

# TECHNICAL SPECIFICATION



---

## Primary optics for concentrator photovoltaic systems

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 27.160

ISBN 978-2-8322-5422-6

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

## CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	7
4 Primary optics for concentrator photovoltaic systems.....	9
5 Optics.....	13
5.1 Source spectrum.....	13
5.2 Optical material properties .....	13
5.2.1 Spectral transmittance of lens material .....	13
5.2.2 Spectral hemispherical reflectance of mirrors .....	17
5.2.3 Dispersion: Abbe number of CPV primary lens materials .....	18
5.2.4 Refractive index $n_D$ of CPV primary lens materials .....	19
5.3 Focusing characteristics: Focal length, lens efficiency, focal spot size and uniformity.....	20
5.3.1 Preliminaries .....	20
5.3.2 Method A .....	22
5.3.3 Method B.....	23
5.3.4 Method C.....	26
6 Mechanics .....	29
6.1 Minimum radius .....	29
6.2 Surface hardness.....	29
6.3 Impact resistance (dynamic) .....	29
6.3.1 Definitions .....	29
6.3.2 Setup of experiments.....	30
6.3.3 Procedure.....	30
6.3.4 Presentation of results.....	30
7 Materials .....	30
8 Geometry .....	31
8.1 General.....	31
8.2 Definitions.....	31
8.3 Fresnel lenses and Fresnel mirrors.....	31
8.4 Presentation of drawing and tables .....	31
8.5 Data exchange.....	34
9 Visual appearance.....	34
9.1 Imperfections, blemishes .....	34
9.2 Clarity and colour.....	34
9.2.1 Haze (and schlieren; scorch) .....	34
9.2.2 Colour .....	35
Bibliography.....	36
Figure 1 – Example of efficiency versus spot size – Encircled energy level of 95 % .....	8
Figure 2 – Example of a primary lens parquet, set up for the hail impact test .....	30
Figure 3 – Drawing of general dimensions of Fresnel lens parquet.....	32
Figure 4 – Detail X from Figure 3 – Flange and lens of Fresnel lens parquet.....	33

Figure 5 – Detail Y from Figure 3 – Thickness of lens substrate (glass) and superstrate (silicone).....	33
Figure 6 – Detail Z from Figure 5 – Drawing of prism with tip radius $R_t$ and groove radius $R_g$ .....	34
Table 1 – Characteristics: product identification .....	9
Table 2 – Characteristics: optics .....	10
Table 3 – Characteristics: mechanics .....	11
Table 4 – Characteristics: materials .....	11
Table 5 – Characteristics: geometry .....	12
Table 6 – Characteristics: visual appearance .....	12
Table 7 – Methods and results of the round robin for the focal characteristics of Fresnel lenses .....	21

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PRIMARY OPTICS FOR CONCENTRATOR  
PHOTOVOLTAIC SYSTEMS**

## 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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62989, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

Enquiry draft	Report on voting
82/1281/DTS	82/1376/RVDTS

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

This document 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

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

**IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.**

# PRIMARY OPTICS FOR CONCENTRATOR PHOTOVOLTAIC SYSTEMS

## 1 Scope

This document encompasses key characteristics of primary optical elements (lenses and mirrors) and lens or mirror parquets for concentrator photovoltaics including: optical performance, mechanical geometry, mechanical strength, materials, and surface morphology. The document identifies the essential characteristics, the corresponding quantities of interest, and provides a method for measurement of each quantity.

This document allows lens and mirror manufacturers, concentrator module manufacturers, test laboratories and other interested parties to define lens/mirror qualities and inspect lenses and mirrors. There are no pass/fail criteria associated with the document.

This document defines the test conditions rather than to specify the precise setup of a measurement apparatus. For example, this enables laboratories to acquire reliable and comparable measurement results irrespective of the existing large variety of experimental setups for focal spot characterization. High priority is given to comparable and reproducible measurements of the irradiance distribution in the focal plane and of the optical efficiency. This requires trade-offs that reduce the similarities to outdoor conditions. Furthermore, it is intended not to refer to properties of specific solar cells as this document is dedicated to concentrator optics.

The terms for lenses are applicable for mirrors, unless otherwise specified.

## 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 60050-845, *International Electrotechnical Vocabulary. Lighting*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 62108:2007, *Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval*

IEC 62788-1-4, *Measurement procedures for materials used in photovoltaic modules – Part 1-4: Encapsulants – Measurement of optical transmittance and calculation of the solar-weighted photon transmittance, yellowness index, and UV cut-off wavelength*

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

ISO 489:1999, *Plastics – Determination of refractive index*

ISO 10110-1:2006, *Optics and photonics – Preparation of drawings for optical elements and systems – Part 1: General*

ISO 10110-7, *Optics and photonics – Preparation of drawings for optical elements and systems – Part 7: Surface imperfection tolerances*

ISO 10110-8:2010, *Optics and photonics – Preparation of drawings for optical elements and systems – Part 8: Surface texture; roughness and waviness*

ISO 10110-19:2015, *Optics and photonics – Preparation of drawings for optical elements and systems – Part 19: General description of surfaces and components*

ISO 10303-21, *Industrial automation systems and integration – Product data representation and exchange – Part 21: Implementation methods: Clear text encoding of the exchange structure*

ISO 11664-1 (CIE S 014-1/E:2006), *Colorimetry – Part 1: CIE standard colorimetric observers*

ISO 11664-2 (CIE S 014-2/E:2006), *Colorimetry – Part 2: CIE standard illuminants*

ISO 11664-4 (CIE S 014-4/E:2007), *Colorimetry – Part 4: CIE 1976 L\*a\*b\* Colour space*

ISO 14782, *Plastics – Determination of haze for transparent materials*