



**NSAI**  
Standards

Irish Standard  
I.S. EN 16603-20-08:2014

## Space engineering - Part 20-08: Photovoltaic assemblies and components

**I.S. EN 16603-20-08:2014**

*Incorporating amendments/corrigenda/National Annexes issued since publication:*

The National Standards Authority of Ireland (NSAI) produces the following categories of formal documents:

I.S. xxx: Irish Standard — national specification based on the consensus of an expert panel and subject to public consultation.

S.R. xxx: Standard Recommendation — recommendation based on the consensus of an expert panel and subject to public consultation.

SWiFT xxx: A rapidly developed recommendatory document based on the consensus of the participants of an NSAI workshop.

*This document replaces/revises/consolidates the NSAI adoption of the document(s) indicated on the CEN/CENELEC cover/Foreword and the following National document(s):*

*NOTE: The date of any NSAI previous adoption may not match the date of its original CEN/CENELEC document.*

*This document is based on:*

EN 16603-20-08:2014

*Published:*

2014-08-27

*This document was published under the authority of the NSAI and comes into effect on:*

2014-09-13

ICS number:

NOTE: If blank see CEN/CENELEC cover page

NSAI  
1 Swift Square,  
Northwood, Santry  
Dublin 9

T +353 1 807 3800  
F +353 1 807 3838  
E standards@nsai.ie  
W NSAI.ie

Sales:  
T +353 1 857 6730  
F +353 1 857 6729  
W standards.ie

Údarás um Chaighdeáin Náisiúnta na hÉireann

EUROPEAN STANDARD

**EN 16603-20-08**

NORME EUROPÉENNE

EUROPÄISCHE NORM

August 2014

---

ICS 49.140

English version

## Space engineering - Part 20-08: Photovoltaic assemblies and components

Ingénierie spatiale - Partie 20-08: Ensembles et composants photovoltaïque

Raumfahrttechnik - Teil 20-08: Fotovoltaische Baugruppen und Komponenten

This European Standard was approved by CEN on 10 February 2014.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



**CEN-CENELEC Management Centre:  
Avenue Marnix 17, B-1000 Brussels**

## Table of contents

---

<b>Foreword .....</b>	<b>10</b>
<b>Introduction.....</b>	<b>11</b>
<b>1 Scope.....</b>	<b>12</b>
<b>2 Normative references .....</b>	<b>13</b>
<b>3 Terms, definitions and abbreviated terms.....</b>	<b>14</b>
3.1 Terms from other standards.....	14
3.2 Terms specific to the present standard .....	14
3.3 Abbreviated terms.....	19
<b>4 General .....</b>	<b>22</b>
4.1 Overview .....	22
4.1.1 Objective and organization.....	22
4.1.2 Interfaces with other areas .....	23
4.2 Physical properties .....	24
4.3 Test and storage.....	25
4.3.1 Test environment .....	25
4.3.2 Test tolerances and accuracies.....	25
4.3.3 Margins.....	26
4.4 Critical materials .....	26
<b>5 Photovoltaic assemblies.....</b>	<b>27</b>
5.1 Overview .....	27
5.1.1 Description.....	27
5.1.2 Purpose and objective.....	27
5.2 Conditions and method of test .....	28
5.3 Photovoltaic assembly design.....	29
5.3.1 Overview.....	29
5.3.2 Parameters related to parts, materials and processes (PMP).....	29
5.3.3 Parameters related to design .....	30
5.4 PVA manufacturing.....	34
5.4.1 Process validation .....	34

5.4.2	Defect acceptability .....	34
5.4.3	In-process testing .....	34
5.4.4	Identification and traceability .....	35
5.4.5	Recording .....	36
5.5	PVA tests .....	36
5.5.1	Qualification tests .....	36
5.5.2	Acceptance tests for qualification coupons .....	41
5.5.3	Definition of tests and checks .....	42
5.6	Failure definition .....	53
5.6.1	Failure criteria .....	53
5.6.2	Failed qualification coupons .....	53
5.7	Data documentation .....	53
5.8	Delivery .....	54
5.9	Packaging, packing, handling and storage .....	54
<b>6</b>	<b>Solar cell assemblies .....</b>	<b>55</b>
6.1	General .....	55
6.1.1	Testing .....	55
6.1.2	Conditions and methods of test .....	55
6.1.3	Deliverable components .....	55
6.1.4	Identification and traceability .....	55
6.2	Production control (process identification document) .....	56
6.3	Acceptance tests .....	56
6.3.1	General .....	56
6.3.2	Test methods and conditions .....	56
6.3.3	Electrical performance acceptance test (EPA) .....	57
6.4	Qualification tests .....	57
6.4.1	General .....	57
6.4.2	Qualification .....	59
6.4.3	Test methods, conditions and measurements .....	60
6.5	Failure definition .....	71
6.5.1	Failure criteria .....	71
6.5.2	Failed SCAs .....	72
6.6	Data documentation .....	72
6.7	Delivery .....	72
6.8	Packing, dispatching, handling and storage .....	72
6.8.1	Overview .....	72
6.8.2	ESD Sensitivity .....	72

## EN 16603-20-08:2014 (E)

<b>7 Bare solar cells</b> .....	<b>73</b>
7.1 Testing, deliverable components and marking .....	73
7.1.1 Testing .....	73
7.1.2 Deliverable components.....	74
7.1.3 Marking .....	74
7.2 Production control (process identification document) .....	74
7.3 Acceptance tests .....	75
7.3.1 General .....	75
7.3.2 Test methods and conditions .....	76
7.3.3 Documentation.....	76
7.4 Qualification tests .....	77
7.4.1 General .....	77
7.4.2 Qualification .....	79
7.5 Test methods, conditions and measurements.....	80
7.5.1 Visual inspection (VI) .....	80
7.5.2 Dimensions and weight (DW).....	82
7.5.3 Electrical performance (EP) .....	82
7.5.4 Temperature coefficients (TC).....	83
7.5.5 Spectral response (SR).....	84
7.5.6 Optical properties (OP) .....	84
7.5.7 Humidity and temperature (HT).....	85
7.5.8 Coating adherence (CA) .....	86
7.5.9 Contact uniformity (CU).....	87
7.5.10 Contact thickness (CT).....	87
7.5.11 Surface finish (SF) .....	87
7.5.12 Pull test (PT) .....	88
7.5.13 Electron irradiation (EI) .....	88
7.5.14 Proton irradiation (PI).....	89
7.5.15 Photon irradiation and temperature annealing (PH).....	90
7.5.16 Solar cell reverse bias test (RB).....	90
7.5.17 Thermal cycling (CY).....	91
7.5.18 Active-passive interface evaluation test (IF) .....	91
7.5.19 Flatness test (FT).....	91
7.6 Failure definition .....	92
7.6.1 Failure criteria .....	92
7.6.2 Failed components.....	92
7.7 Data documentation.....	92

7.8	Delivery .....	92
7.9	Packing, dispatching, handling and storage .....	93
7.9.1	Overview .....	93
7.9.2	ESD Sensitivity .....	93
<b>8</b>	<b>Coverglasses .....</b>	<b>94</b>
8.1	Overview .....	94
8.1.1	Purpose .....	94
8.1.2	Description .....	94
8.2	Interfaces .....	94
8.3	Testing, deliverable components and marking .....	95
8.3.1	Testing .....	95
8.3.2	Deliverable components .....	95
8.3.3	Marking (coating orientation) .....	96
8.4	Production control (Process identification document) .....	96
8.5	Acceptance tests .....	96
8.5.1	Acceptance test samples .....	96
8.5.2	Acceptance test sequence .....	97
8.5.3	Test methods and conditions .....	97
8.5.4	Documentation .....	97
8.6	Qualification tests .....	98
8.6.1	General .....	98
8.6.2	Qualification .....	98
8.7	Test methods, conditions and measurements .....	100
8.7.1	Visual inspection (VI) .....	100
8.7.2	Transmission into air (TA) .....	101
8.7.3	Electro-optical properties (EO) .....	102
8.7.4	Mechanical properties .....	102
8.7.5	Reflectance properties (OP) .....	103
8.7.6	Normal emittance ( $e_N$ ) (NE) .....	105
8.7.7	Surface resistivity .....	105
8.7.8	Flatness or bow (FT) .....	105
8.7.9	Transmission into adhesive (TH) .....	106
8.7.10	Boiling water test (BW) .....	106
8.7.11	Humidity and temperature .....	106
8.7.12	UV exposure (UV) .....	107
8.7.13	Electron irradiation (EI) .....	108
8.7.14	Proton irradiation (PI) .....	108

**EN 16603-20-08:2014 (E)**

8.7.15	Breaking strength (BS).....	108
8.7.16	Thermal cycling (CY).....	109
8.7.17	Abrasion resistance (coated surface) (AE) .....	109
8.7.18	Coating adhesion (TD).....	109
8.8	Failure definition .....	109
8.8.1	Failure criteria .....	109
8.8.2	Failed components.....	110
8.9	Data documentation.....	110
8.10	Delivery .....	110
8.11	Packing, dispatching, handling and storage.....	110
<b>9</b>	<b>Solar cell protection diodes.....</b>	<b>111</b>
9.1	Overview .....	111
9.2	Testing, deliverable components and marking.....	111
9.2.1	Testing.....	111
9.2.2	Deliverable components.....	113
9.2.3	Marking.....	113
9.3	Production control (process identification document).....	113
9.3.1	Integral protection diodes.....	113
9.3.2	External protection diodes.....	113
9.4	Acceptance tests .....	114
9.4.1	General.....	114
9.4.2	Integral protection diodes.....	114
9.4.3	External protection diodes.....	114
9.4.4	External and integral diodes.....	115
9.4.5	Test methods and conditions .....	115
9.4.6	Documentation.....	116
9.5	Qualification tests .....	116
9.5.1	General.....	116
9.5.2	Integral protection diodes.....	116
9.5.3	External protection diodes.....	117
9.5.4	Integral and external protection diodes.....	118
9.6	Test methods, conditions and measurements.....	119
9.6.1	General.....	119
9.6.2	Visual inspection (VI) .....	119
9.6.3	Dimensions and weight (DW).....	120
9.6.4	Thermal cycling (CY).....	121
9.6.5	Burn in (BI).....	121



9.6.6	Humidity and temperature (HT).....	122
9.6.7	Contact uniformity (CU).....	122
9.6.8	Contact thickness (CT).....	123
9.6.9	Surface Finish (SF) .....	123
9.6.10	Contact adherence (CA) .....	123
9.6.11	Pull test (PT).....	124
9.6.12	Electron irradiation (EI) .....	124
9.6.13	Temperature annealing (TA) .....	125
9.6.14	Temperature behaviour (TB).....	125
9.6.15	Diode characterization (DC).....	126
9.6.16	Human body ESD (DE).....	127
9.6.17	Switching test (DS).....	128
9.6.18	Life test (DL) .....	130
9.7	Failure definition .....	132
9.7.1	Failure criteria .....	132
9.7.2	Failed components.....	133
9.8	Data documentation.....	133
9.9	Delivery .....	133
9.10	Packing, despatching, handling and storage.....	133
9.10.1	Overview.....	133
9.10.2	ESD sensitivity .....	133
<b>10</b>	<b>Sun simulators and calibration procedures.....</b>	<b>134</b>
10.1	Sun simulators.....	134
10.1.1	Spectral distribution.....	134
10.1.2	Irradiance uniformity.....	142
10.1.3	Irradiance stability .....	142
10.2	Standard cell and Sun simulator calibration .....	143
10.2.1	Primary standards.....	143
10.2.2	Secondary working standards (SWS).....	144
10.2.3	Standards cells documentation .....	145
10.2.4	Maintenance of standards .....	146
10.2.5	Recalibration and intercomparison.....	146
10.2.6	Sun simulator calibration and maintenance.....	146
<b>11</b>	<b>Capacitance measurement methods .....</b>	<b>147</b>
11.1	Single junction solar cell capacitance measurement.....	147
11.1.1	Overview.....	147
11.1.2	Signal measurement method .....	148

**EN 16603-20-08:2014 (E)**

11.1.3	Measurement procedure .....	148
11.1.4	Measurement analysis .....	152
11.1.5	Measurement of the capacitance of a multi-junction cell .....	155
11.2	Time domain capacitance measurement .....	155
11.2.1	Overview .....	155
11.2.2	Measurement procedure .....	156
<b>Annex A (normative) Source control drawing for photovoltaic assembly (SCD-PVA) - DRD .....</b>		<b>158</b>
<b>Annex B (normative) Source control drawing for solar cell assembly (SCD-SCA) - DRD .....</b>		<b>164</b>
<b>Annex C (normative) Source control drawing for bare solar cell (SCD-BSC) - DRD .....</b>		<b>169</b>
<b>Annex D (normative) Source control drawing for coverglass (SCD-CVG) - DRD .....</b>		<b>178</b>
<b>Annex E (normative) Source control drawing for External Protection Diodes (SCD-EPD) - DRD .....</b>		<b>184</b>
<b>Annex F (normative) Process identification document (PID) - DRD .....</b>		<b>188</b>
<b>Annex G (normative) Data documentation package (DDP) - DRD .....</b>		<b>190</b>
<b>Bibliography .....</b>		<b>193</b>
 <b>Figures</b>		
Figure 4-1: Specification hierarchy .....		23
Figure 6-1: Definition of cell defects .....		61
Figure 6-2: Test points for electrical performance measurement .....		63
Figure 7-1: Definition of bare solar cell defects .....		81
Figure 8-1: Methods of defining coverglass orientation .....		96
Figure 8-2: Edge chip parameters .....		101
Figure 8-3: Corner chip parameters .....		101
Figure 8-4: Coverglass manufacturing tolerance limits .....		103
Figure 8-5: Schematic for calculating surface resistivity .....		105
Figure 8-6: Definition of coverglass flatness .....		106
Figure 9-1: Diode forward and reverse test profile .....		129
Figure 9-2: Diode switching test profile .....		130
Figure 11-1: Solar cell impedance measurement equipment .....		149
Figure 11-2: Channel balancing and reduction of the parasitic inductances .....		150

Figure 11-3: Measurement of the resistance value of the shunt in the measuring conditions (shunt in parallel with the input of the network analyser).....	151
Figure 11-4: Small signal electrical schema biased with a DC voltage associated impedance .....	153
Figure C-1 : BSC front side .....	171
Figure C-2 : BSC rear side .....	172
Figure C-3 : BSC contact.....	172

## Tables

Table 4-1: Test tolerances on temperature .....	26
Table 5-1: Qualification test plan for PVA .....	37
Table 5-2: Acceptance test plan .....	42
Table 6-1: Qualification test plan for SCA.....	58
Table 6-2: Maximum dimensions of corner chips, edge chips and surface nicks .....	61
Table 7-1: Acceptance test matrix .....	75
Table 7-2: Qualification test plan for bare solar cells .....	78
Table 7-3: Maximum dimensions of corner chips, edge chips and surface nicks .....	81
Table 8-1: Qualification test plan for coverglasses.....	99
Table 9-1: Acceptance test matrix IPD .....	114
Table 9-2: Acceptance test matrix EPD .....	114
Table 9-3: Qualification test plan for integral protection diode.....	117
Table 9-4: Qualification test plan for external protection diodes.....	118
Table 9-5: Diode life test parameters.....	132
Table 10-1: AM0 solar spectral irradiance (WRC).....	135
Table 10-2: Classes of single and multi-source solar simulators.....	140
Table 10-3: Classes of solar simulators with respect to nonconformity of irradiance uniformity .....	142
Table 10-4: Classes of solar simulators with respect to temporal instability of irradiance...	143
Table B-1 : Minimum current requirement for solar assemblies (25 °C or operating temperature) .....	166
Table C-1 : Electrical performance pass-fail criteria.....	174

## Foreword

---

This document (EN 16603-20-08:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-20-08:2014) originates from ECSS-E-ST-20-08C Rev.1.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2015, and conflicting national standards shall be withdrawn at the latest by February 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

---

The qualification, procurement, storage and delivery of space solar arrays are defined in the dedicated solar array specification, where requirements for the solar array electrical layout, structure and mechanism are specified.

This Standard outlines the requirements for the qualification, procurement, storage and delivery of the main assemblies and components of the space solar array electrical layout: photovoltaic assemblies, solar cell assemblies, bare solar cells, coverglass and protection diodes. This Standard does not outline the requirements for the qualification, procurement, storage and delivery of the solar array subsystem, comprising the solar panels, structural parts and mechanisms.

The general requirements are covered in the main part of this Standard (clauses 5 to 11). Annex A to Annex E specify the contents of the source control drawing of photovoltaic and solar cell assemblies, bare solar cells coverglasses and protection diodes and include the inspection data, physical and electrical characteristics, other ratings and acceptance and qualification specific requirements, which can be different for each space project.

This Standard is divided into five specific subjects, each one corresponding to each assembly or component:

- Clause 5 defines requirements for photovoltaic assemblies,
- Clause 6 for solar cell assemblies,
- Clause 7 for bare solar cells,
- Clause 8 for coverglasses,
- Clause 9 for protection diodes.

Two additional clauses are dedicated to Sun simulators and calibration procedures (clause 10 and capacitance measurement methods (clause 11).

# 1 Scope

---

This Standard specifies the general requirements for the qualification, procurement, storage and delivery of photovoltaic assemblies, solar cell assemblies, bare solar cells, coverglasses and protection diodes suitable for space applications.

This standard does not cover the particular qualification requirements for a specific mission.

This Standard primarily applies to qualification approval for photovoltaic assemblies, solar cell assemblies, bare solar cells, coverglasses and protection diodes, and to the procurement of these items.

This standard is limited to crystalline Silicon and single and multi-junction GaAs solar cells with a thickness of more than 50  $\mu\text{m}$  and does not include thin film solar cell technologies and poly-crystalline solar cells.

This Standard does not cover the concentration technology, and especially the requirements related to the optical components of a concentrator (e.g. reflector and lens) and their verification (e.g. collimated light source).

This Standard does not apply to qualification of the solar array subsystem, solar panels, structure and solar array mechanisms.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

This is a free preview. Purchase the entire publication at the link below:

[Product Page](#)

- 
- [Looking for additional Standards? Visit Intertek Inform Infostore](#)
  - [Learn about LexConnect, All Jurisdictions, Standards referenced in Australian legislation](#)
-