, and uses top loading to minimize torn sample bags. The JCC-13 is a transportable counter, designed for verification inspections at multiple sites.

The JCC-13 and JCC-14 provide a flatter axial response and higher efficiency than the JCC-12.

COMPONENTS

- sample cavity with variable size
- ring of 18 He-3 detectors (arranged in two concentric rings, divided into three groups of six) embedded in the polyethylene.
- three JAB-01 Amplifier/ Discriminator circuit boards

A JSR-12 Neutron Coincidence Analyzer, a computer and analysis software are required for coincidence counting but are not included with the JCC-13 or JCC-14.

SPECIFICATIONS

HV Setting	1760 V
Gate Setting	64 µs
Die-Away Time	45 µs
Detector Efficiency	42% with smallest sample configuration
Sensitivity Range	0.1 to 500 g Pu
Size, JCC-13/14	58.4 x 33.3 cm (23 x 13.1 in.) H x Dia
Weight, JCC-13/14	34 kg (75 lb)
Sample Cavity Size:	
JCC-13	15.75 x 6.1 cm (6.2 x2.4 in.) H x Dia
JCC-14	15.75 x 5.2 cm (6.2 x 2.1 in.) H x Dia
He-3 Active Length	39.4 x 2.54 cm (15.5 x 1 in.) L x Dia

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) http://www.canberra.com
2) Menlove, H.O., Holbrooks, O.R. and Ramalho, A. (1982). Inventory Sample Coincidence Counter Manual. Report LA-9544-M. Los Alamos, New Mexico: Los Alamos National Laboratory.
3) Miller, M.C., Menlove, H.O. and Russo, P.A. (1991). A High Efficiency Neutron Coincidence Counter for Small Samples. Proceedings of the Fourth International Conference on Facilities Operations – Safeguards Interface, p. 420. Albuquerque, New Mexico.

Accounting (NDA): Neutron Counter

159

Very High Efficiency Neutron Counter (VHEnC)

MODEL: Model 2203

SUPPLIER:	**ANTECH, ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Neutron Counter
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH, ORTEC
MANUFACTURER:	ANTECH, ORTEC

PURPOSE

VHEnC counter is used for the determination of the plutonium mass in intermediate and low level waste in 200 litre drums.

DESCRIPTION

The operation of the instrument is based on passive neutron counting of the correlated neutrons arising from spontaneous fission of the even Pu nuclides, principally Pu-240.

The VHEnC can be operated in different measurement modes: conventional shift register coincidence counting (reals) mode (with a calibration function) to reach lower level detection thresholds, the absolute multiplicity counting mode (histogram function) to perform matrix correction where sufficient Pu mass is present in the chamber or totals counting mode for very low level measurements. Plant measured isotopic ratios can be used by the software to convert Pu-240 effective mass to total Pu mass.

The system can also be operated as an absolute neutron multiplicity system, independent of calibration for intermediate level waste.

The VHEnC is available with ‘Add-a-Source’ Cf-252 based matrix correction capability, as an option. This is a well established technique for matrix correction and is appropriate where low count rates and small quantities of material are present in the measurement chamber. 'Add-a-Source' complements matrix correction by neutron multiplicity counting. The system consists of typically an 80 mCi Cf-252 source deployed on a ‘Teleflex’ cable with associated shielding, motor drive and control.

COMPONENTS

- neutron detection system:
  - 160 He-3 detector tubes, 25.4 mm x 1.0 m at 6 Atmospheres (16 polyethylene modules each containing ten tubes)
- junction box:
  - high voltage distribution circuitry
  - charge collection circuitry
  - AMPTEK model A-111 charge sensitive amplifiers
- outer shielding of 270 mm thickness of polyethylene
- removable internal cadmium thermal neutron filters
- 80 mCi Cf-252 source (optional)
- AMSR-150 shift register

SPECIFICATIONS

Detection efficiency	typically 36% with Cd filters deployed and between 41% and 45% with the internal Cd liner removed
Operating Voltage	~ 1650 volts
Die-away time	<40 ms
Minimum detection limit	between 1.3-15 mg Pu-240 effective in coincidence (reals) mode equivalent to between ~20 and 250 mg total Pu (military grade)
Dimensions	(L x W x H) 3.3 m x 1.8 m x 2.1 m
Weight	3500 kg approx

SOFTWARE

LANL INCC code

ADDITIONAL INFORMATION

REFERENCES

1) www.ortec-online.com,
2) www.antech-inc.com

Accounting (NDA): Neutron Counter

160

Active Well Coincidence Counter (AWCC)

MODEL: Model 2442

SUPPLIER: **ANTECH, ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Neutron Counter
METHOD: Neutron coincidence counting

MEASURED PROPERTIES: Effective isotope mass
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Transportable
ENVIRONMENT OF USE: Industrial
DEVELOPER: LANL, ANTECH
MANUFACTURER: ANTECH, ORTEC

PURPOSE

The Active Well Coincidence Counter (AWCC) is a transportable high-efficiency counter for the measurement of both uranium and plutonium.

DESCRIPTION

For uranium measurement the AWCC is used in Active Mode. Two americium-lithium neutron sources are inserted – one in the base and one in the plug unit – and the AWCC is operated in random driver mode. Uncorrelated neutrons produced by the Am-Li sources induce fission in U-235 samples in the measurement chamber. The coincidence counter electronics of the ANTECH Advanced Multiplicity Shift Register can be used to determine to coincidence count rate, which is attributable to the induced fission in U-235. Using this method the mass of uranium is readily determined.
Two Action Modes are available depending on the size of the U-235 sample.
The AWCC in Thermal Active Mode is most appropriate for measuring low-enriched uranium materials. In this mode the sleeve and end plug cadmium coverings are removed.
Fast Active Mode is employed for the measurement of highly enriched material such as uranium metal, uranium thorium fuel and LWR fuel pellets. In this mode the cadmium plates and sleeve are inserted.
In Passive Mode the Am-Li neutron sources are removed and the AWCC can function either as a neutron coincidence counter or a neutron multiplicity counter, again using the appropriate features of the ANTECH AMSR. The detector measurement chamber can be enlarged by removing the two internal polyethylene disks and the nickel reflector. It can also be operated in the horizontal position with the end plugs removed and with a material test reactor (MTR) holder in position for the measurement of uranium in MTR measurements.

COMPONENTS

- 42 He-3 detectors at 4 atm pressure with 6 Amptek charge sensitive amplifiers
- two Am-Li sources: 4.8 x 10,000 n/sec (for U determination)
- adjustable measurement chamber
- multiplicity shift register ANTECH AMSR-150
- cadmium sleeve, end plugs
- Electrical connections:
  - high voltage - SHV,
  - 5 V supply for head amplifiers - BNC,
  - Signal output - BNC,
  - Mixer RS-232 output— 9 w male 'D'

SPECIFICATIONS

Detection limit:	
Thermal active mode	approximately 1 g of U-235
Fast active mode	approximately 23 g of U-235
Detection efficiency	26% to 31%
Measurement chamber size	20.6 cm high x 22.9 cm diam. (8.1" x 9"), adjustable
High Voltage	1,680 volts
Weight	130 kg approx
Overall envelope including handle and frame	71.1 cm long x 63.5 cm wide x 104 cm high

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com
www.antech-inc.com

Accounting (NDA): Densitometer

161

Multi-channel gamma absorption meter

MODEL: ГАМ

SUPPLIER:	**MAYAK, PA**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Densitometer
METHOD:	Densitometry Active
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	MAYAK, PA
MANUFACTURER:	MAYAK, PA

PURPOSE

Remote monitoring mass concentration uranium and other heavy elements in technological solutions.

DESCRIPTION

Principle of operation is based on selective photoelectric absorption of gamma-quanta from specific source come through a monitoring solution.

COMPONENTS

- Measuring transducer ГАМ-ПМ (1 unit)
- Control unit ГАМ-УД (1 unit)
- Sensor ГАС-2Д (to 8 units)

SPECIFICATIONS

```
Range of measured uranium mass concentration, kg/m³              from 0 to 150
Limits of main permissible error of the absorption meter, kg/m³:
           if information is output at numeric display           +0,5(1+Cu/100)
           using current output                                  +0,5(1+Cu/100).(1+D/250)
           where Cu – magnitude of uranium mass concentration, kg/m²
                  D – range of measured magnitude, kg/m²
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

Средства измерения и контроля. Каталог 2005, ПО «Маяк»/Measurement and control instrumentation. Catalog 2005, PA “Mayak”

Accounting (NDA): Densitometer

162

Hybrid K-edge densitometer

MODEL: HKED

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Densitometer
METHOD:	Gamma Active
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu, other actinides
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL
MANUFACTURER:	ORTEC

PURPOSE

HKED instrument is designed for analysis of input solutions in fuel reprocessing plants, analysis of output product in fuel reprocessing plants, measurement of actinide-bearing samples in the analytical laboratory setting.

DESCRIPTION

HKED is available as laboratory instrument or as input solution instrument and allows for custom configurations to match to existing hot cell with suitable fail safe sampling handling methods. For calibration purposes there can be chosen any standards including the suites of standards having different enrichment factors.

COMPONENTS

SPECIFICATIONS

Measurement range	from 100mg to 100's of g of the 6 major Actinides (U, Pu, etc), with ratios of major to minor to 100's

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

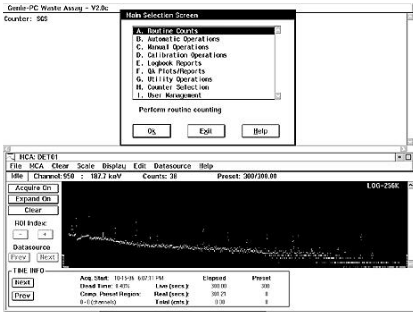
Accounting (NDA): Software

163

Gamma Waste Assay Software

MODEL: GWAS

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma



MEASURED PROPERTIES:
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Waste
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The Gamma Waste Assay Software (GWAS) is used with all Canberra gamma waste assay systems and the menus share a common look and feel with other Canberra Systems products.

DESCRIPTION

The GWAS software can utilize all of the features of the Genie-PC software including:
• The Editors: nuclide library editor, analysis sequence editor, certificate file editor and MCA hardware setup editor.
• All Genie-PC Analysis Algorithms: peak search and peak locate algorithms, library driven search and analysis algorithms, area correction algorithms, calibration algorithms, nuclide identification algorithms, MDA algorithms, etc.
• All Genie-PC QA trending and plotting capabilities.
• All Genie-PC MCA View Control window features.
• All Canberra Instrument Control Bus (ICB) NIM setup, adjustment, and status commands.
• Full storage of all data, setup parameters, calibration parameters, and analysis results in a file structure which facilitates review of data or reanalysis of questionable results.
All Genie-PC analysis engines can be used in this package. It utilizes a commercial relational database (DB2) to track sample information, datafile locations, and key analysis results. The GWAS database structure is identical to Canberra's Neutron Assay Software (NAS) database structure so that neutron and gamma results can be combined to maintain an integrated set of database results. It comes with an extensive QA package for ensuring good measurement control and includes trending with warning setpoints for investigation and action, control charting, etc. The software includes customer editable report template files to permit customization. The Genie-PC MCA view window is available at all times and it has multiple matrix corrections algorithms.
Optional non-uniformity correction routines are available.

COMPONENTS

GWAS is normally sold in a package with all other required Canberra software. The complete package includes the following:
S400C Genie-PC Basic Spectroscopy Software.
S401C Genie-PC Gamma Analysis Option.
S405C Genie-PC Quality Assurance Software.
S431C Genie-PC Gamma Waste Assay Software.
S480C DB2 Relational Database.
Software also required when used in certain applications.
S432C Genie-PC Transmission Correction Software.
S438C Genie-PC Gamma Waste Automation Software.

SPECIFICATIONS

Minimum recommended computer requirements:

Processor	486 Processor with 66 MHz clock speed
Memory	24 MB
Operating system	OS/2
Hard disk capacity	500 MB

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Software

164

Gamma-Ray Spectrum Analysis Code for Determining Plutonium Isotopic Abundances MGA

MODEL: S508, S349

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LLNL
MANUFACTURER:	Canberra

PURPOSE

MGA (Multi-Group Analysis) code is used with systems based on germanium detectors to accurately determine the relative abundances of various actinide isotopes in any size and type of plutonium sample (metal, oxide, solution).

DESCRIPTION

The Multi-Group Analysis (MGA) software determines relative plutonium isotopic abundances in nondestructive assay applications and determines the relative amounts of other non-plutonium actinides. It incorporates a sophisticated peak fitting and multiplet deconvolution algorithm to improve the accuracy in samples with complex isotope mixtures. It requires no efficiency calibration for matrix density, thickness or container characteristics. It operates in either one or two detector modes. In addition to the primary application of measuring Pu isotopics, MGA can be used to determine other actinides such as U-235, U-238, Np-237 and Am-241.In the single detector mode, MGA uses information from several regions of the energy spectrum that lie within an energy range of approximately 0-300 keV or in the high energy only mode from 0-1000 keV. In the two detector mode, MGA uses information from the low energy spectrum which has a range of about 0-1000 keV. The primary analysis in the low energy only and two detector modes is performed using the multiplet region at 94-104 keV. This region is a very complex multiplet, consisting of gamma ray peaks from plutonium and its progeny as well as numerous x- rays. But it is in this region where the most intense gamma ray emissions occur, thus providing the best possible detection sensitivity. MGA also uses the characteristic plutonium lines at 129 keV and 208 keV which must also be present. To be able to unfold this complex multiplet region, MGA automatically adjusts the energy and peak shape calibration for each spectrum using peaks that are characteristic of all plutonium samples; 59keV, 129keV, and 208keV. To take into account the physical processes that affect the observable gamma ray intensities at different energies, such as the detector efficiency as a function of energy, and gamma ray attenuation in absorbing materials between the sample and the detector as well as within the plutonium sample itself, MGA internally develops an intrinsic efficiency curve by evaluating 10 peaks from three isotopes. Most common applications can be accommodated with a single detector. The Canberra LEGe is the detector of choice in such cases due to its exceptional low energy peak shape and resolution characteristics over a wide range of count rates. Such a high performance detector is recommended for optimum performance with MGA. In some applications, particularly those involving thick or dense container walls, the high energy spectrum collected with a typical coaxial detector is recommended to supplement the low energy MGA spectrum In some cases the high energy only mode is recommended. In this case, in addition to the normal low energy spectrum peak regions, three high energy regions are examined and evaluated. While this results in a more complex system implementation, Canberra systems designed around this technique can still be operated by routine operating personnel.

COMPONENTS

SPECIFICATIONS

Measurement time	several minutes
Accuracy	<1%

SOFTWARE

Canberra MGA is available in DOS, Windows 3.1 (S349 Model), Windows NT/2000/XP (S508 Model). The software can be ... Assay Software (NAS).

ADDITIONAL INFORMATION

Canberra MGA was developed by LLNL and Canberra.

REFERENCES

1) http://www.canberra.com
2) R. Gunnink, MGA: Gamma-Ray Spectrum Analysis Code for Determining Plutonium Isotopic Abundances, Vol. 1 and 2, UCRL-LR-103220, LLNL, April 3, 1990.

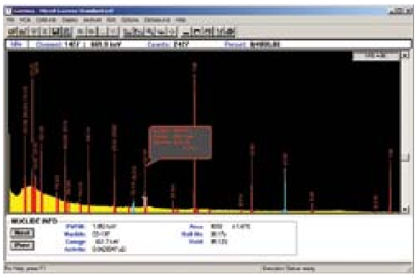
Accounting (NDA): Software

165

Genie-2000 Basic Spectroscopy Software

MODEL: S500, S502, S504

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma, alpha
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	Canberra
MANUFACTURER:	Canberra



PURPOSE

Genie-PC is a comprehensive software package for data acquisition and spectrum analysis using personal computers. It provides independent support for multiple detectors and extensive networking capabilities. Acquisition and analysis capabilities are fully integrated into the two graphical user interface environments - an interactive mode for knowledgeable spectroscopist and a batch mode for routine, repetitive counting operations.

DESCRIPTION

The basic spectroscopy software performs the following functions in spectrometric systems:
- control the multichannel analyzers and display the spectra. Canberra PC based multi-channel analyzers are supported.
- record and write spectrometric information on the disk. Special CAM format provides storage of all parameters and results on single file providing the data integrity.
- spectra operations in manual and automatic modes: calibration, search and preliminary identification of peaks, calculation of peak parameters.
- create a reports. Reports are based on the templates that user can modify according to his own requirements.

The Genie 2000 Basic Spectroscopy Software includes a set of base spectroscopic analysis algorithms such as Unidentified 2nd difference peak locate, VMS standard peak search, User specified ROI peak locate, Library (Gamma-M) peak locate, Library (simple) peak locate, Peak area calculations, Sum/non-linear least squares fit. Additional analysis algorithms are available as part of the S501 Genie 2000 Gamma Analysis Option and S509 Alpha Analysis Option packages. These algorithms include efficiency correction, peak net area background subtraction, nuclide identification, automatic interference correction and weighted mean activity and MDA calculation.

The Genie 200 Basic Spectroscopy Software is delivered in the following versions: multi-input systems software (S500 model) – supports unlimited number of inputs; single input systems software (S502 model) – supports one MCA input, and InSpector MCA software (S504 model) – supports only InSpector-2000, InSpector and NaI InSpector analyzers.

Genie 2000 can be used with following optional software:
S501 Gamma Analysis Option.
S509 Alpha Analysis Option.
S505 Quality Assurance Software.
S506 Interactive Peak Fit Software.
S573 In Situ Object Calibration Software (ISOCS).
S574 LabSOCS Laboratory Calibration Software.
S544 NuChart Nuclide Table Software.
S534 Abacos-2000 Whole Body Counting Software.
S537 Abacos-2000 Lung Counting Software.
S572 IMCA Uranium Enrichment Software.
S535 Uranium-Plutonium InSpector Software.
S529C NDA 2000 Integrated Neutron/Gamma Waste Assay Software.
Apex Lab Productivity Suite.
Apex-Alpha Alpha Spectroscopy Software.

COMPONENTS

SPECIFICATIONS

```
The minimum computer requirements are: Pentium 4 with 2 GHZ clock speed, 128 MB of RAM, 400
GB of hard disk capacity, 1.44MB floppy, CD ROM, integrated 10/100 Ethernet interface,
Windows 2000 or XP Profession
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Software

166

MGA-U Multi-Group Uranium Analysis Software

MODEL: S507

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Multi-Group Analysis for Uranium (MGA-U) software is integrated into Canberra waste and safeguards instruments to perform a sophisticated analysis with minimal operator interaction.

DESCRIPTION

The Multi-Group Analysis for Uranium (MGA-U) determines uranium enrichment in non-destructive assay applications and uses sophisticated peak fitting and multiplet deconvolution to provide analysis results. In the normal mode, it requires no efficiency calibration for matrix density, matrix type, or container characteristics. In the enrichment meter mode, it does require one calibration measurement with known container characteristics.

In the normal mode, MGA-U uses information from either two or three regions of the energy spectrum, depending on the specific application. For most applications, two regions that lie within an energy range of approximately 0-300 keV are used. The primary enrichment information is derived from the U-235 and U-238 gamma peaks in the 88 - 100 keV energy range. Additionally, the K-beta region is used to develop a local intrinsic efficiency curve - to establish the detector efficiency as a function of energy, the amount of attenuation caused by the sample container and the amount of self-absorption in the uranium material itself. The process eliminates the need for an efficiency calibration prior to making sample measurements.

In the enrichment meter mode, MGA-U requires one calibration measurement with a standard of known enrichment and known container wall thickness. The results of this calibration measurement are automatically stored for further use on any samples with known container wall thicknesses. The enrichment meter mode is useful for very thick container walls where the normal mode may not have enough data to provide good results or for freshly processed samples.

The Canberra LEGe is the detector of choice for MGA-U work due to its exceptional low energy peak shape and resolution characteristics over a wide range of count rates. Such a high performance detector is recommended as MGA-U is dealing with regions of the spectrum where very complex gamma/x-ray multiplets are encountered.

COMPONENTS

SPECIFICATIONS

```
Assay time              up to one hour to get reasonable statistics
Accuracy                from 1 to 2%
```

SOFTWARE

ADDITIONAL INFORMATION

Software model S507C operates under Windows NT, Windows 2000, Windows XP operating systems.

Spectra collected with HpGe detectors, which are optimized for high resolution at low energies, are recommended.

REFERENCES

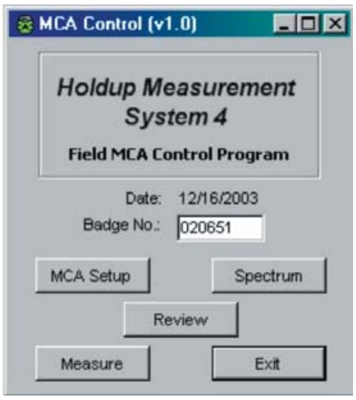
http://www.canberra.com

Accounting (NDA): Software

167

Holdup Measurement System

MODEL: HMS4



SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	Holdup
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Used for hold-up measurements.

DESCRIPTION

The HMS4 software includes two sets of programs; the main program that runs on a host personal computer (PC), and others running on a bar-code reader or portable PC.

The bar-code reader or portable PC is referred to as the Controller. The Host computer program performs setup and calibration of multichannel analyzer/detector pairs, loads the controller with operational parameters, receives measurement data from the controller, maintains measurements and derived results in databases, and prints reports.

The field Controller programs control multichannel analyzer (MCA) setup functions, data acquisition, store measurement data as accumulated, and allow the user to review previous collected data and spectra.

It contains several new holdup correction algorithms such as the Finite Source correction and the Self-Attenuation correction. These algorithms have been integrated into the software for the capability of full error correction. HMS4 now supports twenty (20) spectral regions-of-interest (ROI) to aid the user measuring plutonium. The data from each Measurement Period (or campaign) is easily accessed from the main menu. All measurement data dumps are date and time stamped and allow for an 80-character comment field, which can be used for extra notes.

HMS4 is written in Microsoft Visual Basic .NET® as part of the Microsoft Visual Studio .NET® 2003 development package. It uses Microsoft Access® (Microsoft Office 2000/XP format) database files. The reports are generated with the Crystal Decisions, Inc., Crystal Reports report generator, which is included with the Visual Basic .NET package. The software for the Controller (Pocket PC devices) is written in Microsoft embedded Visual Basic® as part of the Microsoft embedded Visual Tools v3.0® development package for Windows CE.

COMPONENTS

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

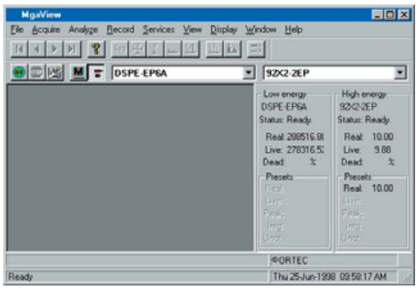
Accounting (NDA): Software

168

Safeguards Software MGA++

MODEL: MGA-B32 V1.06

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu, U
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LLNL
MANUFACTURER:	ORTEC



PURPOSE

The MGA++ software suite analyzes actinide gamma-ray spectra to determine isotopic ratios of plutonium, uranium, and other actinides in arbitrary samples. Samples may vary in size (milligram to kilogram quantities), isotopic and chemical composition, and age since chemical purification and removal of Am-241.

DESCRIPTION

MGA++ will operate correctly on any system supporting ORTEC multichannel buffer hardware under Windows 2000/XP. While MGA++ can control compatible MCA hardware directly, MAESTRO-32 is a prerequisite for instrument setup.
MGA Analysis Mode:
- Produces weight percent results for 238,239,240,241Pu, 241,243Am, 237,239Np, and 235,238U
- Determines 242Pu
- Operates with a single-planar HPGe detector for 0–300 keV or with a planar and a coaxial HPGe detector for 0–1000 keV
- No calibration standards needed to correct for matrix or container effects
- Automatic energy and peak shape recalibration

There are about ten energy regions in a plutonium gamma-ray spectrum which may be used to calculate isotopic abundances. Those in the 94–104 keV region and the peaks at 129 and 148 keV are the most intense. Although those regions are difficult to analyze, yield precision of 1% or better can be achieved.
MGA handles both freshly-separated and aged samples. MGA can accurately determine the relative abundance of 235U in a sample.
MGAHI Mode:
MGAHI uses physical parameters to take into account both attenuation and emission of gamma rays, and does not require a detector efficiency calibration. MGAHI is useful when sources are heavily shielded, and in a high background, space-limited environment.
U235 Analysis Mode:
U235 uses a single planar HPGe detector and operates in the energy range 0–300 keV. It determines the relative isotopic ratios for Uranium. In a similar fashion to MGA and MGAHI, no primary calibration is required for efficiency or for absorbers in the matrix or in the sample container. It determines:
- Relative ratios for 235U, 234U, and 238U
- Automatically checks for the presence of Pu using the 129 keV peak
- Operates with a single-planar HPGe detector from 0–300 keV
- No calibration standards necessary to correct for matrix or container effects
- Corrects for internal sample absorption and absorbers placed between sample and detector
- Peak shape calibration determined from user-defined spectral peaks, reloadable from file, or from default values

COMPONENTS

MGA-B32 consists of:
1) an upgraded version of the original MGA code, which relies on the 100-keV region;
2) U235, a uranium isotopic analysis code that uses gamma rays less than 300 keV; and
3) MGAHI, a plutonium isotopic analysis code that uses the 200 keV–1 MeV energy region. The codes analyze gamma-ray data collected with a HPGe detector. All of the executable software is 32-bit Windows compliant.

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

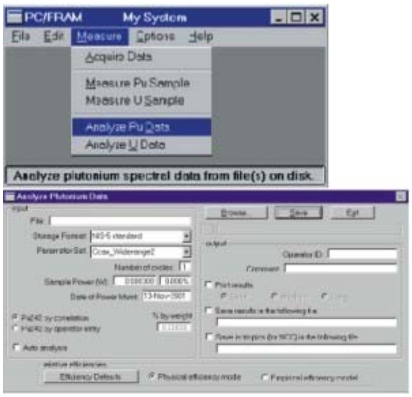
www.ortec-online.com

Accounting (NDA): Software

169

Plutonium and Uranium Isotopic Analysis Software

MODEL: PC/FRAM-B32 V4.3



of PC/FRAM V4.3; Bottom-Plutonium analysis c

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu, U, Am, MOX
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	ORTEC

PURPOSE

Software analyzes Pu, and a wide variety of heterogeneous samples containing Pu, Am, U, and other nuclides including 242Pu.

DESCRIPTION

PC/FRAM-B32 analyzes the gamma-ray spectrum taken with a single germanium detector, of plutonium-bearing, uranium-bearing, or mixed items and quantifies the distribution of plutonium or uranium isotopes. 241Americium and other transuranic isotopes (including uranium in mixed uranium-plutonium oxides) that contribute measurable gamma rays to the spectrum can also be quantified relative to plutonium. In Version 4.3, use of CdTe (Cadmium Telluride) detectors is also supported.
PC/FRAM-B32 analyzes spectra from items containing only uranium, and quantifies the uranium isotopic distribution. These measurements are performed on samples of arbitrary size, geometry, and physical and chemical composition.
PC/FRAM-B32 has the capability of supporting two different languages. Currently English and Russian are the two languages

COMPONENTS

SPECIFICATIONS

As a CONNECTIONS-32 family member, PC/FRAM-B32 will operate correctly on any system supporting CONNECTIONS-32 compatible hardware. This means ALL ORTEC multichannel buffers, including the latest DSPEC® Plus, DSPEC jr and digiDART digital hardware and DART® Portable MCA, Los Alamos M3CA, Rossendorf MiniMCA 166, and various Canberra, Nuclear Data, and Silena hardware systems via the EtherNIM™ MatchMaker™ module. The software will operate on any system already supporting Windows 95/98/NT/2000. PC recommendations are a minimum of a 200 MHz Pentium processor with 32 MB RAM. A math coprocessor is required.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

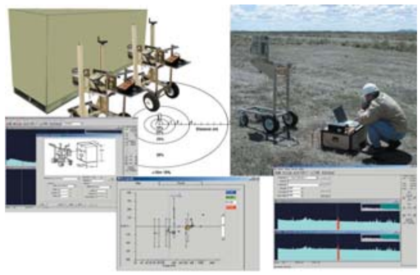
170

Advanced Software for Gamma-Ray Waste Assay

MODEL: ISOTOPIC-32

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC



PURPOSE

ISOTOPIC-32 is used for quantitative assay of gamma-emitting waste samples both fissile and non-fissile of many shapes and sizes.

DESCRIPTION

The acquisition control and quantitative analysis functions are integrated into a concise package for use in PC-based in-situ gamma spectroscopy systems for the determination of radioactive content of containers, objects, surfaces and soils. Semi-empirical methods allow calibration with a single point source. Support for multiple detector systems or sequentially gathered spectra with choice of averaging methods is provided. Operates in both supervisor and operator modes with supervisor-controlled operator access to specified functions.
In supervisor mode, all features and functions of ISOTOPIC are available. The supervisor may calibrate the system, create libraries, define sample geometries, matrices, collimators to be used and other functions for later use by the operator. He can also define which features the operator may access.
Operator need only start the acquisition, select the configuration (nearest standard container configuration), and enter the "book keeping data" such as container ID, type, weight and the critical measurement data, such as detector-to-container distance.
The standard container configurations and collimator configurations are defined and specified by the supervisor. A container configuration includes the default dimensions, materials, and matrix detail. Any number of these configurations may be specified and recalled by the operator when needed. When the analysis is complete, the operator can adjust the container/matrix physical parameters (such as matrix density or container wall thickness) to optimize the results, by the use of the isotope plot that shows the percentage difference between the corrected measured activity and the activity calculated for the reference peak for each nuclide. The supervisor selects the reference peak. The operator may optimize the analysis, adjusting the container, matrix, and weight fraction uranium, to refine the results. In the case of uranium analysis, if the U-235 enrichment is known, it may be entered and then the U-238 and U-234 values are computed more accurately for samples containing weak uranium activity.
ISOTOPIC is recommended for use with the ORTEC digiDART Portable MCA system. However, all ORTEC MCBs (past and present) and all other devices supported by ORTEC CONNECTIONS-32 are compatible. Support is built-in for advanced operations (where provided in hardware): amplifier gain/shaping control, Auto-PZ, "optimize" and InSight™ mode, digiDART and DART® field mode, graphical setting of MCB spectrum stabilizer and statistical uncertainty peaks.
ISOTOPIC includes a comprehensive library editor for building custom analysis libraries. It also includes full integration of the Nuclide Navigator library tool (sold separately as model C53-B32). ISOTOPIC will use Nuclide Navigator if installed, and can read Nuclide Navigator libraries in Microsoft Access Database format (no conversion necessary), and save libraries in database format for use by Nuclide Navigator.

COMPONENTS

SPECIFICATIONS

As a CONNECTIONS-32 product, ISOTOPIC requires a Windows 2000/XP platform. Interfacing of MCB hardware to the system may be by USB, Ethernet, printer port, serial port, or ORTEC Dual-port Memory. ISOTOPIC will run on any PC that supports the above Windows OS and has 20 MB of disk space.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

171

Software for the Quantitative Analysis of Gamma-Ray Spectra from NaI(Tl) Detectors ScintiVision-32

MODEL: A35-B32

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

ScintiVision is a fully functional MCA Emulator and quantitative analysis software package, written specifically for analysis of gamma spectra from NaI detectors, and supports the EG&G ORTEC MCA hardware. Non-ORTEC ADCs from Canberra, Nuclear Data, and Silena are supported via the MatchMaker EtherNIM acquisition interface. Integrated support is included for non-ORTEC MCAs such as the LANL M³CA.
It performs quantitative and qualitative analysis in real time with user-selective settings.

DESCRIPTION

ScintiVision has been designed specifically for the unique characteristics of NaI detector spectra which are quite different than those from germanium detectors. Sodium iodide's broader peaks lead to more interferences and poorer signal-to-noise ratios.
Software performs: isotope identification, peak search, correction for peaked background, decay correction both to sampling date and for decay during acquisition of short half-life nuclides, automatic deconvolution of multiplet peaks, nuclide activity averaging, limit of detection calculation.
ScintiVision's Gaussian cross correlation peak search is adapted to the resolution and peak shape of the particular NaI detector being used. Multiplets located by the peak search process are deconvoluted by a method which allows the number of peaks, the peak positions, and their width and area to vary until the minimum value of Chi-squared is obtained. The user may vary the fitting parameters from the defaults. (These settings are then password protected.)
Nuclide identity candidates are tested statistically. Before a nuclide is reported as present, it must, in addition, pass a "Fraction Limit" test which checks to see that a sufficient number of peaks of the nuclide have been individually identified; this ensures that positive identification is statistically reasonable. These tests all but entirely eliminate "false alarm" misreporting of nuclides not
present in a sample.
Reported nuclide activities are calculated for each peak and then used to calculate a weighted average activity in the final output report.
Peaks found but not identified by the library can be reported.

COMPONENTS

SPECIFICATIONS

As a CONNECTIONS-32 product, ScintiVision requires a Windows 2000/XP platform. Interfacing of MCB hardware to the system may be by Ethernet, Printer Port, or ORTEC Dual-port memory.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

172

Nuclides Database Software Nuclide Navigator III

MODEL: C53-B32

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

An interactive Windows software for use with gamma spectroscopy analysis software (GammaVision-32) or as a stand-alone package to view, query, and extract gamma- and alpha and beta-decay information and identify isotopes.

DESCRIPTION

The PC-based chart can be scrolled in any direction or a specific nuclide can be accessed directly by entering its chemical symbol.
Software allows to choose the type of decay (Alpha, Beta, or Gamma), view parent or daughter isotopes information, select the order (by energy or branching ratio), review the nuclear and physical properties of the isotopes, create and edit the libraries, define search criteria for specific energy peaks, view a decay scheme in PDF format.
Input and output data can be in Microsoft Access database (MDB) format or the ORTEC format for GammaVision (LIB) libraries. Nuclear Navigator is totally compatible with any gamma analysis software.

COMPONENTS

This nuclide library database includes:
- TORI database;
- NUDAT library updated from Brookhaven National Laboratory’s latest archive;
- Erdtmann and Soyka database;
- some handy pre-selected libraries for environmental and nuclear power plant counting;
- calibration libraries for the standard mixed gamma and mixed europium sources.

Each library contains the appropriate alpha, beta, and/or gamma decay.

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

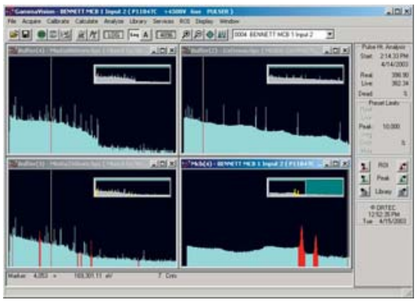
Accounting (NDA): Software

173

Gamma-Ray Spectroscopy Software

MODEL: GammaVision-32 V6

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry



MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC

PURPOSE

GammaVision is an integrated product providing acquisition control, spectral display and quantitative analysis of data acquired on ORTEC MCA hardware from a HPGe detector. It provides compatibility with the DSPec line of products (DSPec, DSPec Plus and DSPec jr), as well as the digiDART. In addition, GammaVision-32 supports the LANL M³CA, Rossendorf MiniMCA-166 and ORTEC TRUMP-PCI interface card. It is a full 32-bit Windows application, operating under Windows 2000/XP.

DESCRIPTION

The GammaVision Quantitative Analysis has an automatic total analysis mode, which allows launching an analysis and then proceeding to your next task; interactive analysis modes allow reanalyzing part or all of the spectrum, with visual inspection of deconvolution results; a suspected nuclides feature marks the most likely candidate for peaks found in the spectrum, but not in the library; simultaneous library and peak search directed analysis for the lowest possible detection limits; deconvolution of up to 22 components within a single multiplet is done with automatically chosen background-fitting technique, chosen from straight line, stepped, and parabolic functions. The program provides interactive graphically displayed calibration with single function efficiency curve fitting and peaked background correction. 15 MDA methodologies can be chosen for specific regulatory adherence. Acquisition options allow for automatic acquisition for a group or single detector.
Both library-directed and Mariscotti peak finders are used to locate and quantitize the spectrum peaks. The library-directed method gives the most accurate peak areas in low level spectra and in complicated spectra. The Mariscotti method locates all the other peaks in the spectrum - ensuring that no peaks are ignored in the analysis report.
All peaks ultimately used for the calculation of activity are validated by passing a user-set sensitivity criterion, passing a shape test to determine if interference is present, and passing a test to make sure that the centroid matches the library energy. Valid peaks have their activities rolled into a running, weighted average to produce reported activities of the best precision available. Invalid peaks are disqualified from activity calculation and are reported along with an explanation for their disqualification. Built in geometry correction and materials absorbtion data are included, along with QA according to ANSI N13.30 and a configurable Report Writer. The standard GammaVision-32 reports are in simple text format that can be read into LIMS information databases.

COMPONENTS

SPECIFICATIONS

Operating system	Windows 2000/XP
Interfacing	by Ethernet, printer port, serial port, or ORTEC Dual-port Memory

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

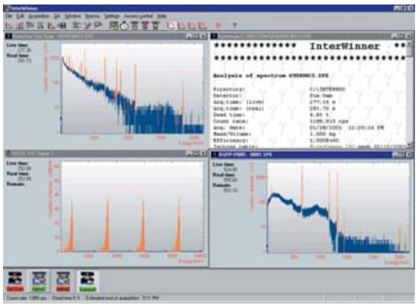
174

Gamma and Alpha Spectroscopy Software

MODEL: InterWinner 6

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma, alpha spectrometry

MEASURED PROPERTIES: Isotopic composition, element concentrarion
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC



PURPOSE

InterWinner provides MCA Emulation, Data Acquisition, and Analysis Software for Gamma and Alpha Spectroscopy. Data acquisition from many types of detectors, whether it is charged particle, germanium, or sodium iodide, can be followed by spectral analysis using the specific analysis modules: WinnerAlpha, WinnerGamma, or WinnerNaI.

DESCRIPTION

A configuration tool built into the software allows the user to collect data from the following manufacturer's hardware:
- ORTEC (DSPEC PLUS, DSPEC, 92X, 92X-II, 918A, 919, 919E, 920, 920E, 921, 920E, MatchMaker, DART, DigiDART, TRUMP, MicroACE, TRUMP-PCI, OCTÊTE-PC, OCTÊTE-PLUS, MiniMCA-166;
- Canberra/Tennelec/ND (Accuspec A, Accuspec B, Accuspec, NAI/PLUS, MICRO-MCA, PCAII-Card, PCAIII-Card, PCAP, 8075*, 8077*, 1510*, 8701*, 8706*, 8713*, 8715*, 570 Series*, 580 Series*);
- Silena (AlphaQuattro, 7329, Walklab, 7411*, 7423*);
- FAST/Comtec (MCD4LAP, MCD);
- AMPTEK (Pocket MCA);
- Target (FIELDSPEC, ISA, ISPEC, ISPEC+, NANOSPEC, TISA, TMCA);
- Eurisys/Aptec NRC (7800PC, Eagle, EMCA-2K, EMCAGammaFast, GammaNet, INCARNA, InterFast-1, InterFast-2, MCA5000, MICROspec, MINI20, Porteur, SAFEspec, Voyager)
[*Via ORTEC MatchMaker]
Analysis is performed using the specific modules:
1) WinnerGamma is tuned for use with HPGe spectral data. It contains complete peak fitting with deconvolution capability for multiplets, detector quality assurance, full library creation and editing features, efficiency curve generation, library-based peak search as well as the Mariscotti search, and decay correction including parent/daughter in-growth determination. WinnerGamma also includes logon and password protection capabilities to protect the results and ensure your analyses are what you expect them to be. A calibration standard certificate file editor is included.
2) WinnerAlpha contains the same functionality for alpha spectra to InterWinner as WinnerGamma adds for germanium spectra such as detector quality assurance, library creation and editing, efficiency calibration, and decay correction including parent/daughter in-growth determination. Deconvolution and analysis of charge particle spectra from Surface Barrier or ion-implanted detectors like ORTEC's ULTRA Series can be performed by adding WinnerAlpha to the software package. WinnerAlpha also includes password protection for the InterWinner basic package, a complete Quality Assurance program for each detector in use, and a calibration standard certificate file editor. A macro language and Visual Basic Scripting are also available.
3) WinnerNaI is used to quantify low-resolution spectral data such as that obtained from NaI(Tl), or CsI(Tl) detectors. WinnerNaI uses the single isotope calibration technique for this type of spectral data. As with WinnerGamma and WinnerAlpha, a certificate file editor and password protection are included.
InterWinner 6 supports multiple languages simultaneously including Russian (that requires either Windows 2000 or a Russian version of other Windows Operating Systems to display Cyrillic characters).

COMPONENTS

InterWinner 6 includes:
- ORTEC's MCB Kernel hardware controls;
- Spectrum Simulation Mode (for training);
- basic set of analysis tools:
    - ROI Net Area and simple adjustment factor capabilities,
    - basic library functionality,
    - and simple peak search;
- add-on analysis packages:
    - WinnerGamma
    - WinnerAlpha
    - WinnerNaI

- Macro language and Visual Basic Scripting support (for creating customized programs from the InterWinner software interface);

- optional add-on programs:
  - WinnerScan (analyzing and displaying the continuous data acquisition of several isotopes or ROI's in a spectrum),
  - WinnerComm (allows to exploit the full power of InterWinner through DDE, COM Automation, and TCP/IP interfaces)
  - WinnerAB (support for gross alpha/beta counting of certain gas proportional counting systems)

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

175

Neutron Coincidence Counting Software

MODEL: INCC-B32

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Software
METHOD:	Neutron coincidence counting
MEASURED PROPERTIES:	Effective isotope mass
NUCLEAR MATERIAL(S):	Pu, U
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	LANL
MANUFACTURER:	ORTEC

PURPOSE

INCC is suitable for nondestructive passive and active neutron applications for U and Pu.

DESCRIPTION

INCC-B32 provides the following analysis capabilities when used with appropriate neutron-counting hardware:
- Rates only measurements.
- Passive and active background measurements.
- Americium-lithium (AmLi) initial source measurements.
- Normalization measurement.
- Precision measurements test the short term system stability.
- Verification measurements (five types of passive and four types of active verifications):

The passive verifications determine Pu mass while the active verifications (except for active multiplicity) determine 235U mass. All verifications start with the measurement of count rates, followed by one or more verification calculations. Each verification type has its own analysis method; the rates from an item can be analyzed with several analysis methods simultaneously. The Pu isotopic composition is used by all of the passive methods to convert the effective 240Pu mass to Pu mass; it is also used with the 241Am content in the known alpha method to calculate the alpha value and in the known multiplication method to calculate the effective 239Pu mass. The Pu and Am content is decay corrected from the analysis date or dates to the verification date.

Passive neutron verification techniques include known alpha, known multiplication, add-a-source, multiplicity, curium ratio, and truncated multiplicity. Active techniques include multiplicity, collar, and active/passive. Active multiplicity presently determines the neutron multiplication of a uranium item, but does not determine the uranium mass.

Items may be verified using multiple methods simultaneously. For example, plutonium items may be verified via the passive calibration curve and the known alpha techniques simultaneously. (Collar verifications may not be combined with other verification techniques.)

- Holdup measurements that include the multiple measurements of a glove box at different positions, and calculation of the 240Pu effective mass in a glove box.

Calibration curves are calculated internally in the program using calibration standards and the data being fitted by the Deming least squares fitting process.

All measurement results are stored in both database and text files. Reports may be created, reviewed, and printed for any measurement data or results at any time.

COMPONENTS

SPECIFICATIONS

It runs under Microsoft Windows 2000/XP.

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

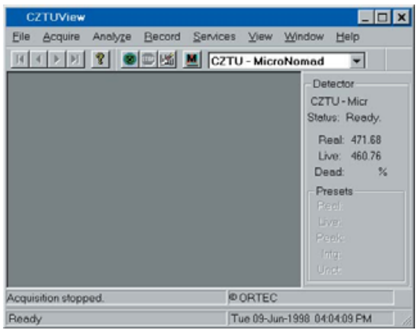
Accounting (NDA): Software

176

CZTU Safeguards Software

MODEL: CZTU-B32 V1.0

SUPPLIER: ORTEC
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry
MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: LLNL
MANUFACTURER: ORTEC



PURPOSE

Determines U-235 enrichment of uranium samples from Cadmium Zinc Telluride (CZT) detector spectra with multi-group analysis. Uranium can be measured either as metal, oxide, hexafluoride, or in solution. Sample shielding that significantly attenuates 100-keV photons will negatively impact the analysis.

DESCRIPTION

CZTU was developed to determine the enrichment of 235U in uranium samples. The program, requiring no special calibration sources, uses information obtainable from the sample spectra themselves to determine the isotopic ratios.
The net peak in a given region is calculated by determining and then subtracting a background function from the raw data. CZT gamma peak shapes are described very well by a Gaussian peak and a low-energy exponential tail. X-ray peak shapes are described very well by a so-called Voigt profile — a convolution of the detector response (a Gaussian and low energy exponential tail) with the intrinsic x-ray energy distribution (a Lorentzian). To fit the data, the energy and intensity of each gamma- or x-ray from the decay of a given isotope are needed. To this are added the fluorescent x-rays created by gammas/x-rays interacting in the source or collimator material. The goal in the calculation process is to find the set of peak shape parameters and intensities that most closely approximate the measured net signal. To find the "best" fit, the equations describing the various peaks are approximated by using firstorder Taylor's series expansions about the trial values of the free parameters. One of the outputs of the fitting process is the "best" amplitude of each isotope peak. These can be used to find the "best" measurement of the isotopic composition of the source.
CZTU assumes samples are in decay equilibrium. Fresh samples can be analyzed two weeks after their known separation date.

All the spectra collected by CZTU are stored in the ORTEC standard spectrum (SPC) format, which can be read by many programs. This format includes all of the CZTU analysis parameters, as well as the hardware description records — everything you need to verify the results. In addition, 10 other popular formats are supported, so that other spectra can be analyzed with this modern version of CZTU analysis. At the end of each analysis, the results are automatically stored in the Access format database, as well as printed or displayed for the operator.

COMPONENTS

SPECIFICATIONS

MCAs supported:
- All ORTEC multichannel buffer hardware (networked or standalone).
- portable MCA types such as the Los Alamos designed M3CA and the GBS/Rossendorf MiniMCA166
- Lab systems based on ORTEC MCBs such as the DSPEC family, 900-series NIM MCBs, and TRUMP™
- MCA plug-in cards
- non-ORTEC hardware systems using the MatchMaker™ Acquisition Interface Module.

Measurement region: 50 to 200 keV
Uncertainty of enrichment results:

Isotope	Range (wt %)	Absolute Accuracy (%)
U-238	5-30	15
	30-99	10
U-235	0.1-1.0	15
	1.0-70	10
	70-95	15
U-234	0.01-1.0	10-30

Operating system: Windows 2000/XP.

SOFTWARE

MAESTRO-32 and WINPLOTS are included with CZTU for any other spectrum viewing and plotting.

ADDITIONAL INFORMATION

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Software

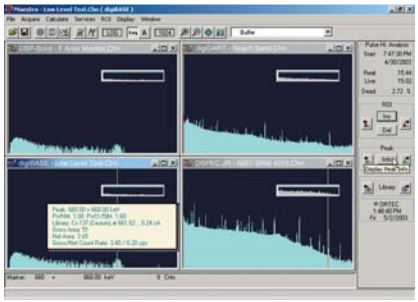
177

MCA Emulation Software

MODEL: MAESTRO-32 V6

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Software
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: ORTEC
MANUFACTURER: ORTEC



PURPOSE

MAESTRO-32 V6 is MCA Emulator for use with all ORTEC Multi-Channel Buffer (MCB) products.
MAESTRO-32 is the total 32-bit solution for data acquisition, spectrum display, analysis, reporting and MCB control in the personal computer environment. It provides independent support for multiple detectors, qualitative analysis functions, extensive networking abilities, interactive graphical user interface (GUI), etc.
MAESTRO-32 integrates acquisition control, "Smart" MCA and quantitative analysis functions for use in conjunction with PC-based gamma and alpha spectroscopy workstations.

DESCRIPTION

The new Mutiple Detector Interface in MAESTRO-32 V6 allows viewing up to 8 Detector and 8 Buffer windows simultaneously for a total of 16 interactive windows.
Acquisition options allow for automatic acquisition for a group or single detector.
Peak ROIs are marked quickly with the mouse or keyboard using familiar Windows mouse and keyboard commands. With built-in semiquantitative analysis, reports of peak area, centroid energy, peak count rate, and nuclide activity are easily produced.
MAESTRO-32 provides:

- Mariscotti fast peak search, with nuclide identification by library lookup
- Activity, net and gross areas (with uncertainty), centroid and shape for peaks
- Control of advanced hardware functions of all MCBs
- Data protection with "detector locking" by name, not by workstation
- Comprehensive JOB STREAMING
- Integrated Local Area Network (LAN) support

COMPONENTS

SPECIFICATIONS

Number of detectors supported	up to 250 detectors
Operating system	Windows 2000/XP platform
Interfacing	by Ethernet, printer port, serial port, or ORTEC Dual-Port Memory
MCAs supported	All ORTEC MCBs (past and present) and all other devices supported by ORTEC CONNECTIONS-32

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): XRF System

178

Portable X-ray Analyzers

MODEL: AMTK-20, AMTK-21

SUPPLIER:	**PNPI**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	XRF System
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu, impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	PNPI
MANUFACTURER:	PNPI

PURPOSE

These devises are created for implementation of different types of X-Ray fluorescent analysis at facilities directly in points of contact of detector unit of the device and researched surface, that is without preparing samples.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Range of working energy	from 6 to 140 keV
Energy resolution	from 0.4 to 1.5 keV
Limit of element detecting with Z > 50 with confidence probability of 99% with measurement during 15 seconds in dependence on content of filler, contents of interfering elements and so on, in weighing percentages	0.01-0.1%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.gatchina.biz/pnpi

Accounting (NDA): XRF System

179

Analyzer of material composition

MODEL: «РеСПЕКТ»

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	XRF System
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu, impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

X-ray spectrometer ReSPECT is developed for express determination of mass concentration of elements contained in analyzed sample.

DESCRIPTION

The range of measurement characteristics is changed from super-low to macro concentrations . 50 elements (from Na to U) can be determined simultaneously per one measurement (10 - 1000 seconds).
Samples of different sizes, forms (solid, powder, pulps, aerosols, filters and other) are analyzed nondestructively.
The range of determined concentrations is from 0.0001% to 100%.

COMPONENTS

SPECIFICATIONS

```
Chamber for samples:
   Diameter                                              440 mm
   High                                                  100 mm
   Diameter of cavity for samples                        32 m
   Removable carrousel                                   with 16 cavities
Source of X-ray radiation:
   Impulsion X-ray tubes of a squib type                 2
   Materials of anode                                    Ag, Ti, Cr, Mo, Re and other
   Power, dispersed by anode                             no more than 120 watt
   Regulation of voltage  bumpless                       from 0 to 50 keV
   Regulation of anode current                           from 0 to 2.4 mA
   The system of water cooling                           a loop
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): XRF System

180

X-ray fluorescence spectrometer

MODEL: XRF InSpector

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: XRF System
METHOD: XRF

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Field, laboratory
DEVELOPER: Canberra, Antwerp University
MANUFACTURER: Canberra

PURPOSE

Spectrometer is used for multi-elemental analysis.

DESCRIPTION

Analysis method is based on exciting the characteristic X-ray from elements constituting the sample analyzed, subsequent radiation data acquisition and spectra processing.
Sample analyzed can be of any form, for example, liquid, solid, powder, suspension, gaseous.

COMPONENTS

- Si(Li) or LEGe detector with cryostat of portable (MAC) or stationary (Model 7500) construction;
- modified multi-channel analyzer InSpector of Canberra 1200 model including the spectrometric amplifier, ADC, digital spectrum stabilizer, and required power supplies;
- portable or desktop computer (100 MHz Pentium, 16 MB RAM, Windows 95 or Windows NT);
- block of Fe-55, Cd-109 and Am-241 exciting sources housed in special unit of round-robin type.

SPECIFICATIONS

Detector size:	
Si(Li) type	80 mm^2
LEGe type	100 mm^2
Measurement range	1 ppm to 100%

SOFTWARE

WinAxil software package S5005 v.4.00 is used for analyzer control and spectra processing that allows for qualitative analysis s.

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): XRF System

181

Solution analysis system

MODEL: Hybrid K-Edge/XRF Analyzer

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	XRF System
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra, ITU Karlsruhe
MANUFACTURER:	Canberra

PURPOSE

System is designed to determine the content of heavy elements (primarily, uranium and plutonium) in homogenous liquids even of high specific activity. The solution analysis system is intended to be used in environment of radiochemical facilities processing the irradiated fuel.

DESCRIPTION

The Hybrid K-Edge/XRF Analyzer is designed to identify and quantify several heavy elements in homogeneous liquid or solid samples simultaneously. The KED and XRF analyses can be run simultaneously or individually on a single sample or on separate samples, depending upon the application and the required accuracy.

KED measurements can be run for single element samples (like Th, U, or Pu) and for dual element pairs such as Th/U and U/Pu. A highly collimated beam from the X-ray tube passes through a sample vial containing about 2 mL of the sample material. At the element-specific K absorption edge energy the attenuation changes abruptly when this element is present in the sample The energy at which this jump occurs unambiguously defines the element and the height of the jump is a measure of the concentration of the element in the sample.

A standalone XRF measurement is the preferred mode for analysis of very dense solid samples or for liquid samples of low concentrations.

Samples containing several heavy elements can be measured in the combined KED/XRF mode. In this mode, the XRF channel determines element ratios and the KED measurement the reference basis for the determination of absolute concentrations.

COMPONENTS

System is a combination of K-edge densitometer and X-ray fluorescence analyzer. Typical configuration incorporates:
- constant potential X-ray system
- two LEGe detectors
- standard NIM electronics
- computer

SPECIFICATIONS

```
KED analysis:
 Precision for heavy element           better then 0.5% at the one sigma level
 concentrations in solution of         for a counting time of 20 minutes
 greater than 50 g/L:

XRF analysis:
 Precision:                            better than 1% for concentrations above 1 g/L,
                                       10% at 0.05 g/L.
 Limit of detection:                   0.01 g/L with a counting time of 20 minutes

Combined KED/XRF analysis:
 Precision for U/Pu solution in        0.1-0.2% (for the major element concentration 100 g/L)
 a concentration ratio of 1/1000:      0.7% (for ratio determination)
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) Ottmar, H. ESARDA Bulletin No. 4 (April 1983).
2) Ottmar, H. and Eberle, H. KFK Report 4590 (February 1991).
3) http://www.canberra.com

Accounting (NDA): XRF System

182

X-ray spectrometer

MODEL: ARL 9900 series (XP, XP+)

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	XRF System
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solids
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

ARL 9900 permits the rapid and precise analysis of solid samples of various kinds. It detects the presence of up to 83 elements (from B to U, 5 to 92 in the periodic table) in concentrations ranging from parts per million to 100%. Can be used for uranium analysis if corresponding calibration and software will be available.

DESCRIPTION

The ARL 9900 series of X-ray spectrometers combines two X-ray techniques – X-ray fluorescence (XRF) and X-ray diffraction (XRD) in one instrument.

COMPONENTS

- X-ray generator (depending on Model)
- primary beam filter (up to 4 standard, other - on request)
- up to 32 monochromators
- universal goniometer (up to three goniometer configurations available)
- patented XRD system
- counting electronics (multi-channel analyzer)
- sample changer and cassettes
- cooling system

Analysis devices contained in a vacuum chamber

SPECIFICATIONS

Element range	Boron (Nr. 5) to >Uranium(Nr. 92)
Spectrometer capacity	32 fixed channels or 1 goniometer and 24 fixed channels or 1 goniometer, 1 XRD system and 14 fixed channels
Dimensions	H 166 cm, D 136.5 cm, W 93 cm with basic sample changer
Weight	approximately 750 kg

SOFTWARE

WinXRF is the analytical software governing the operation of the ARL 9900 and the processing of data. It uses the Windows®

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): XRF System

183

X-Ray Fluorescence Spectrometer

MODEL: ARL OPTIM'X

SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	XRF System
METHOD:	XRF
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solids, liquids, powders
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

Fast analysis of solids, liquids and loose powders covering all elements from fluorine (F) to uranium (U) in sequential mode. Can be used for uranium analysis if corresponding calibration and software will be available.

DESCRIPTION

This instrument implements the wavelength dispersive X-ray fluorescence (WDXRF) technique for the chemical analysis of solids and liquids. This unique and compact instrument can be configured with a series of Multichromators™ for simultaneous analysis and/or with a SmartGonio™ for sequential analysis and flexibility.

COMPONENTS

- X-ray tube
- Multichromator™
- goniometer SmartGonio™
- counting electronics
- sample loading system

SPECIFICATIONS

Element range	fluorine (Z=9) to uranium(Z=92)
Dimensions	H 126 cm, W 88 cm, D 82 cm with basic sample changer
Weight	approximately 250 kg

SOFTWARE

Designed for Windows XP Professional, the comprehensive and user-friendly WinXRF analytical software supports

ADDITIONAL INFORMATION dling.

Instrument components, configuration, as well as program setting depend on the element to be measured and are determined in the order for purchase.

REFERENCES

http://www.thermo.com/

Accounting (NDA): XRF System

184

Sequential X-Ray Fluorescence Spectrometer

MODEL: ARL ADVANT'X series

SUPPLIER: **Thermo Scientific**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: XRF System
METHOD: XRF

MEASURED PROPERTIES: Element Concentration
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Solids, liquids
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Laboratory
DEVELOPER: Thermo Scientific
MANUFACTURER: Thermo Scientific

PURPOSE

Instrument is designed for analysis of up to 84 elements of the periodic table in conductive or nonconductive solids or liquids in the range from ppm levels to 100%. Can be used for uranium analysis if corresponding calibration and software will be available.

DESCRIPTION

COMPONENTS

- X-ray generator
- goniometer
- counting electronics (multi-channel analyzer)
- sample changer
- cooling system

SPECIFICATIONS

Element range	beryllium (Nr. 4) to transuranics (>Nr. 92)
Dimensions	H 94 cm, D 83 cm, W 109 cm
Weight	approximately 450 kg

SOFTWARE

The comprehensive and user-friendly WinXRF analytical software supports spectrometer operation and data handling under It includes powerful standard-less analysis packages, QuantAS, UniQuant and OptiQuant.

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com/

Accounting (NDA): Waste Measurement System

185

Radioactive waste inventory system

MODEL: СКГ-02-02

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industria
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Control of radiation parameters, classification and passportization (inventory monitoring) of radioactive waste in 200 dm³ drums.

DESCRIPTION

СКГ-02-02 system provides following functionality:
- measurement of gamma spectra, search for and identificaiton of radionuclides, calculation of specific activit at three levels along the height of the waste drum with averaging the measurement results thanks to drum rotation around its axis;
- classification of waste drums controlled according to results of specific activity calculation into following categories: are not the waste, low activity waste, medium activity waste, high activity waste;
- measurement of waste drum weight;
- control of gamma radiation dose rate at the mean height of the drum and at the distance of 0.1 m from the drum surface;
- storing of measurement results in form of spectra and calculated activity values in the data base with binding to drum ID;
- generation of a report on measurement results and its printing on operator's request

COMPONENTS

- Foundation with rotating platform and system crate
- Three УДС–Г-40x40-485 (or УДС–ГЦ-40x40-485, УДС–Г-63x63-485, УДС–ГЦ-63x63-485, УДС–ГЦ-В380-38x38-485) gamma radiation scintillation detecting units (digital) with collimators
- БДГ-02 gamma radiation detecting unit
- БКУ-01-02 commutation and control unit
- ВБ-1 platform electronic scales
- Motor-reductor
- Control computer
- Calibrating source (Europium-152)

SPECIFICATIONS

Number of spectrometric sections	3
Channel number of each spectrometric section	1024
Energy resolution at 662 keV for each section	no more than 8 %
Gamma radiation energy range	from 0.05 to 3.0 MeV
Integral nonlinearity within the measurement energy range	± 1%
Specific activity measurement range (at confidence probability of 0.95):	
Cs-137, БBq/kg	from 25 to 6*10^6
Co-60, Bq/kg	from 20 to 1.5*10^6
Allowable limits of relative activity measurement error (P= 0,95)	± 30 %
Measurement range of gamma dose rate	from 0.1 to 1*10^5 µZv/h
Allowable limits of relative gamma dise rate error	± 20 %
Operating temperature range	from +5 to +40 ˚C
Drum weight measurement range	from 10 to 500 kg
Allowable limits of relative weighting error	no more than ±1 kg
Overall size	700mm x 1200mm x 1525mm
Overall weight	no more than 350 kg

SOFTWARE

Software package«Diogen» provides for automated gamma spectra processing, storing the spectra and processing results in

ADDITIONAL INFORMATION

g the processing result report, authorized access to the data base via local net.
The software allows for operation in following user modes:
- "Administrator" mode: system set-up and configuration (energy, half-width calibration, exposure time setup, selection of analyzed radionulide list, setup of data processing parameters);
• "Operator" mode: performing the measurements (sample measurement, energy calibration correction, background control);

• "Test" mode: inspection of serviseability of system's modules.

REFERENCES

Accounting (NDA): Waste Measurement System

186

Segregated Waste Clearance Monitors

MODEL: Model 3300-200

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

The ANTECH Model 3300-200 is designed to assist the task of quantifying and clearing segregated gamma ray emitting waste from nuclear facilities or demonstrating that tools and equipment are contamination free.

DESCRIPTION

The Model 3300-200 can measure a variety of sample containers including paper or plastic sacks of 10 - 20 kg in weight although larger items up to the capacity of the Model 3300-200 (i.e. 200 litres or less) can be measured. Because of the near 4-π geometry there is no requirement to rotate the bag or sack.

Plastic scintillation detectors are mounted on all six sides of the counting chamber to provide uniform measurement throughout the chamber. The high sensitivity is achieved by using large surface area plastic scintillator detectors coupled with charge sensitive amplifiers with both upper and lower level discriminators. An embedded microprocessor performs data acquisition, system diagnostic testing, input monitoring and background discrimination.

COMPONENTS

- high efficiency plastic scintillator detector panels (2, 4 or 6 panels)
- aluminium liner
- loading platform with a load cell (weighing scales)
- counting chamber
- 40-character LCD display
- indicator lights
- 25 mm of lead shielding
- RS-232/Ethernet network interface (optional)

SPECIFICATIONS

```
Detection Sensitivity ( point source located in the centre
of the measurement chamber in a standard background of ~100 nSv/h):
 Minimum Detectable Activity (MDA) of
 10kg sample in 120 seconds (typical):     85 Bq Co-60 (2σ)
                                           50 Bq Cs-137 (2σ)
 Chamber dimensions                        (H x W x D) 800 mm x 500 mm x 500 mm
 Operating temperature                     10 to 35 ˚C
 Relative Humidity                         10 to 30%
 Overall Dimensions                        (H x W x D) 1350 mm x 890 mm x 920 mm
 Weight                                    1420 kg
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Accounting (NDA): Waste Measurement System

187

Waste Segregation Gamma Box Scanner, Waste Segregation Gamma Container

MODEL: Model 3700-B25, Model 3700-600

Top-Model 3700-B25; Bottom-Model 3700-600

SUPPLIER: **ANTECH Corporation**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Gamma

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: ANTECH Corporation
MANUFACTURER: ANTECH Corporation

PURPOSE

The ANTECH 3700-XXX is a modular assay solution for the segregation of gamma emitting waste in large packages (as well as ISO containers, vehicles – B25 model).

DESCRIPTION

The principle of the measuring system is that of making possible the taking of multiple measurements of the same container from different measuring points thereby obtaining multiple estimates for the activity which is inside. These results (after correction for geometry and attenuation) may then be combined to produce a best estimate of the container total activity. “Outliers” from the container average are pointers to inconsistencies which lie in either matrix or source distribution inhomogeneity.
In operation, the container passes past the detector measurement station and stops at multiple measurement points, for example 25%, 50% and 75% of the length of the container. At each point, the multiple collimated HPGe detectors perform multiple simultaneous measurements. In a typical configuration, four detectors are positioned, two on each side of the measurement station, resulting in this example, in 12 assay measurements for the container.

COMPONENTS

Each standard spectroscopy sub-system (typically 4) comprises the following:
- ORTEC PROFILE Series GEM HPGE detector with SMART-1 electronic package
- X-Cooler non-LN2 HPGe detector cooling
- transmission sources (optional)

SPECIFICATIONS

Assay accuracy	25-65% (typical)
Measurement time	45 minutes (3 15-minute measurements)

SOFTWARE

Data acquisition and analysis software is based on ORTEC multi-detector version of Isotopic –32 V3.0 waste assay code.
ADDITIONAL INFORMATION ng of the multiple detector spectra and processes the result. Each detector to be used in the assay is calibrated with a simple multi-nuclide point source, and the program then extrapolates the calibration to the actual geometry and matrix conditions present at each measurement point. The results from each detector are then averaged and stored within an industry standard data base.

REFERENCES

www.antech-inc.com

Accounting (NDA): Waste Measurement System

188

Differential Die Away Active/Passive Neutron System

MODEL: Model 4200-600

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

The ANTECH Model 4200-600 is an enhanced efficiency active/passive neutron counter designed for the measurement of plutonium and uranium in nuclear waste and housed in an ISO shipping container.

DESCRIPTION

The Model 4200-600 can be operated in conventional totals active mode or the more advanced Fission Fission neutron Correlation coincidence counting (reals) mode. This latter mode reduces the amount of effort required to calibrate the measurement system.

In active totals mode, pulses of neutrons are used to interrogate a waste drum placed in the measurement chamber. A neutron generator is pulsed at 100 Hz producing 14-MeV neutrons. The neutrons are slowed down in graphite providing a source of thermal neutrons that cause induced fission in the U-235 and Pu-239 in the waste. Each pulse generates approximately 1 x 10^6 neutrons. Cadmium shielded detector packages are used to measure the prompt fission neutrons (from induced fission) in a time period (~500 µs) when neutrons from the initial generator burst have been cleared from the fast detector packages. Additional He-3 flux monitors are placed in the measurement chamber and provide a measure of the interrogating neutron intensity and its die away characteristics. A later time period is used to determine the background due to delayed neutron production from fission products and from any spontaneous fission nuclides present. The fissile mass is proportional to the net fissile signal normalized to the interrogating flux.

Passive mode operation uses conventional neutron counting of the correlated neutrons arising from spontaneous fission of the even Pu nuclides, principally Pu-240. Plant measured isotopic ratios (from high resolution gamma spectrometry) can be used by the software in order to convert Pu-240 effective mass to total Pu mass.

COMPONENTS

- neutron detection system:
  - 88 He-3 tubes, 25.4mm diameter at 4 Atmosphere pressure, embedded in a cadmium clad polyethylene moderator arranged in 18 fast detector packages (three per side).
- 18 high voltage junction boxes (one for each package):
  - Amptek charge sensitive amplifier/discriminator circuit
  - connections for high voltage, low voltage and signal cables
- polyethylene back shielding
- conveyor/loading platform

SPECIFICATIONS

Measurement limit (active mode)	0.61 mg Pu-239 and 0.91 mg U-235
Detection efficiency (passive mode)	approximately 12% (empty chamber)
Measurement time (active mode)	200 seconds
Measurement chamber size	1250mm x 850mm x 850mm
Overall size	1710mm x 2417mm x 1702mm excluding conveyor/loading platform
Weight	9500 kg approximately

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

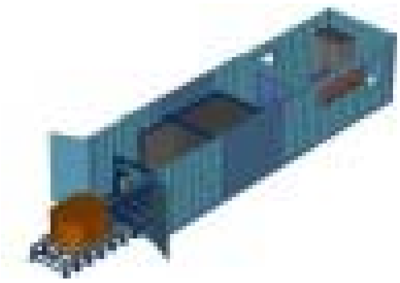
Accounting (NDA): Waste Measurement System

189

Neutron Active Crate Counter

MODEL: nACC - Series 5400

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron coincidence counting Active
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation



PURPOSE

The ANTECH Neutron Active Crate Counter (nACC) is an enhanced efficiency active/passive neutron counter designed for the measurement of plutonium and uranium in nuclear wastes contained in a variety of crates and waste boxes such as B25 and SWB.

DESCRIPTION

Counter is capable of both 'active' operation for the measurement of fissile nuclides combined with a conventional 'passive' mode capability for the measurement of the fertile nuclides, principally 240Pu giving complete flexibility for the measurement of Pu and U in waste.

The measurement is based on the differential die away principle using thermalized neutrons from a D-T generator to create induced fissions in fissile material present in the waste. A neutron generator is pulsed at 100 Hz producing 14-MeV neutrons, that are slowed down in the graphite providing a source of thermal neutrons that cause induced fission in the 235U and 239Pu in the waste. Cadmium shielded detector packages are used to measure the prompt fission neutrons (from induced fission) in a time period (~500 µs) when neutrons from the initial generator burst have been cleared from the fast detector packages. Additional He-3 flux monitors are placed in the measurement chamber and provide a measure of the interrogating neutron intensity and its die away characteristics. A later time period is used to determine the background due to delayed neutron production from fission products and from any spontaneous fission neutrons present. The fissile mass is proportional to the net fissile signal normalized to the interrogating flux. The system must be calibrated for uranium and plutonium mass using representative matrices.

The passive mode operation uses conventional neutron counting of the correlated neutrons arising from spontaneous fission of the even Pu nuclides, principally Pu-240. Plant measured isotopic ratios (from high resolution gamma spectrometry) can be used by the software in order to convert Pu-240 effective mass to total Pu mass.

COMPONENTS

The nACC contains:
- 24 fast neutron detector packages (4 in each of the two sides, the top and bottom and the two ends), each containing 4 x 3He tubes (1 inch Cd shielded, 4 atmospheres fill pressure).
- 24 high voltage junction boxes (one for each package) containing:
  - Amptek charge sensitive amplifier and discriminator circuit
  - connections for high voltage, low voltage and signal cables
- multi-channel scaler for active mode operation combined with a time correlation analyser (TCA) for passive mode operation.
- polyethylene back shielding
- assay chamber graphite liner
- 3He flux monitors
- D-T neutron generator
- optional HPGe gamma spectrometer for Pu isotopic ratio determination.

SPECIFICATIONS

Passive mode detection efficiency	approximately 5% (empty chamber)
Active mode Lower Limit of Detection (LLD)	10 mg Pu-239 (in empty chamber) 100 mg Pu-239 (for measurement of waste containing a metal matrix up to ~2g/cc) 750 mg – 1g Pu-239 (in severely moderating matrices) (The LLDs for U-235 measurement in similar waste matrices are likely to be higher by approximately 50% across the board)
Overall size	(L x W x H) 10' x 8' x 7'
Weight	~8000kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

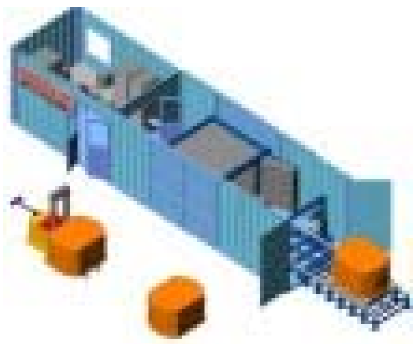
www.antech-inc.com

Accounting (NDA): Waste Measurement System

190

Neutron Passive Crate Counter

MODEL: nPCC - Series 5100



SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

The ANTECH Neutron Passive Crate Counter (nPCC) is used for the determination of the Pu-240 mass in TRU Waste transport containers.

DESCRIPTION

The operation of the instrument is based on passive neutron counting of the correlated neutrons arising from spontaneous fission of the even Pu nuclides, principally Pu-240.

The Passive Neutron Crate Counter can be operated in conventional shift register coincidence counting (reals) mode (with a calibration function) to eliminate the (α,n) neutron signal, the absolute multiplicity counting mode (histogram function) or totals counting mode. Plant measured isotopic ratios can be used by the software to convert Pu-240 effective mass to total Pu mass.

COMPONENTS

- neutron detection system:
  - 34 polyethylene moderated detector modules each containing eight, 6.5 atmosphere 1-inch diameter He-3 tubes arranged in two rows in 4π-geometry.
- junction boxes:
  - high voltage distribution and charge collection circuitry
  - AMPTEK model A-111 charge sensitive amplifiers
- 270 mm thickness of polyethylene
- Advanced Multiplicity Shift Register (AMSR-150) or ANTECH Time Correlation Analyser (TCA)
- optional 'Add-a-Source' Cf-252 system (80 µCi 252Cf source) for matrix correction
- optional High Purity Germanium (HPGe) gamma ray spectrometry system for determining Pu isotopic ratios.

SPECIFICATIONS

Detection efficiency	typically ~30% with Cd filters deployed and ~40% with the internal Cd liner removed
Operating Voltage	~1650 volts
Minimum detection limit	92 mg Pu-240 effective in coincidence (reals) mode between ~1.54 grams total Pu (military grade)
Weight	4000 kg approximately
Approximate overall dimensions	(L x W x H) 10' x 8' x 7'

SOFTWARE

LANL INCC code

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Accounting (NDA): Waste Measurement System

191

Flat-Squared Neutron Coincidence Counter

MODEL: JCC-41

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Neutron coincidence counting
Passive
MEASURED PROPERTIES: Effective isotope mass
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM: MOX, waste, carbides, etc.
STATUS: Serial Production (special order)
PORTABILITY: Transportable
ENVIRONMENT OF USE: Industrial
DEVELOPER: LANL, Canberra
MANUFACTURER: Canberra

PURPOSE

The JCC-41 is designed for in-plant measurements of large plutonium samples (up to several kg Pu), but can be used for plutonium waste samples with milligram quantities of plutonium. It is intended to assay plutonium samples including PuO2, mixed oxides (PuO2-UO2), metal carbides, fuel rods, fast critical assemblies, solution, scrap, and waste.

DESCRIPTION

The JCC-41, which is based on Monte Carlo design calculations performed at Los Alamos National Laboratory [1], measures the effective Pu-240 mass in a sample by detecting coincidence neutrons from the spontaneous fission of the even numbered isotopes of plutonium.
A cadmium sleeve surrounds the sample cavity to prevent the reentry of thermalized neutrons into the sample, which could induce fission in the sample and adversely affect the results. It provides radiation protection for personnel as well as background reduction.
Outside the cadmium sleeve is a polyethylene/cadmium liner to flatten the axial response. Twenty-four He-3 tubes are embedded in the high-density polyethylene. The tubes are arranged in a single ring around the sample with optimum spacing between the tubes for maximum counter efficiency.
The tubes are divided into six groups of four with each group wired together and connected to one of the six JAB-01 Amplifier/ Discriminator circuit boards which are mounted inside a high voltage junction box. LED indicator lights are place externally on the junction box to indicate proper operation of each JAB-01 channel. The external polyethylene shielding and special design (graphite end plugs and polyethylene/cadmium liner) give uniform response axially over the sample cavity, making the counter relatively insensitive to matrix effects.

COMPONENTS

- JCC-41 counter head:
  - twenty-four He-3 detectors, 2.5 cm diameter, 71 cm length
  - fast Amptek electronics
- cylindrical-shaped sample cavity
- exterior neutron shielding
- sample hoist mechanism
- electrical connections between the JCC-41 and the JSR-12:
  - +5 V
  - HV
  - single "ORed" output signal
- additional Cf-252 neutron source, 5 x 104 neutron/second for normalization

A JSR-12 Neutron Coincidence Analyzer, a computer and analysis software are required for coincidence counting but are not included with the JCC-41.

SPECIFICATIONS

Detector efficiency	>24%
Sensitivity	better than 28 counts/sec per gram Pu-240
Measurement time	1000 sec
Precision	2.4% for 0.06 gram Pu-240
Measurement range	several mg to several kg Pu
Sample cavity size	51.6 cm x 24.4 cm (H x Dia)
Overall size	204.5 cm x 62.2 cm x 62.2 cm
Counter size	92.5 cm x 62.2 cm x 62.2 cm
Weight	318 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) Menlove, H.O., Palmer, R., Eccleston, G.W., and Ensslin, N., Flat-Squared Counter Design and Operation Manual. Report LA-11635. Los Alamos, New Mexico: Los Alamos National laboratory (LANL), 1989.
2) http://www.canberra.com

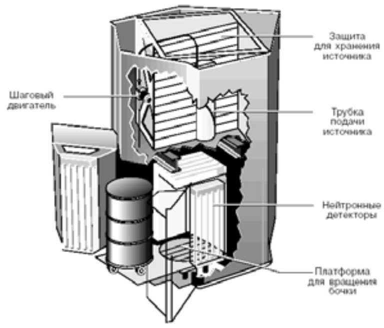
Accounting (NDA): Waste Measurement System

192

Passive/Active Cf-252 Shufflers

MODEL: WM-3200

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Neutron



MEASURED PROPERTIES: Effective isotope mass
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: LANL
MANUFACTURER: Canberra

PURPOSE

The WM-3200 systems are useful for non-destructive assay of milligram to kilogram quantities of both U and Pu in a wide variety of forms and matrix materials.

DESCRIPTION

The WM-3200 Series Passive/Active Shuffler System operates in an active interrogation mode to measure fissile radionuclides. A high-speed transfer mechanism "shuffles" an intense Cf-252 source between the shield assembly and the counting chamber for 11 seconds. When the source is in the shielded position, delayed neutrons (3.5 sec delay) from the sample are counted (during 7 seconds). The passive mode measures spontaneously fissioning radionuclides (i.e., Pu-238, Pu-240, Pu-242, Cf-252, Cm-242 and Cm-244).
These counters perform active interrogation of fissile isotopes in 200 L drums, passive measurement of even isotopes of plutonium, and have an add-a-source option for matrix corrections and thermal interrogation for improved sensitivity. The counters use fast interrogation for reduced self-shielding effects.

COMPONENTS

- 64 He-3 neutron counters;
- Cf-252 neutron source, 8 x 108 neutron/second;
- Teleflex cable for source moving;
- drum rotation platform;
- computer-based control and analysis system;
- 1800 kg radiation shield consisting of tungsten, high density polyethylene, and borated polyethylene.

SPECIFICATIONS

```
Measurement time             1000 seconds
Detector efficiency          17.5%
Sensitivity:
    active fast mode         300 mg U-235
    active thermal mode      20 mg U-235
    passive mode             4 mg Pu-240-effective
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) http://www.canberra.com
2) Los Alamos National Laboratory, Application Note “The 252-Californium Shuffler”, March, 1990.

Accounting (NDA): Waste Measurement System

193

Curved Passive Neutron Slab Counters

MODEL: WM-3500

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Effective Isotope Mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The WM-3500 Series Curved Passive Neutron Slab Counters measure the plutonium content in drums, crates and other containers of different shape and size.

DESCRIPTION

The slabs can be configured closely around a drum or separated and placed on opposite sides of a crate. The high-density polyethylene moderator slabs have a welded stainless steel skin for easy decontamination and fire protection. The units are transportable to allow easy repositioning around a drum or crate.

COMPONENTS

- four slab counters:
  - 8 He-3 proportional tubes, 91 cm active length, 2.5 cm diameter, 4 atm
  - curved high density polyethylene moderator
  - JAB-01 preamplifier/amplifier/discriminator board
- welded stainless steel skin

SPECIFICATIONS

Detector efficiency	19.4%
Sensitivity	<3 mg Pu-240-effective (<50 mg weapons grade plutonium)
Measurement time	20 minutes
Measurement chamber size	114 x 54 cm, H x Dia
Overall size	114 x 86 cm, H x Dia

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

194

Large-Volume Decommissioning Counter
MODEL: WM-2400

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma Passive
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The WM-2400 Large-Volume Decommissioning Counters are designed to measure the gamma emitting radionuclides in waste drums of up to 1 m³ volume and automatically separate radioactive from nonradioactive waste.

DESCRIPTION

The WM-2400 Series has multiple Ge and/or NaI detectors for qualitative and quantitative analysis, allowing radionuclide-specific release limits. Detectors and samples are totally enclosed in a low-background steel shield. A weight-sensing sample turntable rotates during an assay. Software corrects for sample density and correlates gamma emitters to non-gamma emitters based on waste stream type.

The system features free-release measurement of decommissioning material including thermal insulation, steel pipes, electrical wiring and concrete. It also has automatic "clean/contaminated" decision, automated operation for high throughput applications, large sample volume-1 m³ (250 gallon), energy and density calibration, and uses Ge or NaI(Tl) detectors.

COMPONENTS

- Ge and/or NaI detectors
- low-background steel shield
- sample turntable
- software

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

195

Q² Low Level Waste Assay System

MODEL: WM-2100 Series

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma Passive
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, TRU
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The WM-2100 Series Q² low-level waste assay systems provides qualitative and quantitative analysis, allowing radionuclide-specific release limits for individual isotopes

DESCRIPTION

The detectors and samples are totally enclosed in a thick low-background steel shield. The weight-sensing sample turntable is mounted on the door and rotates during an assay. Software corrects for sample density and correlates gamma emitters to non-gamma emitters based on waste stream type.
The WM-2100 Series meets 1 Bq/g for free-release of waste and certifies low-level waste classification and TRU waste classification. It discriminates between natural and man-made radionuclides and classifies mixed waste as hazardous only. This device provides legally defensible verification of results and calculates alpha/beta emitters that cannot be measured directly using customer-provided correlations. It also calculates the plutonium and uranium isotopics using optional Multi-Group Analysis (MGA) Code.

COMPONENTS

- three 20% Germanium detectors (or NaI)
- ICB NIM electronic module
- 10 cm (4 in.) or 15 cm (6 in.) low-background steel shield
- automatic weighting system
- sample turntable

SPECIFICATIONS

Measurement time	10 minutes
Sample size	208 l, 64 x 89 cm (Dia x H)
Sample weight	454 kg
Sensitivity (depending on density):	
U-235	0.1 to 0.3 pCi/g
U-238	0.07 to 26.7 pCi/g
Pu-239	3.1 to 47 nCi/g
Operating temperature	0 to 40˚C
Humidity	0 to 95%, non-condensing
Power	110/220 V, 3kVA
Overall size	152 x 172 x 122 cm
Weight	7260 to 9980 kg

SOFTWARE

Spectrometric package Genie-PC, basic waste measurement software WAS.

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

196

Passive Neutron Coincidence Drum Counters

MODEL: WM-3100/HENC

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Neutron coincidence counting
Passive
MEASURED PROPERTIES: Effective Isotope Mass
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM: Waste
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The systems assays plutonium in low-level waste contained in 200 l drums.

DESCRIPTION

The WM-3100 Series Passive Neutron Drum Counter with He-3 detectors arranged on all sides provides accurate, precise and sensitive assay of plutonium content in 118 L (32 gallon) to 200 L (55 gallon) drums.
The add-a-source option improves the accuracy of the measurement for matrices with a high hydrogen content. High Efficiency Neutron Counter (HENC) has all the design features of WM-3100; further, 32% efficiency for Pu results in a lower MDA and correction for matrix effects on localized Pu sources, using the advanced multiplicity technique.

COMPONENTS

- neutron counter with:
  - 113 He-3 neutron detectors, 2.54 cm diameter, 7.5 atm
  - high density polyethylene moderator
  - Amptek-based fast preamplifier/discriminator circuit boards (Model JAB-01)
- coincidence electronics
- computer hardware
- application software

SPECIFICATIONS

Detector efficiency	>30%
Count time	1000 sec
Sensitivity	0.73 mg Pu-240-effective with 0.006 cps coincidence background
	2.74 mg Pu-240-effective with 0.02 cps coincidence background
	0.4 mg Pu-240-effective with 2.6 cps coincidence background
Overall size	362 x 195 x 270 cm (L x W x H)
Weight	8200 kg

SOFTWARE

Canberra's S430 Neutron Analysis Software converts the corrected count rate to Pu-240-effective (combination of Pu-238, Pu-

ADDITIONAL INFORMATION otal measurement uncertainty.

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

197

Passive Neutron Slab Counters

MODEL: WM-3400

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron coincidence counting Passive
MEASURED PROPERTIES:	Effective Isotope Mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The WM-3400 Series Passive Neutron Drum Slab Counters perform a go/no-go measurement of the plutonium content in drums up to 200 L (55 gallons) by passive neutron measurement.

DESCRIPTION

WM 3400 determines plutonium content in 200 l drums by measuring the neutron coincidence from spontaneous fission for even plutonium isotopes.
A drum-positioning fixture is attached to the front of the counter for repeatable positioning near 200 L drums.
The 200 L counter is attached to a cart for easy mobility. This device is transportable to allow positioning in front of a drum.

COMPONENTS

- single slab of high-density polyethylene with six He-3 tubes, 91.4x2.5 cm
- low-noise amplifiers/discriminators JAB-01
- drum-positioning fixture
- neutron coincidence analyzer JSR-12 (separate order)
- cart
- portable computer
- printer

SPECIFICATIONS

Detector efficiency	2.2%
Overall size	113.0 x 45.7 x 83.1 cm

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

198

Segmented Waste Assay System

MODEL: WM-2200 Series

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma, alpha Passive
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, TRU
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Segmented waste assay systems measure transuranic radionuclides and fission/activation products in containers of low-density waste. This device quantifies TRU and alpha/gamma waste.

DESCRIPTION

Segmented waste assay system WM2200 is designed for precise quantitative analysis of gamma radiation nuclides contained in activation, fission products and transuranic wastes. High system precision is provided by using collimated HPGe detector. Container measured is divided in some vertical segments and activity of each segment is determined. For this the material matrix correction technique is used allowing to calculate the average sample density for each segment.
Versions of the system handle from 20 L (5 gal) to 320 L (85 gal) and up to 900 kg drums.

COMPONENTS

- high-resolution HPGe detector
- LN2 Dewar or cryoelectric (LN2-free, electrically-cooled)
- controller GE/Fanuc Series 90
- manual or automatic rotator platform
- transmission source
- conveyor (Model WM2211)
- bar code reading system (Model WM2211)
- doze rate meter (model WM 2211)

SPECIFICATIONS

Measurement time	one minute per segment
Detector efficiency	30%
Energy resolution	1.9 keV at 1332 keV
Measurement range	0.1 to 1000 g U-235 or Pu-239
Sensitivity (for 0.3 g/m³ waste density):	
U-235	0.1 g
U-238	59 g
Pu-239	0.2 g

SOFTWARE

WM2200 system uses Canberra's waste gamma assay software GWAS operating in Genie-PC environment. Program rogram uses all standard Genie-PC procedures for high resolution gamma spectrometry. In addition GWAS includes some additional functions such as upper level menu simplifying program control, some matrix correction functions including average density calculation, differential peak absorption, absorption correction, improved quality assurance and measurement control procedures, automated calibration procedures, etc.

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

199

Gamma Monitor for Objects and Waste Bags

MODEL: CONDOR

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Transportable
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The CONDOR monitor is used for fast checking gamma radiating nuclides with energies from 50 to 2000 keV in waste bags, tools and other miscellaneous objects, with an extremely high sensitivity.

DESCRIPTION

Monitor is easy to use. When the unit is turned on the green power light comes on. Initialization phase involving acquisition of current background for subtraction. To make a check, follow the diagram and the messages displayed on the screen: open the entrance door, introduce the bag or object to be monitored, close the door, hold the measurement button pressed for two seconds. The automatic sequence of the check is indicated by symbols on the screen; after the measuring period, the message “Measurement Completed” is displayed and the operator can then remove the object by the other door and proceed to next control.
If a pre-set threshold is exceeded, an audible alarm warns the operator and the red indicator “ALARM” appears on the screen; the alarm can then be cancelled with a key-operated contactor. The results of measurement can be printed out: time/date, “BKG” background value, “Net” count and result of check “OK” or “ALARM”.
Once the last object has been checked, the device automatically switches to current background acquisition.
The unit can be used with a two door sequence (entrance and exit doors) or with one door sequence only. (The exit door is locked and only the entrance (front) door is used for control.)

COMPONENTS

The device includes:
- spacious measuring cavity in the form of a cube, accessed through a door;
- three plastic 500 x 500 x 50 mm scintillator detectors (3 x 12.5 liters) with photomultiplier tube
- removable decontaminable stainless steel plates
- amplification and processing electronics,
- keyboard,
- flat color display screen

SPECIFICATIONS

Radiation detected	gamma photons with energy over 50 keV: Am-241, Cs-137, Co-60, etc.
Power	230 V/ 50 Hz or 110 V/60 Hz mains, 2.9 m cable, power rating 100 W
Overall dimensions	810 x 1370 x 1160 mm, width x height (casters included) x depth
Weight	1500 kg with 10 mm shielding; 2100 kg with 20 mm shielding; 2700 kg with 30 mm shielding
Inside dimensions	600 x 600 x 850 mm, width x height x depth (300 liters)
Operating temperature range	0 to +45 °C (+32 to +113 °F)

SOFTWARE

ADDITIONAL INFORMATION

Options:
- Additional detectors (a maximum of three, in the front door, the rear door and the top of the device) to increase sensitivity
- Thicker lead shielding: 20 mm or 30 mm
- Scales for automatic weighing of packages (20 g to 60 kg) and calculation of the specific activity for a given radioisotope or mixture with self-absorption correction

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

200

Tomographic Gamma Scanner

MODEL: WM2900 TGS

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, TRU
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The system is designed to accurately quantify plutonium, uranium, fission and activation products in a variety of containers from 20 L pails to 200 L drums in overpacks.

DESCRIPTION

Tomographic gamma scanner WM2900 provides quantitative analysis gamma radiation fission and activation products as well as transuranium elements in low density wastes. Different system variants can accommodate containers of 20 to 340 liters volume and up to 1000 kg weight.
The container is divided into a number of vertical and radial volume elements (voxels). The activity is quantified in each of these voxels using matrix correction techniques based on the activity content and matrix properties of each voxel.
Data is acquired by scanning hardware with high resolution HPGe detector electronics. Matrix mapping is performed by applying Beers Law to rays from the center of each voxel to the center of the detector face. Special image reconstruction software is used to allow for the response of the collimator in combination with the properties of the waste. A comprehensive graphics package allows the attenuation map and emission image to be visualized from different perspectives.
Densitometry can also be used with additional external transmission source.
Special software is used for reconstruction and visualization of volume activity distribution.

COMPONENTS

The mechanism consists of one or more of the following modules:
- 2442 detector vertical drive module,
- 2942R-27 turntable rotation module or optional in-line conveyor rotator,
- 2442T transmission vertical drive module,
- 2942S single transmission source shield and shutter.

Detector:
- high efficiency “P” type coaxial high purity germanium detector or
- wideband detectors of BeGe series

SPECIFICATIONS

Waste activity measurement range:	
gamma sources (Co-60, Cs-137)	from 1.85E+4 to 3.7E+9 Bq
transuranium elements (U-235, Pu-239)	from 0.4 to 1000 g
Sample size	200 L (55 gal) drum
Detector efficiency	60%
Resolution	2.0 keV at 1332 keV
Density	less than 0.3 g/cc
Background	less than 0.02 mR/hr
Total assay time	60 minutes
Typical accuracies	±20% for 200 L drums with densities up to 1 g/cc
Power requirements:	
counting electronics	15 A at 110 V
mechanical system	60 Hz, 220 V ac, 20 A
Overall size (W x D x H)	2920 mm x 1830 mm x 2670 mm (115 x 72 x 105 in.)
Weight:	
detector drive, detector and collimator	998 kg (2200 lb)
rotator module	590 kg (1300 lb)
transmission drive module and shield	335 kg (734 lb)

SOFTWARE

System operates under control of specialized software package developed in Genie-2000 environment, Non-Destructive Assay

ADDITIONAL INFORMATION

REFERENCES

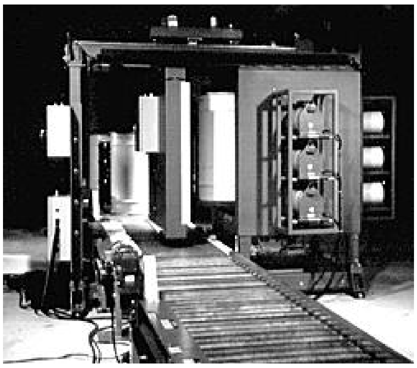
http://www.canberra.com

Accounting (NDA): Waste Measurement System

201

IQ³ Automated Low Level Waste System

MODEL:



SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Gamma

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Waste
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The system is designed to quantify plutonium and uranium in 200 L drums at levels below 10 nCi/g and at the same time perform plutonium isotopics measurements on drums containing less than 10 mg of plutonium. At this level low level waste drums can easily be segregated from TRU drums.

DESCRIPTION

For TRU drums the IQ³ system utilizes several techniques to provide accurate quantification of the fissile content of the drum. These include transmission correction to determine the drum matrix density, lump detection using multi energy assays, and non uniformity correction using Canberra's Non Uniformity Correction Software (NUCS).

COMPONENTS

- 4π, 15 cm thick, low background steel shield used as a measurement chamber
- loading system
- transmission source mechanism
- two sets of three (LEGe) detectors
- PLC control system

SPECIFICATIONS

Detection level	<1 mg Pu-239
Container sizes	up to 300 L (85 gal), 400 kg, 76 cm (30 in.) diameter and 100 cm (39.5 in.) high
Minimum detection level	less than 1 mg of weapons grade plutonium at 99.7% confidence level less than 10 mg of U-235 at the 99.7% confidence level
Maximum fissile gram content	250 gm of Pu
Overall size	244 x 330 x 260 cm
Weight	14 515 kg

SOFTWARE

- Gamma Waste Assay Software (GWAS)

ADDITIONAL INFORMATION re

REFERENCES

http://www.canberra.com

Accounting (NDA): Waste Measurement System

202

Integrated Waste Assay System

MODEL: IWAS

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron, gamma
MEASURED PROPERTIES:	Element mass
NUCLEAR MATERIAL(S):	U, Pu, TRU
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

IWAS is designed to quantify plutonium and uranium in 55 gallon drums and 85 gallon over-packs. The IWAS provides passive and active neutron interrogation and quantitative gamma analysis, allowing rapid characterization of TRU wastes for proper shipment and disposal.

DESCRIPTION

The system is designed to be operated as an automated counting system which can process batches of drums, or can be incorporated in a facility process line. It is based on the Canberra High Efficiency Neutron Counter (HENC) design with integrated Differential Die-Away (DDA) and High Resolution Gamma-Ray Systems and provides quantitative and isotopic gamma-ray analysis, passive neutron multiplicity coincidence counting, active neutron interrogation using differential die-away technique. Because all assays are performed by the same system in a single assay sequence, there is no confusion over item ID or modification of drum contents between assays.

COMPONENTS

- measurement chamber - 4π, 40 to 55 cm thick High Density Polyethylene (HDPE) moderator/shield
- sample handling mechanism
- passive neutron assay system using 122 He-3 proportional tubes
- gamma-ray assay system with two or more High Resolution Germanium Detectors - Broad Energy Germanium (BEGe) detectors

SPECIFICATIONS

```
Neutron detection efficiency          27% for Pu-240
Spontaneous fission neutrons and
       a coincidence sensitivity      47 cps/gram Pu-240 effective
Detection levels:
    passive neutron analysis          4 mg to 1.7 mg Pu-240 effective in 600 to 3600 s
                                      (This corresponds to 30 mg weapons grade Pu
                                      (6% Pu-240) in 3600 seconds)
    active neutron analysis           6-45 mg total Pu, 10-70 mg U-235
    gamma analysis                    10 mg Pu-239 in a 600 second count time, 16 mg U-235
Overall dimensions of the
  passive/active neutron counter      645 cm long by 400 cm wide and 254 cm tall
Overall weight                        approximately 8000 kg
```

SOFTWARE

The system is operated from Canberra’s NDA 2000 software.

ADDITIONAL INFORMATION

REFERENCES

1. “The Design of a High Efficiency Neutron Counter (HENC) for Waste Drums to Provide Optimized Sensitivity for Plutonium Assay,” H.O. Menlove, et al., Proceedings of the 5th Nondestructive Assay and Nondestructive Examination Waste Characterization Conference,” Salt Lake City, UT, January 14-16, (1997).
2. “Q2 – A Very Low Level Quantitative And Qualitative Waste Assay And Release Certification,” F. Bronson, Proceedings of Waste Management ‘90, February 25-28, 1990, University of Arizona, Tucson, Arizona.
3. http://www.canberra.com

Accounting (NDA): Waste Measurement System

203

Waste Crate Assay System

MODEL: WCAS

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Neutron coincidence counting, gamma spectrometry

MEASURED PROPERTIES: Effective Isotope Mass
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM: Waste
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The Waste Crate Assay System (WCAS) is designed for low level waste assay to determine the transuranic (TRU) activity of contaminated solid waste in containers up to 1.43 x 1.43 x 1.20 m crates.

DESCRIPTION

The WCAS is based on the Canberra Waste Drum Assay System (WDAS) design with integrated High Resolution Gamma-Ray System and provides simultaneous passive neutron coincidence and high resolution gamma isotopic analysis allowing rapid characterization of plutonium wastes.
The system is designed to be operated as an automated counting system which can process batches of drums, or can be incorporated in a facility process line.
The WCAS counter automatically loads and unloads drums into the assay chamber. The general sequence of events for the system in analysis mode is as follows:
1. The sliding door opens and the conveyor moves the crate into the assay chamber.
2. The sliding door closes.
3. Operator enters the pertinent information on the sample.
4. Add-A-Source movement is automatically controlled by the PLC and the matrix correction measurement is controlled by the software.
5. Passive neutron and gamma isotopic measurements are run simultaneously.
6. Upon completion of the assay the door opens and the sample automatically exits the counter.
Results from individual neutron and gamma-ray assays are combined automatically by the NDA-2000 software. Because the assays are performed in the same system in a single assay sequence there is no confusion over item ID or modification of sample contents between assays.

COMPONENTS

Components of the system include:
- neutron counter with 96 3He proportional tubes,
- Amptek based fast preamplifier/discriminator circuit boards (Model JAB-01),
- coincidence electronics,
- computer hardware,
- high resolution gamma detectors,
- Broad Energy Germanium (BEGe) detectors,
- digital signal processing for the gamma-ray analysis and application software,
- trolley/conveyor mechanism.
- 4π, 20 cm thick High Density Polyethylene (HDPE) moderator/shield as a measurement chamber

SPECIFICATIONS

Neutron detector efficiency	18% for Pu-240 fission neutrons
Minimal detection level	less than 6 mg Pu-240
Overall dimensions of the passive/active neutron counter	422 x 486 x 286 cm (L x W x H)
Overall weight	approximately 8000 kg
Crate sizes	up to 1660 L (1.4 x 1.4 x 1.2 m)

SOFTWARE

- Multi-Group Analysis (MGA) software.

s Software

ADDITIONAL INFORMATION

The software converts the correct neutron coincidence rate to Pu-240 effective. The plutonium isotopic abundances are then calculated and used to convert the measured Pu-240 effective mass to a total plutonium mass.

REFERENCES

1. “The Design of a High Efficiency Neutron Counter (HENC) for Waste Drums to Provide Optimized Sensitivity for Plutonium Assay” H.O. Menlove, et.al., Proceedings of the 5th Nondestructive Assay and Nondestructive Examination Waste Characterization Conference”. Salt Lake City, UT, January 14-16, (1997).
2. “Q2 – A Very Low Level Quantitative And Qualitative Waste Assay And Release Certification”. F. Bronson, Proceedings of Waste Management ‘90, February 25-28, 1990, University of Arizona, Tucson, AZ.
3. http://www.canberra.com

Accounting (NDA): Waste Measurement System

204

Low-Level Waste Assay and Segregation System QED

MODEL: Model 3400-210, 3400-340C

SUPPLIER: **ANTECH, ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu, Th
PHYSICAL FORM(S) OF NM: Waste
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: ANTECH, ORTEC
MANUFACTURER: ANTECH, ORTEC

PURPOSE

This gamma ray system is designed for identifying, quantifying, and sorting low-level radioactive wastes.

DESCRIPTION

The drum is manually loaded with a conveyor and rotated on a platform inside the low background shield in order to average out matrix attenuation effects. For counting of 208 (340 – 340C model) liter drums, the HPGe detectors are installed in the "top", "middle" and "bottom" positions. A fourth intermediate position, with removable plug, is provided between the bottom and middle positions to facilitate the counting of smaller waste packages, for example cardboard boxes.
System allows correction for matrix material density and detection of inhomogeneity. Naturally occurring radioactive materials activities may be excluded from results.

COMPONENTS

- three HPGe coaxial detectors, 36 sq cm, length 40 mm (PROFILE GEM-F7040) or 54 sq cm, length 30 mm (PROFILE GEM-FX8530)
- ORTEC DSPEC jr 2.0
- X-COOLER II cryo-cooler
- conveyor or door (depending on model) mounted turntable
- moveable remote operator console (connected by Ethernet)

SPECIFICATIONS

Energy resolution	750 eV at 122 keV, 1.95 keV at 1.332 keV (GEM-F7040) at 14.4 keV, 650 eV at 122 keV, 1.90 keV at 1.332 keV (GEM-FX8530)
Measurement time	1 min.
Nominal relative efficiency	40% (GEM-F7040), 50% (GEM-FX8530)
Peak shape FWTM/FWHM typical	1.9
FWFM/FWHM typical	2.65 (GEM-F7040), 2.9 (GEM-FX8530)
Peak To Compton ratio	50:1 (GEM-F7040), 55:1 (GEM-FX8530)
Load cell capacity	up to 208 liter (55 gal.) or 340 liter (340C model) containers weighing up to 725 kg (1600 lbs)

Detection limits for a 55 gallon drum, with matrix densities as specified, in a 30 minute count according to the NUREG4.16 detection limit methodology:

GEM-F7040:

Nuclide	Energy keV	Detection Limit (pCi/g)				
		Matrix Density g/cc				
		0.1	0.2	0.3	0.8	1.8
CS-137	662	0.07	0.04	0.03	0.02	0.02
Th-232	911	0.23	0.13	0.10	0.06	0.05
Th-228	583	0.10	0.06	0.04	0.03	0.03
TH-234	93	3.04	2.03	1.47	0.79	0.68
U-235	185	0.14	0.09	0.06	0.05	0.04
U-238	1001	6.06	3.48	2.51	1.57	1.32
PU-239	414	4506	2737	2035	1483	1198

GEM-FX8530:

Nuclide	Energy keV	Detection Limit (pCi/g)

		Matrix Density g/cc				
		0.1	0.2	0.3	0.8	1.8
Cs-137	662	0.05	0.03	0.02	0.01	0.01
Th-232	911	0.17	0.10	0.08	0.04	0.04
Th-228	583	0.06	0.04	0.03	0.02	0.02
Th-234	93	1.60	1.07	0.77	0.41	0.36
U-235	185	0.07	0.05	0.03	0.03	0.02
U-238	1001	4.84	2.78	2.01	1.26	1.05
Pu-239	414	2575.11	1564.17	1162.64	847.22	684.49

SOFTWARE

ORTEC GammaVision-32,

ADDITIONAL INFORMATION

t communications

REFERENCES

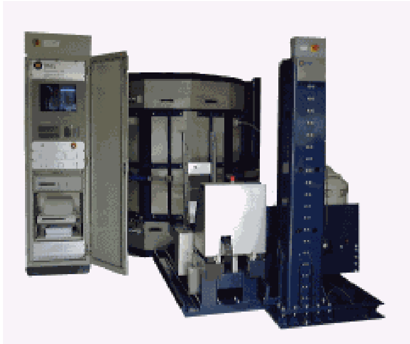
www.ortec-online.com

Accounting (NDA): Waste Measurement System

205

Combined Passive Neutron/Gamma Multiplicity Drum Monitor

MODEL: Series 2200



SUPPLIER:	**ANTECH, ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Waste Measurement System
METHOD:	Neutron/gamma multiplicity counting
MEASURED PROPERTIES:	Effective Isotope Mass
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	Waste
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH, ORTEC
MANUFACTURER:	ANTECH, ORTEC

PURPOSE

ANTECH Series 2200 Passive neutron Multiplicity Drum Monitor (nMDM) is a comprehensive measurement system for the determination of plutonium mass in intermediate/low level waste in 220 litre drums.

DESCRIPTION

The operation of the instrument is based on passive neutron coincidence/multiplicity counting. Windows NT software controls the semi-automatic drum loading, the neutron data acquisition and the analysis algorithms. The system can be integrated with a germanium gamma-ray drum scanner for Pu isotopic ratio determination using PC/FRAM or other isotopic analysis code. For pair correlation counting in neutron coincidence mode the frequency histogram is used to generate the 'Reals' rates for each of the 16 gates. Each 'Reals' rate can be used with a multi-gate calibration function to determine the Pu-240eff mass and hence the total Pu mass. For a wide range of Pu containing materials (PCM) such as PuO_2 and PCM with unitary neutron multiplication (M=1), triple neutron correlation may be used in absolute multiplicity counting mode. In these cases Pu-240eff mass and total Pu mass are determined without the use of a calibration function and the matrix characteristics are determined from the measured detection efficiency.

COMPONENTS

- neutron detection system - 64 He-3 detector tubes (16 rectangular polyethylene modules each with 4 tubes), 25.4 mm x 1.0 m at 4 Atm
- high voltage junction box:
  - Amptek charge sensitive amplifier/discriminator circuit
  - connections for high voltage, low voltage and signal cables
- outer polyethylene shield, 210 mm thick
- internal cadmium liner
- lead shielding (optional)
- ANTECH 1000 Series neutron Time Correlation Analyser (TCA) multiplicity counter

SPECIFICATIONS

```
Detector efficiency                                    20% (64 tubes)
Die-away time                                          68 ms
Sensitivity at sea level (estimation):
  multiplicity counting (n triple correlation)         50 - 100 mg Pu-240 eff (Cd fitted)
  coincidence counting (n pair correlation)            10 - 50 mg Pu-240 eff (Cd fitted)
Dimensions (L x W x H)                                 3.3 m x 1.8 m x 2.1 m
Operating Voltage                                      1600 V (4 Atm. He-3)
```

SOFTWARE

PC/FRAM

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com
www.antech-inc.com

Accounting (NDA): Waste Measurement System

206

Holdup Measurement System

MODEL: HMS4

SUPPLIER: **ORTEC**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Waste Measurement System
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM: Holdup
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: LANL, ORNL and the Y-12 National Security Complex
MANUFACTURER: ORTEC

PURPOSE

Designed for materials holdup measurements for uranium and plutonium in order to determine the changes in holdup inventories in process plants.

DESCRIPTION

The HMS4 holdup measurement system makes it all as easy as possible for the operator, who need carry only a small, lightweight mobile unit which guides the operation and automatically logs the data with unique coding. This nearly eliminates the expense of having to repeat a measurement due to a data entry error.
The mobile unit is set up ready to go at the base station. When the operator completes the measurements, the unit is returned to the base to download the data. The host computer maintains all history and current data in an easy-to-use database. All needed reports and QA are available there.

COMPONENTS

- NaI Detector
- Portable Multichannel Analyzer (supported types: ORTEC DART, MicroNOMAD, digiDART (recommended) or Rossendorf MCA-166
- Field Controller
- Host Computer

SPECIFICATIONS

Detector Resolution: <8% FWHM at 662 keV

SOFTWARE

HMS4-B32 Holdup Software written in Microsoft Visual Basic .NET that uses Microsoft Access (Microsoft Office 2000/XP e generated with the Crystal Reports report generator (Crystal Decisions, Inc.) The software for the Controller (Pocket PC devices) is written in Microsoft embedded Visual Basic as part of the Microsoft embedded Visual Tools v3.0® development package for Windows CE.

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Spectrometer

207

X-radiometric system of analysis of material element content and density of liquid technological mediums in flow

MODEL: РЦП-1

SUPPLIER:	**VNIITFA**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	X-ray spectrometry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	VNIITFA
MANUFACTURER:	VNIITFA

PURPOSE

Analyzer identifies and determines the content for more than 70 chemical elements in analyzed media: from calcium (Ca-20) to uranium (U-92).

DESCRIPTION

Analysis of elements of interest and their densities is base on radiometric method of analysis. Characteristic radiation of analyzed elements, background and scattering radiation are detected by silicon unit of detection which does not need cooling by liquid nitrogen.

The installation provides continues analysis of material composition and density in flow of liquid technological medium at enrichment and mine-metallurgic enterprises and color metallurgic enterprises without sampling and preparing samples.

COMPONENTS

SPECIFICATIONS

```
Resolution of the detector                    180-230 eV for Mn photopeak of 5.9 keV
Detector's error-free running time            no less than 1E+5 hours
Range of determined element contents          from 0.001 to 80%
Low limit of determined element contents      up to  nE-3 - nE-4
```

SOFTWARE

ADDITIONAL INFORMATION

RF Register, №24070-02

REFERENCES

http://www.vniitfa.ru

Accounting (NDA): Spectrometer

208

Analyzer of uranium mass concentration

MODEL: Сирень-Микро

SUPPLIER:	**TH-Automatica**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial, laboratory
DEVELOPER:	MSZ, JSC
MANUFACTURER:	MSZ, JSC

PURPOSE

The device is used for measurement of uranium mass concentration in technological solutions.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Ranges of measured uranium mass concentration in solutions, g/dm^3:

for nitric oxide solutions	0...200
for organic solutions	0...80

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.td-automatika.ru

Accounting (NDA): Spectrometer

209

Four-channel gamma-spectrometer. Analyzer of U-235 mass concentration

MODEL: Яеа

SUPPLIER:	**TH-Automatica**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Solution
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial
DEVELOPER:	MSZ, JSC
MANUFACTURER:	MSZ, JSC

PURPOSE

The device is created for automatic measurement of U-235 mass concentration in technological solutions for assurance of technological process conditions, for assurance of nuclear safety, and for MC&A applications.

DESCRIPTION

COMPONENTS

SPECIFICATIONS

Range of measured uranium mass concentration	0… 1.0 g/dm³
Error	0.5 g/dm³

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.td-automatika.ru

Accounting (NDA): Spectrometer

210

Portable Scintillation Gamma Spectrometer

MODEL: ГАММА-1С/NB1

SUPPLIER:	**Aspect**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, industrial, field
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

The spectrometer is intended to determine the isotope composition of radioactive materials, activity of radionuclides in packing sets, enrichment of uranium compounds in transport containers, gamma dose rate, as well as to carry out qualitative and quantitative analysis of various items for presence of gamma-emitting radionuclides under both laboratory and hard field conditions.

DESCRIPTION

Detection of gamma radiation, shaping and accumulation of spectra are performed in scintillation detection unit of УДС-ГЦА type made in form of cylindrical monoblock and powered from built-in batteries. УДС-ГЦА communicates with computer via serial wire (RS-485 or RS-232) or wireless (radiochannel type - Bluetooth, operating distance - no less than 10 m) channel. Notebook type computer processes the spectrometric information with «SpectraLineHandy» program.

COMPONENTS

- УДС-ГЦА-40x40-RS-BT1 self-contained digital scintillation detecting unit (on the base of 40x40 NaI(Tl) crystal) or УДС-ГЦА-B380-38x38-RS-BT1 self-contained digital scintillation detecting unit (on the base of 38x38 LaBr3(Ce)) with processor of digital signal processing, built-in system of stabilization and temperature compensation by the reference peak of the light-emitting diode
- NoteBook type computer with installed «SpectraLineHandy» software package for Windows
- Collimator with the holder for detector transaportation
- Holder for detecting unit
- Calibration source with the holder (supplied on request)
- Case

SPECIFICATIONS

Gamma radiation measurement range	from 0.05 to 3.0 (or 2.0) MeV
Energy resolution at 662 keV (Cs-137):	
for УДС-ГЦА-40x40-RS-BT1	no more than 8.0 %
for УДС-ГЦА-B380-38x38-RS-BT1	no more than 3.5 %
Integral nonlinearity	± 1 %
Number of spectrometer channels	1024
Maximal input statistical load	no less than 1.5x10^5 cps
Activity measurement range for Cs-137	from 8 to 10^5 Bq
Allowable limits of relative basic error of activity measurement P=0.95)	±(10–50)%
Gamma dose rate measurement range	from 0.1 to 100 µZv/h
Instability of conversion characteristic for 24 hours of continuous operation (time instability)	no more than 1 %
Operating temperature range	from –20 to +50 ˚C
Overall size (mm, no more than):	
Detecting unit	Ø79x376
Collimator assembly	146x250x215
Holder	height - 1.3 m
Case	470x355x170
Weight (kg, no more than):	
Detecting unit	1.6
Collimator assembly	12
Holder	2
Case	1

SOFTWARE

«SpectraLineHandy» software allows for:

ADDITIONAL INFORMATION ers, control of data collection in acquisition modes "unrestricted", with real and life time exposure, as well as consecutive measuremenets together with single measurements by predefined algorithm;

- energy, FWHM, peak shape calibrations, detection efficiency calibration, and approximation "curves" calculation;
- determination of gamma emitting radionuclides' isotopic composition, measured sample activity calculation by different methods;
- determine the activity of open sources in given geometry, packing sets (transport containers), the specific activity in distant objects;
- store the spectra and measurement results in database.

REFERENCES

www.aspect.dubna.ru

Accounting (NDA): Spectrometer

211

Stationary spectrometric complex

MODEL: СКС-07(09)П-Г-Р

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

Spectrometric complex СКС-07П(09)П_Г_Р is created for measurement of activity of samples using gamma and X-ray radiation, for evaluation of uranium enrichment and plutonium isotopic composition.

DESCRIPTION

Spectrometric complex allows for measuring uranium and plutonium in non-point geometry, for automatic processing measurement results, for outputting and storage of information in friendly form for user.

COMPONENTS

- Measurement system with detection unit;
- Processor of pulse signals SBS, installed into personal computer;
- software;
- set of implements;
- documentation.

SPECIFICATIONS

Energy resolution for gamma-line of 1332.5 keV	from 1.7 to 2.4 keV
Energy region of measured radiation	from 3 to 3000 keV
Limit of permissible main error of transformation characteristic	no more than 0.05 %
Maximum input statistical load	no more than 2E+5 pps for t=1 µs

SOFTWARE

ADDITIONAL INFORMATION

Put in the RF Register

REFERENCES

http://www.greenstar.ru/

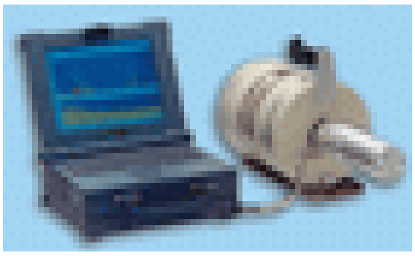
Accounting (NDA): Spectrometer

212

Portable spectrometer

MODEL: СКС-07(09)П-Г(М)

SUPPLIER: **Green Star**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Spectrometer
METHOD: Gamma



MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu, Impurities
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, industrial
DEVELOPER: Green Star
MANUFACTURER: Green Star

PURPOSE

DESCRIPTION

Space saver portable spectrometric complex is realized based on processors of pulse signals of SBS family, installed into personal computer like Notebook.
The complex is made in usual and industry performance (operation temperature: -20... +40 ˚C, resistance to vibrations, impacts, moisture, dust).
Portable spectrometric complexes СКС-07П are equipped by scintillation detectors based on NaI and CsI crystals of any sizes and configurations.
Portable spectrometric complexes СКС-07П are equipped by hand-held semiconductor detectors made from HPGe produced by firms EG&G ORTEC (USA) and CANBERRA (USA)

COMPONENTS

SPECIFICATIONS

SOFTWARE

Complexes are equipped by software responsible for controlling all spectrometer function and parameters, and for processing … calculate specific volume, mass, and surface activities of radionuclides and dose rate of every one of them for more frequent configurations. Complexes measure uranium enrichment, plutonium isotopic composition, activities of nuclides in transport containers and other.

ADDITIONAL INFORMATION

Put in the RF Register

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Spectrometer

213

Universal portable spectrometric complex "Kolibry"

MODEL: СКС-08П

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Laboratory, Industrial
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

The Spectrometer is created for measurement for special tasks such as determination of uranium enrichment, pollution of areas, hold-up in equipment, dose loads and other, which do not demand database supporting and complex algorithms of processing in situ.

DESCRIPTION

The spectrometer is issued in two main modifications:

N - (lite) – for working with scintillation detectors tapped on one or two hard-wire scheme;
T - (universal) - for working with any types of detectors.

COMPONENTS

- spectrometric system (amplifier, analogue-digital converter)
- calculator
- graphical unit of displaying information
- keyboard
- power supply for preamplifier

SPECIFICATIONS

Gain constant of amplifier	rogrammable from 2 to 512, roughly - 8 steps on 6 Db, smooth - 1024 values in limits of 6 Db
Time constant of formation	1 µs (for T modification)
Number of channels	2048, 1024, 512, 256, 1024, 4096 and 8192 should be pointed in order
Integral non-linearity	< 0.05 %
Time of continuous work from built-in accumulators	> 24 hours without accounting of detector consumption
Mass	473 grams
Working temperature span	from -20°C to +40° C

SOFTWARE

ADDITIONAL INFORMATION

Put in the RF Register

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Spectrometer

214

Specialized spectrometric complexes SKS: Kolibry

MODEL: KC-004

SUPPLIER:	**Green Star**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, Industrial
DEVELOPER:	Green Star
MANUFACTURER:	Green Star

PURPOSE

The Spectrometer is created for measurement for special tasks such as determination of uranium enrichment, pollution of areas, hold-up in equipment, dose loads and other, which do not demand database supporting and complex algorithms of processing in situ.

DESCRIPTION

Specialized spectrometric complex CKC is a version of "Kolibry" processor of pulse signals for embedded applications.
The device differs from basic construction of KC-003 by absence of display, keyboard and accumulators.
Processor has a power supply of constant voltage of 9 – 18 V. On additional order Current generator 0,2 – 0,9 A can be installed for power supplying coolers based of Peltie effect; DL shaper for work with high loads; other devices.

COMPONENTS

SPECIFICATIONS

Gain constant of amplifier	programmable from 2 to 512, roughly - 8 steps on 6 Db, smooth - 1024 values in limits of 6 Db
Number of channels	2048, 1024, 512, 256, 1024, 4096 and 8192 should be pointed in order
Integral non-linearity	< 0.05 %
Differential non-linearity	< 0.5 %
Connection interface to computer	RS232
Working temperature span	from -20 ˚C to 40 ˚C

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.greenstar.ru/

Accounting (NDA): Spectrometer

215

Basic radiometer spectrometric for measurement in-situ

MODEL: РПГ- 09П "КУПОЛ"

SUPPLIER:	**SNIIP - Automatics**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu, Impurities
PHYSICAL FORM(S) OF NM:	
STATUS:	Limited Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Laboratory, Industrial
DEVELOPER:	SNIIP - Automatics
MANUFACTURER:	SNIIP - Automatics

PURPOSE

The device is created for detection, identification, quality and quantity material analysis, dissymmetric situation control by detection of gamma-radiation and processing information using device algorithms.

DESCRIPTION

The device can be used by control services of custom, boarders, radiation and ecology control services, at enterprises on production of fissile materials, for inspection purposes and other areas for field measurements.

COMPONENTS

SPECIFICATIONS

Channel number	256/1024
Region of detecting gamma-radiation energy, keV	from 30 to 3000
Region of detecting counting rate from background, pulses/second	to 30000
Integral non-linearity, %	no more than 1
Time without charge of accumulators	24 hours
Mass (with accumulator and detection unit (crystal of 25x25 mm), kg	no more than 0.9
Temperature region (in dependence on display),°C	-10 ...+50

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://sniip-automat.narod.ru/

Accounting (NDA): Spectrometer

216

Portable analyzer of nuclear materials based on CdTe detector

MODEL: CTSS-1

SUPPLIER: **PNPI**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Spectrometer
METHOD: Gamma

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu, Impurities
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, Industrial
DEVELOPER: PNPI
MANUFACTURER: PNPI

PURPOSE

The system CTSS-1 is created for converting quant of X-ray and gamma-ray to electrical signals of proportional amplitude for determination of material element content.

DESCRIPTION

The device is used by inspectors of IAEA. The system can be used in industry and laboratory conditions.

COMPONENTS

SPECIFICATIONS

SOFTWARE

Software AN-MCA was created for spectra processing, working under Windows-95/98, NT. The program can analyze main centroids of peaks, energy resolution (on half of peak amplitude and on tenth of peak amplitude), as well as to perform other calculations including statistical processing. The software separates three ranges of interest (ROI).

ADDITIONAL INFORMATION

REFERENCES

http://www.gatchina.biz/pnpi

Accounting (NDA): Spectrometer

217

Segmented Gamma Scanner

MODEL: Model 3200-320

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

Model 3200-320 is designed for the non-destructive assay of up to 200 litre drums and 200 litre drums contained in a 320 litre (85 gal) overpack drum containing gamma-ray emitting nuclear waste. It is relevant to waste in a variety of matrices and chemical forms.
Versions available for cans and up to 400 litre drums.

DESCRIPTION

The method involves rotating the drum or sample while scanning a vertical segment and it is applicable to waste where the chemical form and the relationship between the nuclide and matrix may be unknown. The method provides a vertical profile of gamma-ray transmission through the drum and nuclide concentration within the waste drum. The measurement procedure is highly automated and requires little operator interaction.
The assay method for the nuclides of interest is accomplished by measuring the intensity of a characteristic gamma-ray from each nuclide. The intensity of the characteristic gamma-ray is corrected for count rate losses and attenuation in the sample. The relationship between the observed gamma-ray intensity and nuclide content is obtained by comparison to similarly corrected gamma-ray intensities observed during the gamma-ray measurement of known mass calibration standards.
The drum is rotated about its vertical axis and simultaneously scanned, segment by segment along the vertical axis. This method of scanning reduces the effects of nonuniformity in density and nuclide distribution. Corrections are made for count dependent losses from pulse pile-up and analyser dead time, as these are monitored during the measurement process. The system will operate in either one or two pass mode, as specified by the operator.
For each linear segment of the drum the average linear attenuation coefficient is calculated by measuring the transmitted intensity of an external gamma-ray transmission source. The source is mounted directly opposite the gamma-ray detector on the far side of the drum.

COMPONENTS

- germanium Coax detector
- transmission sources
- digital MCA based on the ORTEC DSPec Junior
- replaceable collimator
- mobile operator control console

SPECIFICATIONS

Measurement time	less than 15-30 minutes
Detector efficiency	20%
Sample size	variable to a maximum of 320 L
Overall instrument size	1835mm long, 1512mm wide, 1785mm high

SOFTWARE

MasterScan SGS analysis software complies with Standard Test Method for Nondestructive Assay by Segmented Passive

ADDITIONAL INFORMATION

rd No.C1133. Software runs under Windows NT4.

REFERENCES

www.antech-inc.com

Accounting (NDA): Spectrometer

218

Universal Gamma Scanner

MODEL: Series 3610

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Laboratory
DEVELOPER:	LANL
MANUFACTURER:	ANTECH Corporation

PURPOSE

The Universal Gamma Scanner(UGS) determines the inventory of U, Pu, and other radio-nuclides in non homogeneous samples including pyrochemical salt residues. It can measure the samples with Am-241 content which cannot be measured by neutron techniques and is suitable for measuring Pu Oxide in cans.

DESCRIPTION

The Universal Gamma Scanner(UGS) for cans combines the functions of Pu isotopic ratio analysis and Tomographic Gamma Scanner (TGS) in a single automated mobile instrument. The instrument can be used for combined or separate measurements and is intended for use in Safeguards and for waste assay.
Isotopic ratio analysis of Pu is performed using PC/FRAM code developed at the Los Alamos National Laboratory (LANL). An 8k channel spectrum is obtained during the TGS scans and this data is used to obtain the isotopic ratios, including the ratio of U, Am and other radionuclides to Pu. The isotopic ratio result data can be used for safeguards or accountancy purposes or combined with either Pu-240 effective data (from neutron measurements) or specific power data (from calorimetry measurements) to determine total Pu mass.
The second measurement component of the instrument is the transportable Tomographic Gamma Scanner (TGS) which uses transmission corrected, single photon emission computerised axial tomography to determine the spatial distribution and quantity of radio-nuclides using High Resolution Gamma-ray Spectroscopy (HRGS).
A Se-75 transmission source allows the determination of a 3-D spatial map of the attenuation coefficient at any energy by interpolating between the gamma-ray peaks of Se-75 at several energies. Once the attenuation coefficient maps have been established for the sample, emission tomography is used to determine the distribution of selected radioisotopes within the sample. Two pass (transmission followed by emission) measurements are performed.

COMPONENTS

- germanium coax detector
- digital MCA based on the ORTEC DSPec Plus
- 30-200,Ci Se-75 transmission source
- Cd-109 dead time source
- mobile operator control console
- trolley

SPECIFICATIONS

Detector efficiency	25%
TGS analysis	typically 4800 4k channel spectra for each measurement
Isotopic Analysis	one 8k channel emission spectrum
Measurement time	less than one hour.
Accuracy	better than 10% for measurement of cans and 20% for matrices with average density 2 g/cm³
Overall size	1520 mm long, 710 mm wide and 1070 mm high
Maximum sample size	200 mm diameter x 350 mm (8”x 14”) and 20 kg in weight

SOFTWARE

User friendly software rune under windows NT4 and meets Nuclear software QA requirements of NQA-1 (required by WIPP

ADDITIONAL INFORMATION

PC/FRAM code (LANL) is used for Pu isotopic ratio analysis.

REFERENCES

www.antech-inc.com

Accounting (NDA): Spectrometer

219

Uranium Enrichment Meter

MODEL: IMCA

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Laboratory, field
DEVELOPER:	LANL
MANUFACTURER:	Canberra

PURPOSE

The IMCA (InSpector Multichannel Analyzer) is a portable gamma-ray spectrometric system designed to measure the enrichment of uranium using the uranium enrichment meter method. Both NaI and HPGe low energy detectors can be used. The IMCA is designed to be operated by safeguards inspectors outside the laboratory environment.
Methodology was developed by LANL.

DESCRIPTION

The underlying method is based on detecting and processing the gamma radiation spectra in 185 keV region. Unlike the multi-group method the method of enrichment meter is uncritical to detector energy resolution and so the system on its base can work with any spectrometric detector.
The InSpector is modified to accept 1- or 2- microsecond shaping times and accepts a signal from a thermistor from an optional Am-241-seeded NaI detector. The spectra are automatically acquired, stored, and analyzed with special uranium enrichment software. The enrichment software is integrated with dedicated, application specific measurement and analysis procedures. The IMCA supports both high and low resolution system requirements operating from the same software by allowing quick changes between NaI or LEGe detector types.
It offers support of any number of sodium iodide or germanium detectors in a variety of configurations between any number of IMCAs. The rapid exchange and setup of different detectors is quick and easy between individual IMCA units and detectors. Widely differing calibration and sample types are supported.
Reliable operation under conditions affecting NaI detector performance (age of NaI crystal, temperature drifts) is provided regardless of the presence of enriched uranium. There is minimal operator interaction; personnel with varying degrees of training and experience can easily use the measurement system; it has built-in performance monitoring; it is designed to monitor and troubleshoot the systems performance after actual use.

COMPONENTS

- modified Canberra InSpector Multichannel Analyzer (portable MCA with digital signal processor InSpector-2000)
- notebook computer
- NaI or a LeGE detector (CdTe is also possible with latest version)
- special application software.

An IMCA/NaI system is known as the PMCN (Portable Multichannel Analyzer with NaI Detector) whereas an IMCA/LEGe detector is known as the PMCG (Portable Multichannel Analyzer with a Ge Detector).

SPECIFICATIONS

Operating temperature	from -10 to +50 ˚C
Max. container wall thickness	15 cm
Weight	3.2 kg (including batteries)
Notebook computer weight	1.5 to 3 kg

SOFTWARE

The specially designed IMCA InSpector counting procedure software combines all of the separate features of the system into a

ADDITIONAL INFORMATION sive and simple to operate. It is based on the Genie-PC software environment using the custom tools to create a fully interactive and proceduralized, graphical user interface.

REFERENCES

1) http://www.canberra.com
2) G.H. Gardner, M. Koskelo, R.L. Mayer II, B.R. McGinnis, M. Moeslinger, B. Wishard, “The IMCA: A Field Instrument for Uranium Enrichment Measurements”, presented at the 37th Annual INNM Meeting, Naples Florida, U.S.A., July, 1996.

Accounting (NDA): Spectrometer

220

U-Pu InSpector

MODEL: U-Pu InSpector

SUPPLIER: **Canberra**
USE CATEGORY: Accounting (NDA)
DEVICE/METHOD TYPE: Spectrometer
METHOD: Gamma spectrometry

MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Portable
ENVIRONMENT OF USE: Laboratory, field
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The U-Pu InSpector is a portable instrument that can measure the isotopic composition of samples containing uranium and/or plutonium.

DESCRIPTION

To determine the isotopic composition of uranium, plutonium and mixed samples the system uses the results of processing the gamma and X-ray sample spectra in region of 80-120 keV obtained with special high resolution germanium detector by multi-group method.
The spectra are automatically acquired, analyzed and stored with the help of MGA software which has been integrated with dedicated, application specific measurement and analysis procedures.
This shield reduces the intensity of the background gamma rays in the important 100 keV region by 23 orders of magnitude. At 200 keV, the attenuation is still four orders of magnitude.

COMPONENTS

- shielded Low Energy Germanium (LEGe) detector
- Multi-Attitude Cryostat (MAC)
- portable spectroscopic station on the base of InSpector-2000 portable MCA with digital signal processor
- notebook computer
- Multi-Group Analysis (MGA, MGA-U) Software
- rugged metal carrying case
- collimator insert

SPECIFICATIONS

Energy region	84 keV to 130 keV (for uranium)
	below 210 keV (for plutonium)
Detector active surface area	5 cm²
Resolution (FWHM) at 122 keV	(550-600 eV) at rates up to 50,000 counts per second
Measurement time	few minutes
Accuracy	within 1%
Weight	3.2 kg (including batteries)

SOFTWARE

The specially designed U-Pu InSpector Software (Model S535) includes MGA-U and MGA Software packages.

ADDITIONAL INFORMATION

r plutonium (MGA) has been developed by Ray Gunnik to analyze plutonium gamma ray spectra to accurately determine the relative abundances of plutonium and other actinides in a sample. It requires only energy calibration and can be used to measure virtually any size and type of plutonium sample. The masses of other actinides in the sample, like Am-241, Np-237 and U-235 are given relative to the total plutonium mass. MGA also calculates the total uranium to plutonium (tot U/Pu) ratio. It is based on Canberra's Genie-PC software environment which offers extensive customization.
MGA-U program has been developed to measure the uranium isotopic composition. It also doesn't require efficiency calibration and can provide the measurement result accuracy of 1-2% for few minutes.
Software operates under Windows 95, Windows NT, and OS/2 operating systems.

Minimal computer configuration: 80486 processor, 10 MB (16 MB is recommended) RAM, 200 MB hard drive.

REFERENCES

1. R. Gunnink: MGA: A Gamma-Ray Spectrum Analysis code for Determining Plutonium Isotopic Abundances. LLNL report: UCRL-LR-103220, April 1990.
2. R. Gunnink, W. Ruhter, P. Miller, J. Goerten, M. Swinhoe, H. Wagner, J. Verplancke, M. Bickel, S. Abousahl: MGAU: A New Analysis Code for Measuring U-235 Enrichments in Arbitrary Samples. IAEA Symposium on International Safeguards, Vienna, Austria, March 8-14, 1994.
3. http://www.canberra.com

Accounting (NDA): Spectrometer

221

In Situ Object Counting System

MODEL: ISOCS

SUPPLIER:	**Canberra**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Field
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

ISOCS system cab be used for following applications in MC&A area:
- determination of isotopic composition and activity of containers, drums, bags, and other objects' content without opening. Leakage measurement;
- measurement of gamma radiating nuclides activity and determination their isotopic composition within pipelines, tanks and other process equipment without opening;
- quantitative determination of residual activity on holdups difficult for sampling.

DESCRIPTION

System measures activity of gamma radiating nulcides of different sizes and shapes.
All measurements can be performed in-situ in real time mode, that allows to resign traditional technique including sampling, transporting the samples and measuring samples in laboratory. In addition, ISOCS system may also be used as laboratory gamma spectrometer for measuring activity of gamma radiation sources both in point and volume sources.

COMPONENTS

Typical system includes:
- coaxial germanium detector in portable multiposition cryostat MAC,
- tripod with collimators and laser target designator ISOXSHLD,
- portable analyzer InSpector-2000
- notebook

SPECIFICATIONS

`Detector efficiency: 40 to 65 %`

SOFTWARE

System is supplied with Genie-2000 software and programs for calculation detector calibrations by efficiency complex

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Accounting (NDA): Spectrometer

222

Advanced Digital Gamma-Ray Spectrometer for HPGe Detector Systems

MODEL: DSPEC Pro, DSPEC jr 2.0, DSPEC PLUS

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

The measurement of Special Nuclear Materials (SNM) at high count rates.
DSPEC is used in high-rate spectroscopy applications (for example, measurement of not stationary samples (e.g., flowing through a pipe), for samples in motion (examples of such applications include aerial and land-based surveying and portal monitoring). Combined with high performance list mode, the DSPEC Pro is the instrument of choice for mobile vehicle survey systems.

DESCRIPTION

Spectrometers integrate ZDT™ "loss-free counting" correction and Low Frequency Rejector (LFR) technology (DSPEC Pro, jr 2.0)

COMPONENTS

DSPEC Pro, jr 2.0:
- Detector Interface Module (DIM)
- built in support for SMART-1 HPGe detectors
- TTL port for support of sample changer systems
- 240 x 160 pixel backlit LCD
- internal battery

SPECIFICATIONS

Accuracy	area of reference peak changes <±3% from 0 to 50,000 counts per second
Integral nonlinearity	<±0.025%
Differential nonlinearity	<±1%
Maximum system throughtput	>100,000 cps
Dimensions:	
DSPEC Pro, jr 2.0	8.1 H x 20.3 W x 24.9 D cm (3.2 H x 8 W x 9.8 D in.)
DIM	11.2 x 3.13 x 6.5 W cm (4.4 x 1.25 x 2.6 W in.)
DSPEC PLUS	32.5 cm W x 34.8 cm D x 14.5 cm H (12.80 in. W x 13.70 in. D x 5.70 in. H)
Weight:	
DSPEC Pro, jr 2.0	1.0 kg (2.2 lb)
DIM	<240 g (0.5 lb)
DSPEC PLUS	7.7 kg (17 lbs)
Operating Temperature Range	0 to 50°C

SOFTWARE

- ORTEC CONNECTIONS-32 (built in DSPEC PLUS) software supports up to 127 USB-connected devices per computer.

ADDITIONAL INFORMATION

- GammaVision-32

REFERENCES

www.ortec-online.com

Accounting (NDA): Spectrometer

223

Battery Powered Portable HPGe Gamma Spectrometer

MODEL: trans-SPEC, trans-SPEC-100

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Field
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Spectrometer can be used for nuclear materials hold-up measurements, nuclear safeguards inspections, in-situ waste assay measurements.

DESCRIPTION

COMPONENTS

- HPGe detector is a P-type ("ORTEC GEM") crystal of dimensions 50 mm x 30 mm or P-type crystal of dimensions 65 mm diameter x 50 mm length (100 model);
- Hymatic SAX101-002 high reliability, low power Stirling Cooler (>50,000 hours lifetime. Dual piston, 1 W nominal lift at 100° Kelvin):
- active digital noise reduction filter (LFR);
- built-in 240 x 160 pixel LCD display;
- numeric keypad.

SPECIFICATIONS

Memory storage	>90 4k spectra in internal memory
Power source	internal battery (>3 hours), supplemental external battery, automobile battery (any 12 V dc), line power; all with automatic switchover
Detector dimensions:	
trans-SPEC	50 mm diameter x 30 mm deep nominal
trans-SPEC-100	65 mm diameter x 50 mm deep nominal
Relative Efficiency	15% typical (trans-SPEC) or >40% typical (trans-SPEC-100)
Resolution	≤1450 eV @ 122 keV and ≤2.15 keV @ 1332 keV (trans-SPEC) ≤1600 eV @ 122 keV and ≤2.3 keV @ 1332 keV (trans-SPEC-100)
Peak Shape	≤1.9 typical (FWTM/FWHM)
Integral nonlinearity	<±0.025% over top 99.5% of spectrum, measured with a mixed source
Differential nonlinearity	<±1%
Maximum Overall Dimensions (including handle, Ge detector endcap and shock absorbers) :	
trans-SPEC	37.3 cm L x 16 cm W x 32 cm H (14.7" L x 6.3" W x 12.6" H)
trans-SPEC-100	39.4 cm L x 16.3 cm W x 32 cm H(15.5" L x 6.55" W x 12.6" H)
Weight:	
trans-SPEC	22.9 lb (10.39 kg)
trans-SPEC-100	23.3 lb (10.65 kg)
Internal battery life	>3 hours at 25°C with a cold detector on fully charged internal battery
Input power	10-17 V dc 30 Watt or via auto-sensing Mains powered Battery Charger
Temperature operation range	-15°C to +50°C
Relative humidity	<90% at 35°C, noncondensing
Communications ports	USB 1.1 connection provided at the rear panel, protected by dust cover

SOFTWARE

MAESTRO-32

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (NDA): Spectrometer

224

Gamma Gage II Portable HPGe Gamma Ray Spectrometer

MODEL: Gamma Gage II

SUPPLIER:	**ORTEC**
USE CATEGORY:	Accounting (NDA)
DEVICE/METHOD TYPE:	Spectrometer
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Holdup
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Gamma Gage II is intended for nuclear materials holdup, and portable safeguards isotopic ratio measurements as well waste assay and site characterization measurements.

DESCRIPTION

Portable HPGe Gamma-Ray Spectrometer with Integral LN2 Dewar is available in all-attitude and compact multi-orientation dewar types. It is available for all GEM, GMX, SLP or GLP detectors.

COMPONENTS

SPECIFICATIONS

Standard holding times	in the range 1-5 days
Weight	<11 lbs for 24-hour holding time version

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.ortec-online.com

Accounting (Reference Material): Certified Reference Material

225

Uranium Isotope Certified Reference Materials

MODEL:

SUPPLIER:	**UEIP**
USE CATEGORY:	Accounting (Reference Material)
DEVICE/METHOD TYPE:	Certified Reference Material
METHOD:	Analytical Chemistry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Uranium Hexafluoride, Uran-uranic oxide powder
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	UEIP
MANUFACTURER:	UEIP

PURPOSE

Uranium Isotopic Certified Reference Materials (CRMs) are used for:
- precise and crucial measurements of uranium isotope content by comparative methods;
- checking uranium isotopic measurement accuracy;
- calibrating and testing of uranium isotope measuring apparatus.

Precision of Uranium Isotope CRMs ensures both the needs of enrichment technological process and product isotopic contents control at the international specification levels.

DESCRIPTION

These CRMs are certified by special spectrometric methods, using several precise mass spectrometers and calibration mixtures made from pure uranium isotopes.
Each CRM is characterized by its relative content of uranium isotopes U-234, U-235, U-236, and U-238. An additional characteristic is the U-235/U-238 ratio. Certified values are given in the Catalog [1].
Uranium Isotopic CRMs are available in the form of uranium hexafluoride as well as in the form of uran-uranic oxide.
Uranium hexafluoride CRMs are distributed in metallic sample containers (nominal uranium content is 10 grams), and oxide CRMs (uranium content of each is 1 gram) are supplied in little glass flasks placed in safety shipping containers.
High purity Uranium Isotopes (e.g. U-235 of 99.99 % purity, U-238 of 99.999 % purity) produced at the UEIP are used for fabricating Uranium Isotopic CRMs.

COMPONENTS

SPECIFICATIONS

```
Number of types of Uranium Isotope CRMs       110
Purity of CRMs isotopic components for:
                                 U-235        99.99%
                                 U-238        99.9999%
Range of U-235 contents in CRMs               from 0.000011 to 99.9947 Atom %
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Uranium Isotope Certified Reference Materials. Catalog. Ural Electrochemical Integrated Plant. Russian Federation Ministry of Atomic Energy. 1997.

Accounting (Reference Material): Certified Reference Material

226

NBL CRM 111-A Uranium-233 in Nitrate

MODEL:

SUPPLIER: **NBL**
USE CATEGORY: Accounting (Reference Material)
DEVICE/METHOD TYPE: Certified Reference Material
METHOD: Analytical Chemistry
MEASURED PROPERTIES: Isotopic Composition
NUCLEAR MATERIAL(S): U
PHYSICAL FORM(S) OF NM: Solution
STATUS:
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: NBL
MANUFACTURER: NBL

PURPOSE

DESCRIPTION

Date of certificate: January, 1990. (NOTE: This CRM contains Special Nuclear Material. Buyers must hold a valid US NRC License or qualify under a current US DOE contract.)

COMPONENTS

5 milligrams of uranium dissolved in 10 g of 0.8 N nitric acid and sealed in a glass ampoule.

SPECIFICATIONS

```
Properties Certified:
   Uranium concentration              2.06684 ± 0.00052 moles U/gram solution
   Isotopic abundance:
                U-233                 99.4911 ± 0.0006 At%
                U-234                 0.1847 ± 0.0002 At%
                U-235                 0.0790 ± 0.0002 At%
                U-236                 0.0166 ± 0.0002 At%
                U-238                 0.2286 ± 0.0004 At%
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Accounting (Reference Material): Certified Reference Material

227

NBL CRM 129 Uranium Oxide (U3O8) Assay Standard

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (Reference Material)
DEVICE/METHOD TYPE:	Certified Reference Material
METHOD:	Analytical Chemistry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Powder
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

DESCRIPTION

This CRM was originally issued in 1978 by the National Bureau of Standards (NBS) as Standard Reference Material (SRM) 950b. Date of certificate: October, 1987 (Revision of NBS Certificate dated March, 1978)

COMPONENTS

Approximately 22 grams of normal uranium oxide (U3O8) powder packed in a glass bottle

SPECIFICATIONS

```
Property certified:
            U3O8                99.968 ± 0.018 Wt%
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Accounting (Reference Material): Certified Reference Material

228

NBL CRM 112-A Uranium Metal Assay Standard

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (Reference Material)
DEVICE/METHOD TYPE:	Certified Reference Material
METHOD:	Analytical Chemistry
MEASURED PROPERTIES:	Element Concentration
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Metal
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

DESCRIPTION

This CRM was originally issued in 1972 by the National Bureau of Standards (NBS) as Standard Reference Material (SRM) 960. Date of certificate: October, 1987 (Revision of NBS Certificate dated May, 1972).

COMPONENTS

26 grams of normal uranium, as a single metal rod, sealed in a plastic bag and stored in a plastic case.

SPECIFICATIONS

```
Properties certified:
       Uranium (etched metal basis)             99.975 ± 0.006 Wt%
       Relative Atomic Weight                   238.0289
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Accounting (Reference Material): Certified Reference Material

229

NBL CRM 126 Plutonium Metal

MODEL:

SUPPLIER: **NBL**
USE CATEGORY: Accounting (Reference Material)
DEVICE/METHOD TYPE: Certified Reference Material
METHOD: Analytical Chemistry
MEASURED PROPERTIES: Element Concentration, Isotopic Composition
NUCLEAR MATERIAL(S): Pu, Pu-239
PHYSICAL FORM(S) OF NM: Metal
STATUS:
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: NBL
MANUFACTURER: NBL

PURPOSE

DESCRIPTION

Date of certificate: January, 1986. (NOTE: This CRM contains Special Nuclear Material. Buyers must hold a valid US NRC License or qualify under a current US DOE contract.)

COMPONENTS

Single piece of solid Pu metal weighing 1 gram, sealed in a glass tube under a reduced-pressure argon atmosphere.

SPECIFICATIONS

```
Properties certified (for Oct.1, 1985):
       Pu Assay                                 99.962 ± 0.018 Wt%
       Pu-239                                   97.925 ± 0.001 At%
       Relative Atomic Weight                   239.073
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Accounting (Reference Material): Certified Reference Material

230

NBL CRM 116 Uranium (Enriched) Metal

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (Reference Material)
DEVICE/METHOD TYPE:	Certified Reference Material
METHOD:	Analytical Chemistry
MEASURED PROPERTIES:	Element Concentration, Isotopic Composition
NUCLEAR MATERIAL(S):	U
PHYSICAL FORM(S) OF NM:	Metal
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

DESCRIPTION

Date of certificate: June, 1978. (NOTE: This CRM contains Special Nuclear Material. Buyers must hold a valid US NRC License or qualify under a current US DOE contract.)

COMPONENTS

1.5 grams of enriched uranium metal. Primary packaging is a polyethylene sample vial contained in a secondary cardboard cylinder with metal bottom and metal screw cap.

SPECIFICATIONS

```
Properties certified:
     Uranium (etched metal basis)                  99.967 ± 0.006 Wt%
     U-235                                         93.121 ± 0.004 Wt%
                                                   93.183 ± 0.004 At%
     Relative Atomic Weight                        235.201
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Accounting (Reference Material): Certified Reference Material

231

NBL CRM 128 Pu-239/Pu-242, 1:1 Atom Ratio

MODEL:

SUPPLIER:	**NBL**
USE CATEGORY:	Accounting (Reference Material)
DEVICE/METHOD TYPE:	Certified Reference Material
METHOD:	Analytical Chemistry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	Pu, Pu-239, Pu-242
PHYSICAL FORM(S) OF NM:	Solids
STATUS:	
PORTABILITY:	
ENVIRONMENT OF USE:	
DEVELOPER:	NBL
MANUFACTURER:	NBL

PURPOSE

DESCRIPTION

This CRM was prepared using plutonium materials obtained from the Oak Ridge National Laboratory Isotope Sales Group with the approval of the DOE Research Materials/Transplutonium Program Committee.
Date of certificate: October, 1985. (NOTE: This CRM contains Special Nuclear Material. Buyers must hold a valid US NRC License or qualify under a current US DOE contract.)

COMPONENTS

Approximately 1 milligram of a nominal 1:1 mixture of Pu-239 and Pu-242, as evaporated plutonium nitrate (solid) contained in a Teflon bottle. The packaging is designed for in-situ dissolution by the user.

SPECIFICATIONS

```
Properties certified:
    Pu-239/Pu-242 Atom Ratio                    0.9993 ± 0.0002 as of October 1, 1984.
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. NBL Certified Reference Materials Catalog, New Brunswick Laboratory, January 1998.

Containment and Surveillance: Portal Monitor

232

Installations of radiation control

MODEL: РИГ-08П

SUPPLIER: **SNIIP - Konvel**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Portal Monitor
METHOD: Gamma
MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: SNIIP - Konvel
MANUFACTURER: SNIIP - Konvel

PURPOSE

Installations of radiation control РИГ-08М are created for continuous monitoring level of radiation background and signaling when there is excess of relative value of radiation background over specific threshold.

DESCRIPTION

Installation can be used for controlling radiation situation indoors and outdoors. .Level of radiation background of photon ionizing radiation is controlled using value of measured effective dose rate.
Installation can be used for detection of radioactive pollution of clothes and cargos at nuclear heating plants and radiation-dangerous object, as well as for detection of non-authorized moving radiation materials by pedestrians or vehicles through controlled areas at radiation dangerous and radiation-avoidable objects.
Installations have two modifications: РИГ-08М-1 with one tower, РИГ-08М-2 with two towers.
Installation can be used for the following operation conditions:
- РИГ-08М-1 with working distance of 1,5 m and maximum movement rate of controlled materials and pedestrians of (4,0±0,4) km/hour.
-РИГ-08М-2 with distance of 0,8 m between towers and maximum movement rate of controlled materials and pedestrians of (4,0±0,4) km/hour.
- РИГ-08М-2 with distance of 4 m between towers and maximum movement rate of controlled materials.

COMPONENTS

SPECIFICATIONS

Measurement region of effective dose rate of photon radiation, mc Sv/hour	0.1 - 3
Limits of main relative measurement error of effective dose rate, %	±30
Energy region of detected photon radiation, MeV	0.01 - 1.25
Sensitivity to radiation of 137-Cs, (pulses/second)/(mc Sv/hour), no less	
for РИГ-08М-1	5000
for РИГ-08М-2	10000
Level of own background, no more than, mc Sv/hour	0.04

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.convel.ru/

Containment and Surveillance: Portal Monitor

233

Radiation monitors (transport)

MODEL: ЯНТАРЬ-1А

SUPPLIER:	**Aspect**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Detection of radioactive and nuclear materials at automated on-line monitoring of cargos transported by automobile.

DESCRIPTION

They are used at customs check points, nuclear power plants, NM mining and processing plants, military nuclear facilities and storages.

COMPONENTS

SPECIFICATIONS

```
Limit of detection, no more than:
    Cs - 137                     300 kBq
    Co - 60                      150 kBq
    Ba - 133                     240 kBq
    Pu                           3 g
    U                            315 g
    Pu shielded                  80 g
________________
Note: Pu – a sample of high enriched plutonium Pu-239, U – a sample of high enriched uranium
U-235

Control area parameters:
    Width                       6 m
    Height                      4 m
    Object speed                15 km/h

Limits of radioactive and nuclear material detections are given for detection probability of
0.5 at confidence probability of 95%, background intensity no more than 20μR/h, false alarm
frequency no more than 1/1000, control area parameters and object speed listed above.
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Portal Monitor

234

Radiation monitors (transport)

MODEL: ЯНТАРЬ-1Ж

SUPPLIER:	**Aspect**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Detection of radioactive and nuclear materials at automated on-line monitoring of cargos transported by rail-way transport.

DESCRIPTION

Monitors are used at customs check points for rail-way rolling stocks , nuclear power plants, NM mining and processing plants.

COMPONENTS

SPECIFICATIONS

Limit of detection, no more than:

Cs - 137	890 kBq
Co - 60	445 kBq
Ba - 133	710 kBq
Pu	10 g
U	1450 g
Pu shielded	290 g

Note: Pu – a sample of high enriched plutonium Pu-239, U – a sample of high enriched uranium U-235

Parameters of control zone:

width	6.2 m
height	4 m
speed of object	25 km/hour

Limits of detection of radioactive and nuclear materials are provided for probability of detection of 0,5 and for confidence probability of 95%, background intensity of no more than 20 mcR/hour, false alarm rate no more than 1/1000, parameters of control zone and speed of object provided above

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Portal Monitor

235

Radiation monitors (transport)

MODEL: ЯНТАРЬ-2Л

SUPPLIER:	**Aspect**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Detection of radioactive and nuclear materials at automated on-line monitoring of cargos transported by rail-way and automobile transport.

DESCRIPTION

Monitors are used at nuclear power plants, metallurgical and garbage processing integrated plants, NM mining and processing plants, military facilities and storages.

COMPONENTS

SPECIFICATIONS

```
Limit of detection, no more than:
    Cs - 137                            170 kBq
    Co - 60                             85 kBq
    Ba - 133                            145 kBq
    Pu                                  2.5 g
    U                                   250 g
    Pu shielded                         -
________________________
Note: Pu – a sample of high enriched plutonium Pu-239, U – a sample of high enriched uranium
U-235

Parameters of control zone:
    width                               6 m
    height                              4 m
    speed of object                     15 km/hour
_________________________________
Limits of detection of radioactive and nuclear materials are provided for probability of
detection of  0.5 and for confidence probability of  95%, background intensity of no more
than 20 mcR/hour, false alarm rate no more than 1/1000, parameters of control zone and speed
of object provided above.
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Portal Monitor

236

Radiation monitor (pedestrian)

MODEL: Янтарь-1П3

SUPPLIER: **Aspect**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Portal Monitor
METHOD: Gamma, neutron

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Aspect
MANUFACTURER: Aspect

PURPOSE

Detection of radioactive and nuclear materials at automated on-line monitoring of personnel.

DESCRIPTION

Monitors are used at customs check points, nuclear power plants, NM mining and processing plants, military facilities and storages.

COMPONENTS

SPECIFICATIONS

```
Detection limit, no more than:
    Cs - 137                                80 kBq
    Co - 60                                 40 kBq
    Ba - 133                                65 kBq
    Pu                                      0.3 g
    U                                       10 g
    Pu shielded                             52 g
________________________
Note: Pu – a sample of high enriched plutonium Pu-239, U – a sample of high enriched uranium
U-235

Parameters of control zone:
    width                                   1.5 m
    height                                  2 m
    speed of  object                        5 km/hour
_________________________________
Limits of detection of radioactive and nuclear materials are provided for probability of
detection of  0.5 and for confidence probability of  95%, background intensity of no more
than 20 mcR/hour, false alarm rate no more than 1/1000, parameters of control zone and speed
of object provided above.
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Portal Monitor

237

Radiation monitor (pedestrian)

MODEL: Янтарь-2П

SUPPLIER:	**Aspect**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Detection of radioactive and nuclear materials at automated on-line monitoring of personnel.

DESCRIPTION

Monitors are used at customs check points, nuclear power plants, NM mining and processing plants, military facilities and storages.

COMPONENTS

SPECIFICATIONS

```
Detection limit, no more than:
    Cs - 137                                44 kBq (11 kBq)*
    Co - 60                                 23 kBq (7 kBq)*
    Ba - 133                                35 kBq (11 kBq)*
    Pu                                      0.3 g
    U                                       10 g
    Pu shielded                             52 g
________________________
Note: Pu – a sample of high enriched plutonium Pu-239, U – a sample of high enriched uranium
U-235
      *There are detection limits at control zone width of 0.7 m in the parenthesis

Parameters of control zone:
    width                                   3 m
    height                                  2 m
    speed of  object                        5 km/hour
_________________________________-
Limits of detection of radioactive and nuclear materials are provided for probability of
detection of  0.5 and for confidence probability of  95%, background intensity of no more
than 20 mcR/hour, false alarm rate no more than 1/1000, parameters of control zone and speed
of object provided above.
```

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Portal Monitor

238

Radiation monitor

MODEL: TCPM61, TCPM82

SUPPLIER:	**VNIIA**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, X-ray
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	VNIIA
MANUFACTURER:	VNIIA

TSRM61

PURPOSE

- automatic detection of nuclear materials and radioactive substances (NRM) to prevent illicit trafficking through pedestrian and transport checkpoints;
- monitoring the radioactive contamination of transport vehicles, environment, and detection of ionizing radiation sources in different technological and production processes.

DESCRIPTION

System operation is based on detecting NRM X-rays and gamma radiation in the range of 40 to 3000 keV on the natural background, which is measured and taken into account during signal analysis.
System is euqipped with audio, digital and light indication.

COMPONENTS

- power and control unit (PCU),
- 1 to 8 detection units (DU),
- set of connection cables

SPECIFICATIONS

Detection threshold (for one DU, 3 s monitoring time at the distance of 50 cm from DU):	
for nuclear materials, g	1.8 (U-235); 0.15 (Pu-239)
for radioactive substances, kBq	87 (Co-60); 102 (Cs-137); 70 (Am-241); 107 (Ra-226)
for gamma radiation exposure rate exceeding the background, (μR/h)	12 (Co-60); 3.4 (Cs-137); 0.47 (Am-241); 10.8 (Ra-226)
False alarm frequency	1 per 1000 passages
Power supply	mains 220 V AC, 50 Hz, 30 W
Continuous operating time	unlimited
Operating temperature range	-40 to +50 °C
Weight and dimensions of the detection unit:	
TCPM61	no more than 2.5 kg; 370x60x60 mm
TCPM82	no more than 1.7 kg; 332x60x38 mm
Weight and dimensions of the power and control unit:	
TCPM61	no more than 5.4 kg; 310x265x130 mm
TCPM82	no more than 1.6 kg; 196x126x70 mm
Range of monitoring time adjustment:	
TCPM61	0.2 - 100 sec
TCPM82	1 - 100 sec

SOFTWARE

The software allows adjusting detection sensitivity on site.

ADDITIONAL INFORMATION

RS485 (RS232) Interface allows using the monitors jointly with other systems.
TCPM61 monitor has the conformance certificate

REFERENCES

http://www.vniia.ru

Containment and Surveillance: Portal Monitor

239

Radiation Monitoring System

MODEL: TCPM85

SUPPLIER:	**VNIIA**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Neutron Passive
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	VNIIA
MANUFACTURER:	VNIIA

PURPOSE

- automatic detection of nuclear materials and radioactive substances (NRM) to prevent unauthorized transporting them through the access control points (ACP) by persons or using transport vehicles;
- monitoring radioactive contamination of transport vehicles, regions, and detection of ionization sources in different technological and production processes.

DESCRIPTION

System operation is based on detecting NRM neutron radiation in the range 40 to 3000 keV on the natural background, which is measured and taken into account during signal analysis.
System is equipped with audio, digital and light indication.

COMPONENTS

- power and control unit (PCU),
- 1 to 8 detection units (DU),
- additional moderators,
- set of connection cables.

SPECIFICATIONS

Detection threshold (for one DU, 3 s monitoring time at the distance of 50 cm from DU)	50 g Pu
Range of monitoring time adjustment	1 - 100 s
False alarm frequency	1 per 1000 passages
Power supply	mains 220 V AC, 50 Hz, 100 W
Continuous operating time	unlimited
Operating temperature range	-40 to +50 °C
Dimensions:	
neutron detector unit	460x140x70 mm
power and control unit	196x126x70 mm
Weight:	
detection unit	no more than 6 kg
additional moderator	no more than 4,8 kg
power and control unit	no more than 1,6 kg

SOFTWARE

The software allows adjusting detection sensitivity on site.

ADDITIONAL INFORMATION

RS485 (RS232) Interface allows using TSRM61 jointly with other systems.

REFERENCES

Containment and Surveillance: Portal Monitor

240

Pedestrian radiation monitor

MODEL: КПРМ-П1

SUPPLIER:	**RFNC VNIIEF**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	RFNC VNIIEF
MANUFACTURER:	RFNC VNIIEF

PURPOSE

Pedestrian radiation monitor КПРМ-П1 is created to control if pedestrians crossed controlled areas have nuclear materials.

DESCRIPTION

The monitor is an all-metal structure with a base and a detection towers which contain main parts of the monitor.
Operation modes:
-monitor self testing;
-background analysis
- RM test on "carrying" a radioactive object;
- test by "throwing" a radioactive object through the area controlled by the monitor;
- testing an unauthorized access to the monitor installation.
Indication of operation modes of the monitor and self-testing results is performed.

COMPONENTS

- pillars for passage;
- detector units - 4 pieces (2 per pillar), total detection area - 5500 cm²;
- sound and light signalization units;
- infrared detector indicating a controlled area "occupancy";
- interface RS-232 or RS-485.

SPECIFICATIONS

Detection limit of the monitors for gamma-radiation background of 25 mcR/hour and speed of control source from 1,0 to 1,2 m/second through path zone	0.3 g of Pu for minimum irradiating structure (domain); 10 g of high enriched uranium (content of U-235 is no less than 89%) for minimum irradiating structure (domain)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.vniief.ru

Containment and Surveillance: Portal Monitor

241

System for detection of subject made from metal and radioactive materials

MODEL: «Спектр»

SUPPLIER:	**Dedal, JSC SPC**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	Dedal, JSC SPC
MANUFACTURER:	Dedal, JSC SPC

PURPOSE

The device can be applied at passages and post controls of different civilian and war facilities like as airports, industry facilities, nuclear power stations, nuclear facilities, administrative and community offices, banks, customs and other.

DESCRIPTION

The device is constructed to detect non-authorized movement as metal objects (weapon, tools, containers for radioactive materials and other) and objects-sources of radiation (nuclear materials, radionuclides and so on).
SPECTR combines functions of a metal detector and a radiation monitor.

COMPONENTS

The device has a rigid arc (portal), indication and control console, electronic unit. The electronic unit is placed into upper part of arc.
Indication and control console contains:
- Light indicator and sound signalizer to inject an alarm signal;
- Light indicators of relative doze rate of radiation;
- Light indicators of relative size of metallic object and of type of metal (ferromagnetic, non-ferromagnetic);
- Functional keyboard for setting sensitivity, choice of loudness and tonality of alarm signal, switching operation regimes, performing setting and testing.

SPECIFICATIONS

Detection limit:	
239-Pu	0.3 g
235-U	10 g
238-U	100 g
137-Cs	12 kBq
60-Co	6 kBq
Sensitive of doze rate of neutron radiation no less than	5 nSv/hour
Speed of movement:	
Metal objects	from 0.3 to 5 m/second
Radioactive materials	from 0 to 1 m/second
Ambient temperature	+5 … +50 °C

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.dedal.ru/

Containment and Surveillance: Portal Monitor

242

Vehicle Portal Monitor (Combined Technology)

MODEL: Model 5123, 5125

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	LANL
MANUFACTURER:	ANTECH Corporation

PURPOSE

Portal monitors are designed to detect radioactive materials and, with neutron detection capability, to detect the presence of plutonium by passive neutron counting.

DESCRIPTION

ANTECH portal monitors are available in two basic configurations, Gamma ray measuring (5123 series) based on the use of sensitive plastic scintilator detectors and combined gamma ray and neutron measuring (series 5125), again using sensitive plastic scintilators but combined with high pressure He-3 detectors.
The shielded and collimated plastic scintilator detectors use low noise photo multiplier tubes. In the case of combined technology portals, the polyethylene moderated high-pressure He-3 detector tubes, providing enhanced neutron detection sensitivity, are connected to high-speed charge collection electronics and operate in neutron totals counting mode.
The monitors can operate in either continuous pass through or hold and measure mode, depending on the application and sensitivity requirement.

COMPONENTS

Typical installation consists of two of the assemblies on either side of the vehicle carriageway. Each cabinet contains:
- 6 scintillation panels per complete System (4 panels for Series 5123)
- 6 neutron horizontal panels each containing 2 He-3 tubes
- onboard microprocessor controller
- RS-232/Ethernet interface
- power supplies,
- amplifier,
- ORTEC digiBASE
- and high voltage bias supplies
- occupancy and speed detection circuits
- battery and charger

SPECIFICATIONS

Detection levels	8-10 grams total Pu (military grade) approximately 1 kg highly enriched U
Vehicle transit measurement 0-30 km/hr accuracy	within 10%
Battery back-up	12 hours minimum
Dimensions of twin pillar configuration (L x W x H):	
5125 model	2.5 m x 0.5 m x 3 m (typically 4.5 m separation)
5123 model	950 mm x 400 mm x 3020 mm (each pillar, 4.5 to 5 m separation)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.antech-inc.com

Containment and Surveillance: Portal Monitor

243

Pedestrian Portal Monitor

MODEL: Series 5103 and 5105

SUPPLIER:	**ANTECH Corporation**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	ANTECH Corporation
MANUFACTURER:	ANTECH Corporation

PURPOSE

The portal monitors are designed to detect radioactive materials and, with neutron detection capability, to detect the presence of plutonium by passive neutron counting.

DESCRIPTION

ANTECH portal monitors are available in two basic configurations, Gamma ray measuring (Series 5103) based on the use of sensitive plastic scintilator detectors and combined gamma ray and neutron measuring (Series 5105), again using sensitive plastic scintilators but combined with high pressure He-3 detectors.
The operation of ANTECH portal monitors is automated through the use of an onboard microprocessor controller, which performs system diagnostic testing, input monitoring and background discrimination. The controller employs algorithms based on the sequential probability ratio (SPR) test, developed originally by Fehlau and others at LANL.

COMPONENTS

- plastic scintilator detectors (Series 5103 has 4 scintillation panels, 5 if bottom unit fitted)
- low noise photo multiplier tubes
- ORTEC digiBASE
- polyethylene moderated high-pressure He-3 detector tubes (5105 model)
- RS-232/Ethernet interface
- power supplies,
- amplifires,
- high voltage bias supplies

Pedestrian Portal Monitors are available in the standard configuration with twin vertical pillars. It is also available without detectors in the bottom (floor) unit.

SPECIFICATIONS

Detection levels (Series 5103)	0.4 grams total Pu (military grade) approximately 10 g highly enriched U
Overall dimensions of twin pillar configuration (L x W x H)	680 mm x 140 mm x 2200 mm (each pillar)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

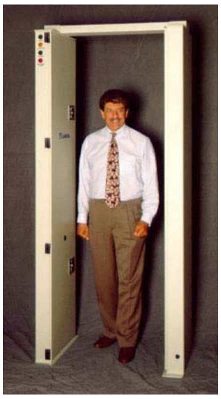
www.antech-inc.com

Containment and Surveillance: Portal Monitor

244

SNM Pedestrian Portal Monitors

MODEL: JPM-21A, JPM-22A, JPM-41A, JPM-42A



SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	HEU, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	LANL, Canberra
MANUFACTURER:	Canberra

PURPOSE

Special Nuclear Material (SNM) Portal Monitors prevent unauthorized removal of fissile material such as U-235 and Pu-239.

DESCRIPTION

The portals collect and analyze radiation data and sound an alarm to notify authorities of possible diversion of SNM. The portals are not designed to identify the material causing the alarm, just to provide highly sensitive screening of persons and vehicles, with a low false alarm rate. The response to an alarm is site-specific.

Two measurement techniques are employed in SNM portal monitors – neutron and gamma. The choice depends on the type and amount of SNM to be detected. At uranium facilities, the need to monitor for HEU limits the choice to a gamma-ray monitor. At plutonium facilities either gamma-ray or neutron monitors may be used, depending on the desired detection limit.

To detect SNM the monitor senses a radiation intensity increase by comparing its monitoring measurements with an alarm threshold derived from previous unoccupied background measurements. Factors affecting portal monitor performances are isotopic content, chemical composition, size of the SNM particles, ambient background; electronic noise; distance between the detectors; type, number or size of radiation detectors; and passage speed (for pass-through mode).

Monitors use the Sequential Probability Ratio Test (SPRT) [1] instead of moving average or fixed ratemeter alarm points. Once the portal is occupied, the portal controller examines very small count intervals. Each time interval is analyzed using the SPRT and compared to two thresholds: a background and a background plus transient.

Canberra's pedestrian portal monitors are available in several detector configurations that can be operated in either a walk-through or wait-in mode, depending on the desired detection levels. Monitoring occurs as the pedestrian walks between two pillars housing the detectors. There are four standard configurations of pedestrian monitors: JPM-21A Gamma Pedestrian Portal Monitor, JPM-22A Gamma Pedestrian Portal Monitor with Metal Detector, JPM-41A Neutron Pedestrian Portal Monitor and JPM-42A Neutron/Gamma Vehicle Portal Monitor.

The JPM-21A has four plastic scintillator detectors. In a walkthrough mode, the JPM-21A can detect subgram quantities of weapons-grade or reactor-grade plutonium and gram quantities of HEU.

When the gamma detectors are integrated with a commercially available metal detector, the JPM-22A can detect shielded SNM by providing an indication of suspicious metal containers that could be used by pedestrians to shield SNM. The portal controller automatically sets the sensitivity levels in the metal detector based on the direction of traffic. This feature allows different detection levels for metal going into the plant than that going out.

The JPM-41A Neutron Pedestrian Portal detects gram masses of shielded SNM that cannot be detected by gamma-ray based monitors. It is also used where the gamma-ray background varies. The portal configuration is identical to the JPM-31A Neutron Vehicle Monitor with fewer 3He detectors.

The JPM-42A is based on a Los Alamos National Laboratory design. It is an integrated neutron and gamma-ray portal monitor for detecting gram masses of shielded plutonium. Lower detection limits are possible for unshielded plutonium and HEU using the gamma detectors. The JPM-42A also takes up less space than a separate JPM-21A and JPM-41A.

COMPONENTS

- large area plastic scintillation detectors, shielded and collimated by lead sheets (four 38 x 152 x 790 mm scintillators for 21A, 22A, and 42A models,) or He-3 proportional counters (2 tubes for 41A, and 42A models)
- low-noise photomultiplier tubes (PMTs) (for gamma monitors)
- intelligent portal controller
- variance analyzer
- secured RS-232 communication port
- SCAs and LLD
- low noise electronics
- rugged, weather-tight, and tamper proof enclosure
- metal detector (JPM-22A)

SPECIFICATIONS

```
(for Model JPM-21A):
Sensitivity:
    walk-through mode (1.3 m/s)          0.3 g for low burnup plutonium (6% Pu-240,
```

	93% Pu-239, 1% impurities)
	10 g of HEU
	0.05 reactor grade Pu
wait mode	0.08 g for low burnup plutonium
	3 g of HEU
	0.01 reactor grade Pu
False alarm rate	1/2100
Power supply	optional Battery Backup for eight hours
Overall size	height is 213 cm; width -117 cm; spacing between pillars 74 cm
Weight	181 kg (3mm lead shield)

SOFTWARE

ADDITIONAL INFORMATION

The JPM-21A is compatible with the Canberra's JPM-41A neutron monitor in that the two can be placed together to provide the maximum detection capability.

REFERENCES

1) http://www.canberra.com
20 P.E. Fehlau, K.L. Coop, and K.V. Nixon, “Sequential Probability Ratio Controllers for Safeguards Radiation Monitors”, Proceedings of the 6th ESARDA Symposium on Safeguards and Nuclear Material Management, Venice, Italy, May 14-18, 1984.

Containment and Surveillance: Portal Monitor

245

SNM Vehicle Portal Monitors

MODEL: JPM-11A, JPM-12A, JPM-31A, JPM-32A

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	HEU, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	LANL, Canberra
MANUFACTURER:	Canberra

PURPOSE

SNM Vehicle Portal Monitors are designed for the detection of SNM in moving vehicles.
The monitors can operate in single or dual traffic mode.

DESCRIPTION

The portals collect and analyze radiation data and sound an alarm to notify authorities of possible diversion of SNM. The portals are not designed to identify the material causing the alarm, just to provide highly sensitive screening of persons and vehicles, with a low false alarm rate. The response to an alarm is site-specific.

Two measurement techniques are employed in SNM portal monitors – neutron and gamma. The choice depends on the type and amount of SNM to be detected. At uranium facilities, the need to monitor for HEU limits the choice to a gamma-ray monitor. At plutonium facilities either gamma-ray or neutron monitors may be used, depending on the desired detection limit.

To detect SNM the monitor senses a radiation intensity increase by comparing its monitoring measurements with an alarm threshold derived from previous unoccupied background measurements. Factors affecting portal monitor performances are isotopic content, chemical composition, size of the SNM particles, ambient background; electronic noise; distance between the detectors; type, number or size of radiation detectors; and passage speed (for pass-through mode).

Monitors use the Sequential Probability Ratio Test (SPRT) [1] instead of moving average or fixed ratemeter alarm points. Once the portal is occupied, the portal controller examines very small count intervals. Each time interval is analyzed using the SPRT and compared to two thresholds: a background and a background plus transient.

The configuration of vehicle portal monitors varies depending on the required detection limit. There are four standard configurations of vehicle monitors: JPM-11A Gamma Vehicle Monitoring Station, JPM-12A Gamma Vehicle Monitor, JPM-31A Neutron Vehicle Monitor and JPM-32A Neutron/Gamma Vehicle Monitor. The JPM-11A is operated while the vehicle is stationary while the JPM-12A, JPM-31A and JPM-32A are drive-through monitors.

The JPM-11A Gamma Portal Monitoring Station resembles a carport with detectors located above and below the stopped vehicle and arranged to view the entire vehicle. The large number of detectors, therefore, large surface area, in combination with a wait-in mode of operation makes the JPM-11A capable to detecting subgram quantities of low-burnup and reactor-grade plutonium or tens of grams of HEU.

The JPM-12A Gamma Vehicle Monitor is designed for drive-through monitoring where larger quantities of SNM may be encountered, for example, fabricated items containing ten grams or larger quantity of low burnup plutonium, or kilogram quantities of HEU, spent fuel, 238Pu, 233U or high-burnup plutonium. It usually is positioned on opposite sides of a lane of traffic near a vehicle trap to force the vehicle to slow down, which improves sensitivity.

The JPM-31A Neutron Vehicle Monitor is a drive-through monitor that can detect tens of grams of shielded weapons-grade or reactor grade plutonium, which cannot be detected by gamma-based detectors due to attenuation of the gamma rays in the shielding. It is also used where the gamma-ray background varies and may contribute to nuisance alarms, or the gamma-ray background is too large to meet the required MDA.

The JPM-32A Neutron/Gamma Vehicle Portal Monitor is a combination system that includes both neutron and gamma detectors, similar to those used in the JPM-12A and JPM-31A discussed earlier.

COMPONENTS

- large area plastic scintillation detectors, shielded and collimated by lead sheets (four 38 x 152 x 790 mm scintillators for 12A, 32A models, sixteen – for 11A model) or He-3 proportional counters (eight tubes for 31A and 32A models)
- low-noise photomultiplier tubes (PMTs) (for gamma monitors)
- intelligent portal controller
- variance analyzer
- secured RS-232 communication port
- SCAs and LLD
- low noise electronics
- rugged, weather-tight, and tamper proof enclosure
- metal detector (JPM-22A)

SPECIFICATIONS

(for JPM-12A):

Sensitivity:	
HEU	1 kg
low burnup plutonium	10 g (6% Pu-240, 93% Pu-239, 1% impurities)
reactor grade plutonium	1.2 g
False alarm rate	1/2100
Operation temperature	-40 ˚C to +40 ˚C
Power supply	optional battery backup for 8 hours operation (at 20 ˚C) uninterruptable power supply (UPS) lines (at harsh climates)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1. Fehlau, P.E., Coop K.L., and Nixon, K.V., Sequential Probabilty Ratio Controllers for Safeguards Radiation Monitors, Proceedings of the 6th ESARDA Symposium on Safeguards and Nuclear Material Management, Venice, Italy, 1984.
2. http://www.canberra.com

Containment and Surveillance: Portal Monitor

246

Portal monitor

MODEL: RadSentry

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Portal Monitor
METHOD: Neutron, gamma

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Field
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

Prevention of illegal movements of special nuclear materials (SNM) and other radionuclides.

DESCRIPTION

Each detection block is separate module with optimal sensitivity to neutron and gamma radiation. Detection modules (radiation sensor panels, RSP) are connected together in configuration required to provide necessary geometric efficiency.

COMPONENTS

- one or more RSP panels:
    - scintillation gamma radiation detectors on the base of polyvinyl toluene
    - He-3 neutron counters
    - RSP electronics:
        - individual electronic blocks of high voltage and signal processing
        - 2 photomultipliers
        - gain stabilization circuit
        - 256 channel ADC, 8 single channel analyzers
- control unit,
- occupation sensors
- alarm signal board and/or computer.

RSP panels are installed at different positions to provide required sensitivity and efficiency for specific application.

SPECIFICATIONS

Background level:	
gamma radiation background	10 µR/h
neutron radiation background	<5 counts/sec (for system)
False alarm	no more than 1 in 1000 (over gamma or neutron channel)
Distance to the source	point nearest to detector (0.5 m for pedestrian, 2.4 m for transport)
Source movement speed	1.2 m/s (pedestrian), 8 km/h (transport)
Accuracy of reference source activity measurement	± 20%
Alarm triggering probability	more than 0.5 in confidence interval 95%(ASTM C 1236_99)
Nominal detection sensitivity:	

Isotope or SNM	Pedestrian (1 panel, 2 m height)	Vehicle (2 panels, 2 m height)	Cargo (4 panels, 4 m height)
241-Am	200 µCi	450 µCi	450 µCi
Neutrons(252-Cf)	1.2E+4 neutron/s	1.2E+4 neutron/s	1.2E+4 neutron/s
Enriched uranium(ASTM)	10 g	800 g	800 g
Pu (ASTM) - gamma	0.3 g	9 g	9 g
Pu (ASTM) - neutrons	30 g	180 g	180 g

Scintillator size:	
surface area	6290 cm²
volume	24000 cm³
3-He proportional counters size	150 x 5 cm (diameter x length)
Overall size	185.4 x 72.4 x 24.1 cm
Weight	254 kg
Operating temperature	from -40 °C to +50 °C
Control unit power supply	120/220 V ac, 50/60 Hz
RSP supply	24 V dc (4 Wt per RSP)
Height of monitoring zone for	

```
standard systems:
  pedestrian system                    2 meters
  vehicle system                       2 meters
  cargo system                         4 meters
  rail system                          5 meters
```

SOFTWARE

RadSentry software for portal monitors (by order)

ADDITIONAL INFORMATION systems (by order)

REFERENCES

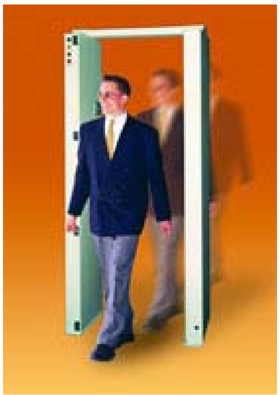
1. ANSI N42.35-2004, «American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security,» 11 Feb 2004.
2. IAEA TechDoc, «Technical/Functional Specifications for Border Radiation Monitoring Equipment,» International Atomic Energy Agency, Dec 2003 (draft)
3. «Radiation Protection Instrumentation Installed Radiation Monitors for the Detection of Radioactive and Special Nuclear Materials at National Borders,» INTERNATIONAL ELECTROTECHNICAL COMMISSION, Jan 2004 (draft)
4. ASTM C 1169-97, «Standard Guide for Laboratory Evaluation of Automatic Pedestrian SNM Monitor Performance,» 1997
5. ASTM C 1236-99, «In-plant Performance Evaluation of Automatic Vehicle SNM Monitors,» 1999
6. United States Bureau of Customs and Border Protection, «Specifications for Radiation Portal Monitor Systems,» prepared by Pacific Northwest National Laboratory, Revision 6.7. 25 June 2003.
7. http://www.canberra.com

Containment and Surveillance: Portal Monitor

247

Pedestrian portal gamma/neutron monitor

MODEL: CPM - PGN



SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	LANL, Canberra
MANUFACTURER:	Canberra

PURPOSE

Detection of nuclear materials carried by pedestrians.

DESCRIPTION

The CPM-PGN is a pedestrian monitor capable of detecting gamma-rays and neutrons. This system is designed to be used in security applications where the need to monitor for the illicit trafficking of Special Nuclear Material (SNM) is required. The CPM-PGN monitors are designed to be operated in either a walkthough or pause-and-count mode. The walkthrough mode is designed for maximum throughput with minimum interruption in traffic flow. Individuals pass through the portal monitor at a normal walking speed, which is about 1.3 meters per second. In the pause-and-count mode, the individual stops in the portal monitor which then counts the individual until the portal monitor becomes unoccupied, alarms, or reaches a maximum time, providing better sensitivity than the walkthrough mode. Should the presence of SNM be detected, a visual and audible alarm sound locally, at the remote indicator panel (optional) or at both panels depending upon user selectable parameters made during setup. A separate alarm is provided for both gamma and neutron channels.

COMPONENTS

Monitor has two independent measurement channels:

• gamma channel for detection of light-shielded materials on the base of four plastic scintillation detectors of large volume (38 x 152 x 790 mm) with lead shielding on the back and sides of the scintillators

• neutron channel for detection of shielded materials on the base of two neutron counters of 51 mm diameter and 1820 mm length.

Detector pairs are located at side pillars of the monitor. One pillar contains electronic block consisting of power supply system and microprocessor controller.

SPECIFICATIONS

```
False alarm probability for
 gamma doze rate in area of monitor
 location of 20 µR/hour                                    1/1000
Gamma channel sensitivity at gamma
 doze rate of 20 µR/hour (determined
 for spherical material form):
       Monitoring in walkthrough mode
       (for individual moving at 1.3 m/s):
                  highly enriched uranium                  10 g
                  low burn-up plutonium                    0.3 g
                  (6% Pu-240, 93 % Pu-239,
                  1 % impurities)
                  power generating plutonium               0.05 g
                  Cs-137                                   less than 37 000 Bq
                  Co-60                                    less than 37 000 Bq
       Monitoring in pause-and-count mode
                  Highly enriched uranium                  3 g
                  Low burn-up plutonium                    0.08 g
                  (6% Pu-240, 93 % Pu-239,
                   1 % impurities)
                  Power generating plutonium               0.01 g
                  Cs-137                                   less than 37 000 Bq
                  Co-60                                    less than 37 000 Bq
       Neutron channel sensitivity:
                  Low burn-up plutonium                    30 g
                  (6% Pu-240, 93 % Pu-239,
                  1 % impurities)
(Monitor sensitivity corresponds to Category 2 in walkthrough monitoring mode and Category 3
in pause-and-count mode monitoring mode)
```

Exterior dimensions (H x W x D)	219.1 x 100.8 x 76.2 cm (86.25 x 39.7 x 30 in.)
Weight	451 kg (with lead) (994 lb)
Operating temperature	–5°C to +50°C (+23 °F to +122°F)
Electrical power	120/250 V ac 50/60 Hz, 3.0/1.5 A

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Portal Monitor

248

Vehicle, Rail and Freight Cargo Monitors

MODEL: Detective-ASP Series

SUPPLIER:	**ORTEC**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma spectrometry
MEASURED PROPERTIES:	Isotopic Composition
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Field
DEVELOPER:	ORTEC
MANUFACTURER:	ORTEC

PURPOSE

Detective-ASP Series provide the detection of Uranium and Plutonium, shielded or unshielded, even in the presence of other sources.
These systems provide the following identification/classifications: 233-U, 235-U, 237-Np, 239-Pu, Depleted Uranium, Natural Uranium, Enriched Uranium, Reactor Grade Pu, Weapons Grade Pu; 232-U, 238-U, 238-Pu, 240-Pu, 241-Am; 232-Th and daughters; etc.

DESCRIPTION

The basis of every ORTEC Detective-ASP portal is high purity germanium (HPGe) as the gamma ray detector which provides an ability to identify and classify gamma-emitting radionuclides.
Advanced software, already in use in the successful Detective series hand-held radioisotope identifiers (HHRID's), and developed further in actual portal monitor field trials, ensures that the ORTEC Detective-ASP portal systems detect/identify/alarm/report in REAL TIME and in a way that meets operational needs.
A sophisticated analysis approach analyzes data "one gamma-ray at a time" from as many as six IDMs per RSP in REAL TIME. Advanced real-time correlation techniques enhance sensitivity and distinguish and locate hot spots more characteristic of suspect devices from the more homogenous distribution associated with bulk cargos.
Each occupancy record contains:
• Gamma and neutron gross count rate data
• Identified source(s) list
• Vehicle speed and position data,
• Spectroscopic data
• Neutron count data
• Occupancy sensor data and all VIS data

COMPONENTS

Detective-ASP portal monitors contain:
- one or more (up to 12) Radiation Sensor Panels (RSP) that include:
  - one or more HPGe IDM modules containing:
    - integrated high purity germanium detector in long life cryostat, 85 mm dia. x 30 mm deep active volume.
    - 16k channel, high-performance MCA with digital stabilization.
    - detector bias supply.
    - USB 2.0 communications.
  - one or more large-volume moderated 3He tubes (optional when neutron detection is not required).
  - a data acquisition and control computer (one per RSP)
  - occupancy and speed sensors
  - NEMA-4X enclosure (if required).
  - internal heating and air conditioning
- Portal Control System (PCS)
- Supervisory Computer
- Annunciator Panel(s)
- Detection Zone Occupancy and Speed Sensors
- Vehicle Identification System (VIS)
- Uninterruptable Power Supply (UPS)

SPECIFICATIONS

False alarm	less than 1 in 10,000
IDM design life	>50,000 hours
Operating temperatures	-40 to + 55°C, up to 100% relative humidity

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

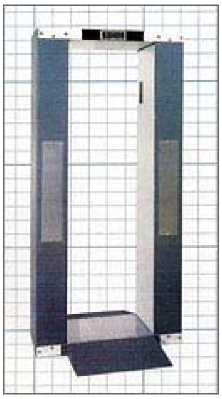
www.ortec-online.com

Containment and Surveillance: Portal Monitor

249

Pedestrian Portal Monitor

MODEL: SPM-906



SUPPLIER:	**Thermo Scientific**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Portal Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Thermo Scientific
MANUFACTURER:	Thermo Scientific

PURPOSE

Monitor is used for SNM detection – U-235 and Pu-239. Designed for use in an indoor area.

DESCRIPTION

This monitor is designed to automatically perform consistent, thorough scanning on a walk-pause-walk basis.
When an alarm occurs, the system will sound an audio alarm, and indicate which detector(s) alarmed to help locate the source of contamination. When the system is idle, the background is continuously updated. In the event of a power outage, an internal battery provides of eight hours of continuous operation.

COMPONENTS

- two, 12" x 38" x 1.5" (30 x 97 x 3.8 cm) organic plastic scintillator detectors per pillar;
- one, 10" x 12" x 1.5” (25 x 30 x 3.8 cm) organic plastic scintillator detector at both the head and foot;
- 0.75” (1.9 cm) lead shielding;
- hand-held terminal or computer with a Windows 95/NT communications program.

SPECIFICATIONS

False alarm rates	less than 1 in 1,000 passages
Passage time	variable from walk-through to 10 seconds; typically 3 seconds on a walk-pause-walk basis
Continuous battery operation	8 hours
Dimensions	88" h x 40" w x 18” d (224 x 100 x 46 cm), pillar spacing is fixed at 24" (61 cm)
Weight	1200 lbs (544 kg) complete monitor, 1500 lbs (682 kg) packed
Operating temperature	from - 32° to 122° F (0° to 50° C)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.thermo.com

Containment and Surveillance: Software

250

General Advanced Review Software

MODEL: GARS

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Software
METHOD: Video Surveillance

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY:
ENVIRONMENT OF USE:
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The General Advanced Review Software (GARS) is responsible for performing an efficient review of digital images which are created on a number of supported surveillance systems.

DESCRIPTION

Utilizing surveillance plug-in modules implemented via Windows Dynamic Link Libraries (DLLs), GARS currently supports three surveillance systems: the GEMINI and MOX/MUX systems from Canberra and the DCM-14 system from Neumann GmbH. Presently, the GARS is a cross-platform application available for the Windows 95/98 and Windows NT platforms. The program implements a rapidly executing motion detection algorithm that analyzes adjacent images to detect potential changes in user-defined areas in the images. The GARS functions handled by the DLLs are: the creation of all review files, image verification (authentication), image decompression, selection of surveillance preferences, and the creation of reports. The current GARS performs image decompression, motion detection analysis, and image display “on-the-fly”.
GARS also offers multi-camera support (up to 32 cameras per surveillance), persistent zoom for image playback of maximum sized images, a resize/maximize function for screen resolutions greater than 800 x 600, and an improved Graphical Overview tool for reviewing scene specific or interval information. GARS also has the ability to load scenes from as many as eight different directories, the ability to specify time and date range of images to be loaded, and can continue reviewing data without having to recreate a da¬tabase after the program has been exited, then restarted. In addition, GARS offers enhanced DCM-14 support, which now covers review of VACOSS seal data, direct review of DCM-14 PC cards and stream files, and the ability to review DCM-14 generated key encrypted and authenticated images.

COMPONENTS

The Review Station incorporates:
- disk docking port/station into which a Removable Hard Disk (RHD) containing stored digital images is inserted
- CD-ROM reader, enabling review via a CD-ROM containing the compressed surveillance image files
- PC card reader to review images from a DCM-14 PC card

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Software

251

GEMINI Safe Server Software Suite

MODEL:

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Software
METHOD:	Video Surveillance
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The GEMINI Safe Server Software Suite is designed for use in remote monitoring/unattended applications.

DESCRIPTION

This suite of programs allows any file to be authenticated and/or encrypted and stored for later access via remote monitoring.
GEMINI Safe Server establishes the parameters to be used including authentication, encryption and host country access.
The GEMINI Safe Server Local Setup and GEMINI Safe Server Setup programs allow the user to setup the GEMINI Safe Server Service either locally at the machine or remotely via a local area network (LAN) or through a Remote Access Server (RAS) connection.
GEMINI Check is a GUI application that has a look and feel similar to Microsoft Windows Explorer. This program allows the user to visually determine if a file has been encrypted or authenticated. Additionally, the user can decrypt a file, verify the authenticity of a file, remove the authentication, securely delete a file or launch a file through the browser window.
GEMINI Safe is a command line application that allows the user to only add authentication to a file, apply encryption only to a file, or apply both authentication and encryption to a file.
GEMINI Authentication (GemAuth) is a program that will check authentication on a passed in file.

COMPONENTS

Includes the following programs:
- GEMINI Safe Server Service
- GEMINI Safe Server Local Setup/Setup
- GEMINI Check
- GEMINI Safe
- GEMINI Authentication

SPECIFICATIONS

All programs (other than the GEMINI Safe Server Service) will run under either Microsoft Windows® 95 or Microsoft Windows NT (Server and Workstation).

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Hand-held Monitor

252

Neutron search detector

MODEL: NSD-A03

SUPPLIER: **Aspect**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Hand-held Monitor
METHOD: Neutron, gamma
MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial, field
DEVELOPER: Aspect
MANUFACTURER: Aspect

PURPOSE

- Control for illicit trafficking of nuclear materials
- Search for Pu contamination
- Inspection of nuclear waste
- Monitoring of neutron radiation fields

DESCRIPTION

NSD-A03 is a hand-held device with self-contained power supply, display and keyboard having the built-in high sensitive He-3 neutron detector in polyethylene moderator and Geiger-Muller counter for measuring gamma radiation EDR in order to ensure the operator safety.

COMPONENTS

- NSD-A03 device
- Network adapter
- Stand for device charging
- RS-232 cable
- Transmitter RS-232-USB UPORT 1110.
- Case
- Service software on CD

SPECIFICATIONS

Absolute sensitivity to neutron radiation	no less than 20s^-1 per neutron/cm² (equivalent to 2s^-1 fron Cf-252 source with intensity of 12*10^4 s^-1, at exposure of 1 m from sensitive surface of detector)
Minimal detectable neutron flux value from neutron Cf-252 source in "SEARCH" mode, with probability of 0.5 at confidence probability 95% at the distance of 1 m, device speed of (0,5±0,05) m/s	no more than (1.5*10^4 ± 20%) s-1
False alarm rate for neutron channel at standard neutron background)	less than 1 per 10 minutes
ERD measurement range for gamma radiation	from 1μZv/h to 1*10^4 μZv/h
Allowable limit of gamma radiation ERD relative basic error	30%
Continuous operation time from built-in batteries	no less than 16 hours
Operating temperature range	from - 20 to +50 ˚C
Dust and water protection class	IP54
Overall size	no more than (300 x 200 x 150) mm
Weight	no more than 5 kg

SOFTWARE

Built-in software allows for operation in SEARCH and TIMER-COUNTER modes.

ADDITIONAL INFORMATION

g the neutron counting rate over the background value with regard to statistical significance of obtained values. Difference is displayed on LCD, confirmed with LED and sound. In SEARCH mode, the value of gamma radiation ERD is continuously displayed, and the tsafety hreshold installed is continuously controlled. TIMER-COUNTER mode allows for counting the number of neutrons detected during exposure time set up by operator. Delivery set includes the service program«MKC Manager».

REFERENCES

www.aspect.dubna.ru

Containment and Surveillance: Hand-held Monitor

253

Portable radiation monitor

MODEL: «ГРАНАТ»

SUPPLIER:	**Aspect**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Hand-held Monitor
METHOD:	Gamma, neutron
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Individual Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial, field
DEVELOPER:	Aspect
MANUFACTURER:	Aspect

PURPOSE

Detection, localization and identification of radioactive and nuclear materials at inspection of different objects and territories with possible hidden application.

DESCRIPTION

Portable radiation monitor «Гранат» is a hand-held device with self-contained power supply built-in shockproof sealed case. Device has built-in detectors: on the base of 75*75 mm NaI(Tl), Geiger-Muller counter, neutron detector with six proportional counters in polyethylene moderator. It also has a built-in GPS-module, is equipped with external control panel with LED indication and internal graphical display with keyboard (available only when case is open).
Device provides following functionalities:
• High sensitivity
• Search, localization and identification in the real time mode
• High stability
• Store of spectra, measurement results and GPS data
• Easy of operation - one-hand manipulation with two buttons
• Wireless data communication with computer
• Built-in nuclide library recommended by IAEA with following isotope type categories: special, medicine, industrial, natural

COMPONENTS

- Radiation monitor unit in shockproof sealed case
- SONY NP-F-970 type lithium-ion battery
- Network adapter
- Serial interface cable
- Combination lock

SPECIFICATIONS

Measuring energy range	from 0.05 to 3 MeV
Relative energy resolution	no more than 9 %
Monitor sensitivity in search mode to gamma radiation	detection of nuclear and radioactive materials, causing the equivalent dose rate of 0.05 μZv/h (over background) at the monitor surface with probability of 0.8 at confidence probability of 95 %
Monitor sensitivity in search mode to neutron radiation	detection of Cf-252 source with neutron flux of 1.2x10^4 s^-1 at 1 m distance during movement with 0.5 m/sec
False alarm rate in search mode	no more than one false alarme: - for 1 min of countinuous operation for gamma channel - for 10 min of continuous operation for neutron channel
Allowable limit of relative basic error when measuring gamma radiation EDR	± 30 %
Number of stored spectra	no less than 1000
Operating temperature range	-20 to 50 °C
Continuous battery operation time	no less than 16 hours
Dust and water proof by GOST 14254-96	IP67
Overall size	no more than (406x330x174) mm
Weight	no more than 10 kg

SOFTWARE

Built-in software allows for operation in following user modes:

ADDITIONAL INFORMATION

- Search for sources, classification of radionuclides by types, record of spectra
- Device control from an external panel

EXPERT MODE :

- Set-up of measurement parameters
- Review of identification results
- Work with spectra and library of radionuclides

In addition the «MKC Manager» service program is supplied, and the program of spectra processing for PC is provided by order

REFERENCES

Containment and Surveillance: Hand-held Monitor

254

Hand-held radiation monitor

MODEL: БИРК-3

SUPPLIER:	**RFNC VNIIEF**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Hand-held Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	U, Pu
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	RFNC VNIIEF
MANUFACTURER:	RFNC VNIIEF

PURPOSE

Hand-held radiation monitor BIRK-3 is a device for equipment of MC&A systems, Physical Protection Systems and is used for examination of people, vehicle, luggage, baggage, rooms and areas.

DESCRIPTION

The monitor БИРК-3 carries on continuous watching for radiation background and provides an alarm signal if controlled parameters exceed limits of specified threshold.

COMPONENTS

SPECIFICATIONS

Detection limit of the monitors for gamma-radiation background of 25 µR/hour and speed of control source relative of working surface of the detector (10.0 to 0.5 cm) with speed of (0.50±0.05)m/second	0.1 g of Pu for minimum irradiating structure (domain); 3.0 g of high enriched uranium (content of U-235 – no less than 89%) for minimum irradiating structure (domain)
Frequency of false alarm of the monitor	no more than 1 false alarm per 1 minute of continuous operation of the monitor
Monitor weight	no more than 1 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.vniief.ru

Containment and Surveillance: Hand-held Monitor

255

Hand-held radiation monitor

MODEL: ГНОМ-5

SUPPLIER: **VNIIA**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Hand-held Monitor
METHOD: Neutron

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: VNIIA
MANUFACTURER: VNIIA

PURPOSE

- scanning people, transport vehicles and railway cars that pass the checkpoints in order to prevent potential theft of nuclear materials and radioactive substances (NRM) that emit neutrons;
- monitoring of environment radioactive contamination (area, rooms), food products, hold up and leakage of radioactive materials from pipelines and etc.

DESCRIPTION

Monitor operation is based on detecting the neutron radiation of NRM on the natural background, which is measured and taken into account during signal analysis.
The monitor is equipped with the audio and digital indication. Whenever the NRM radiation exceeds the alarm threshold, the monitor makes a sound, the tonality of which changes depending on the neutron count rate.
The monitor can scan transport vehicles and packages with the external moderator and scan people without it.

COMPONENTS

- small-dimension remote detection unit,
- control unit
- coupling rod (extender)
- external moderator.

SPECIFICATIONS

Detection threshold at scanning speed no more than 0.5 m/s at distance 10 cm	10 g Pu
False alarm frequency	set in the range 0.1 to 1.0 per minute
Power supply	4 AA batteries
Time of continuous operation	30 hours
Operating temperature range	-40 to +50 °C
Weight (without the rod and external moderator)	0.65 kg
Weight of the external moderator	0.4 kg
Dimensions:	
control unit	175x37x37 mm
detection unit	Ø 65x175 mm
external moderator	Ø 85x175 mm

SOFTWARE

ADDITIONAL INFORMATION

The monitor has the automatic battery discharge indication.
The monitor can be connected to PC via a standard interface.
The detection unit can turn on 90°.

REFERENCES

http://www.vniia.ru

Containment and Surveillance: Hand-held Monitor

256

Hand-held radiation monitor

MODEL: ГНОМ, ГНОМ-2

SUPPLIER: **VNIIA**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Hand-held Monitor
METHOD: Gamma, X-ray

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: VNIIA
MANUFACTURER: VNIIA

GNOME

PURPOSE

- scanning people, transport vehicles and railway cars that pass the checkpoints in order to prevent potential theft of nuclear materials and radioactive substances (NRM);
- monitoring for environment radioactive contamination (area, rooms), food products, hold up and leakage of radioactive materials from pipelines and etc.

DESCRIPTION

Device operation is based on detecting NRM X- and gamma-rays in the range of 40 to 3000 keV on the natural background, which is measured and taken into account during signal analysis.
Monitor is equipped with the audio and digital indication. Whenever the NRM radiation exceeds the alarm threshold, the monitor makes a sound, the tonality of which changes depending on the gamma ray count rate.

COMPONENTS

- small-dimension remote detection unit (DU),
- control unit (CU),
- 0.5…3 m (ГНОМ) or 0.5…1 m (ГНОМ-2) coupling rod (extender).

SPECIFICATIONS

	ГНОМ	ГНОМ-2
Detection threshold at scanning speed no more than 0.5 m/s at distance 10 cm:		
for nuclear materials, g	2 (U-235); 0.15 (Pu-239)	0.5 (U-235); 0.05 (Pu-239)
for radioactive substances, kBq	44 (Co-60); 54 (Cs-137); 40 (Am-241); 50 (Ra-226)	
for gamma radiation exposure rate exceeding the background, (μR/h)	171 (Co-60); 51 (Cs-137); 7.5 (Am-241); 136 (Ra-226)	
False alarm frequency	set in the range 0.1 to 1.0 per minute	
Power supply	4 AA batteries	
Time of continuous operation	30 hours	
Operating temperature range	-40 to +50 °C	
Weight (without the rod)	0.43 kg	0.75 kg
Volume	0.5 dm³	
Overall dimensions of CU		175x37x37 mm
Overall dimensions of DU		176x40x32 mm

SOFTWARE

ADDITIONAL INFORMATION

The monitor has the automatic battery discharge indication.
The monitor can be connected to PC via a standard interface.
The ГНОМ monitor has the conformance certificate.
For ГНОМ-2 monitor: the detection unit can turn on 90°, and there is a capability to apply headphones for sound signals.

REFERENCES

http://www.vniia.ru

Containment and Surveillance: Hand-held Monitor

257

Personal Radiation Detector/Dosimeter

MODEL: 1703 MO-1

SUPPLIER:	**BNC**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Hand-held Monitor
METHOD:	Gamma
MEASURED PROPERTIES:	Radiation Intensity
NUCLEAR MATERIAL(S):	Any radiation source
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field
DEVELOPER:	BNC
MANUFACTURER:	BNC

PURPOSE

The instrument is recommended for detecting and locating radiation sources in both indoor and outdoor environments.

DESCRIPTION

When ON the detector continuously monitors the environment for radiation and alerts the user with a loud audible and visual alarms, silent vibration alarms, or both if a radiation source is detected or a radiation threshold is exceeded. All operations history is stored in the device's permanent (non-volatile) memory, protecting the data even when the battery is removed. The stored data can also be transferred from 1703MO-1 to a personal computer via its infrared interface.

COMPONENTS

- CsI(Tl) detector
- Geiger-Muller tube
- several optional data transmitters
- software
- single AA battery

SPECIFICATIONS

Sensitivity	
for Am-241	0.7 cps/(mR/h) [80 cps/[µSv/h)]
for Cs-137	1 cps/(mR/h) [100 cps/(µSv/h)]
Energy range	0.033 – 3.0 MeV
DER measurement range	10 mR/h – 1000 mR/h [0,1 µSv/h – 9999 µSv/h]
Maximum permissible intrinsic relative error of DER measurement	±30%
Response time	0.25 s
Rate of false alarms in the mode of gamma radiation registration at the radiation background 20 µR/h	mean time to false alarm >12h
Battery lifetime	up to 1,000 hours
Data collection	1,000 data points
Environmental:	
temperature range	-22 to +122 ˚F (-30 to +50 ˚C)
humidity	up to 95% at 95 ˚F (+35 ˚C)
Dimensions	2” x 1” x 3”
Weight, including battery	7.05 oz (200 g)

SOFTWARE

Command center software with building/perimeter mapping or GPS modules

ADDITIONAL INFORMATION

REFERENCES

www.berkeleynucleonics.com

Containment and Surveillance: Hand-held Monitor

258

Pocket gamma-neutron monitor

MODEL: PM-1401GN

SUPPLIER: **Thermo Scientific**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Hand-held Monitor
METHOD: Gamma, neutron

MEASURED PROPERTIES: Radiation Intensity
NUCLEAR MATERIAL(S): U, Pu
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Field
DEVELOPER: Thermo Scientific
MANUFACTURER: Thermo Scientific

PURPOSE

The PM-1401GN is designed to search for, detect, and locate radioactive and nuclear materials in a variety of situations. Such devices also provide an excellent tool for extending stationary monitoring systems to expand the surveillance or to verify alarms of such systems and locate the offending item(s).

DESCRIPTION

The PM-1401GN is a small hand-held radiation detector with separate detectors for both gamma and neutron radiation. It is a small, lightweight, and very simple to operate unit designed specifically for the detection of SNM. It comes equipped with a belt clip allowing hands free operation. For more severe environments, an optional nylon holster is available.

COMPONENTS

- CsI (Tl) scintillator;
- He-3 counter tube with mixture of He-3 (8 atmospheres) and argon (2 atmospheres);
- one AA size battery;
- IR-interface.

SPECIFICATIONS

Gamma measurement range	0.05 to 40 µSv/h (5 - 4000 µR/h) Equivalent dose rate Cs-137
Gamma energy range	0.06 to 3.0 MeV
Neutron energy range	thermal to 14 MeV
Measurement time	0.25 seconds
Alarm types	audio tone and/or vibration
Life expectancy	approximately 600 hours with AA battery
Data collection	900 data points stored in non-volatile memory
Operating temperature	-30° to 50° C (-22° to 122° F)
Water tightness	IP67 (optional water resistance to 20 meters)
Drop test	0.7 m (27.5 inches) onto concrete surface
Dimensions	97 x 57 x 32 mm (3.8 x 2.2 x 1.2 inches). Not including clip
Weight	365 g (12.9 oz). Including battery

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.thermo.com/rmp

Containment and Surveillance: Video Surveillance System

259

All in One Camera Systems

MODEL: ALIS, ALIP


Top-ALIS; Bottom-ALIP

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Video Surveillance System
METHOD:	Video Surveillance
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The All In One System (ALIS) and All in One Portable Camera System (ALIP) are an intelligent camera systems for safeguards surveillance applications.

DESCRIPTION

The camera systems enable the user to perform a quick set-up of the system as required for a specific surveillance application without additional equipment (no need for a PC). The set-up menus appear on the DCMVT 100 screen, and the different selections can be made using the built-in pointing device on the right hand side of the module. The view of the CCD camera can also be controlled by the DCMVT 100 monitor when switched to “live video”.
The system offers a variety of operational modes, e.g. different parameters can be set for day and night surveillance or for working days and weekends.
Camera operates with fixed interval recordings (5 seconds to 18 hours) and/or through front-end scene change detection including “motion history” (pre- and post-event images). Images recorded are stored on PC-Card (PCMCIA) hard disk or flash card.
In the event of a mains loss, the Lithium-Ion battery guarantees a reliable operation without loss of surveillance.

COMPONENTS

The camera systems consist of:
- Digital Camera Module DCM-14 equipped with a PC-Card,
- DCMVT 100 monitor module,
- power supply for worldwide use,
- lithium-ion battery (ALIS)
- microprocessor-controlled battery pack for 10 Li-Ion batteries (ALIP)

SPECIFICATIONS

Supply voltage range	85-265 V ac, 47-440 Hz 110-330 V dc.
Input current	0.6 A, 100 V ac 0.3 A, 230 V ac.
Battery backup	up to ten days with built-in Lithium-Ion battery (ALIS) up to 100 days with 10 built-in Lithium-Ion batteries (ALIP)
Operating temperature	5 °C to 40 °C (41 °F to 104 °F)
Storage temperature	-40 °C to 70 °C (-40 °F to 158 °F) (ALIS) -25 °C to 70 °C (-13 °F to 158 °F) (ALIP)
Size:	
ALIS	33.0 x 26.0 x 19.5 cm (13.0 x 10.2 x 7.7 in.) (L x W x D)
ALIP	36.5 x 33.5 x 19.5 cm (14.4 x 13.2 x 7.7 in.) (H x W x D)
Weight:	
ALIS	7.5 kg (16.5 lb)
ALIP	11.6 kg (25.6 lb)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Video Surveillance System

260

Digital Camera Module

MODEL: DCM-14

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Video Surveillance System
METHOD: Video Surveillance

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Dr. Neumann Consultants
MANUFACTURER: Canberra

PURPOSE

The Digital Camera Module is a complete autonomous surveillance system for safeguards applications.
By combining a CCD camera to the DCM-14, Dr. Neumann Consultants has designed a surveillance device with authentication and encryption, external triggers, scene change detection, and VACOSS-S seals.

DESCRIPTION

Images are taken by the CCD camera and are then collected by the DCM-14. Images collected by the heartbeat trigger of the camera are compressed and stored in the ring-buffer memory. The compression algorithm, a modified JPEG algorithm implemented in the software, has three different qualifications which result in a low, medium, and high resolution image. A variety of trigger configurations are available and can be set during installation. These sources can come from outside the camera, or the camera itself can be set to reduce the number of unnecessary images, thereby focusing the manual review on only those images deemed critical. The DCM-14 operates as a server for images and is equipped with an exchangeable PC-Card for local storage of the compressed images. Generally, sixty compressed medium resolution images fit on a 1 MB memory chip of the PC-Card. The PC-card can be reviewed and analyzed using a notebook PC with a PC-Card slot. An image can be compared with the previous image to detect a scene change. The scene change algorithm corrects for global lighting changes and allows for trigger level adjustments. The algorithm either operates on the whole image without setting regions of interest or sets a maximum of twenty regions of interest in one image. The authentication algorithm is a complex formula based on triple DES algorithm with a changing key every twenty four hours. A key set can be generated inside the module using a real random number generator. The DCM-14 will only reuse a key approximately once every five years. The encryption algorithm is based on an implementation of the DES cipher and on a key set generated and changed by the DCM-14 module. Utilizing a communications server and enhanced GARS software, a complete safeguards review of DCM-14 surveillance images from a remote location may be performed. Images from one or multiple cameras are downloaded from the PC-Card of each DCM-14 to the communications server via one of two available RS-485 communication port. The images can then be downloaded from the server to a remote computer using the GARS software. Additional capabilities of the GARS software include back-end motion detection and authentication verification of the DCM-14 surveillance data.

COMPONENTS

- Exchangeable PC-Card
- Flexible Trigger Engine
- Ring Buffer Memory

SPECIFICATIONS

```
Controller:
     System Memory              2 MB SRAM (battery buffered)
     Firmware Memory            512 KB FLASH EPROM
     Image memory               256 KB
     CPU                        DSP TMX320LC31 running at 20 MHz
Interface:
     Serial Ports               RS-485 isolated interface for party-line operation or
                                  isolated single-ended coaxial interface.
                                RS-232-like serial interface for service, setup and
                                  external triggering
     PC-Card Interface          Type III
     Seal Interface             VACOSS-S interface
Operating temperature range     5 to 40 °C (41 to 104 °F)
Storage temperature range       -25 to 70 °C (-13 to 158 °F)
Dimensions (L x W x H)          252 x 147 x 39 mm (10 x 5.8 x 1.5 in.)
Weight                          0.8 kg (1.8 lb) without PC-Card and Battery
```

SOFTWARE

GARS software

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Video Surveillance System

261

Digital Single Channel Optical Surveillance System

MODEL: DSOS

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Video Surveillance System
METHOD:	Video Surveillance
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Transportable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The Digital Single Channel Optical Surveillance System (DSOS) is designed for unattended one-camera surveillance for safeguards. For remote applications, the camera and control/recording unit can be installed at separate locations (up to 1200 meters). The functions of the DSOS are almost identical to those of the All In One System (ALIS).

DESCRIPTION

The DSOS is a one-channel digital image surveillance system using VDIS components. DSOS enables the user to perform a quick setup of the system as well as easy retrieval of the recorded data without the need for additional equipment (e.g. no monitor or keyboard). The setup menus appear on the DCMVT 100 screen, and the different selections can be made using the built-in jog dial (pointing device) on the right hand side of the module. The CCD camera view can also be controlled by the DCMVT 100 monitor when switched to “live video”. In addition, the monitor displays summary event data at the end of the surveillance period.

Each DCM-14 requires a PC-Card; the one in the recording unit stores the images and related data and the one in the camera unit serves as a backup. The required capacity of the PC-Card per inspection interval depends on the picture-tak¬ing interval set by the user (five seconds to a maximum of 18 hours), as well as the complexity of the image information. The image data compression algorithm implemented into the DCM-14 permits the storage of approximately 60 images per megabyte of PC-Card storage.

In the event of a mains loss, the Lithium-Ion battery guar¬antees a reliable operation without loss of surveillance.

VACOSS-S seal can be connected for location identifica¬tion or other purposes and can generate triggers (pre- and post-event images).

COMPONENTS

DSOS consists of two units:

- camera unit (on top) that includes:
  - CCD camera
  - digital Camera Module DCM-14
- control and recording unit (bottom part) that equipped with:
  - second DCM-14 that serves as the recording device,
  - monitor DCMVT 100, and
  - universal power supply

SPECIFICATIONS

Supply voltage range	85-265 V ac, 47-440 Hz 110-330 V dc
Input current	1.2 A, 100 V ac 0.6 A, 230 V ac
Operating temperature	5 °C to 40 °C (41 °F to 104 °F)
Storage temperature	-40 °C to 70 °C (-40 °F to 158 °F)
Overall dimensions:	
camera unit	33.0 x 26.0 x 19.5 cm (12.9 x 10.2 x 7.7 in.) (L x W x D)
recording and control unit	57 x 49 x 16 cm (22.4 x 19.3 x 6.3 in.) (L x W x D)
Weight of recording and control unit	17.7 kg (39 lb)

SOFTWARE

The review of recorded images is possible with any PC, laptop, or desktop running Windows® 98, Windows NT®, Windows

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Video Surveillance System

262

Digital Multi-channel Optical Surveillance System

MODEL: DMOS

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Video Surveillance System
METHOD:	Video Surveillance
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial, field
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The Digital Multi-channel Optical Surveillance (DMOS) system has been designed to replace the analog multi-channel system used for safeguards, bringing digital processing capabilities to analog systems currently in use. The system is designed for unattended safeguards operations, but can easily be adapted for remote monitoring operations. The DMOS system offers authentication and encryption and can be used with other monitoring devices, such as radiation monitoring and electronic seals.

DESCRIPTION

The DMOS system collects and saves images from up to 32 cameras simultaneously. The images are stored on the server and can be reviewed locally at the facility or remotely. The camera component uses the digital camera module DCM-14 as the core component to perform image capture, compression, authentication, encryption, power management, battery backup, and local image storage to overcome power outages. The camera uses one Sony lithium-ion battery as a backup battery so that the camera can operate for ten days at ten minute intervals in the event of a power loss.

Housed in a 19 inch tamper-resistant/tamper-indicating rack, the DMOS system contains a keyboard with an integrated pointing device, which is suitable for field use and easy to maintain. Based on a rather strong modular design, the DMOS system is easy to service and works well with commercial off-the-shelf (COTS) equipment, lowering costs and allowing for manufacturer support. The DMOS uses a standard safeguards approved VDIS camera system with the same camera components used in all surveillance systems, eliminating the need for retraining of personnel.

COMPONENTS

DMOS consists of:
- Intel-based PC running under Windows NT Server 4.0, which utilizes the Remote Access Service (RAS) capabilities of NT for remote communications and download of data
- TFT display (1024 x 768 pixels),
- keyboard,
- Digital Linear Tape (DLT) drive,
- custom-built digital camera module (DCM-14) consisting of a low power consumption CCD camera
- modem or ISDN adapter (optional)
- DC/DC converter,
- optical isolated video amplifier DCM-OJP,
- DMOS software.

SPECIFICATIONS

Mains requirement	90-265 V ac, 50-60 Hz
Operating temperature	10 °C to 35 °C (50 °F to 95 °F)
Storage temperature	-30 °C to 50 °C (-22 °F to 122 °F)
Relative humidity (non-condensing):	
operating	8% - 90%
storage	5% - 95%

SOFTWARE

DMOS software package consists of custom-made software modules.

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Video Surveillance System

263

Surveillance system

MODEL: GEMINI

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Video Surveillance System
METHOD:	Video Surveillance
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Stationary
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Gemini is a modular, digital network-capable system for secure, unattended, visual surveillance.

DESCRIPTION

Activation causes a picture to be taken immediately and the trigger event is noted and recorded along with the time and date of the trigger.

GEMINI can also automatically dial a preset modem number to remotely announce the occurrence of an event or simply report its "state of health" on a regular basis. Stored images are reviewed with the General Advanced Review Software (GARS), sold separately.

COMPONENTS

GEMINI is housed within a tamper-proof enclosure and include two fully independent surveillance units that contains:
- a camera unit which captures and authenticates images
- system control unit that processes and stores acquired data
- a power management unit
- 4 inputs for external trigger devices

SPECIFICATIONS

Surveillance interval	random
External triggers	4 inputs
Storage capacity	3 months of video data
Recording media	digital
Power supply	5 days of battery back-up on board

SOFTWARE

GARS software package

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Video Surveillance System

264

Surveillance system

MODEL: GEMINI-N

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Video Surveillance System
METHOD: Video Surveillance

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The GEMINI-N Surveillance System is a multiple camera surveillance system specifically designed to support remote surveillance for safeguards applications. The System is designed to collect digital surveillance data from up to eight GEMINI-N camera modules.

DESCRIPTION

The main console collects authenticated digital images from up to eight GEMINI-N cameras and stores them on the PC-Card flash storage. Additionally, the user can set camera parameters from the main console, while a graphical interface provides the user with a visual indicator that the system is functioning properly.
The GEMINI-N camera module offers two modes of operation: time lapsed or motion detection. Images are sampled at two second intervals and are trans¬mitted via Ethernet to the main console for storage. In the event a network connection cannot be established, images are stored on an optional backup flash memory card until the network connection can be re-established.
The digitizing process is accomplished by bringing the analog camera video signals into the frame-grabber.
The combination of high speed sampling with rigorous filters ensures that motion is detected very rapidly and that “false alarms” are minimized.
To establish a continuous surveillance baseline, state-of-health images are recorded at a predetermined interval; ranging from one-minute to 24 hours, without regard to whether motion is detected. All saved images will be tagged with time, date, camera serial number and reason for trigger.
The GEMINI-N is able to run two days on batteries with one camera attached at a five-minute fixed interval frequency.

COMPONENTS

GEMINI-N includes:
- main console including:
  - industrial computer
  - LCD Monitor
  - keyboard with trackball
  - Ethernet HUB with fiber optic converters
  - 24 V Battery backup system
  - up to eight – PCMCIA adapters
  - AC Mains outlet
- camera module including:
  - UTP-to-Fiber optic converter
  - Delta 2000/E motherboard
  - low light camera
  - commercial frame-grabber
  - local backup storage capability on a flash PC-Card
- RS-485/RS-232 communication port

SPECIFICATIONS

SOFTWARE

Camera operates on Linux operating system

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal

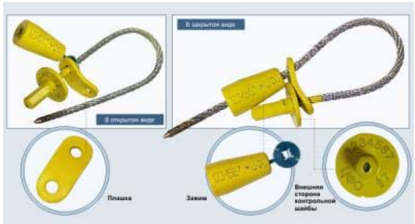
265

Locking-sealing force device

MODEL: «Спрут-универсал»

SUPPLIER: **Strazh, Group of companies**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Strazh, Group of companies
MANUFACTURER: Strazh, Group of companies



PURPOSE

Locking-sealing force device “Sprute -Universal” is a device of unitary action, used in locking units with diameter of a sealing window of no less than 6 mm.

DESCRIPTION

«Спрут-универсал» is installed in the following manner: flexible cable is threaded at first through a sealing window of a locking unit, then through a free window of a tinted box and a loop from the flexible cable is tighten. Then a terminal is severed from a plastic holder and is threaded turning by the cone forward through the free end of the flexible cable tightly to the tinted box. To open the sealing device, the shank end (a cylindrical part of the control washer) is cut with a clipper «Страж» not far from the control washer and took off the control washer away from the flexible cable.

COMPONENTS

• Flexible cable – a female element;
• Tinted box – a connecting element;
• Terminal – a fixing element.
Individual control sigh (7 figures) is plotted on the surfaces of the terminal and the control washer.
Seals have 11 elements of protection from falsification.

SPECIFICATIONS

Break down force	More than 20кN (2000 kgs)
Diameter of the flexible cable	5.8 mm
Length of the flexible cable	330 mm, 450 mm, 850 mm
Material of the terminal	steel
Material of the flexible cable	steel
Material of the tinted box	steel
Working region of temperature	from -60 ˚C to 120 ˚C

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № POCC RU.C305.H.00182 from 05.04.2000

REFERENCES

www.strazh.ru, Каталог (catalog)

Containment and Surveillance: Seal

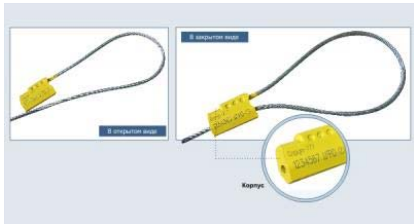
266

Locking-sealing force device

MODEL: «Спрум-777»

SUPPLIER: **Strazh, Group of companies**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Strazh, Group of companies
MANUFACTURER: Strazh, Group of companies



PURPOSE

Locking-sealing force device«Спрут-777» is a device of unitary action, used in locking units with diameter of sealing window of no less than 5 mm and in that cases when it is needed advanced stability to criminal actions.

DESCRIPTION

Sealing subjects by locking-sealing device «Спрут-777» is performed manually, without subsidiary instruments, threading the flexible cable through sealing window of the locking unit and then trough input window of the seal body and tightening a loop from the flexible cable. Locking stage of the device is tested by trying to move the body along the flexible cable to the side of remission of the loop. Removal of the locking-sealing device is carried on by cutting the flexible cable by a cable-clipper.

COMPONENTS

- seal body with a locking machinery;
- flexible cable rigid in the body.

Individual control sigh (7 figures) is plotted on the surfaces of the seal body.
Seals have 10 elements of protection from falsification.

SPECIFICATIONS

Break down force	more than 20кN (2000 kgs)
Diameter of the flexible cable	4.7 mm
Length of the flexible cable	500 mm, 850 mm, 1000 mm
Material of the terminal	steel
Material of the flexible cable	steel
Working region of temperature	from -60 ˚C to 120 ˚C

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № РОСС RU.C305.H.00250 from 29.06.2001

REFERENCES

www.strazh.ru, Каталог (catalog)

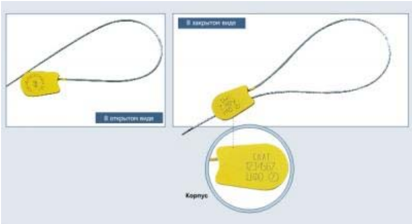
Containment and Surveillance: Seal

267

Locking-sealing force device

MODEL: «Скат»

SUPPLIER:	**Strazh, Group of companies**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control



MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Strazh, Group of companies
MANUFACTURER:	Strazh, Group of companies

PURPOSE

Locking-sealing force device «Скат» is a device of unitary action, used in locking units with diameter of a sealing window of no less than 2.5 mm.

DESCRIPTION

Locking-sealing force device «Скат» is installed manually in the following way: a flexible metal cable is threaded through multiple sealing windows of a locking unit, then the free end of the flexible cable is moved into the input window of the seal body, pulling the flexible cable through the body and tightening the loop. Taking off the locking-sealing force device «Скат» is performed by biting the flexible cable with nail-nippers.

COMPONENTS

- seal body;
- stop element inside the seal body, including 2 fixers;
- flexible cable rigid in the body.

Individual control sigh (7 figures) is plotted on the surfaces of the body.
Seals have 7 elements of protection from falsification.

SPECIFICATIONS

Break down force	more than 3.5кN (350kgs)
Diameter of the flexible cable	2.2 mm
Length of the flexible cable	500 mm, 1000 mm, 2000 mm
Material of the seal body	aluminum alloy
Material of the flexible cable	steel
Working region of temperature	from -60 ˚C to 120 ˚C

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № POCC RU.C305.H.00135 from 24.03.1999

REFERENCES

www.strazh.ru, Каталог (catalog)

Containment and Surveillance: Seal

268

Locking-sealing force unit

MODEL: «Клещ-60СЦ»

SUPPLIER:	**Strazh, Group of companies**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control

MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Strazh, Group of companies
MANUFACTURER:	Strazh, Group of companies

PURPOSE

Locking-sealing force device«Клещ-60СЦ» is a device of unitary action, used in locking units with diameter of a sealing window of no less than 9 mm, for example, for blocking doors of storage rooms, cargo transports, containers, vans.

DESCRIPTION

Locking-sealing force device «Клещ-60СЦ» is locked by manually in the following way: the stem is passed top-down through the match template sealing windows of the locking unit, then on the end of the stem is threaded the bushing. Locking stage of the device is performed by testing on possibility of free turning the stem inside the bushing in locked status, and also trying to take off the brushing from the stem. Taking off the locking-sealing force device «Клещ-60СЦ» is performed by biting the stem with nail-nippers «Страж».

COMPONENTS

- Stem;
- Bushing;
- Locking element.

Individual control sigh (7 figures) is plotted on the surfaces of the stem and brushing.
Seals have 8 elements of protection from falsification.

SPECIFICATIONS

Break down force	more than 12 кN (1200 kgs)
Diameter of the stem	8.5 mm
Length of the stem	60 mm
Material of the bushing	steel
Material of the stem	steel
Working region of temperature	from -60 ˚C till 120 ˚C

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № POCC RU.C305.H.00137 from 26.03.1999

REFERENCES

www.strazh.ru, Каталог (catalog)

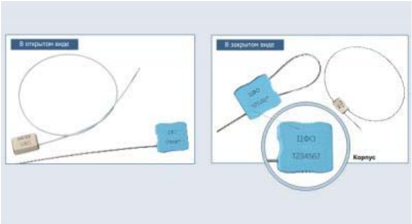
Containment and Surveillance: Seal

269

Loking-sealing device

MODEL: Кобра 1.0

SUPPLIER:	**Strazh, Group of companies**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control Passive
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Field
DEVELOPER:	Strazh, Group of companies
MANUFACTURER:	Strazh, Group of companies



PURPOSE

Universal, small size device intended forsimultaneous locking and sealing the different objects (including the dangerous ones) that are open-air and maritime climate operated and have the diameter of sealing bores no less than 1.0 mm.

DESCRIPTION

There are three modifications of «КОБРА - 1.0» differing by slender column (rope) diameter and material, and by seal body dimensions.

COMPONENTS

SPECIFICATIONS

Diameter of slender column (rope)(Seal body 1)	1.5 mm
breaking force	more than 1.2 kN (120 kgf)
Diameter of slender column (rope)(Seal body 2)	1.0 mm
breaking force	more than 0.8 kN (80 kgf)
Standard length of slender column (Seal body 1)	300 mm, 500 mm, 1000 mm
Standard length of slender column (Seal body 2)	250 mm, 1500 mm, 2000 mm, 5000 mm
Seal body material (Body 1 and 2)	styroplast
Slender column (rope) material	steel, nylon (Seal body 1), brass (Seal body 2)
Operating temperature range	from -40°C to 80°C

SOFTWARE

ADDITIONAL INFORMATION

Other locking-sealing devices: Спрут-универсал, Спрут 777, Спрут 777М, Скат, Закрутка, Клещ-60СЦ, Страж-2.С, Страж-4.С, Страж-5.С, Клещ-1200К, Клещ-1000К

REFERENCES

www.strazh.ru, Каталог (Catalog)

Containment and Surveillance: Seal

270

Control metal seal

MODEL: «МК-01»

SUPPLIER: **Strazh, Group of companies**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Strazh, Group of companies
MANUFACTURER: Strazh, Group of companies

PURPOSE

Control metal belt seal of a unitary action for sealing any subjects with diameter or width of sealing windows no less than 8 mm.

DESCRIPTION

Control metal seal «MK-01» -a belt locking metal seal with locking unit made from 2 locking rings.
Individual control sigh (7 figures) is impressed on the surfaces of the metal belt.

COMPONENTS

SPECIFICATIONS

Seal width	8.0 mm
Working length	170 mm
Total length of the seal	200 mm
Material of the seal	belt zinc-coated steel
Locked unit	two metal locking rings
Working region of temperature	from -60C° to 60C°

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № РОСС RU.C305.H.00223.
There are other metal seals: МЛ-01, МК-Клипс.

REFERENCES

www.strazh.ru, Каталог (Catalog)

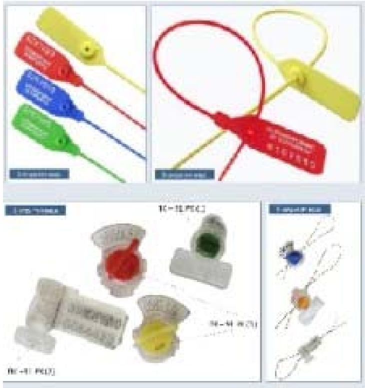
Containment and Surveillance: Seal

271

Control plastic seal

MODEL: ПК-91ОП, ПК-91ТП, ПК-91РХ

SUPPLIER:	**Strazh, Group of companies**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Strazh, Group of companies
MANUFACTURER:	Strazh, Group of companies



Top-ПК-91ОП; Bottom-ПК-91РХ

PURPOSE

Control plastic (ПК-91РХ - rotor type) seal of a unitary action for sealing any subjects with diameter of sealing windows no less than 2.3 mm (ПК-91ОП), 3.0 mm (ПК-91ТП) or 0.4 mm (ПК-91РХ).

DESCRIPTION

There are four modifications of control plastic seals «ПК – 91 ОП» differing diameters and working lengths. Individual control sigh is plotted on the surfaces of the seal by thermal printing or laser. The belt locking seal uses a locking unit in form of a four-leafs grip, made from thermostable material “DELRIN” of firm DU PONT (USA). The seal is locked manually, unsealed by a clipper or a knife.

Working part pf ПК-91РХ is a sealing wire or fishing line. There are three modifications of control seals ПК - 91 РХ: ПК - 91 РХ (1), ПК - 91 РХ (2), ПК - 91 РХ (3).

COMPONENTS

SPECIFICATIONS

	ПК-91ОП	ПК-91ТП	ПК-91РХ
Diameter of the seal	2.3 mm	3.0 mm	
Working length	135/220/320 mm	135 mm	
Total length of the seal	190/280/370 mm	190 mm	
Diameter of the seal	3.8 mm		
Working length	420 mm		
Total length of the seal	560 mm		
Working part (wire or fishing line) diameter			0.4 mm to 0.7 mm
Working length (wire or fishing line)			unlimited
Material of the seal	polypropylene	poliamide or polypropilene	gauzy styroplast
Locking unit	metal grip with 6-leafs	3-leafs grip of thermostable material	rotor-type plug of polypropilene
Operating temperature		from -40 C° to 60 C°	

SOFTWARE

ADDITIONAL INFORMATION

Certificate of RF MVD (Ministry of Internal Affairs) № POCC RU.C305.H.00223.

There are other plastic seals: ПК-93, ПК-01, ПК-02

REFERENCES

www.strazh.ru, Каталог (catalog)

Containment and Surveillance: Seal

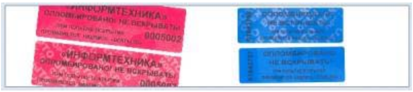
272

Control self-adhesive seal

MODEL:

SUPPLIER: **Strazh, Group of companies**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Strazh, Group of companies
MANUFACTURER: Strazh, Group of companies



PURPOSE

Control self-adhesive seal of a unitary action can be used for almost any smooth surface and for majority rough and uneven surfaces.

DESCRIPTION

Control self-adhesive seal of a unitary action has a special protective thermo-layer for printing on metal, wood, plastic, carton and other surfaces. The seal has high adhesive qualities and sustains high temperature gap. Superscription «ВСКРЫТО» or «OPEN» appears on the surface of the seal when the seal is unsealed and does not disappeared when this seal is stuck repeatedly.
There are two main modifications of indicating labels, differing overall sizes.

COMPONENTS

SPECIFICATIONS

Length of the label	22 mm
Width of the label	66 mm
Length of the label	20 mm
Width of the label	100 mm
Working region of temperature	from -40 ˚C to 80 ˚C
Material of the label	polyester/polyethylene/acryl
Package	1000 seals in a roll

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.strazh.ru, Каталог (Catalog)

Containment and Surveillance: Seal

273

Controlling scotch

MODEL:

SUPPLIER: **Strazh, Group of companies**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Strazh, Group of companies
MANUFACTURER: Strazh, Group of companies

PURPOSE

Control self-adhesive seal of a unitary action can be used for almost any smooth surface and for majority rough and uneven surfaces.

DESCRIPTION

Control self-adhesive belt (scotch) of a unitary action has a special protective thermo-layer for printing on metal, wood, plastic, carton and other surfaces. The self-adhesive belt has high adhesive qualities and sustains high temperature gap. Superscription «ВСКРЫТО» or «OPEN» appears on the surface of the seal when the seal is unsealed and does not disappeared when this seal is stuck repeatedly.
There are two main modifications of indicating scotch, differing overall sizes.

COMPONENTS

SPECIFICATIONS

Length of the scotch	66 mm
Width of the scotch	45 mm
Length of the scotch	76 mm
Width of the scotch	27 mm
Working region of temperature	from -40 ˚C to 80 ˚C
Material of the scotch	polyester/acryl

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.strazh.ru, Каталог (Catalog)

Containment and Surveillance: Seal

274

Locking-sealing force device

MODEL: ЗП-1

SUPPLIER:	**RFNC VNIITF**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	RFNC VNIITF
MANUFACTURER:	RFNC VNIITF

PURPOSE

The passive seal of multiple action for identification of non-authorized access with possibility of automatic identification of unique characteristics of the seal with a special equipment. The seal provide the controlled screw connections of parts of the controlled subject.

DESCRIPTION

Registration of the unique optic image creating when the seal is installed and destroying when the seal undergoes to non-authorized opening.

Accessory equipment can by supplied for installation/opening the seal. Safety of the seal is controlled by automatic registration of seal image with an autonomous device like АРП-1М.

COMPONENTS

- metal corps;
- reference plastic window;
- protective plastic window;
- sealing washera;
- connecting screw with a special window in the screwed end;
- wire, Ø 0.4mm-0.5 mm.

It is possible in addition to put in a company logo and an alphanumeric control sigh.

SPECIFICATIONS

Overall sizes:	
Corps	no more than Ø 24mm x 20 mm
Connecting screw with a special window in the screwed end	one of series M8, M10, M12
Weight	no more than 20 gram
Working region of temperature	-55.. +45 ˚C
Material of the corps	aluminum alloy or stain steel
Wire	yellow metal, Ø 0.5… 0.7 mm
Number of resets	10

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

Containment and Surveillance: Seal

275

Optical loop seal

MODEL: ОПП-1М

SUPPLIER: **RFNC VNIITF**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: RFNC VNIITF
MANUFACTURER: RFNC VNIITF

PURPOSE

The passive seal of multiple action for identification of non-authorized access with possibility of automatic identification of unique characteristics of the seal with a special equipment.

DESCRIPTION

Registration of the unique optic image creating when the connecting element of the seal (the loop) is installed and destroying when the seal undergoes to non-authorized opening.
Accessory equipment can by supplied for installation/opening the seal. Safety of the seal is controlled by automatic registration of seal image with an autonomous device like АРП-1М.

COMPONENTS

- metal corps;
- reference plastic window;
- protective plastic window;
- screwed end;
- wire, Ø 0.4 mm-0.5 mm.

It is possible in addition to put in a company logo and an alphanumeric control sigh.

SPECIFICATIONS

Overall sizes:	
Corps	no more than Ø 24mm x 20 mm
Weight	no more than 5 gram
Working region of temperature	-55.. +45 ˚C
Material of the corps	aluminum alloy or stain steel
Wire	yellow metal, Ø 0.5… 0.7 mm
Number of resets	10

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

Containment and Surveillance: Seal

276

Optical cable screw seal

MODEL: ОПТБ-2

SUPPLIER: **RFNC VNIITF**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: RFNC VNIITF
MANUFACTURER: RFNC VNIITF

PURPOSE

The passive seal of multiple action for identification of non-authorized access with possibility of automatic identification of unique characteristics of the seal with a special equipment.

DESCRIPTION

Identify badge of the seal is a unique optical image.
It is possible in addition to put in a company logo and an alphanumeric control sigh.

COMPONENTS

SPECIFICATIONS

Overall sizes	Ø 30.5 x 20 mm
Working region of temperature	-55.. +45 ˚C
Material	stainless steel
Connecting element	cable, Ø 1… 3 mm
Interface	screw window M10
Number of resets	10

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

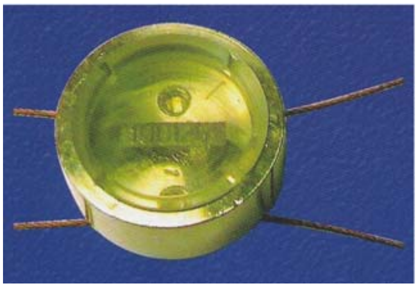
Containment and Surveillance: Seal

277

Optical stationary cable seal

MODEL: ОПТС-2

SUPPLIER: **RFNC VNIITF**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control



MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Stationary
ENVIRONMENT OF USE: Industrial
DEVELOPER: RFNC VNIITF
MANUFACTURER: RFNC VNIITF

PURPOSE

The passive seal of multiple action for identification of non-authorized access with possibility of automatic identification of unique characteristics of the seal with a special equipment.

DESCRIPTION

Identify badge of the seal is a unique optical image.
It is possible in addition to put in a company logo and an alphanumeric control sigh.

COMPONENTS

SPECIFICATIONS

Overall sizes	Ø 30.5 x 20 mm
Working region of temperature	-55.. +45 ˚C
Material	stainless steel
Connecting element	cable, Ø 1… 3 mm
Interface	two screw windows M10
Number of resets	10

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

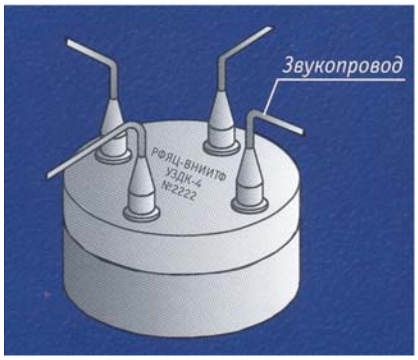
www.vniitf.ru, Рекламные листки (Dodgers)

Containment and Surveillance: Seal

278

Ultrasonic seal

MODEL: УЗДК-4



SUPPLIER:	**RFNC VNIITF**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control Active
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	RFNC VNIITF
MANUFACTURER:	RFNC VNIITF

PURPOSE

4-channel active device for indication of intrusion is design for continuous group control of units of issue.

DESCRIPTION

The device has:
- nonvolatile inner journal of events;
- free running mode with transferring of alarm messages through RS-422.

COMPONENTS

SPECIFICATIONS

Environmental fulfillment	by GOST 15150
Current consumption	15 mA for supply voltage of 24 V

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

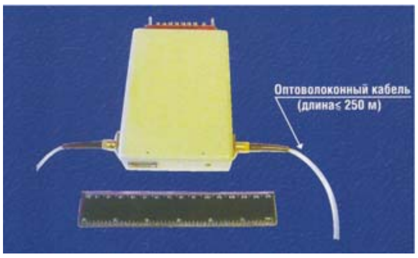
Containment and Surveillance: Seal

279

Fiber-optic seal

MODEL: ОВП-1

SUPPLIER: **RFNC VNIITF**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control
Active
MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: RFNC VNIITF
MANUFACTURER: RFNC VNIITF



PURPOSE

Active fiber-optic loop seal of multiple action is created for continuous group control of units of issue.

DESCRIPTION

The device has:
- nonvolatile inner journal of events;
- free running mode with transferring of alarm messages through RS-485.
- two-ford reservation of electric supply.

COMPONENTS

SPECIFICATIONS

`Environmental fulfillment  on GOST 15150`

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

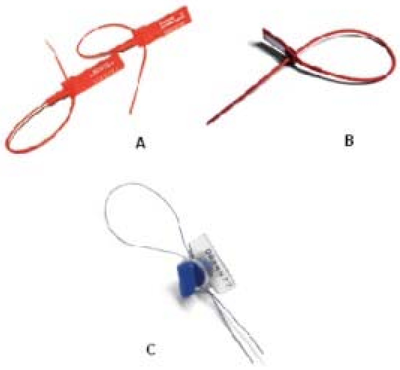
Containment and Surveillance: Seal

280

Universal Numbered Indicator Plastic Seals

MODEL: Альфа-М, Секьюрпул, Ротосил II

SUPPLIER: **Siltech, Ltd.**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control
Passive
MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Field
DEVELOPER: Unknown
MANUFACTURER: Unknown



A: Альфа-М, В:Секьюрпул, С:Ротосил II

PURPOSE

Universal numbered indicatir plastic seals are used for sealing the different objects (Альфа-М (М1) and Альфа ММ - those having the diameter of sealing bore more than 2 mm; Секьюрпул 3,8 мм - those with extended distance between the sealing bores; Ротосил-II - different metrological and measuring euqipment).

DESCRIPTION

Allow for operative detecting the unauthorized access to guarded object. Seals are easy installed by hand. To install "Ротосил" they recommends to use twisted wire of GLW 8, GLW 85, GLW 9 / ПР-С 0,65, GNW 9 / ПР-Н 0,75 type with diameter of 0.65 to 1.1 mm. Seals are removed with shears or wire-cutter.
Main distinguishing feature of Альфа-ММ seal against Альфа-М (М1) is closing of flexor from the direction opposite marking. All "Альфа" modifications have two versions - standard and frost-resisting. Frost-resisting variant is marked by asterisk located in front of individual number.
Extended diameter of Секьюрпул flexor (3.8 mm) provides the increased seal strength.
Ротосил-II has several degrees of protection and original design of ratchet gear.

COMPONENTS

SPECIFICATIONS

	Альфа	Секьюрпул	Ротосил
Material: locking element	polypropilene, steel insert	polypropilene	acryl
Seal dimenstions, mm			6.7x4.75x11.1
Total length, mm	342	500	
Working length, mm	255	410	
Flexor diameter, mm	2	3,8	
Operating temperature, °C:			
standard version	-20 to +60	-40 to +60	-30 to +80
frost-resisting variant	-40 to +60		
Field for additional marking (logotype), mm	25x12		
Package	1000 pcs in box, packed by 10 pcs	1000 pcs in box, packed by 10 pcs	1000/5000 pcs in box, packed by 100 pcs
Package size, mm	550x220x150	560x235x330	360x220x130 / 700x370x235
package weight, kg	3,3 (Альфа-М) 3,0 (Альфа-М1) 2,9 (Альфа-ММ)	6,9	2,7 / 15

SOFTWARE

ADDITIONAL INFORMATION

Other seals of the same type: Байлок (Bylock), Бидирект (Bedirect), Гриптайт (Griptyte), Пулсекьюр (Pulsecure), Пул Флай (Pulfly), Рингсил (Ringseal), Силтек (Sealtech).

REFERENCES

www.siltech.ru | www.brooxlm.com.ru

Containment and Surveillance: Seal

281

Hawser-type Numbered Locking-Sealing Devices

MODEL: Кэйбл Лок 2,5

SUPPLIER:	**Siltech, Ltd.**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control Passive
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial, Field
DEVELOPER:	Unknown
MANUFACTURER:	Unknown

PURPOSE

Numbered locking-sealing device of hawser type «Кэйбл Лок 2,5» is used for sealing the wagons, air-, rail, and marine containers, tanks, storage rooms, depositories and other subjects with sealing bore of not less than 2.6 mm diameter. Seal «Кэйбл Лок 2,5» is the most effective when sealing the objects with misaligned sealing bores.

DESCRIPTION

Seal operates as a locking device and is removed by hawser cutter. It is very corrosion-resistant. Seal numeration is made with laser marking technology. Seal is installed manually without special instruments, removed by hawser cutters.

COMPONENTS

Monoblock seal construction includes:
- strong aluminium body with locking mechanism;
- high-strength flexible hawser made of galvanized steel, that spontaneously untwists when cutting and makes it impossible to masking the breaking sign.

Seal body colors - blue, yellow, green, red.

SPECIFICATIONS

Material of seal body/ flexor	aluminium alloy/galvanized steel hawser
Dimenstions of seal body, mm	28 x 25 x 8
Hawser length, mm	250
Hawser diameter, mm	2.45
Space for stamp, mm	20 x 20
Locking force, kgf	no more than 3
Breaking force, kgf	550
Sequience number (laser mark)	6 digits
Operating temperature, °C	from - 65 to + 55
Package	500 pcs per box
Package size, mm	300 x 270 x 160

SOFTWARE

ADDITIONAL INFORMATION

Other seals of the same type: Кэйбл Сил 2000 (Cable seal 2000); Мэтфлэкс 1,6 (Metflex 1.6) ; Мэтэр Вэлв (Meter Valve).

REFERENCES

www.siltech.ru | www.brooxlm.com.ru

Containment and Surveillance: Seal

282

COBRA Seal

MODEL: COBRA

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control Passive
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	Any
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	SNL
MANUFACTURER:	Canberra

PURPOSE

The Cobra Seal is a passive, fiber-optic loop seal designed to efficiently provide accountability and control of material or items regulated by treaty or agreement.

DESCRIPTION

The seal is installed by looping the fiber-optic cable through the item that is to be sealed and then feeding the cable ends into the seal body. Two clamping pins secure the cable in the seal body and a specially designed cutting blade cuts the fiber-optic cable in a random manner, thereby creating a unique signature that can be viewed and recordered by the Cobra III Seal Imaging System.

Seal verification can be performed at a later time by comparing a new image of a seal to a reference image taken when the seal was originally installed. Any differences found may indicate that the seal has been tampered.

COMPONENTS

- polycarbonate seal body:
  - two clamping pins
  - one cutting blade
- loop of fiber-optic cable:
  - 64 fibers (polymethyl methacrylate resin in fluorinated polymer cladding)

SPECIFICATIONS

Seal dimensions	2 in x 1 in x .5 in (5 cm x 2.5 cm x 1.5 cm)
Fiber diameter x quantity	0.265 mm x 64
Operating temperature	from -55 ˚C to +70 ˚C
Weight (approximate)	0.06 g/m
Minimum bending radius	10 mm
Fiber cable attenuation	actual 280 dB/km, guarantee 360 or less dB/km
Tensile strength:	yield point stress 0.4 kg, strain 5% breaking point stress 0.6 kg, strain 100%

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

1) http://www.canberra.com
2) The Cooperative Monitoring Center (CMC), Sandia National Laboratory publication/ Публикация Кооперативного центра мониторинга Сандийской национальной лаборатории.

Containment and Surveillance: Seal

283

Fiber Optic Seal

MODEL: VACOSS 5.0

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: AQUILA
MANUFACTURER: Canberra

PURPOSE

The VACOSS 5.0 seal is intended for high reliability and long duration surveillance in those applications that require periodic access.

DESCRIPTION

The VACOSS 5.0 seal is comprised of two major components: the seal itself and the fiber-optic cable. At each end of the fiber optic cable is a terminating connector which inserts into two fiber optic receptors located on the top of the seal. The fiber terminators pass through a 0.250" opening. Captive nuts lock the connectors in place. One end of the fiber is typically prepared in advance and the other end is terminated to length in the field. Two LEMO connectors are also located at the top of the seal for communication with an external computer with reader software.
The fiber optic loop is interrogated with an infrared light beam at random intervals, averaging once every 250 milliseconds. Continuity of light transmission through the fiber optic loop is monitored electronically by the seal.
Opening the fiber loop requires approximately 3 seconds without gloves, and the fiber termination cannot be removed from the connector without indicating an open condition. Dates and times, opening or closing of the loop, tampering, and interrogations are stored in the seal and can be reviewed at a later time with the VACOSS reader. The fiber itself is glass with a plastic index layer and kevlar strength members inside a thermoplastic sheath. There is no known method of splicing the fiber in the interval between interrogations.
The seals design is rugged and resistant to tampering. The electronic circuitry (including the light emitting diode and detector) is potted in an X-ray resistant compound of epoxy and ceramic particles to deter attempts at reverse engineering. A tamper switch detects any opening of the seal housing, and all openings are recorded as tamper events. The seal has the option of an external power supply using the LEMO connectors. The internal batteries are disconnected when the seal is powered by an external supply but will immediately switch to the internal batteries if external power is interrupted. No loss of continuity of knowledge will occur during the transition. The internal batteries will provide backup protection for over 10 years if external power is continuous.
For installations with multiple seals in proximity, the seals may be daisy chained using the LEMO connectors in the “Party Line Mode.” All seals connected in this fashion can be read by the adapter box in sequence without changing the connection. A real-time external alarm indication could be implemented for externally powered seals.

COMPONENTS

- seal body including a tamper switch
- loop of fiber optic cable of 500□m diameter
- RS-232 LEMO serial cable (for communication with interrogating device)
- RS-485 interface module (optional)
- wireless interface module (optional)

SPECIFICATIONS

Duration of surveillance on the internal battery:	2 years
Interrogation interval	250 millisec
Memory	128 Bytes RAM, 2 KB ROM
Number of stored events	up to 258
Operating temperature	from -10 ˚C to +50 ˚C
Overall size	125 x 33 x 45 mm
Weight	300 g

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal

284

Electronic seal

MODEL: Argus

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	AQUILA
MANUFACTURER:	Canberra

PURPOSE

The family of Argus seals are electronic seals whose recorded data can be read remotely. The user is instantly given detailed verification information, eliminating the need for a complicated and thorough human visual inspection.

DESCRIPTION

Once applied, the sealing wire creates a unique resistance pattern which cannot be replicated. This resistivity measurement is coupled with the seal's serial number to make a unique identification number for the seal. The construction of the sealing wire is such that it is not possible to measure the wire resistance from the outside of the seal. Depending on the requirements of the user, there are three types of Argus seals: short range Argus, (Argus CR), long range Argus (Argus E-Seal LR), and long range Argus with memory (Argus E-Seal LRV). The seal data can be read via RF with a small, hand-held computer such as the HP200 Palmtop.

COMPONENTS

SPECIFICATIONS

Operating temperature	-20 ˚C to 60 ˚C
Seal size	45 mm x 20 mm x 45 mm

	Argus CR	Argus E-Seal LR	Argus E-Seal LVR
Reading distance	10 cm	10 m	10 m
Life time	Unlimited	5-10 years	2-3 years
Power supply	No batteries	Lithium battery 200mA/h (lifetime 1 year at 20 readings per day)	
Seal engagement	One time	One-time	Re-usable
Advantages	Low cost seal, to replace copper seals		Records 260 events as Vacoss seal

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal

285

E-Tag Mechanical Seal

MODEL:

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	AQUILA
MANUFACTURER:	Canberra

PURPOSE

The E-Tag Mechanical Seal is an inexpensive solution to the issue of seal validation.

DESCRIPTION

E-Tag mechanical seal is a standard metal (copper) seal with small, cheap electronic tag (E-Tag) implanted into the seal body. The E-Tag contains a unique electronic serial number that is written in ROM at the time of manufacture. Mechanical Seals are easily and instantly read by a variety of hand-held devices without the need to remove the seal from the container. This makes random validation of seals possible at any time.

COMPONENTS

- standard copper seal body
- implanted E-Tag

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

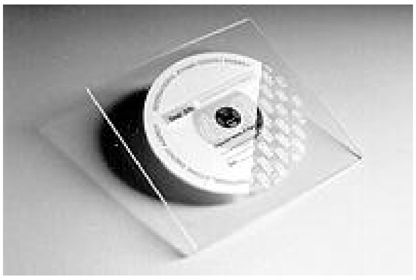
Containment and Surveillance: Seal

286

Paper Tape E-Tag Seal

MODEL:

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control



MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: AQUILA
MANUFACTURER: Canberra

PURPOSE

Designed to address the issue of seal validation, the Paper tape E-Tag Seal is a tamper indicating device (ID) containing an electronically verifiable identification signature in its read-only memory. The electronic ID signature prevents counterfeiting attempts which traditional Paper Tamper seals are susceptible to because they do not have any form of unique identification to prove that the original tape is authentic.

DESCRIPTION

Placing the seal is simple. The E-Tag, measuring 1/8" thick by a little over 1/2" in diameter, is placed in a hole in the metal retainer ring. The retainer ring is self-adhesive on one side. The adhesive attaches the E-Tag to the surface of the container being sealed. Then a circular paper tamper tape with a hole in the center that allows access to the E-Tag is placed over the retainer ring and completely covers and overlaps the edges of the retainer ring. The E-Tag is read by making touch contact with the tag and the metal side of the container. In fact, a fixture may be built into the container holder (whether it is an instrument or a storage shelf) that can be used to verify that the tag is in place.

COMPONENTS

- sandwich containing a thin E-Tag
- thin metal retaining ring
- Advertape vinyl tamper tape

SPECIFICATIONS

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal

287

Smart Bolt

MODEL:

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS:
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra, VNIIEF, SNL, Hi-G-Tek
MANUFACTURER: Canberra

PURPOSE

The Smart Bolt is an enhanced sealing and bolting system used to safeguard nuclear material. A single Smart Bolt attached to the cover of each nuclear material storage cask or container provides tamper resistance.

DESCRIPTION

There are available two type of Smart Bolt:
Multiple-use Smart Tag is used for sealing the conventional containers for fissile materials storage and transportation or for any other cargo whose integrity is required providing a high reliability and tamper indication. Smart Bolt stores the identification number and installation time of the sealed container and cargo, as well as up to 48 bytes of arbitrary information. Up to 255 tamper events (attempts at removing or destroying the bolt) may be stored in the multi-use bolt. The Smart Bolt automatically time records the initial ten tamper events and stores the time of the last tamper event. Information generated by the bolt is protected with a 128-bit password. Easily replaceable lithium batteries provide continuous operation for 4.5 years with the capacity of 600 mA.
The Smart Bolt with piezo-generator is used for sealing the conventional containers for long-term storage of fissile materials (developed specifically for the storage facility at “Mayak”, Chelyabinsk-70). It stores the identification number of the sealed container and cargo, as well as up to six bytes of arbitrary information. Up to 63 tamper events may be stored in the Smart Bolt. Information generated by the bolt is protected with a 64-bit password. The Smart Bolt with Piezo-generator operates without a battery and has an expected operating lifetime of 30 years.
Both the multi-use and Smart Bolt with Piezo-generator are designed as M10 fastening bolts. The Smart Bolt used in conjunction with the Unified Adapters System simplifies the inspection operations and provides the inspector with remote inspection capabilities.

COMPONENTS

SPECIFICATIONS

Operating temperature	-40 ˚C to +85 ˚C
Continuous operation	4.5 years (multi-use bolt)
	30 years (bolt with piezo-generator)
Size	32 x 32 x 40 mm (multi-use bolt)
	32 x 32 x 55 mm (bolt with piezo-generator)

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal

288

DataSeal System

MODEL: DataSeal

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial, field
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

The DataSeal System is designed to enable remote sealing verification and automatic data collection of secured cargos in transit and in storage.

DESCRIPTION

The DataSeal is mounted and removed onto and off of the container by using a set of mounting fixtures.
The sealing wire prevents tampering or any attempt to open or bypass the DataSeal without alerting the system and recording the event. The core of the sealing wire is made of numerous chrome plated wires, randomly connected at the ends. The wires are shielded with a stainless steel hose. Any attempt to tamper with the wire or to open, cut, or bridge it will be detected by the DataSeal System. The sealing wire has long plugs that allow the user to open or close the DataSeal by pulling only the plug, not the wire itself. The DataSeal, together with the sealing wire and mounting fixture, forms the complete as¬sembly used in most applications.
DataSeal has an ability to log data and communicate this information through a Handheld DataTerminal. This allows the "Electronic Manifest" of the sealed cargo to be written into the DataSeal's memory. The information collected by the DataSeal may include vehicle ID, container and invoice numbers, cargo description, quantities, destination, etc. The DataSeal is capable of logging 55 events. The logged information can be downloaded into the database for storage and processing. As an option, communication between the DataSeal and the Handheld DataTerminal can be encrypted with 3DES encryption to prevent fraud as well as seal duplication.
The Handheld DataTerminal is used to write information into the DataSeal's memory at the departure point and then to retrieve the information at the destination point. The events logged in memory are also downloaded into the Handheld DataTerminal.
The DataReader is used to interrogate the DataSeal to obtain its ID and status at a distance of up to 50 meters. It is used for tracking and sealing verification of containers in transit, protection of containers in storage, and remote, automatic data collection of cargo as it passes through checkpoints. Each DataReader can communicate with numerous DataSeals simultaneously and can verify their presence and status.

COMPONENTS

The DataSeal System includes three major components:
1. The DataSeal Portable Electronic Seal that includes:
- Transmitter/Receiver Unit
- Real-Time Clock
- Processor
- Memory
- Sensing Circuitry for sealing verification
2. The Handheld DataTerminal
3. The DataReader

SPECIFICATIONS

Sealing wire length	85 cm or 110 cm
DataSeal memory:	
user memory	2048 bytes
events memory	55 events
Seal power	3.6 V internal lithium battery
Operating temperature:	
Seal and reader	-40 °C to +70 °C (-40 °F to +158 °F)
Data terminal	-20 °C to +70 °C (-4 °F to +158 °F)
Storage temperature:	
Seal and reader	-40 °C to +80 °C (-40 °F to +176 °F)
Data terminal	-20 °C to +80 °C (-4 °F to +176 °F)
Humidity:	
Seal and reader	90% non-condensing
Data terminal	50% non-condensing
Overall size:	

Seal	50 x 37 x 80 mm (2 x 1.5 x 3 in.)
Reader	19.5 x 16.5 x 9.5 cm (7.7 x 6.5 x 3.7 in.)
Data terminal	210 x 100 x 45 mm (8.3 x 3.9 x 1.8 in.)
Weight:	
Seal	100 g (3.5 oz.)
Reader	1000 g (35.3 oz.)
Data terminal	500 g (17.6 oz.)

SOFTWARE

The Handheld DataTerminal' software may be adapted for use in numerous applications. The information collected by the

ADDITIONAL INFORMATION

downloaded to a PC via an RS-232 connection.

REFERENCES

: http://www.canberra.com

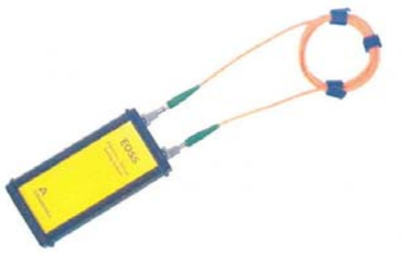
Containment and Surveillance: Seal

289

Electronic Optical Sealing System

MODEL: EOSS

SUPPLIER: **Canberra**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal
METHOD: Access Control



MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: Canberra
MANUFACTURER: Canberra

PURPOSE

The Electronic Optical Sealing System (EOSS) is a reusable active fiber optic seal for long term surveillance. The EOSS seal does not prevent opening and closing, instead, it records these events.

DESCRIPTION

The EOSS seal employs a light source and light sensor to record any open/close events. Source and sensor are connected outside the seal housing through a fiber optic cable, which takes the place of the sealing wire used in a typical non-electronic seal. Sealing is achieved by sending light pulses through the fiber optic cable and monitoring the received signal. If the cable is closed, the light pulses are immediately received. If no pulse is received, the seal is considered opened. The seal timestamps every open/close events and stores them in an event log, which is also capable of storing other information, including operator activities or state of health information. Data is automatically stored in an encrypted database file which can be viewed and analyzed offline (without connecting to the seal). Data can be exported to a customized XML document, which can in turn be distributed and processed across various computer platforms and database systems. A PC/notebook computer connected to the communication port of the seal allows users to view event log entries. Data is provided with authentication tags, which are created by a message authentication code (MAC) that combines the data with a secret key consisting of random numbers. The access authorization and data authentication of the EOSS seal is based on the TDES symmetric block cipher. To facilitate the distribution and selection of the keys, the seal reader uses a special utility program.

COMPONENTS

EOSS seal consists of:
- seal body
- light source
- light sensor
- fiber optic cable
- internal lithium battery

SPECIFICATIONS

Laser peak power	<0.4 mW
Laser wavelength	130 nm
Operational lifetime	2 years
External power	2 VDC to 18 VDC
Memory	8 Kbytes flash memory divided into 64 byte pages
Overall size	125 x 60 x 35 mm (4.9 x 2.3 x 1.3 in.)
Weight	260 g (9.1 oz.)

SOFTWARE

Seal Reader software is employed to communicate with the seal itself. The software, which runs on Windows NT, 2000, and
ADDITIONAL INFORMATION ta from the seals. It can be used for initializing the seals and for diagnostics and maintenance

REFERENCES

http://www.canberra.com

Containment and Surveillance: Seal reader

290

Stand-alone device of the automatic registration of optical seals

MODEL: АРП-1М

SUPPLIER: **RFNC VNIITF**
USE CATEGORY: Containment and Surveillance
DEVICE/METHOD TYPE: Seal reader
METHOD: Access Control

MEASURED PROPERTIES:
NUCLEAR MATERIAL(S):
PHYSICAL FORM(S) OF NM:
STATUS: Serial Production
PORTABILITY: Hand-held
ENVIRONMENT OF USE: Industrial
DEVELOPER: RFNC VNIITF
MANUFACTURER: RFNC VNIITF

PURPOSE

The device is created for automatic registration and control of optic seals.

DESCRIPTION

The device works in the autonomous behavior.
Working parameters:
- registration of optic seals (t < 2 seconds);
- warehousing of information;
- automatic control of optic seals (t < 2 seconds).

The device can exchange digital information with a personal computer through RS-232 and transfer data to another device.

COMPONENTS

SPECIFICATIONS

Environmental fulfillment on GOST 15150

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

Containment and Surveillance: Seal reader

291

A stationary device of the automatic registration of optical seals

MODEL: АРП-1С

SUPPLIER:	**RFNC VNIITF**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal reader
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	
PHYSICAL FORM(S) OF NM:	
STATUS:	Serial Production
PORTABILITY:	Hand-held
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	RFNC VNIITF
MANUFACTURER:	RFNC VNIITF

PURPOSE

Automatic control for location, relocation and integrity of sealed of units.

DESCRIPTION

The device works in a local net of single type devices.
Working parameters:
- access control in the dialog mode;
- automatic control of optic seals and information exchange with a server through RS-485;
- instruction issue on executive units.

COMPONENTS

SPECIFICATIONS

Environmental fulfillment on GOST 15150

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

www.vniitf.ru, Рекламные листки (Dodgers)

Containment and Surveillance: Seal reader

292

Cobra III Seal Imaging System

MODEL:

SUPPLIER:	**Canberra**
USE CATEGORY:	Containment and Surveillance
DEVICE/METHOD TYPE:	Seal reader
METHOD:	Access Control
MEASURED PROPERTIES:	
NUCLEAR MATERIAL(S):	Any
PHYSICAL FORM(S) OF NM:	Any
STATUS:	Serial Production
PORTABILITY:	Portable
ENVIRONMENT OF USE:	Industrial
DEVELOPER:	Canberra
MANUFACTURER:	Canberra

PURPOSE

Cobra III Seal Imaging System is a portable seal inspection station suitable for on-site inspections. The Cobra III Seal Imaging System is designed to photograph, view and print images of seals for review and tamper inspection.

DESCRIPTION

The seal review process involves the following. A seal is inserted into the Cobra III's seal receptacle and a photograph of the fiber optic cable ends is taken using the digital camera. The camera comes with its own built-in liquid crystal color monitor that serves as a viewfinder when photographing seal images and can also be used to display stored images. The Nikon Coolpix 995 camera can digitally store up to 2526 seal images, which may be archived using the included HP PhotoSmart 130 printer or transferred to a PC (not included) using a MS Windows based user interface program (included). The printer is a four-color inkjet printer which produces full color, high-quality image printing directly from the Coolpix 995 digital camera (via USB), a CompactFlash card, or a PC. Once the captured images are printed, the seal images can then be manually reviewed for physical differences by comparing the photographs taken of the sealэs fiber optic cable ends. Any differences found may indicate that the seal has been tampered with.

COMPONENTS

- Nikon Coolpix 995 digital camera
- HP PhotoSmart 130 color printer
- Canberra proprietary optics
- an illumination and alignment accessory
- a portable power pack.
- "QuickStart Sheet" (includes brief instructions for operations most common to inspection applications)
- Factory instruction manuals for the Nikon Coolpix 995 and HP PhotoSmart 130

SPECIFICATIONS

Operating temperature	from -5 ˚C to 40 ˚C (41 ˚F to 104 ˚F)
Power supply	four "D" size alkaline batteries (or standard carbon-zinc cells)
Continuous operation time	full working day of heavy usage
Printer weight	1.33 kg

SOFTWARE

ADDITIONAL INFORMATION

REFERENCES

http://www.canberra.com

6. DETAILED COMPANY INFORMATION

Detailed information on the companies includes addresses, contact information, and in most cases a brief description of the company's profile. In cases where contact information provided in Catalog is not sufficient, the users can obtain it directly from the equipment suppliers.

ANTECH Corporation

A. N. Technology Ltd

9050 Marshall Court
Westmister
Colorado 80031
USA

ANTECH produces instrumentation for measurement and characterisation of special nuclear materials and radionuclides (calorimetry, and neutron and gamma ray measurements).

For UK, Europe and Far East call
+44 (0) 1491 824444
A.N. Technology Ltd.
Unit 5/6, Thames Park
Lester Way, Wallingford
OXON, OX10 9TA
UK
info@antech-inc.com

AQUILA

Aquila Technologies (A Division of MELE Associates, Inc.)

8429-A Washington Place, NE
Albuquerque, NM 87113
(505) 923-3170
(505) 797-1719 FAX

Aquila wholly owned subsidiary of Canberra Industries Inc., is engaged in the development, manufacture, sale, and maintenance of nuclear safeguards equipment for authenticated surveillance and containment, Non-Destructive Assay (NDA) instruments for safeguards, specialized computer systems, and computer networks. In association with the natural course of product development, Aquila is frequently contracted by its product customers to provide engineering support, training, software development, and maintenance and repair services.
Aquila Networking offers consulting, design, integration, development, training, and support services for data management with an emphasis on secure Internet and Intranet business solutions. Aquila's Networking group has the expertise in network integration to assist customers in the design, acquisition, implementation, and support of a new network or modification of an existing one.
Aquila is engaged in the design and manufacture of products and systems for distributed, real-time data acquisition and process control. Aquila products are utilized in aircraft design and simulation, manufacturing process control such as forming glass containers, nuclear fusion research, high-energy particle acceleration experimentation, nuclear energy applications, transportation, surveillance, and industrial testing laboratories.

Aquilon, SPC

Scientific and Production Company Aquilon

JSC "Auqilon
119192, Moscow, Lomonosovsky prospekt, 31, bld.5

Basic direction of "Aquilon" Scientific and Production Company business is developing and manufacturing the modern analytical instrumentation designed for quality and safety control of products, raw materials, technological processes, environment pollution monitoring. One of main "Aquilon" activity is development and production of liquid chromatographs "Stayer", and additional chromatographic equipment. Besides chromatographic equipment the company produces:

• Potentiometric devices: titrators, pH-meters, ionometers, electrodes;
• Inversion voltamperometry devices – voltamperometric analyzers with measurement procedures for determining 15 elements;
• Spectral devices – spectrophotometers, universal flame photometric analyzers;
• Deionizers;
• Moisture analyzers;
•Liquid batchers.

Тел./факс (tel/fax):
(495) 925-7220
(495) 925-7221
(495) 935-0204
(495) 935-0218
(495) 935-0219
E-mail: aquilon@aquilab.ru

Aspect

Scientific and production center "Aspect"

141980 Russia, Moscow region, Dubna, Sakharova str., 6

Scientific and production center "Aspect" is one of leading Russian companies in the field of development and production of modern professional spectrometric, radiometric and dosimetric equipment.

SPC "Aspect" serially manufactures more than 70 kinds of high technology products that are applied in the following fields: radiation control of nuclear and radioactive materials movements at the RF customs check points, nuclear industry facilities, units of RF Ministry of Defence; dosimetric and radiometric monitoring at NPPs, units of RF Ministry of Defence and others; control of and accounting for nuclear and radioactive materials; ecological (radiation) monitoring of areas and industrial objects; scientific and applied researches in the nucler physics field.

Тел./tel 8 (49621) 6-52-72, факс/fax: 8 (49621) 6-51-08
E-mail: aspect@dubna.ru
www.aspect.dubna.ru

Главный инженер - Зайцев Евгений Ильич, 6-52-92, zaitsev@aspect.jinr.ru
Зам. директора, научный руководитель - Иванов Александр Иванович, 6-27-65, ivanov@aspect.jinr.ru
Начальник отдела разработки спектрометрической аппаратуры - Пугачев Александр Николаевич, 6-26-11, pgv@aspect.jinr.ru
Начальник отдела разработки радиометрической и дозиметрической аппаратуры- Хвастунов Михаил Михайлович, 6-37-59,mmx@aspect.jinr.ru

ASTM

American Society for Testing and Materials

ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 USA

MISSION STATEMENT: To be the foremost developer and provider of voluntary consensus standards, related technical information, and services having internationally recognized quality and applicability that:
- promote public health and safety, and the overall quality of life;
- contribute to the reliability of materials, products, systems and services; and
- facilitate national, regional, and international commerce.

http://www.astm.org/

BNC

Berkeley Nucleonics Corporation

2955 Kerner Blvd. Suite D, San Rafael CA 94901

Berkeley Nucleonics Corporation (BNC) manufactures precision electronic instrumentation for test, measurement and nuclear research. Their products include signal / pulse generators and digital delay generators (DDG), multimeters and frequency counters, radiation detectors (RIID) and life sciences instrumentation. Flagship instruments include a 250pS 8-Channel Digital Delay Generator, a NIM Precision Pulse Generator and ANSI compliant handheld isotope identifers (RIID) and radiation pagers (PRD).
BNC’s radiation detection products are applied to detection, dosimetry and isotope identification and in use by HazMat teams, firefighters, first responders, and border protection personnel. Analytical products offer real time medical, industrial, SNM and NORM nuclear isotope identification.
The company has recently begun offering a nationwide radiation detection, surveillance and measurement training program, providing attendees with a comprehensive understanding of principles and techniques for isotope identification and analysis.

email: info@berkeleynucleonics.com

Canberra

Canberra Industries, Inc.

Canberra Industries, Inc.,800 Research Parkway, Meriden, CT 06450, U.S.A.

Canberra Industries, Inc) that is headquartered in Meriden (USA, Connecticut) works on market of nuclear radiation detection for more than 35 years. At present the company is a division of AREVA group and has 12 plants located in USA, France, Belgium, Great Britain, and Canada. Russian office of the company started its operation in 1992.

Представительство компании Канберра Индастриз, Инк. в России
Canberra Industries, Inc.
Россия, 117997, Москва, ул. Миклухо-Маклая,16/10, ИБХ, корпус 32, офисы 406, 417-420
Телефоны/Факсы: (495) 429-65-77, (495) 429-66-11
Электронная почта: cprussia@canberra.ru.
Домашняя страница: www.canberra.ru

Dedal, JSC SPC

Joint Stock Company “Scientific and Production Complex “Dedal”

141980 Dubna, Moscow region, Zholio-Curie str.,20, bld. 41, DCC, p/o box 159

Joint Stock Company “Scientific and Production Complex “Dedal” is one of the leading Russian companies developing and producing the devices and technical systems for physical protection of objects of special importance and increased danger of both civil and military destination, including video surveillance systems, access control systems; technical means for detecting the weapon items, precious metals, and nuclear materials.

Тел./tel: (49621) 2-81-50
Факс/fax:(49621) 2-81-60

Отдел маркетинга (marketing office)
Тел./Факс (tel/fax): (49621) 6-51-63
E-mail: marketing@dedal.ru

Dr. Neumann Consultants

Dr. Neumann Consultants

Econics-Expert, Ltd.

Moscow, Vernadsky prospect, 86, bld. 2 MITHT, Econics-Expert, Ltd.

Scientific and production company “Econics-Expert” develops and manufactures the modern electrochemical and photometric instruments for analytical and laboratory control of water, provision, and raw food quality, soils; production certification; research studies, student and aspirant practical work, including:
- pH-meters “Expert-pH”;
- liquid analyzers of "Expert-001" series (pH-meters – ionometers, pH-meters-ionometers-BOC-thermooximeters);
- conductometers-salinity meters of “Expert-002” series;
- photometers “Expert-003”;
- corrosion meters "Expert-004";
- voltamperometric (polarographic) analyzers “Expert-VA” for determining the microquantities of heavy metals (zinc, cadmium, lead, copper, and others), iodine, selenium, arsenic, mercury, methanol and other toxic components;
- coulometers “Expert-006”;
- Fisher titrators “Expert-007M” ;
- analyzers of chemical oxygen consumption (COC) and biochemical oxygen comsumption (BOC).

Тел./факс (tel/fax): (495)936-89-41, (495)936-89-42, (495)936-89-43
E-mail: ionomer@kbpauk.ru, ionomer@ionomer.ru
URL: http:/ionomer.ru

Finnigan

Finnigan Corporation

355 River Oaks Parkway

Finnigan Corporation was established in 1967 to start commercial production of quadrupole mass spectrometers, and later expanded the product line to organic/magnetic sector and isotope ratio mass spectrometers. Finnigan is also instrumental in developing computer control and data acquisition, chemical ionization, and ion trap mass spectrometers.

Green Star

"Green Star" Business Group

RF, 123060, Moscow, Raspletina str.,5

"Green Star" Business Group (BG) includes limited companies "Green Star Technologies" business, research instrumentation facility "Green Star Instruments" and "Development Bureau GS. "Green Star" BG produces alpha, beta, and gamma spectrometric stations used for analysis of different objects and samples. Including an identification, accounting and control of radioactive and nuclear materials at all stages of nuclear fuel cycle – exploring, mining, enriching, fabricating the fuel rods and assemblies, technological control at NPP and facilities, spent fuel reprocessing, storage and disposal of nuclear waste, radiation control of industrial facilities and environments.

Тел.: (499) 943-20-31
тел./факс / 943-27-94.
E-mail: grstar@mega.ru ; grstar@sniip.ru ; admin@greenstar.ru

IFTP

Institute of Physical & Technical Problems

p/o box 39, Dubna, Moscow region, Russia, 141980

Institute is engaged in development and manufacturing of the following: 1) semiconductor detectors (GeLi, Si, diamond); 2) detection blocks and spectrometric section on the base of developed detectors; 3) radio-isotopic devices: level gauges for liquid and free-flowing materials in vessels of large diameter, thickness gauges for sheet and strip materials (beta and gamma absorption), densitometers for liquid and pulp materials (absorption), aerosol mass concentration and surface density gauges; 4) fire signalizators for atomic industry and NPP.

Плотников Владимир Павлович - директор ИФТП (director)
tel/тел. (096-21)62789, 65783
fax/Факс: (09621) 65082
Щербаков Геннадий Михайлович - главный инженер (chief designer)
tel/тел. (096-21)66182, 62789
fax/Факс: (09621) 65082
E-mail: vasiliev@main1.jinr.dubna.su
Федорков Виктор Георгиевич - нач. отдела (head of department)
tel/тел.: (09621)22880, 62789
fax/Факс: (09621) 65082
E-mail: fedorkov@isotop.dubna.su
Скакодуб Владимир Андреевич - нач.отдела (head of department)
tel/тел. (096-21)65783, 62789
fax/Факс: (09621) 65082
E-mail: vasiliev@main1.jinr.dubna.su

LANL

Los Alamos National Laboratory

P.O. Box 1663
Los Alamos, NM
87545

Los Alamos National Laboratory is a premier national security research institution, delivering scientific and engineering solutions for the nation's most crucial and complex problems. Their primary responsibility is ensuring the safety, security, and reliability of the nation's nuclear deterrent.

Technology Partnerships and Licensing (сотрудничество в области технологий):
Technology Transfer (передача технологий)
505-665-9090
Procurement (закупки):
Procurement Help Desk (PHD) (справочная служба по закупкам)
505-606-0368
e-mail: PHDhelp@lanl.gov

LIMACO

300028, Russia, Tula, Boldina str. 94, JSC"LIMACO"

"Limaco" company is established in 1992 and is one of leading Russian firms specialized in developing and manufacturing the measuring instrumentation of civil designation for different industries, including the radar level meters for measuring the level of liquid and bulk materials.

Телефон/Факс (phone/fax):
(4872) 26-44-09, 26-94-70
E-mail: in@limaco.ru

LLNL

Lawrence Livermore National Laboratory

7000 East Avenue • Livermore, CA 94551

Lawrence Livermore National Laboratory (LLNL) is a part of the National Nuclear Security Administration (NNSA) within the Department of Energy (DOE). LLNL is currently managed by Lawrence Livermore National Security, LLC.
LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. With its special capabilities, the Laboratory also meets other pressing national security needs, which include countering the proliferation of weapons of mass destruction and strengthening homeland security against the terrorist use of such weapons.

Main Operator (925) 422-1100
Fax (925) 422-1370, Fax verification (925) 422-2529

Lockheed Martin Energy Systems (Oak Ridge Y-12 Site)

Lockheed Martin Energy Systems Y-12 Plant

P.O. Box 2009

http://www.ornl.gov/Y-12

MAYAK, PA

FSUE Production Association MAYAK

456780, г. Озёрск, Челябинской области, пр. Ленина, д. 31

Federal state unitary enterprise "Production Association "Mayak" is Russian nuclear weapon complex facility that is part of Federal Atomic Energy Agency. PA "Mayak" structure includes reactor, radiochemical, chemical and metallurgical, radioisotopic, and instrument making industries. Instrument making plant designs and produces the means for measuring and automation, systems for parameters control and technological process control.

Факс
(35130) - 23826
Телетайп
624352, 624372 «ЯНТАРЬ»
Телекс
124864 ATOM RU
www.po-mayak.ru
E-mail mayak@po-mayak.ru

Генеральный директор
Баранов Сергей Васильевич
телефон секретаря: (35130) 25153

MCC

FSUE "Mining and Chemical Combine"

662972 , Zheleznogorsk, Krasnoyarsky kray, Lenina str., 53

MChC was designed as a weapons grade plutonium production facility. Its first water-graphite production reactor was put on line in 1958 and the second - in 1961. Both reactors were taken off line in 1992. Currently MChC is involved in development of new non-radio-chemical activities such as production of silicon materials, and storage and reprocessing of commercial nuclear fuel.

Телеграф:	Железногорск 288006 «СТАРТ»
Телефон:	(8-3912)66-23-37
	(8-39197)5-20-13
Телефакс:	(8-3912)66-23-34
e-mail:	atomlink@mcc.krasnoyarsk.su

Mettler Toledo

ZAO "Mettler-Toledo Vostok", Sretensky Blvd, 6/1 Office 6, 101000 Moscow

METTLER TOLEDO is a global manufacturer and marketer of precision instruments for use in laboratory, industrial and food retailing applications

Тел.: (495) 651-98-86, 651-68-75
факс: (495) 621-68-15, 621-78-68
E-mail: inforus@mt.com
Интернет: www.mtrus.com, www.mt.com

Красноярск
Тел.: (3912) 68-19-30, 68-19-31,
68-19-32
Факс: (3912) 68-19-29
E-mail: mtsiberia@mt.com

Екатеринбург
Тел./факс: (343) 373-72-98, 373-74-79
E-mail: mtural@mt.com

Ростов-на-Дону
Тел./факс: (863) 218-10-78, 218-10-79
E-mail: mtsouth@mt.com

Самара
Тел./факс: (8462) 70-37-09
E-mail: mtvolga@mt.com

Хабаровск
Тел./факс: (4212) 48-54-55
E-mail: Dmitry.Saprykin@mt.com

Казахстан
Тел.: +7 (7272) 98-08-34,
+7 (7272) 50-63-69
Факс: +7 (7272) 98-08-35
E-mail: mtca@mt.com

Украина, Белоруссия и Молдова
Тел.: +38 (044) 461-78-02
Факс: +38 (044) 461-78-53
E-mail: infoubm@mt.com

MSZ, JSC

Public corporation "Machine Building Plant"

144001, Russian federation,
Moscow region, Electrostal,
K.Marks str., 12

Public corporation "Machine Building Plant" (MSZ) is one of the biggest Russian enterprises. MSZ is a part of "TVEL" Corporation under Federal Atomic Energy Agency supervision and is one of the leading world manufacturers and suppliers of nuclear fuel for nuclear power plants. Besides, plant fabricates the fuel for research reactors and reactor installations of navy ships.

Телефон (phone): (495) 702-99-01
Факс (fax): (495)702-92-21
E-mail: zymsz@elemash.ru
www.elemash.ru

NBL

New Brunswick Laboratory

U.S. Department of Energy
New Brunswick Laboratory
Building 350
9800 South Cass Avenue
Argonne, IL 60439-4899
NBL: (630) 252-2442
CRM: (630) 252-2767
usdoe.nbl@ch.doe.gov

The U.S. Department of Energy, New Brunswick Laboratory (NBL) provides Certified Reference Materials (CRMs) for use in nuclear and nuclear-related analytical measurement activities. This catalog lists and describes the CRMs currently available to both governmental and private organizations within the international nuclear community. All requests for nuclear standards are contingent upon existing U.S. regulations and international agreements regarding possession of such materials.

Jon W. Neuhoff, Laboratory Director
Office of the Director
PH: (630) 252-2446
FAX: (630) 252-6256
jon.neuhoff@ch.doe.gov
Steven A. Goldberg, Program Manager
Office of the Director
PH: (630) 252-2464
FAX: (630) 252-6256
steven.goldberg@ch.doe.gov
Usha I. Narayanan, Division Director
Safeguards and Evaluation Division
PH: (630) 252-3105
FAX: (630) 252-6256
usha.narayanan@ch.doe.gov

Nu Instruments Ltd

Unit 74 Clywedog Road South
Wrexham LL13 9XS
North Wales, UK

Nu Instruments design and manufacture a range of mass spectrometers and accessories.

UK & Rest of World
sales@nu-ins.com
Tel: +44 (0)1978 661304
Fax: +44 (0)1978 664301

ORNL

Oak Ridge National Laboratory

Oak Ridge National Laboratory
P.O. Box 2008,
Oak Ridge, TN 37831, USA

Oak Ridge National Laboratory (ORNL) conducts basic and applied research and development to create scientific knowledge and technological solutions that build the nation's expertise in key areas of science; increase the availability of clean, abundant energy; restore and protect the environment; and contribute to national security.
ORNL also performs other work for the Department of Energy, including isotope production, information management, and technical program management, and provides research and technical assistance to other organizations.

Phone: (+1)865.574.4160

ORTEC

Advanced Measurement Technology, ORTEC

801 South Illinois Avenue
Oak Ridge, Tennessee 37831-0895
United States

ORTEC is an industry leader in the design and manufacture of advanced high purity germanium and silicon (HPGe and Si) detectors for gamma rays and charged particles respectively. The Company is successfully manufactures NIM modular electronic instruments, as well as integrated spectroscopy electronics based on digital signal processing technology.

Phone: 865-482-4411
Toll: 800-251-9750
Fax: 865-483-0396
Website: http://www.ortec-online.com

Distributor:
Адрес: Москва, Климентовский пер., д. 12, стр.1, офис 2, Pribori Oy,
Проезд: метро "Третьяковская" (схема проезда),
Телефон: (495)-937-45-94,
Факс: (495)-937-45-92,
e-mail: info@pribori.com

PNPI

St-Petersburg Nuclear Physics Institute

PNPI RAS, Gatchina, Leningrad district 188300, Russia

The main directions of scientific activity of "Petersburg Nuclear Physics Institute" (PNPI) are fundamental studies in area of neutron, nuclear, theoretical physics, nuclear reactor physics and engineering, molecular and radiation biophysics, as well as applied scientific developments, for example, automated information and measuring system for radiation environment control.

Тел(Tel). +7(813-71) 46025, +7(813-71) 46047,
Факс(Fax). +7(813-71) 36025, +7(813-71) 31347
Сайт института: www.pnpi.spb.ru

RFNC VNIIEF

Russian Federal Nuclear Center, All-Russian Research Institute of Experimental Physics

607188, Sarov, Nizhegorodsky region, Mira prospect, 37

Russian Federal Nuclear Center – All-Russian Research Institute of Experimental Physics (RFNC VNIIEF) is federal state unitary enterprise that is the biggest scientific and technical Russian center successfully resolving the defense, scientific, and national economic problems. VNIIEF consists of some institutes: of theoretical and mathematical physics, experimental flow dynamics and explosion physics, nuclear radiation physics, laser-physical researches, scientific and technical center of energy high densities and directed radiation fluxes physics, as well as design bureaus and thematic centers.

Костюков Валентин Ефимович - Директор РФЯЦ-ВНИИЭФ (VNIIEF Director, Valentin Kostyukov)
Телетайп: 651203 "Мимоза"
Телекс: 151109 Arsa SU
Тел.: 8 (83130) 4-48-02
Факс: 8(83130) 2-94-94
E-mail: staff@vniief.ru

RFNC VNIITF

Russian Federal Nuclear Center, All-Russian Research Institute of Technical Physics

456770, Chelyabinsky region, Snezhinsk p/o box 245

Main activity directions: fundamental and applied investigations in nuclear physics, physics of high pressures, hydrodynamics, design and engineering works on automatic systems, registration means. Now there are opened a new scientific directions - medical equipment, creation of fiber- optic hardware components, gamma-installations of commercial designation, explosion technology for industry.

web-admin@vniitf.ru

Sibprompribor-Analyt

Russian Federation, Altay Territory, Barnaul, Lenina avenue, 195, of.339

Activity field of scientific and production enterprise “Sibprompribor-Analyt” Ltd. includes the development and serial production of laboratory and industrial analytical instrumentation for concentration control of different chemical solutions, specifically, conductometers, concentration meters, level meters; as well as development and production of analytical instruments and process control systems by individual orders.

Телефон: 8 (3852) 77-09-50
E-Mail: s_pribor@ab.ru
Директор ООО "Сибпромприбор-Аналит" Владимир Алексеевич Мациевский
(“Sibpromprivor-Analyt” Director, Vladimir Matsievsky)

SNIIP - Automatics

123060, Moscow, Raspletina str.,5

“SNIIP-Automatika” is a daughter facility of scientific and engineering center SNIIP – one of the leading Russian organizations in the field of equipment development for detection of ionizing radiations. Main firm activity is production of portable “field” devices for control of fissile and radioactive materials.

Тел. 198-84-43, факс (495) 943-00-63. E_mail: automat@sniip.ru

SNIIP - Konvel

RF, 123060, Moscow, Raspletina str.,5

“SNIIP-CONVEL” specializes in development and production professional high sensitive instrumentation for environment radiation control, unauthorized movements if radioactive substances, LED-based information display systems with integrated measuring channels of radiation and climatic parameters. Radiation control instrumentation produced includes: radiation control systems; radiation monitors; search and stationary dosimeters and radiometers; surface contamination control equipment; portable neutron radiometer; portable liquid radiometer, flowing liquid radiometer; detection blocks.

тел. (499) 946-87-84, (499)192-79-47, моб.8 963 614 06 25
факс: (499) 946-87-84, (499)192-99-07
E-mail: conveln@sniip.ru
http:// www.convel.ru

SNL

Sandia National Laboratories

Sandia National Laboratories, New Mexico
PO Box 5800
Albuquerque, NM 87185-(mail stop)

SNL works in the following areas:
- Nuclear Weapons
- Energy & Infrastructure Assurance
- Nonproliferation
- Defense Systems & Assessments
- Homeland Security
- Science, Technology, & Engineering

Sandia National Laboratories, New Mexico
PO Box 5800
Albuquerque, NM 87185-(mail stop)

Spectr

Development Bureau Spectr

Russia
194044, St.-Peterburg
Chugunnaya str., 20

Main direction of “Development Bureau Spectr” firm business is manufacturing spectral instrumentation. Its production list includes among others the emission spectrometers; spectrophotometers; monochromator MDR-41 and systems on its base; IR-spectrometers; metallographic equipment.

тел/факс: +7 (812) 740-7915, 292-5547, 324-8467, 740-7916
e-mail: okb@spectr.spb.su
Ответственные лица по направлениям:
• Искольский Юрий Семенович – директор по маркетингу и продажам (Yuri Iskolsky – director of marketing and sales)
• Лысов Константин Владимирович – руководитель продаж эмиссионных спектрометров (Konstantin Lysov – administrator of emission spectrometers sale)
• Иванов Валерий Николаевич – руководитель продаж спектрофотометров и монохроматоров (Valery Ivanov –administrator of spectrophotometers and monochromators sale)
• Сыркин Владимир Александрович – руководитель отдела аналитики и сервиса эмиссионных спектрометров (Vladimir Syrkin – head of emission spectrometer analytic and service department)

SSC RF-IPPE

Federal State Unitary Enterprise "State Scientific Centre of the Russian Federation – Institute for Physics and Power Engineering named after A.I.Leypunsky"

249033, Obninsk, Kaluzhsky region, Bondarenko sq., 1

Main trends of the Institute scientific activity is development of liquid metal cooled nuclear reactors. Institute investigates the nuclear physics, nuclear reactor physics, thermal physics, material irradiation study, and so on.

(48439) 9-89-61 (справочная ГНЦ РФ – ФЭИ);
(48439) 9-88-19 (Жуков Александр Васильевич – нач. отдела НТИ);
(495) 953-00-17 доб. 80-43;
(48439) 9-84-12 (канцелярия).
Факс (48439) 6-82-25, 5-84-77
Телетайп (183566) "Альфа"
E-mail: Инновационные проекты и разработки: beg@ippe.ru (Будылов Евгений Григорьевич);
http www.ippe.ru

Strazh, Group of companies

«Strazh" Companies Group (including closed JSCs: "Engineering and Industrial Concern "Strazh", "Strazh and C", "Sealing Systems") is one of leaders in the field of developing, producing, and supplying the heavy-duty and control lock and sealing devices, seals (metal, plastic, self-adhesive) and associated products to different business fields.

Группа Компаний «СТРАЖ»
Телефоны: +7(495) 221-7665, +7(495) 225-9595
Факс: +7(495) 225-9555
www.strazh.ru
e-mail: strazh@strazh.ru

ЗАО «ИПК «СТРАЖ»
Телефоны: +7(495) 372-3081, +7(495) 765-7777
Факс: +7(495) 376-1285, +7(495) 221-7628
www.strazh.su
e-mail: strazh@strazh.su

ЗАО «СТРАЖ и К»
Телефон: +7(495) 221-7669
Факс: +7(495) 657-5775
www.zpu.ru
e-mail: zpu@zpu.ru

ЗАО «Системы Опломбирования»
Телефон: +7(495) 765-0055
Факс: +7(495) 377-8702
www.plomba.com
www.пломба.ру
e-mail: plomba@plomba.ru

Tenzo-M

140050, Moscow region,
Luberetsky district, Kraskovo village
Vokzalnaya str., 38

"Tenzo-M" weighting company is a leading Russian manufacturer and designer of industrial weighting equipment. Company annually produces many dozens of thousands of weighting sensors, scales, batchers and secondary devices foe many industry branches.

+7 (495) 745 30 30
+7 (495) 510 35 53
501-8027, 501-8054
E-Mail: tenso@tenso-m.ru
Sipnet ID: 3373992

TH-Automatica

Traiding house "Automatica"

214031, Smolensk, p/o box 109

Trading house "Automatics" propose their service in area of control-measuring instrumentation, automatic euqipment and other different eiqopment supply since 2000.

Т/ф: (4812) 62-10-28, 61-16-75
31-35-06, 31-21-38
e-mail: info@td-automatika.ru

Thermo Scientific

part of Thermo Fisher Scientific (established as Thermo Electron Corporation)

Corporate Headquarters:
Thermo Fisher Scientific Inc.
81 Wyman Street
Waltham, MA 02454

Company provides the following products and technologies:
- Analytical Instruments
-Reagents & Consumables
- Laboratory Equipment
- Software & Services

Call for mass spectrometry, chromatography, spectrophotometry: +431 333 50 34 0
Density, flow and level measuremets: +44 (0) 160 654 8700

TsvetChrom Ltd.

Nizhny Novgorod reg., Dzerzhinsk, Lenin av. 48 office 250, 606023, Russia

Laboratory equipment produced by the company includes among others the gas, liquid chromatographs, hydrogen generators of "TsvetChrom" series, nitrogen generator "GAL-101", water deionizer "DV-1" and other laboratory devices and accessories.

Телефон/факс: (8313) 26-27-06, 26-27-05, 25-62-62, 27-40-03
E-mail: office@tsvet.com
WWW: http://www.tsvet.com
Директор: Столяров Олег Владимирович (Director, Oleg Stolyarov)
Заместитель директора по коммерческим вопросам: Блохин Дмитрий Викторович (Deputy Director for commercial issues, Dmitry Blokhin)

UEIP

Ural Electrochemical Integrated Plant

109180, Russia, Novouralsk, Dzerzhinskogo str., 2

Ural Electrochemical Integrated Plant (UEIP) is the largest uranium enrichment enterprise in the world. It also designs and manufactures the advanced process control instruments and systems for the nuclear industry, including filters and filtering elements; alpha rays radiometers; optical and digital micromanometers; ALPHA-R dosimeter for personnel control; oxygen magnetothermal analyzer; MTI-350G mass spectrometer for uranium hexafluoride isotope analysis; uranium isotopic reference materials.

E-mail: condor@ueip.ru
Телеграф: Новоуральск, Свердловская обл., КОНДОР, телетайп: 348811, КОНДОР
Факс: (34370) 94141, 566

Коммерческо-сбытовой отдел (Marketing and sales department):
Начальник(Head) - (34370) 5-70-97, 9 85 00;
секретарь (secretary) - (34370) 5 70 93, 9 82 61
E-mail: kso@ueip.ru

UEMP

FSUE "Ural Electromechanical Plant"

Russia, 620137, Ekaterinburg, Studencheskaya str., 9
Post: Russia, 620000, Ekaterinburg, p/o box 74

Federal state unitary enterprise “Ural Electromechanical Plant” (FSUE UEMP) activity is directed at fabricating the production that meets the needs of Rosatom corporative market (production for JSC TVEL, Rosenergoatom, nuclear fuel cycle facilities) and key industrial enteprises of national economy (fuel and energy complex, transport, communications, etc.) and is proved by Russian Gosatomnadzor licenses for designing and producing the equipment for nuclear power plants. Among its production there are atomic-absorption spectrophotometer “Spiral-17”; atomic-absorption spectrophotometer “Analytic-2000”; thermo-luminescence dosimetric system “Sapfir-001”.

ТЕЛЕФОН: +7 (343) 341-92-05
ФАКС: +7 (343) 341-33-70
E-MAIL: uemp@uemp.ural.ru
САЙТ: www.uemz.ru

VMK-Optoelectronika, Ltd.

RUSSIA, 630090, Novosibirsk-90, p.o.box 376 "VMK-Optoelektronika"

VMK Optoelektronika Ltd business is aimed at developing photodiode array-based scientific instruments and producing limited series of these instruments. Basic developments is the multichannel analyzer of atomic emission spectra MAES-10 designed to replace outdated spectrometers and quantometers, of Russian and international production alike.

Тел/факс: +7 (383) 333-33-91
Адрес для курьера: Россия, Новосибирск, Академгородок, пр.Коптюга, 1, к.100;
E-mail: info@vmk.ru

VNIIA

FSUE "All-Russian Research Institute of Automatics"

Post adress: 101000, Moscow, Moscow Post Office, p/o box 918. Legal: 127055, Moscow, Suschevskaya str., 22

Beyond the defence direction the Institute is a head organization of Minatom responsible for nuclear-physical instrumentation and produces some devices for russian nuclear materials control, acounting and physical protection system. Among these instrumentation are radiation monitors with improved sensitivity to uranium and plutonium, instrumentation of detection and identification of isotopic composition and mass of NM by neutron and gamma radiation.

Тел.: (499) 978-7803
Факс: (499) 978-0903, 978-0578
E-mail: vniia@vniia.ru
Контактное лицо по радиационным мониторам:
Новиков Валентин Михайлович
Тел.: (499) 978-9983
Факс: (499) 978-0903, (499) 978-0578
E-mail: vniia@vniia.ru

VNIINM

FSUE "Bochvar Institute of Inorganic Materials"

123098, Moscow, Rogova str., 5a

Main directions of institute activities:
- nuclear fuel, construction materials and fuel rods for different reactors;
- reprocessing the specnt nuclear fuel and radioactive waste;
- materials science, metallophysics, technology of fissile, nuclear and comtsructive materials;
- low- and high- temperature superconductors;
- technology of production and treatment of metals, alloys, composite materials and itms;
- analytical and non-destructive control methods;
- metrological support.

тел.: +7 (499)190-49-94
факс +7 (495) 742-57-21
E-mail: post@bochvar.ru
Секретарь Генерального директора: тел.: +7 (499)190-82-97

VNIITFA

All-Russian Research Institute of Technical Physics and Automatization

115230, Russia, Moscow, Varshavskoye shosse, 46

Institute is a head Minatom organization in the area of non-destructive assay methods used for the process control in nuclear fuel cycle.

www.vniitfa.ru

Vzlet, JSC

190121, St-Peterburg, Masterskaya str., 9
Moscow branch:
127018, Moscow, Nizhniaia Syromiatnicheskaia street, 5/7 (plant "Manometr"), office 705, 706

Closed JSC “Vzlet” is a manufacturer of devices for measuring the flow of liquids, gases and thermal energy, in particular, the devices foe measuring and accounting the liquid flows (by electromagnetic and ultrasonic methods), measuring the levels of different mediums (digital ultrasonic level meter).

Телефон (phone): +7 (812) 714-75-32
Телефакс (fax): +7 (812) 714-71-38
E-mail: mail@vzljot.ru
URL: http://www.vzljot.ru
Заказ оборудования (euqipment order):
(812) 714-8123
(812) 714-8102
Консультации по применению оборудования (equipment maintenance concultation):
(812) 714-8178

Московский филиал (Moscow branch):
e-mail: moscowoffice@vzljot.ru
Phone/Fax: (495) 647-01-66, 647-01-36

WSRC

Westinghouse Savannah River Company (Analytical Laboratories Department)

PO Box A Aiken SC 29802