IEC 63175

Edition 1.0 2021-11

INTERNATIONAL STANDARD

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

colour inside

IEC 63175:2021-11(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 63175

Edition 1.0 2021-11

INTERNATIONAL STANDARD

colour inside

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

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.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63175 has been prepared by IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

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. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

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 µA.

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 lighting*

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:

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

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;
b) relative humidity: 35 % to 65 %, no condensation;
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 ±10 %;
c) frequency: 50/60 Hz ±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.