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TECHNICAL REPORT

colour inside

Radiation instrumentation – Radiation sources used in illicit trafficking detection standards – Guidance and recommendations

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RADIATION INSTRUMENTATION – RADIATION SOURCES USED IN ILLICIT TRAFFICKING DETECTION STANDARDS – GUIDANCE AND RECOMMENDATIONS

FOREWORD

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IEC TR 62971, which is a technical report, has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
45B/817/DTR	45B/821/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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RADIATION INSTRUMENTATION – RADIATION SOURCES USED IN ILLICIT TRAFFICKING DETECTION STANDARDS – GUIDANCE AND RECOMMENDATIONS

1 Scope

This Technical Report (TR) provides guidance and recommendations regarding the availability and use of radiation sources that are needed when testing and evaluating instruments used for the detection of illicit trafficking of radioactive material. The relevant standards are listed in 4.1. Guidance includes the use of surrogate or replacement radioactive materials that could be more easily obtained.

The object of this Technical Report is to provide guidance to instrument manufacturers, users, and testing organisations as to the selection and possible use of radiation sources, source surrogates and source simulation tools when testing and evaluating an instrument's ability to detect and identify illicit trafficking of radioactive material.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-395, *International Electrotechnical Vocabulary – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

3 Terms and definitions, abbreviations and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60050-395 apply.

3.1.1
nuclear material
plutonium, except that with isotopic concentration exceeding 80 % in plutonium-238; uranium-233; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue; any material containing one or more of the foregoing

Note 1 to entry: Additional details regarding source composition can be found in 4.3.

[SOURCE: IAEA-TECDOC-1311-September 2002]

3.2 Abbreviations and symbols

DD Deuterium-Deuterium

DU Depleted Uranium

HEU Highly Enriched Uranium

IAEA International Atomic Energy Agency

NIST National Institute of Standards and Technology
NORM Naturally Occurring Radioactive Material
Np Neptunium
PMMA Poly methyl methacrylate
Pu Plutonium
RGPu Reactor Grade Plutonium
NM Nuclear Material
WGPu Weapons Grade Plutonium

4 Background

4.1 List of relevant standards

The following standards are currently relevant to this Technical Report. Each standard contains requirements for photon and neutron radiation emitting sources including those requirements for NM.

– IEC 62244, *Radiation protection instrumentation – Installed radiation monitors for the detection of radioactive and special nuclear materials at national borders*
– IEC 62327, *Radiation protection instrumentation – Hand-held instruments for the detection and identification of radionuclides and for the indication of ambient dose equivalent rate from photon radiation*
– IEC 62401, *Radiation protection instrumentation – Alarming personal radiation devices (PRD) for detection of illicit trafficking of radioactive material*
– IEC 62484, *Radiation protection instrumentation – Spectroscopy-based portal monitors used for the detection and identification of illicit trafficking of radioactive material*
– IEC 62533, *Radiation protection instrumentation – Highly sensitive hand-held instruments for photon detection of radioactive material*
– IEC 62534, *Radiation protection instrumentation – Highly sensitive hand-held instruments for neutron detection of radioactive material*
– IEC 62618, *Radiation protection instrumentation – Spectroscopy-based alarming Personal Radiation Devices (SPRD) for detection of illicit trafficking of radioactive material*
– IEC 62694, *Radiation protection instrumentation – Backpack-type radiation detector (BRD) for the detection of illicit trafficking of radioactive material*

4.2 Source suppliers

Several radioactive sources are required for testing to IEC standards. Many sources are commercially available for purchase. It is up to each individual organization to identify the manufacturer or supplier based on their specific needs.

4.3 Nuclear Material (NM) sources and materials of interest

At the time of publication, the materials of interest include:

– Depleted Uranium (DU),
– Highly Enriched Uranium (HEU),
– Reactor Grade Plutonium (RGPu), and
– Weapons Grade Plutonium (WGPu).

Due to the availability of DU for testing, it will not be addressed in this Technical Report.

For IEC efforts, HEU has an enrichment of greater than 90 % ^{235}U and DU of no more than 0,4 % ^{235}U. RGPu is defined as containing more than 12 % ^{240}Pu, and WGPu having no more than 6 % ^{240}Pu and not less than 12 % ^{239}Pu.

Standardized test sources containing NM are sealed sources that are characterized by mass, isotope content, geometric shape (e.g., spherical), and age. The characterization should include chemical elements, not just radionuclides.

^{237}Np, ^{232}U, ^{233}U have been discussed as a possible material of interest, but due to very limited availability they will not be addressed further in this Tehcnical Report.

4.4 Neutron sources

Based on the materials of interest to be detected, a fission spectrum source is required at an emission rate of 20 000 neutrons per second. Therefore, each applicable standard requires the use of a ^{252}Cf source having an activity of approximately 185 kBq.

Neutron sources with higher emission rates such as those used for dosimetry or dosemeter calibration (i.e., radiation protection instrument calibration) will produce more scattered neutrons because the source to detector distance must be increased to maintain the same fluence rate produced by the recommended source. Therefore, the use of a neutron source with much higher emission rates is not recommended for illicit trafficking detection instrumentation.

4.5 Surrogate materials and efforts

4.5.1 Materials

– **HEU**

HEU sources are required to produce the radiation test field for spectrometric or identification type instruments. The amount of ^{235}U depends on the requirements in the standard and instrument being tested. Because the main photon energy of ^{235}U is 186 keV, most emissions come from the surface of the source to a depth of approximately 1 mm (based on the 95 % infinite thickness emission rate). As a result, the quantity of a surrogate source can be reduced and still have the same emission as a much larger mass. Surrogate HEU sources have been developed in the form of sealed stainless steel capsules containing porous graphite cylinders saturated with HEU oxide and in the form of thin wall hollow HEU spheres.

– **Uranium**

Uranyl acetate may be used as a check source to verify uranium identification capabilities. The chemical compound can be purchased as a powder although there are many different options as to its composition. Uranyl acetate consists of ^{238}U and ^{235}U at 0,3 % to 0,4 % enrichment depending on the manufacturer. Uranyl acetate is a toxic material.

– **Plutonium radiation surrogate**

A self-contained source of gamma-ray and neutron radiation suitable for use as a radiation source surrogate for WGPu has been developed (See Bibliography: US Patent 7,655,935 B1, Feb 2, 2010). The surrogate source, which does not contain NM, was designed to produce a radiation spectrum similar to that of WGPu over an energy range from 59 keV to 2 614 keV. This WGPu surrogate also emits neutrons having fluxes commensurate with gamma radiation intensities employed. The surrogate source consists of ^{133}Ba, ^{252}Cf, ^{137}Cs, ^{153}Gd, ^{57}Co, ^{155}Eu, ^{177m}Lu, ^{113}Sn, ^{228}Th, ^{95}Zr in an assembly. Further details are available in the referenced patent. This source is relevant for testing the identification capabilities of instruments with an energy resolution that is no better than 5 %.

– **Use of plated sources for handheld detection systems**

Sources made from the plating of ^{239}Pu or ^{235}U to a substrate were investigated as possible surrogates for larger sources that are used to test the identification function of handheld devices. The investigation determined that the amount of material required may not be feasible for plated sources.