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IEC International Standards Under Development For Radiation-Generating Devices

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Abstract

The International Electrotechnical Commission (IEC) is the leading and oldest global organization with over 100 years history of developing and publishing international standards for all electrical, electronic and related technologies, including radiation detection instrumentation. Subcommittee 45B "Radiation Protection Instrumentation" of the IEC has recently started the development of two standards on radiation-generating devices. IEC 62463 "Radiation protection instrumentation – X-ray Systems for the Screening of Persons for Security and the Carrying of Illicit Items " is applicable to X-ray systems designed for screening people to detect if they are carrying objects such as weapons, explosives, chemical and biological agents and other concealed items that could be used for criminal purposes, e.g. terrorist use, drug smuggling, etc. IEC 62523 "Radiation protection instrumentation – Cargo/Vehicle radiographic inspection systems" applies to cargo/vehicle imaging inspection systems using accelerator produced X-ray or gamma radiation to obtain images of the screened objects (e.g. cargo containers, transport and passenger vehicles and railroad cars). The objective of both standards is to specify standard requirements and general characteristics and test procedures, as well as, radiation, electrical, environmental, mechanical, and safety requirements and to provide examples of acceptable methods to test these requirements. In particular the standards address the design requirements as they relate to the radiation

protection of the people being screened, people who are in the vicinity of the equipment and the operators. The standard IEC 62463 does not deal with the performance requirements for the quality of the object detection. Compliance with the standards requirements will provide the manufacturers with internationally acceptable specifications and the device users with assurance of the rigorous quality and accuracy of the measurements in relation to the radiological safety of the equipment. The main characteristics of IEC 62463 and IEC 62523 standards are presented and as well as the IEC methodology of standard development and approval.

Introduction

Personnel X-ray screening assemblies are used to examine persons in order to detect objects that they should not be legally carrying, e.g.: weapons, explosives, smuggled or stolen items such as drugs or diamonds. The screening devices can be divided into three types: one type using the Compton backscattered X-rays (Backscatter system) for the image creation, one using the transmitted X-rays (Transmission system) for the image creation, and a third type as a combination of the other two types (Backscatter +Transmission). All three types consist of an X-ray unit and a detector unit. A scan of a person takes about 10 seconds. The systems are operated by and the image is viewed on an external computer. Sophisticated software is used to evaluate the complex images and to enable the detection of hidden objects.

The main difference between the system types is the position of the detectors. Usually, they also differ in the tube voltage range used, however this is not always the case. Backscatter X-ray systems, (B), use a narrow pencil shaped beam that scans the subject at high speed in a horizontal and vertical direction. Large detectors are installed on the same side of the subject as the X-ray source. The person stands in front of the enclosure and is scanned by the X-ray beam having a typical cross sectional area of approximately 25 mm^2 ; this of course is the quantity limiting the spatial resolution of the system. Usually the person is scanned twice, once from the front and then from the back. Sometimes lateral scans are also performed. Typical systems use fixed peak voltage (kV) and current (mA) settings for the X-ray source. These are typically 50 kV and 5mA. The total aluminum equivalent filtration is in the range from 1 mm to about 7 mm.

Transmission X-ray systems, (T), often use a vertical fan–shaped beam of X-rays and a linear array of detectors. The person stands between the X-ray tube and the detector array and is scanned by the X-ray beam having a typical width of approximately 2 mm. The limiting quantity for the spatial resolution is the size of the detector elements. The scan takes about 10 seconds. Typical systems use a fixed peak voltage (kV) and current (mA). Settings are in the range of about 140 kV to 220 kV and 0.1 mA to about 4 mA. The total aluminum equivalent thickness is in the range of about 1 mm to about 16 mm. The systems are capable of detecting objects within the body. Backscatter plus transmission X-ray systems, (BT), are systems that use both backscattered and transmitted X-rays, during the same scan procedure.

Contrabands such as illicit materials could be concealed also in cargo or vehicles and thus be transported everywhere in the world. Because of this more and more countries have great demands today for equipment for inspecting cargo and/or vehicles. In response to this demand inspection system manufacturers are developing and providing cargo/vehicle radiographic inspection system to assist in the detection of illicit movement of contraband at customs and important ports.

Subcommittee 45B of the IEC has recently started the development of two standards on radiation-generating devices related to the above topics. IEC 62463 "Radiation protection instrumentation – X-ray Systems for Screening of Persons for Security and the Carrying of Illicit Items " is applicable to X-ray systems designed for screening people to detect if they are carrying objects such as weapons, explosives, chemical and biological agents and other concealed items that could be used for criminal purposes, e.g. terrorist use, drug smuggling, etc. IEC 62523 "Radiation protection instrumentation – Cargo/Vehicle radiographic inspection systems" applies to cargo/vehicle imaging inspection systems using accelerator produced X-ray or gamma radiation to obtain images of the screened objects (e.g. cargo containers, transport and passenger vehicles and railroad cars). The main characteristics of IEC 62463 and IEC 62523 standards are presented and as well as the IEC methodology of standard development and approval.

IEC/TC 45/SC 45B

The International Electrotechnical Commission (IEC, http://www.iec.ch) was founded in 1906 and is the oldest organization that is charged with the development and the publication of international standards for all electrical, electronic and related technologies. These international standards serve as a basis for national standardization and as references when drafting international tenders and contracts.

179 Technical Committees (TC) and Subcommittees (SC), and about 700 project teams grouped in working groups carry out the standards work for IEC. The working groups are composed of representatives from all over the world who are experts in their own field and who are members of regulation agencies, research laboratories, manufacturers, and user organizations.

TC 45 "Nuclear Instrumentation" addresses standards development for instrumentation specific to nuclear applications. SC 45B "Radiation Protection Instrumentation" covers all the fields of radiation protection instrumentation. SC 45B, through its working groups (WG) B9 "Installed equipment for radiation and activity monitoring in nuclear facilities" and B15 "Illicit trafficking control instrumentation using spectrometry, personal electronic dosimeter and portable dose rate instrumentation" was charged with the development of two international standards on radiation-generating devices used for personnel security screening and for cargo/vehicle radiographic inspection systems.

To develop a standard, the following general IEC procedure is followed. First, after an observed need for a new standard, the national committees or the TC/SC secretary can propose a new project. Experts from at least 5 countries are needed to start a new project. An appointed Project Leader (PL) proposes the first draft of the standard, incorporates the different suggestions from other experts, and is responsible for the technical standard development and advancement. Concerning the standards that are presented in this paper IEC 62463 is led by a representative from the United Kingdom and IEC 62523 is led by a representative of the Peoples Republic of China.

All standards projects pass through different stages starting as a NP (New Project), one or more CD (Committee Draft), CDV (Committee Draft for Vote) and prior to publication, as FDIS (Final Draft International Standard). At each stage, the standard project is sent for comments and suggestions to the 20 participating national committees and for information to 12 more observing countries of SC 45B. Meanwhile, the draft is circulated electronically to experts from different countries belonging to the corresponding working group. For example, IEC 62523 was circulated between 35 experts from 16 countries.

At the general SC 45B meetings (approximately once per 18 months) or at the interim WG meetings all editorial or technical comments received on the draft standard from national committees and liaising international organizations (ICRP, ICRU, IAEA, ISO etc.) are discussed in depth and a new draft is prepared. The last interim meetings of WG B15 and WG B9 dealing respectively with IEC 62523 and with IEC 62463 occurred in June 2007. WG15 interim meeting was hosted by the IAEA in Vienna and was attended by 20 experts from 10 countries. The WG9 interim meeting hosted by the UK took place in London and was attended by 10 experts from 6 countries.

At the CDV and FDIS stages, the project standard is voted on by the SC45B twenty participating national committees . A standard must be finished in less than 5 years and, when complete, is published simultaneously in English and French. A maintenance period is specified for each newly published standard (generally 5 years) and after this period the standard is reconsidered for a new maintenance period, for revision or for withdrawal.

IEC 62463 "Radiation Protection Instrumentation – X-Ray Systems for the Screening of Persons for Security and the Carrying of Illicit Items"

Scope and object

This International Standard is applicable to X-ray systems designed for screening people to detect if they are carrying objects that could be used for criminal purposes, e.g. terrorist use, drug smuggling, theft etc. These objects include weapons, explosives, chemical and biological agents and other concealed items

With backscatter systems the X-rays are used to detect objects hidden under or within the person's clothing. With transmission systems objects swallowed or hidden in body cavities may be detected. Combined devices, can be used to get both pieces of information simultaneously.

The object of this standard is to lay down standard requirements and also to specify general characteristics, general test procedures, radiation characteristics, electrical characteristics, environmental influences, mechanical characteristics, safety requirements and to provide examples of acceptable methods in terms of dose to the whole or part of the body for each screening procedure and the time taken for each screening procedure.

In particular the standard addresses the design requirements as they relate to the radiation protection of the people being screened, people who are in the vicinity of the equipment and the operators. The standard does not address the performance requirements for the quality of the object detection.

Safety considerations

General

The manufacturer shall provide a description of the radiation safety systems that are designed to prevent, during normal operation of the X-ray screening system, accidental exposure to the operator and public and for ensuring that the person being screened is not exposed above manufacturers stated maximum dose per scan. The accompanying manual provided by the manufacturer shall include details of the fail-safe features of the radiation safety exposure circuit. These details shall also include functional test instructions.

Shielding

The ambient dose equivalent at a distance of 30 cm from all external surfaces of the system, including in the X-ray beam beyond a beam stop or when the shutter is closed shall not exceed 2.5 μSv measured over a period of one hour when the equipment is used at its maximum capacity under any operating conditions. When a person is being screened and the X-ray beam is emanating, shutter or beam stop open, the ambient dose equivalent rate to any area where other members of the public have access shall not exceed 2.5 $\mu Sv\ h^{-1}$ taken over several scans. These dose equivalent rate limits are minimum requirements. National regulations may stipulate lower limits.

System controls and normal operation indications

The operating conditions, namely the tube voltage, kV, and tube current, for each mode of operation shall be pre-set by the manufacturer and shall not be alterable by the system operator. If there is more than one mode, prior to each scan, a mode indicator shall be clearly visible to the operator.

The operator's control panel shall show the following.

• Electrical power to the system is on. Only the operator is permitted to switch on the power and this should require the use of a coded key.

• When the X-rays are being produced an "X-rays on" illuminated sign shall be displayed.

• The operating voltage and tube current for the operating mode shall be displayed when required by an engineer or maintenance staff

• Indication shall be made for both when the shutter or beam stop is open and/or for when the scan is taking place, “scan on”

• The production of x-rays shall only start if the illuminated sign “X-rays” is ready to operate.

Safety indicators and interlocks

A monitoring instrument shall be placed, before the exit beam location, to measure the ambient dose equivalent rate as well as to integrate the scanning exposure. This shall be provided with a dose equivalent alarm which both immediately terminates the exposure and indicates on the control panel should equipment malfunction result in the dose to the subject being screened exceeding any pertaining limit. These safety interlocks, indications and alarms shall be independent of the system’s normal controls and operational indications.

Ambient dose equivalent to a person being scanned

The ambient dose equivalent, H*(10), at the reference point shall not exceed 0.3 μSv per screening procedure (that means the sum of all scans necessary to examine a person) for backscatter systems, (B), and 5 μSv per screening procedure (that means the sum of all scans necessary to examine a person) for transmission systems, (T) and backscatter and transmission systems, (B,T). Other values may be specified as required by national regulations.

IEC 62523 "Radiation Protection Instrumentation – Cargo/Vehicle Radiographic Inspection Systems"

Scope and object

This International Standard applies to cargo/vehicle radiographic-based inspection systems. It is also applicable to the radiographic-based systems used for inspecting various packaging cargo and transport vehicles. The object of this standard is to prescribe the component, classification, technical and radiation protection requirements, and test methods of cargo/vehicle radiographic inspection systems. This standard is not applicable to computed tomography systems, backscatter inspection systems, cargo/vehicle radiographic inspection system using neutron radiation and X-ray systems for the screening of persons.

General characteristics

The inspection systems are designed to create object images for an inspector to detect, locate, and identify contraband hidden in cargo and/or vehicles. They are generally composed of a radiation source(s), detectors, conveyer and control system, the image processing unit, other auxiliary devices/facilities, and, typically, they also control the inspection process and create digital radiographic images of the objects.

Inspection systems shall be equipped with emergency-stop devices such as emergency buttons, emergency lines, etc, that are able to terminate the radiation emission and stop all the driving mechanism of the system when activated. Emergency devices shall be installed at multiple locations including in the operator (control) room and close to the radiation source, the detectors, and the conveyors.

The emergency devices shall only be reset manually. Once any emergency device is activated, the system shall stop operating immediately. It shall not be possible for the system to become operational again unless a local reset has been acknowledged.

The emergency devices shall work in a fail-safe mode. If any emergency device fails, the system shall be prohibited from operation, and a failure status shall be displayed on the control panel and show the location of the failure.

In case of power failure, the radioactive source shutter of a gamma-ray system shall automatically close.

Imaging classifications

This standard provides classification concerning:

- steel penetration of radiation : 4 categories from 400 mm to 200 mm;
- wire detectability: 4 categories from 2 mm wire thickness to 5 mm thickness;
- spatial resolution: 4 categories from 5 mm to 12 mm;
- contrast sensitivity: 4 categories from 0.5% to 2%;
- object recognition capability: 3 categories (satisfactory, acceptable, failure).

Radiological safety test

The maximum ambient dose equivalent rate, not including the natural background, shall not exceed 2.5 μSv h^{-1} outside the supervised area during exposure. The manufacturer shall state the maximum ambient dose equivalent rate at the control panel during the scan. The dose equivalent rate shall not exceed 1 μSv h^{-1} while the control panel is located in the controlled area, however, other national regulatory limits may apply.

If the driver stays in the vehicle during scanning, the ambient dose equivalent level for the driver shall not exceed 0,1 μSv per scan.

If the system exposes any carry-on or checked cargo to more than 10 μSv during the inspection, a sign which advises to remove film of all kinds from the cargo before inspection shall be posted.

Conclusion

In addition to the presented requirements in both standards there are also mechanical, environmental, electrical, electromagnetic and documentation requirements.

Compliance with such standard requirements will provide the manufacturers with internationally acceptable specifications and the device users with assurance of the rigorous quality and accuracy of the measurements in relation to the radiation hazard.

Both IEC 62463 and IEC 62523 are on early stage of development, respectively at CD2 and CD, and their completion and publication is expected around 2010-2011.

A feedback from experts outside IEC would be greatly appreciated.