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NORME INTERNATIONALE

colour inside

Industrial non-destructive testing equipment – Electron linear accelerator

Appareils destinés aux essais non destructifs pour le secteur industriel – Accélérateur électronique linéaire

IEC 62976:2017-05+AMD1:2021-10 CSV(en-fr)

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CONTENTS

FOREWORD 5
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 Equipment sets, names and work conditions 9
4.1 Equipment sets 9
4.2 Name convention 9
4.3 Operating conditions 10
4.3.1 Environmental requirement 10
4.3.2 Power supply 10
5 Technical requirements 10
5.1 Appearance 10
5.2 Control system 10
5.2.1 Design principle 10
5.2.2 Operation of start and stop 10
5.2.3 Functions of control system 10
5.3 Performance 11
5.3.1 X-ray beam energy 11
5.3.2 X-ray homogeneity 11
5.3.3 X-ray beam air kerma rate 11
5.3.4 X-ray beam focal spot 12
5.3.5 X-ray beam asymmetry 12
5.3.6 X-ray sensitivity 12
5.3.7 Dose leakage 13
5.4 Electrical safety 13
5.4.1 Protective grounding 13
5.4.2 Insulation resistance 13
5.4.3 Dielectric strength 13
5.4.4 Protection against electric shock 13
5.5 Reliability 13
5.5.1 Continuous operation 13
5.5.2 Recovery 13
5.5.3 Restart 13
6 Test methods 13
6.1 General requirements 13
6.1.1 Testing conditions 13
6.1.2 Instruments and devices 14
6.2 Visual inspection 15
6.3 Control system test 15
6.4 Performance test 15
6.4.1 X-ray beam energy 15
6.4.2 X-ray homogeneity 16
6.4.3 X-ray beam air kerma rate 17
6.4.4 X-ray beam focal spot 17
6.4.5 X-ray beam asymmetry 19
6.4.6 X-ray sensitivity 19

6.4.7 Leakage dose rate 19
6.5 Electrical safety testing 20
6.5.1 Protective grounding 20
6.5.2 Insulation resistance 20
6.5.3 Dielectric strength 20
6.5.4 Protection against electric shock 20
6.6 Reliability test 20
6.6.1 Continuous operation 20
6.6.2 Recovery 20
6.6.3 Restart 20
7 Inspection rules 21
7.1 Inspection classification 21
7.2 Inspection items 21
7.3 Criterion rule 21
8 ~~Marking~~ Signage, packaging, transportation, storage and accompanying documents 21
8.1 ~~Marking~~ Signage 21
8.1.1 Accelerator signs 21
8.1.2 Component nameplates 22
8.1.3 Labels 22
8.1.4 Warning signs 22
8.2 Packaging 22
8.3 Transportation 22
8.4 Storage 22
8.5 Accompanying documents 23
8.5.1 Instructions 23
8.5.2 ~~Product certification~~ Supplier's declaration of conformity 23
8.5.3 Other documents 23

Figure 1 – Naming convention 9
Figure 2 – Sketch map of the test module 14
Figure 3 – Sketch map of the copper block with a swivelling edge 15
Figure 4 – Schematic diagram of X ray beam radial uniformity measurement 16
Figure 5 – Schematic diagram of the testing module in front of the detector 17
Figure 6 – Schematic diagram of the "Sandwich" test module placement 18
Figure 7 – Schematic diagram of the copper block test module placement 18
Figure 8 – Diagram of leakage dose measurement points 20

Table 1 – Specifications of several commonly used accelerator models 10
Table 2 – Half value layer of materials corresponding to commonly used X-ray beam energies 11
Table 3 – X-ray homogeneity of commonly used X-ray beam energies 11
Table 4 – X-ray beam air kerma rate of different models 12
Table 5 – Detection range of equivalent steel thickness corresponding to commonly used X-ray beam energies 12
Table 6 – Testing conditions 14

Table 7 – Inspection items of the accelerator 21

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL NON-DESTRUCTIVE TESTING EQUIPMENT – ELECTRON LINEAR ACCELERATOR

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IEC 62976 edition 1.1 contains the first edition (2017-05) [documents 45/821/FDIS and 45/824/RVD] and its amendment 1 (2021-10) [documents 45/920/CDV and 45/929/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 62976 has been prepared by technical committee 45: Nuclear instrumentation.

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

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INDUSTRIAL NON-DESTRUCTIVE TESTING EQUIPMENT – ELECTRON LINEAR ACCELERATOR

1 Scope

This document gives the rules of naming, technical requirements, test methods, inspection, ~~marking~~ signage, packaging, transportation, storage and accompanying documents for electron linear accelerator equipment for Non-Destructive Testing (NDT).

This document applies to NDT electron linear accelerator equipment in the X-ray energy range of 1 MeV to 15 MeV, including the accelerator equipment for radiographic film, computed radiography with imaging plates, real-time imaging, digital detector array and industrial computerized tomography.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC Guide 37:2012, *Instructions for use of products by consumers*

ISO 780:2015, *Packaging – Distribution packaging – Graphical symbols for handling and storage of packages*

ISO 19232-1:2013, *Non-destructive testing – Image quality of radiographs – Part 1: Determination of the image quality value using wire-type image quality indicators*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
target
area on the surface of accelerating tube outlet on which the electron beam impinges and from which the primary beam of X-rays is emitted

3.2
linear electron accelerator
LINAC
apparatus for producing high energy electrons by accelerating them along a waveguide. The electrons strike a target to produce X-rays

Note 1 to entry: NDT electron linear accelerator, hereinafter referred to as the accelerator.

[SOURCE: ISO 5576:1997, 2.84]

3.3
X-rays
penetrating electromagnetic radiation, within the approximate wavelength range of 1 nm to 0,0001 nm, produced when high velocity electrons impinge on a metal target

[SOURCE: ISO 5576:1997, 2.129]

3.4
X-ray beam energy
E
maximum X-ray energy in the continuous emission spectrum, equal to the product of the electron charge and the accelerating voltage

Note 1 to entry: E is expressed in megaelectronvolts (MeV).

3.5
wedge X-ray field
X-radiation field with a dose distribution that changes approximately linearly with distance from the beam edge along a line perpendicular to and passing through the radiation beam axis

[SOURCE: IEC 60976, 2007, 3.32]

3.6
half-value layer
thickness of a specified material, which attenuates under narrow beam conditions X- radiation with a particular spectrum to an extent such that the air kerma rate, exposure rate or absorbed dose rate is reduced to one half of the value that is measured without the material. The half-value layer (HVL) is expressed in suitable submultiples of the metre together with the material

[SOURCE: IEC 60601-1-3, 2008, 3.27]

3.7
X-ray beam focal spot
d
dimension across the focal spot of an accelerating tube, measured perpendicular to the central beam axis

Note 1 to entry: d is expressed in millimetres (mm).

3.8
X-ray beam homogeneity
ratio, expressed as a percent, of the dose rate in a plane 1 m from the target and normal to the beam central axis, and acquired at a specified angle from the central axis, to the dose rate in the plane and on the beam axis

3.9
X-ray beam air kerma rate
K
volume of ionization caused by the x-ray beam in air per unit time at 1 m away from target

Note 1 to entry: K is expressed in centigrays per minute (cGy/min).

3.10
X-ray beam asymmetry
ratio of the difference to the average values of the dose rates measured at equal distances from the central beam axis and in a vertical plane normal to the x-ray beam

Note 1 to entry: This ratio is expressed as a percentage.

3.11
X-ray sensitivity
ratio of the minimum defect size that can be observed in the detector to the thickness of the penetrated material

Note 1 to entry: This ratio is expressed as a percentage.

3.12
X-ray head
part of an X-ray installation that contains the accelerating tube and its shield

4 Equipment sets, names and work conditions

4.1 Equipment sets

Generally, the equipment consists of the following components:

a) X-ray head,
b) modulator,
c) temperature control unit (TCU),
d) control system,
e) power distribution cabinet,
f) safety interlock system,
g) interconnecting cables (X-ray head to modulator, modulator to console) and hoses (TCU to X-ray head).

4.2 Name convention

The naming rules of the equipment are shown in Figure 1.

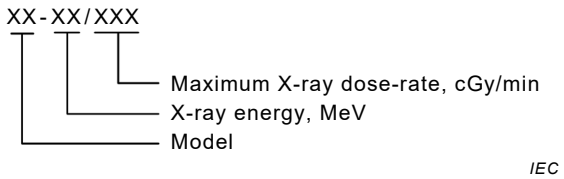

Figure 1 – Naming convention

The specifications of several commonly used accelerator models are shown in Table 1.

Table 1 – Specifications of several commonly used accelerator models

Model No.	Specification	
	X-ray beam energy MeV	Maximum X-ray dose rate cGy/min
XX-2/200	2	200
XX-4/500	4	500
XX-6/1000	6	1 000
XX-9/3000	9	3 000
XX-12/5000	12	5 000
XX-15/12000	15	12 000

4.3 Operating conditions

4.3.1 Environmental requirement

- environment temperature: (5 to 40) °C;
- relative humidity: ≤90 %.

4.3.2 Power supply

- voltage: 380 V ±10 % three-phase four-wire AC system;
- frequency: 50 Hz ±2 % / 60 Hz ±2 %;
- power supply: it is put forward in the product manual according to the accelerator model;
- grounding resistance: special grounding resistance of modulator is less than 4 Ω.

5 Technical requirements

5.1 Appearance

The surface shall be smooth, uniform color, no obvious scratches, bumps or holes.

5.2 Control system

5.2.1 Design principle

The design of the control system shall ensure the safety of the operator, the device and the delivered dose.

5.2.2 Operation of start and stop

Operation of X-ray source start and stop shall be executed in the control console.

5.2.3 Functions of control system

The basic functions of the control system shall include:

- normal start-up and shut-down,
- display of the status of normal, fault, alarm and auto-stop,
- display of the main operational parameters,
- safety interlock,
- emergency stop.

5.3 Performance

5.3.1 X-ray beam energy

Commonly used X-ray beam energies of accelerators are shown in Table 2 and the corresponding half value layer should not be less than the value in Table 2.

Table 2 – Half value layer of materials corresponding to commonly used X-ray beam energies

X-ray beam energy MeV	Steel (Material density: 7,8 × 10^3 kg/m^3) mm	Plexiglas (Material density:1,7 × 10^3 kg/m^3) mm
1	16 ± 0,5	61 ± 2
2	20 ± 0,5	84 ± 2
4	25 ± 0,5	116 ± 2
6	28 ± 0,5	138 ± 2
9	30 ± 0,5	149 ± 2
12	32 ± 0,5	178 ± 2
15	33 ± 0,5	204 ± 2

5.3.2 X-ray homogeneity

X-ray homogeneity shall not be less than the value in Table 3 by using a beam flattening filter.

Table 3 – X-ray homogeneity of commonly used X-ray beam energies

X-ray beam energy MeV	Subtended angle A between beam central axis and axis connecting the centre of focal spot with the point of measurement located on the circumference (°)	X-ray homogeneity %
1	7,5	80
2	7,5	78
4	7,5	75
6	7,5	62
9	7,5	55
12	6,0	50
15	6,0	45

5.3.3 X-ray beam air kerma rate

X-ray beam air kerma rate shall achieve the value shown in Table 4 (can be reduced based on purpose).