

# INTERNATIONAL STANDARD



**Fixed energy high intensity proton cyclotron within the energy range of 10 MeV  
to less than 30 MeV**

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IEC 63175:2021

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INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 27.120.01

ISBN 978-2-8322-1054-1

**Warning! Make sure that you obtained this publication from an authorized distributor.**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIXED ENERGY HIGH INTENSITY PROTON CYCLOTRON WITHIN  
THE ENERGY RANGE OF 10 MeV TO LESS THAN 30 MeV**

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The text of this International Standard is based on the following documents:

Draft	Report on voting
45/930/FDIS	45/932/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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## INTRODUCTION

Particle accelerators have a wide application in the field of nuclear physics, radiation hardening, accelerator-driven energy system (nuclear reactor), and of course radioisotopes production, etc.. Proton cyclotron is one particular class of particle accelerators used for example for the acceleration of negative hydrogen ions.

This document specifies the performance and safety requirements, structure, technical requirements, test methods, identification, packing, transportation, storage and accompanying documents for proton cyclotrons.

Annex A and Annex B are both informative.

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# FIXED ENERGY HIGH INTENSITY PROTON CYCLOTRON WITHIN THE ENERGY RANGE OF 10 MeV TO LESS THAN 30 MeV

## 1 Scope

This document is applicable to hydrogen ion  $H^+$  acceleration proton cyclotrons with one or more fixed energies within the range of 10 MeV to less than 30 MeV and a beam intensity equal to or greater than 300  $\mu A$ .

This document specifies the performance and safety requirements, structure, technical requirements, test methods, identification, packing, transportation, storage and accompanying documents for such cyclotrons.

This type of cyclotrons is intended for industrial use, including medical isotope and neutron production. Therapeutic medical applications are excluded from the scope of this document.

This document is intended for manufacturers of high intensity proton cyclotron within the energy range of 10 MeV to less than 30 MeV, and responsible organizations where such cyclotrons are installed.

## 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.

IEC 60038:2009, *IEC standard voltages*

IEC 60204-1:2016, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60243-1:2013, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*  
IEC 61010-1:2010/AMD1:2016

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 62305 (all parts), *Protection against lightning*

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 8573-1:2010, *Compressed air – Part 1: Contaminants and purity classes*

### 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

##### **cyclotron**

device that uses static magnetic field to make charged particles to whirl and to be repeatedly accelerated by radio frequency electric field with fixed frequency

#### 3.2

##### **beam energy**

kinetic energy of charged particles in a beam through a cyclotron device

#### 3.3

##### **beam intensity**

total charge of charged particles passing through a section in unit time

#### 3.4

##### **phase shift**

difference between the phase of charged particle cyclotron motion and radio frequency voltage at the gap crossing

Note 1 to entry: The expression of phase shift is shown in Formula (B.2).

#### 3.5

##### **unloaded quality factor**

quality factor when the resonator is not connected to any external circuit (no load)

Note 1 to entry: When the resonator is in a stable resonant state, the unloaded quality factor  $Q_0$  is defined as:

$$Q_0 = 2\pi \times \frac{\text{Total energy storage in resonator}}{\text{Energy dissipation of resonator in one cycle}} \quad (1)$$

Note 2 to entry: One example of actual measurement and calculation methods for unloaded quality factor is shown in Annex A.

## 4 Cyclotron composition and operational conditions

### 4.1 Composition

Generally, the cyclotron consists of the following components:

- a) ion source and injection system;
- b) magnet system;
- c) radio frequency system;
- d) vacuum system;
- e) extraction system;
- f) power supply system;
- g) control system;
- h) interlock system for radiation safety;
- i) beam monitoring system;
- j) water cooling system and pneumatic system.

### 4.2 Normal operating conditions

#### 4.2.1 Environmental requirements

Environmental requirements are as follows:

- a) ambient temperature: 15 °C to 35 °C; [IEC 63175:2021](http://standards.iteh.ai/catalog/standards/sist/c071281d-4b8e-4552-b2cf-b9604a8acab9/iec-63175-2021)
- b) relative humidity: 35 % to 65 %, no condensation; <http://standards.iteh.ai/catalog/standards/sist/c071281d-4b8e-4552-b2cf-b9604a8acab9/iec-63175-2021>
- c) indoor and outdoor pressure difference: maintain sufficient negative pressure;
- d) control room: ambient temperature is 15 °C to 26 °C with relative humidity lower than 60 % and no condensation.

#### 4.2.2 Electricity requirements

Electrical requirements for cyclotron power supply environment are as follows:

- a) power supply: a three-phase five-wire (TN-S, IEC 60364-1:2005) or a three-phase four-wire (TN-C-S, IEC 60364-1:2005) AC system. In case of a four-wire system, the cyclotron has to be cabled as a single consumer with five-wire after the first power entry panel;
- b) voltage: listed in Table 1 of IEC 60038:2009, the supply voltage shall not differ from the nominal voltage of the system by more than  $\pm 10\%$ ;
- c) frequency: 50/60 Hz  $\pm 1$  Hz.

#### 4.2.3 Compressed air

Instructions for use shall specify the operating condition range for compressed air supply (ISO 8573-1:2010 [1.4.1]).

#### 4.2.4 Nitrogen

In case nitrogen is used for venting the cyclotron main tank when the cyclotron is under maintenance, instructions for use shall specify the operating conditions.