

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Industrial-process measurement and control – Programmable controllers –  
Part 2: Equipment requirements and tests**

**Mesurage et contrôle des processus industriels – Automates programmables –  
Partie 2: Exigences et essais des équipements**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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 corrigenda or an amendment might have been published.

#### IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

#### IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

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](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://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: [csc@iec.ch](mailto:csc@iec.ch).

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Catalogue IEC - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

#### Recherche de publications IEC - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [csc@iec.ch](mailto:csc@iec.ch).

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



---

**Industrial-process measurement and control – Programmable controllers –  
Part 2: Equipment requirements and tests**

**Mesurage et contrôle des processus industriels – Automates programmables –  
Partie 2: Exigences et essais des équipements**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

---

ICS 25.040.40; 35.240.50

ISBN 978-2-8322-4580-4

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

|                                                                                                                                           |    |
|-------------------------------------------------------------------------------------------------------------------------------------------|----|
| FOREWORD.....                                                                                                                             | 7  |
| INTRODUCTION.....                                                                                                                         | 9  |
| 1 Scope.....                                                                                                                              | 10 |
| 2 Normative references .....                                                                                                              | 12 |
| 3 Terms, definitions, abbreviated terms, acronyms, conventions and symbols .....                                                          | 13 |
| 3.1 Terms and definitions.....                                                                                                            | 13 |
| 3.2 Abbreviated terms, acronyms, conventions and symbols.....                                                                             | 18 |
| 4 Compliance and type tests.....                                                                                                          | 19 |
| 4.1 Compliance with this standard .....                                                                                                   | 19 |
| 4.2 Type tests .....                                                                                                                      | 20 |
| 4.2.1 General .....                                                                                                                       | 20 |
| 4.2.2 Equipment to be tested (equipment under test/EUT).....                                                                              | 20 |
| 4.2.3 Special features for EMC tests .....                                                                                                | 23 |
| 4.2.4 Withstand test conditions.....                                                                                                      | 23 |
| 4.2.5 Climatic tests.....                                                                                                                 | 23 |
| 4.2.6 Functionality verification with temperature .....                                                                                   | 23 |
| 4.2.7 Verification procedure.....                                                                                                         | 27 |
| 4.2.8 Requirements for test programmes and proper functioning verification<br>procedures (PFVPs) to be provided by the manufacturer ..... | 28 |
| 4.2.9 EMC Performance criteria.....                                                                                                       | 28 |
| 4.2.10 General facility/laboratory conditions for tests .....                                                                             | 29 |
| 4.3 Test report.....                                                                                                                      | 29 |
| 5 Normal service conditions and requirements.....                                                                                         | 30 |
| 5.1 General.....                                                                                                                          | 30 |
| 5.2 Operating conditions and requirements.....                                                                                            | 30 |
| 5.2.1 Ambient temperature and relative humidity .....                                                                                     | 30 |
| 5.2.2 Altitude .....                                                                                                                      | 34 |
| 5.3 Mechanical operating conditions and requirements .....                                                                                | 35 |
| 5.3.1 General .....                                                                                                                       | 35 |
| 5.3.2 Vibrations .....                                                                                                                    | 35 |
| 5.3.3 Shock .....                                                                                                                         | 36 |
| 5.3.4 Free falls (portable and hand-held equipment).....                                                                                  | 36 |
| 5.4 Transport and storage conditions and requirements .....                                                                               | 37 |
| 5.4.1 General .....                                                                                                                       | 37 |
| 5.4.2 Ambient temperature and relative humidity .....                                                                                     | 37 |
| 5.4.3 Altitude .....                                                                                                                      | 39 |
| 5.4.4 Free falls (in manufacturer's original packaging).....                                                                              | 39 |
| 6 Functional requirements .....                                                                                                           | 40 |
| 6.1 General.....                                                                                                                          | 40 |
| 6.2 Power input ports.....                                                                                                                | 41 |
| 6.2.1 Requirements .....                                                                                                                  | 41 |
| 6.2.2 Verification of power input ports (a.c. or d.c.).....                                                                               | 42 |
| 6.3 Memory power back-up.....                                                                                                             | 46 |
| 6.3.1 Requirements .....                                                                                                                  | 46 |
| 6.3.2 Verification of memory power back-up requirements .....                                                                             | 46 |
| 6.4 Digital I/Os.....                                                                                                                     | 48 |

|        |                                                                                                           |    |
|--------|-----------------------------------------------------------------------------------------------------------|----|
| 6.4.1  | General .....                                                                                             | 48 |
| 6.4.2  | Positive logic digital I/Os (sinking inputs / sourcing outputs) .....                                     | 48 |
| 6.4.3  | Negative logic digital I/Os (sourcing inputs / sinking outputs) .....                                     | 48 |
| 6.4.4  | Digital inputs (positive logic, current sinking) .....                                                    | 49 |
| 6.4.5  | Digital outputs for alternating currents (positive logic, current sourcing) .....                         | 52 |
| 6.4.6  | Digital outputs for direct current (current sourcing) .....                                               | 57 |
| 6.4.7  | Requirements for discrete channel compatibility with IEC 61131-9 SDCI .....                               | 61 |
| 6.4.8  | Special digital I/O interfaces .....                                                                      | 61 |
| 6.5    | Analog I/Os .....                                                                                         | 61 |
| 6.5.1  | General .....                                                                                             | 61 |
| 6.5.2  | Analog inputs .....                                                                                       | 61 |
| 6.5.3  | Analog outputs .....                                                                                      | 61 |
| 6.5.4  | Analog temperature inputs .....                                                                           | 62 |
| 6.5.5  | Requirements for analog channel compatibility with HART® (Highway<br>Addressable Remote Transducer) ..... | 62 |
| 6.5.6  | Verification of analog I/Os .....                                                                         | 62 |
| 6.6    | Communication interface requirements .....                                                                | 64 |
| 6.6.1  | General .....                                                                                             | 64 |
| 6.6.2  | Verification of communication interface requirements .....                                                | 64 |
| 6.7    | Main processing unit(s) and memory(ies) requirements .....                                                | 64 |
| 6.7.1  | General .....                                                                                             | 64 |
| 6.7.2  | Verification of processing unit requirements .....                                                        | 64 |
| 6.8    | Remote input/output station (RIOS) requirements .....                                                     | 65 |
| 6.8.1  | General .....                                                                                             | 65 |
| 6.8.2  | Verification of local and remote I/O stations .....                                                       | 65 |
| 6.9    | Peripherals (PADTs, TEs, HMIs) requirements .....                                                         | 66 |
| 6.9.1  | General .....                                                                                             | 66 |
| 6.9.2  | Verification of peripheral (PADTs, TEs, HMIs) requirements .....                                          | 67 |
| 6.10   | Self-tests and diagnostics requirements .....                                                             | 67 |
| 6.10.1 | General .....                                                                                             | 67 |
| 6.10.2 | Verification of self-tests and diagnostics .....                                                          | 67 |
| 6.11   | Functional earth .....                                                                                    | 68 |
| 6.12   | Requirements for information on normal service and function .....                                         | 68 |
| 7      | Electromagnetic compatibility (EMC) requirements .....                                                    | 68 |
| 7.1    | General .....                                                                                             | 68 |
| 7.2    | Emission requirements .....                                                                               | 70 |
| 7.3    | EMC immunity requirements .....                                                                           | 71 |
| 7.3.1  | Immunity levels .....                                                                                     | 71 |
| 7.3.2  | Voltage dips and interruptions power ports .....                                                          | 77 |
| 7.4    | Requirements for information on EMC installation .....                                                    | 78 |
| 8      | Marking requirements and information to be provided by the manufacturer .....                             | 78 |
| 8.1    | Verification .....                                                                                        | 78 |
| 8.2    | General marking requirements .....                                                                        | 78 |
| 8.2.1  | Minimum marking requirement .....                                                                         | 78 |
| 8.2.2  | Functional identifications .....                                                                          | 79 |
| 8.2.3  | Functional earth terminals markings .....                                                                 | 79 |
| 8.2.4  | Documentation markings .....                                                                              | 79 |
| 8.3    | Information format and content .....                                                                      | 79 |
| 8.3.1  | Information format .....                                                                                  | 79 |

|                                                              |                                                                                  |     |
|--------------------------------------------------------------|----------------------------------------------------------------------------------|-----|
| 8.3.2                                                        | Information content.....                                                         | 80  |
| 8.3.3                                                        | Information on compliance with this standard.....                                | 80  |
| 8.3.4                                                        | Information on shipping and storage .....                                        | 80  |
| 8.3.5                                                        | Information on a.c. and d.c. power supply.....                                   | 80  |
| 8.3.6                                                        | Information on digital inputs (current sinking) .....                            | 81  |
| 8.3.7                                                        | Information on digital outputs for alternating currents (current sourcing) ..... | 81  |
| 8.3.8                                                        | Information on digital outputs for direct current (current sourcing).....        | 82  |
| 8.3.9                                                        | Information on analog inputs.....                                                | 82  |
| 8.3.10                                                       | Information on analog outputs .....                                              | 84  |
| 8.3.11                                                       | Information on communication interfaces .....                                    | 86  |
| 8.3.12                                                       | Information on main processing unit(s) and memory(ies) .....                     | 86  |
| 8.3.13                                                       | Information on remote input/output station (RIOS) .....                          | 86  |
| 8.3.14                                                       | Information on peripherals (PADTs, TEs, HMIs).....                               | 87  |
| 8.3.15                                                       | Information on self-tests and diagnostics .....                                  | 87  |
| 8.4                                                          | Information on EMC installation .....                                            | 88  |
| 8.5                                                          | Information on reliability.....                                                  | 88  |
| Annex A (informative)                                        | Temperature derating for altitude .....                                          | 89  |
| A.1                                                          | Standard atmosphere modelling.....                                               | 89  |
| A.1.1                                                        | Ambient temperature .....                                                        | 89  |
| A.1.2                                                        | Aerostatics equation .....                                                       | 89  |
| A.1.3                                                        | Air density .....                                                                | 90  |
| A.1.4                                                        | Radiation .....                                                                  | 90  |
| A.1.5                                                        | Derating ratio.....                                                              | 91  |
| A.1.6                                                        | Comparison with IEEE1613 .....                                                   | 91  |
| Annex B (informative)                                        | Digital input standard operating range equations.....                            | 93  |
| Annex C (normative)                                          | Zone C – EMC immunity levels .....                                               | 94  |
| Annex D (normative)                                          | Legacy techniques that are out-dated and not recommended for new design .....    | 97  |
| D.1                                                          | Background .....                                                                 | 97  |
| D.2                                                          | Ambient temperature .....                                                        | 97  |
| D.3                                                          | Type 2 digital input .....                                                       | 97  |
| D.3.1                                                        | Definition .....                                                                 | 97  |
| D.3.2                                                        | Background .....                                                                 | 97  |
| D.4                                                          | Analog inputs.....                                                               | 98  |
| D.5                                                          | Analog outputs.....                                                              | 99  |
| D.6                                                          | CRT displays .....                                                               | 99  |
| Annex E (informative)                                        | Application reasoning for a.c. and d.c. interruptions .....                      | 101 |
| Annex F (normative)                                          | Digital I/O: Current-sourcing input and current-sinking output.....              | 102 |
| F.1                                                          | Digital I/O (negative logic).....                                                | 102 |
| F.2                                                          | Function and verification .....                                                  | 104 |
| Bibliography                                                 | .....                                                                            | 105 |
| Figure 1 – Equipment in the scope and not in the scope ..... |                                                                                  | 11  |
| Figure 2 – Example EUT configurations .....                  |                                                                                  | 21  |
| Figure 3 – General temperature test environment .....        |                                                                                  | 24  |
| Figure 4 – Vented equipment .....                            |                                                                                  | 25  |
| Figure 5 – Non-vented equipment .....                        |                                                                                  | 26  |

|                                                                                                                     |     |
|---------------------------------------------------------------------------------------------------------------------|-----|
| Figure 6 – Panel mounted equipment extending through the wall of a cabinet .....                                    | 27  |
| Figure 7 – Typical interface/port diagram of a modular control equipment .....                                      | 41  |
| Figure 8 – Gradual shut-down/start-up test .....                                                                    | 44  |
| Figure 9 – Fast supply voltage variation test .....                                                                 | 45  |
| Figure 10 – Slow supply voltage variation test .....                                                                | 45  |
| Figure 11 – Positive logic (sinking inputs / sourcing outputs) .....                                                | 48  |
| Figure 12 – U-I operation regions of current-sinking inputs .....                                                   | 49  |
| Figure 13 – Input Type 3 Diagnostic.....                                                                            | 51  |
| Figure 14 – Temporary overload waveform for digital a.c. outputs.....                                               | 53  |
| Figure 15 – Temporary overload waveform for digital d.c. outputs.....                                               | 58  |
| Figure 16 – EMC zones .....                                                                                         | 69  |
| Figure A.1 – A small atmosphere element.....                                                                        | 89  |
| Figure E.1 – d.c. distribution to control equipment and faults .....                                                | 101 |
| Figure F.1 – Negative logic (sourcing inputs / sinking outputs).....                                                | 102 |
| Figure F.2 – Positive logic with faults .....                                                                       | 103 |
| Figure F.3 – Negative logic with faults .....                                                                       | 104 |
| <br>                                                                                                                |     |
| Table 1 – Criteria to prove the performance of an EUT against EMC disturbances .....                                | 29  |
| Table 2 – General facility/laboratory conditions for tests .....                                                    | 29  |
| Table 3 – Operating environments, ambient temperature and relative humidity .....                                   | 30  |
| Table 4 – Dry-heat withstand and immunity tests .....                                                               | 31  |
| Table 5 – Cold withstand and immunity tests .....                                                                   | 32  |
| Table 6 – Change of temperature, withstand and immunity tests .....                                                 | 33  |
| Table 7 – Cyclic (12 + 12) damp-heat withstand test .....                                                           | 34  |
| Table 8 – Multiplication factors for equipment ambient temperature of operation at<br>altitudes up to 5 000 m ..... | 35  |
| Table 9 – Sinusoidal vibration conditions .....                                                                     | 35  |
| Table 10 – Immunity vibration test .....                                                                            | 36  |
| Table 11 – Immunity shock test.....                                                                                 | 36  |
| Table 12 – Free fall on concrete floor for portable and hand-held equipment .....                                   | 37  |
| Table 13 – Storage environments, ambient temperature and relative humidity .....                                    | 38  |
| Table 14 – Transportation environments, ambient temperature and humidity .....                                      | 38  |
| Table 15 – Free fall on concrete floor in manufacturer's original packaging.....                                    | 39  |
| Table 16 – Rated values and operating ranges of incoming power supply .....                                         | 41  |
| Table 17 – Voltage interruptions (functional requirements).....                                                     | 42  |
| Table 18 – Voltage ripple and frequency range immunity test.....                                                    | 43  |
| Table 19 – Gradual shut-down/start-up test .....                                                                    | 44  |
| Table 20 – Supply voltage variation tests .....                                                                     | 44  |
| Table 21 – Voltage interruptions immunity test (Functional tests).....                                              | 46  |
| Table 22 – Back-up duration withstand test.....                                                                     | 47  |
| Table 23 – Change of energy source test.....                                                                        | 47  |
| Table 24 – Operating ranges for digital inputs (current sinking).....                                               | 50  |
| Table 25 – Rated values and operating ranges for current sourcing digital a.c. outputs .....                        | 52  |

|                                                                                                                                          |    |
|------------------------------------------------------------------------------------------------------------------------------------------|----|
| Table 26 – Overload test circuit values .....                                                                                            | 55 |
| Table 27 – Endurance test circuit values.....                                                                                            | 55 |
| Table 28 – Overload and short-circuit tests for digital outputs .....                                                                    | 56 |
| Table 29 – Rated values and operating ranges (d.c.) for current-sourcing digital d.c.<br>outputs .....                                   | 57 |
| Table 30 – Overload and short-circuit tests for digital outputs .....                                                                    | 60 |
| Table 31 – Rated values and impedance limits for analog inputs .....                                                                     | 61 |
| Table 32 – Rated values and impedance limits for analog outputs .....                                                                    | 61 |
| Table 33 – Analog output overload immunity test .....                                                                                    | 63 |
| Table 34 – Insertion/withdrawal of removable units .....                                                                                 | 66 |
| Table 35 – EMC zones & protection considerations.....                                                                                    | 70 |
| Table 36 – Enclosure port tests, Zones A and B.....                                                                                      | 71 |
| Table 37 – Conducted immunity tests, Zone B .....                                                                                        | 72 |
| Table 38 – Conducted immunity tests, zone A.....                                                                                         | 73 |
| Table 39 – Electrostatic discharge immunity test.....                                                                                    | 74 |
| Table 40 – Radiated electromagnetic field immunity test.....                                                                             | 75 |
| Table 41 – Power-frequency magnetic field immunity test .....                                                                            | 75 |
| Table 42 – Fast transient burst immunity test.....                                                                                       | 76 |
| Table 43 – High-energy surge immunity test .....                                                                                         | 76 |
| Table 44 – Conducted r.f. immunity test.....                                                                                             | 77 |
| Table 45 – Voltage dips and interruptions (EMC requirements) .....                                                                       | 77 |
| Table 46 – Voltage dips and interruptions immunity test (EMC tests) <sup>f</sup> .....                                                   | 78 |
| Table 47 – Analog input static characteristics .....                                                                                     | 83 |
| Table 48 – Analog input dynamic characteristics.....                                                                                     | 83 |
| Table 49 – Analog input general characteristics .....                                                                                    | 84 |
| Table 50 – Analog input miscellaneous characteristics.....                                                                               | 84 |
| Table 51 – Analog output static characteristics .....                                                                                    | 84 |
| Table 52 – Analog output dynamic characteristics.....                                                                                    | 85 |
| Table 53 – Analog output general characteristics .....                                                                                   | 85 |
| Table 54 – Analog output miscellaneous characteristics .....                                                                             | 85 |
| Table A.1 – Component temperature derating with altitude, 2 000 m as reference .....                                                     | 91 |
| Table A.2 – Component temperature derating with altitude, 1 500 m as reference, and<br>20 °C at the sea level standard temperature ..... | 91 |
| Table C.1 – Enclosure port tests, Zone C.....                                                                                            | 94 |
| Table C.2 – Conducted immunity tests, Zone C.....                                                                                        | 95 |
| Table C.3 – Damped oscillatory wave immunity test.....                                                                                   | 96 |
| Table D.1 – Standard operating ranges for Type 2 digital inputs (current sinking) .....                                                  | 98 |
| Table D.2 – Rated values and impedance limits for analog inputs .....                                                                    | 99 |
| Table D.3 – Rated values and impedance limits for analog outputs .....                                                                   | 99 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL-PROCESS MEASUREMENT AND CONTROL –  
PROGRAMMABLE CONTROLLERS –****Part 2: Equipment requirements and tests****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.

International Standard IEC 61131-2 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

This fourth edition cancels and replaces the third edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) removal of safety requirements and instead pointing to IEC 61010-2:2011;
- b) addition of negative logic digital inputs and outputs;
- c) addition of Type 3-d digital input;
- d) addition of 2,7 GHz to 6 GHz requirement for Radio-frequency electro-magnetic amplitude modulated immunity;

- e) clarification of temperature testing;
- f) clarification of type testing;
- g) deprecation of certain technologies;
- h) general update of multiple aspects of functionality and EMC;
- i) reorganization of clauses to associate requirements and verifications more closely.

The text of this standard is based on the following documents:

| FDIS          | Report on voting |
|---------------|------------------|
| 65B/1083/FDIS | 65B/1091/RVD     |

Full information on the voting for the approval of this International Standard 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.

A list of all parts in the IEC 61131 series, published under the general title *Industrial-process measurement and control – Programmable controllers*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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 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.**

## INTRODUCTION

IEC 61131-2 is part of a series of standards on industrial control equipment, including programmable controllers, and their associated peripherals and should be read in conjunction with the other parts of the series. However, it can be read and applied alone.

Where a conflict exists between this and other IEC standards, the provisions of this standard should be considered to govern in the area of industrial control equipment, including programmable controllers, and their associated peripherals.

This standard defines for industrial control equipment the following:

- Testing and verifications methods (Clause 4);
- Operating conditions (5.2);
- Temperature and climatic tests (5.2.1);
- Mechanical requirements and tests (5.3);
- Functional requirements and tests for power supplies, I/Os and other components (Clause 6);
- EMC requirements and tests (Clause 7);
- Marking and documentation requirements (Clause 8).

Product safety requirements for PLC and the other types of industrial control equipment now in the scope of this standard are specified in IEC 61010-2-201, which replaces the requirements of Clauses 11 to 14 of IEC 61131-2:2007.

The operating conditions and the temperature derating for altitudes are aligned with IEC 61010-2-201:–<sup>1</sup>.

---

<sup>1</sup> Under preparation. Stage at the time of publication: IEC /CDV 61010-2-201:2016.

# **INDUSTRIAL-PROCESS MEASUREMENT AND CONTROL – PROGRAMMABLE CONTROLLERS –**

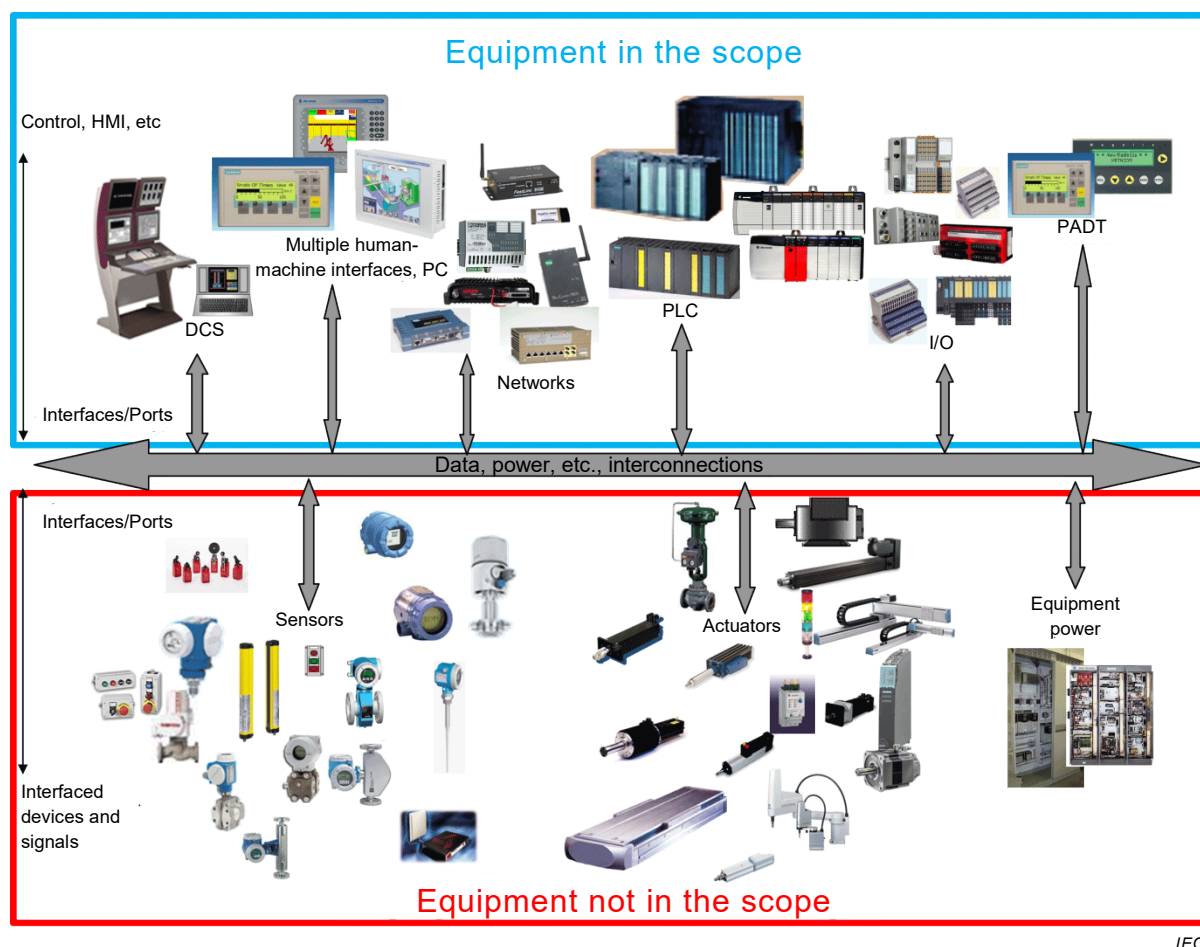
## **Part 2: Equipment requirements and tests**

### **1 Scope**

This part of IEC 61131 specifies functional and electromagnetic compatibility requirements and related verification tests for industrial control equipment of the following types:

- programmable controllers (PLC);
- programmable automation controller (PAC);
- remote I/O;
- programming and debugging tools (PADTs);
- industrial PC (computers) and industrial panel PC;
- displays and human-machine Interfaces (HMI) for industrial use;
- distributed control system (DCS), and DCS components that are listed here in the scope;
- any product where the primary purpose is performing the function of industrial control equipment, including PLC and/or PAC, and/or their associated peripherals which have as their intended use the control and command of machines, automated manufacturing and industrial processes, e.g. discrete, batch and continuous control.

In this document “control equipment” is equivalent to “industrial control equipment” as are PLC and PAC.



IEC

**Figure 1 – Equipment in the scope and not in the scope**

Components of the above named equipment (see Figure 1) included in the scope of this standard are:

- (auxiliary) stand-alone power supplies;
- peripherals such as digital and analog I/O;
- industrial network equipment.

Control equipment and their associated peripherals are intended to be used in an industrial environment and may be provided as open or enclosed equipment.

If control equipment or its associated peripherals are intended for use in other environments (light industrial, commercial, residential), then the specific requirements, standards and installation practices for those other environments shall be additionally applied to the control equipment and its associated peripherals.

Equipment covered in this standard is intended for use in overvoltage category II (IEC 60664-1) in low-voltage installations, where the rated equipment supply voltage does not exceed AC 1 000 V r.m.s. (50/60 Hz), or DC 1 000 V. If control equipment or their associated peripherals are applied in overvoltage category III installations, then additional analysis will be required to determine the suitability of the equipment for those applications.

The object of this standard is to establish the definitions and identify the principal characteristics relevant to the selection and application of control equipment and their associated peripherals.

This standard also specifies:

- a) service (operating, storage and transportation) requirements for control equipment and their associated peripherals (Clause 5);
- b) functional requirements for control equipment and their associated peripherals (Clause 6);
- c) EMC requirements for control equipment and their associated peripherals (Clause 7);
- d) information that the manufacturer is required to supply (Clause 8).

Safety requirements for control equipment and their associated peripherals are specified in IEC 61010-2-201.

The requirements of IEC Guide 106, "Guide for specifying environmental conditions for equipment performance rating", and IEC Guide 107 "Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications," are incorporated herein.

## 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 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12 h cycle)*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3 : Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

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 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-18:2006, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory waves immunity test*

IEC 61000-6-1:2016, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

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

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

IEC 61010-2-201:–2, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-201: Particular requirements for control equipment*

IEC 61131-1, *Programmable controllers – Part 1: General information*

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61131-9, *Programmable controllers – Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)*

IEC TR 61131-4, *Programmable controllers – Part 4: User guidelines*

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61784 (all parts), *Industrial communication networks – Profiles*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols* (available at <http://www.iso.org/obp>)

ANSI/ISA-50.00.01-1975 – (R2012), *Compatibility of Analog Signals for Electronic Industrial Process Instruments*

HCF\_SPEC-13, *HART (Highway Addressable Remote Transducer) Communication Protocol Specification, Rev 7.5*

### **3 Terms, definitions, abbreviated terms, acronyms, conventions and symbols**

#### **3.1 Terms and definitions**

For the purposes of this document, the terms and definitions given in IEC 61131-1 and the following apply.

---

<sup>2</sup> Under preparation. Stage at the time of publication: IEC/ADIS 61010-2-201:2016.

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>

### 3.1.1

#### **ambient temperature**

temperature, determined under prescribed conditions, of the air surrounding the equipment

### 3.1.2

#### **analog input**

device which converts a continuous signal to a discretely valued multi-bit binary number, for use by the control equipment

### 3.1.3

#### **analog output**

device which converts a multi-bit binary number from the control equipment to a continuous signal

### 3.1.4

#### **battery**

electrochemical energy source which can be rechargeable or non-rechargeable

### 3.1.5

#### **current sinking**

property of receiving current

### 3.1.6

#### **current sourcing**

property of supplying current

### 3.1.7

#### **d.c. power network**

local direct current electricity supply network in the infrastructure of a site or building intended for use by one or more different types of equipment and providing power supply independently from the conditions of the public mains network

Note 1 to entry: Examples of a d.c. power network are 125 Vd.c. and 400 Vd.c. power networks utilized in applications such as utility power plants, airport radar UPS, telecom UPS etc. Low voltages such as e.g. 24 V d.c., 48 V d.c., are not suitable for distribution, due to high voltage drop losses. As such these low voltage power sources are not considered d.c. power networks.

### 3.1.8

#### **digital input**

device which converts an essentially two-state signal to a single-bit binary number

### 3.1.9

#### **digital output**

device which converts a single-bit binary number to a two-state signal

### 3.1.10

#### **earth**

conducting mass of the Earth, whose electric potential at any point is conventionally taken as zero

[SOURCE: IEC 60050-195:1998, 195-01-01]

**3.1.11****EMC****electromagnetic compatibility**

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07]

**3.1.12****enclosed equipment**

equipment which includes an enclosure, having safety capability, or combination of an enclosure, having safety capability, and installation provisions enclosing on all sides, with the possible exception of its mounting surface, to prevent personnel from accidentally touching hazardous live, hot or moving parts contained therein and meeting requirements of mechanical strength, flammability, and stability (where applicable)

Note 1 to entry: Examples are portable and hand-held equipment.

[SOURCE: IEC 61010-2-201:–, 3.102]

**3.1.13****enclosure**

housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

**3.1.14****equipment under test****EUT**

representative configuration(s), as defined by the manufacturer, used for type tests (see 4.2)

Note 1 to entry: This note applies to the French language only.

**3.1.15****field wiring**

wiring of the control equipment, which is not installed in the control equipment manufacturer's facility

Note 1 to entry: Examples of field wiring are power supply, digital and analogue input and output wiring.

Note 2 to entry: Control equipment manufacturer's, e.g. pre-assembled or molded cabling is not considered field wiring.

[SOURCE: IEC 61010-2-201:–, 3.105]

**3.1.16****fixed equipment**

electric equipment fastened to a support, or otherwise secured in a specific location

[SOURCE: IEC 60050-826:2004, 826-16-07]

**3.1.17****functional earth**

point or points in a system, an installation or in equipment for connection to earth, for purposes other than electrical safety

**3.1.18****hand-held equipment**

electric equipment intended to be held in the hand during normal use

[SOURCE: IEC 60050-826:2004, 826-16-05]

### 3.1.19

#### **immunity**, <to a disturbance>

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

Note 1 to entry: Not used exclusively to refer to EMC in this standard. It may also refer, for example, to vibration, humidity, etc.

[SOURCE: IEC 60050-161:1990, 161-01-20]

### 3.1.20

#### **immunity type test**

#### **immunity test**

type test verifying that the equipment operation is not altered by the application of specified influencing quantities that are intended to approximate normal operation

### 3.1.21

#### **interface**

shared boundary between one control equipment and another control equipment, or between parts of a control equipment, through which information or electrical energy is conveyed

### 3.1.22

#### **isolated**, <devices, circuits>

devices or circuits without galvanic connection between them

### 3.1.23

#### **module**

part of the control equipment containing (an) identified function(s) processing unit, analog input, etc.), which may plug into a backplane or base

### 3.1.24

#### **multi-channel module**

module containing multiple input and/or output signal interfaces which could be isolated or not isolated from each other

### 3.1.25

#### **normal use**

operation, including stand-by, according to the instructions for use or for the obvious intended purpose

Note 1 to entry: Normal service conditions are stated in Clause 5.

### 3.1.26

#### **open equipment**

equipment which does not protect personnel from accidentally touching hazardous live or moving parts contained therein nor meet requirements of mechanical strength, flammability and stability (where applicable)

[SOURCE: IEC 61010-2-201:–, 3.107]

### 3.1.27

#### **operator**

person commanding and monitoring a machine or process through an HMI connected to the control equipment

Note 1 to entry: The operator does not change the control equipment hardware configuration, software or the application programme. Control equipment is not intended for use by untrained personnel.

Note 2 to entry: The operator is assumed to be aware of the general hazards in an industrial environment.

### 3.1.28

**overvoltage category**, <of a circuit or within an electrical system>

classification based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending upon the means employed to influence the overvoltages

Note 1 to entry: In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements. These interface requirements may be an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category.

Note 2 to entry: Equipment covered in this standard is intended for use in overvoltage category II.

### 3.1.29

**permanent installation**

portion of the control equipment that can only be connected to or disconnected from the control equipment by the use of a tool

### 3.1.30

**port**

access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: Most commonly used with respect to EMC.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified – Note 1 to entry has been modified.]

### 3.1.31

**portable equipment**

equipment intended to be carried by hand and not fixed during normal use

### 3.1.32

**public mains**

power from the conductors/mains of the public utility distribution system

### 3.1.33

**total output current**, <of an output module>

current that a multi-channel module operating at the most adverse combination of normal operation can supply without any part of it (insulation, terminals, exposed conductive parts, etc.) exceeding the specified temperature limits

Note 1 to entry: For a multi-channel module, the total output current is generally less than the sum of the output currents of the channels.

### 3.1.34

**type test**

conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

### 3.1.35

**unit**

integral assembly (which may consist of modules plugged in or otherwise connected within the assembly) connected to other units within the control equipment by means of cables for permanently installed units and cables or other means for portable units

### 3.1.36

#### **withstand type test**

#### **withstand test**

type test verifying that the application of more severe influencing quantities to the equipment does not impair its ability to assume its intended mission

### **3.2 Abbreviated terms, acronyms, conventions and symbols**

#### **Acronym Description**

|       |                                                                                                                                         |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------|
| a.c.  | or "AC" or "alternating current" are all equivalent                                                                                     |
| BCD   | Binary-Coded Decimal                                                                                                                    |
| BIOS  | Basic Input/Output System                                                                                                               |
| CDN   | Coupling/Decoupling Network                                                                                                             |
| CISPR | Comité International Spécial des Perturbations Radioélectriques (CISPR; English: Special International Committee On Radio Interference) |
| CMRR  | Common-Mode Rejection Ratio                                                                                                             |
| CMV   | Common-Mode Voltage                                                                                                                     |
| d.c.  | or "DC" or "direct current" are all equivalent                                                                                          |
| DCS   | Distributed Control System                                                                                                              |
| DIN   | Deutsches Institut für Normung                                                                                                          |
| EMC   | Electromagnetic Compatibility                                                                                                           |
| EMI   | Electromagnetic Interference                                                                                                            |
| ESD   | Electrostatic Discharge                                                                                                                 |
| EU    | European Union                                                                                                                          |
| EUT   | Equipment Under Test                                                                                                                    |
| FDIS  | Final Draft International Standard                                                                                                      |
| FF    | Foundation Fieldbus                                                                                                                     |
| HART  | Highway Addressable Remote Transducer                                                                                                   |
| HMI   | Human Machine Interface                                                                                                                 |
| I/O   | Input/Output                                                                                                                            |
| IEC   | International Electrotechnical Commission                                                                                               |
| IEEE  | Institute of Electrical and Electronics Engineers                                                                                       |
| IEV   | International Electrotechnical Vocabulary                                                                                               |
| ISO   | International Organization for Standardization                                                                                          |
| LSB   | Least Significant Bit                                                                                                                   |
| MOV   | Metal Oxide Varistor                                                                                                                    |
| MTBF  | Mean Time Between Failures                                                                                                              |
| NC    | Normally Closed                                                                                                                         |
| ND    | Not Defined                                                                                                                             |
| NO    | Normally Open                                                                                                                           |
| ODVA  | ODVA, Inc. (formerly "Open DeviceNet Vendor's Association")                                                                             |
| OS    | Operating System                                                                                                                        |
| OTH   | Operating Temperature & Humidity                                                                                                        |
| PAC   | Programmable Automation Controller                                                                                                      |
| PADT  | Programming and Debugging Tool                                                                                                          |
| PAS   | Publicly Available Specification                                                                                                        |

|      |                                             |
|------|---------------------------------------------|
| PC   | Personal Computer                           |
| PELV | Protected Extra-Low Voltage                 |
| PFVP | Proper Functioning Verification Procedures  |
| PLC  | Programmable Logic Controller               |
| PNO  | Profibus Nutzer (User) Organization         |
| PS   | Power Supply                                |
| RC   | Resistor Capacitor                          |
| RIOS | Remote Input/Output Station                 |
| RMS  | Root Mean Square                            |
| RTD  | Resistive Temperature Device                |
| SC   | Subcommittee                                |
| SDCI | Single-drop Digital Communication Interface |
| SDL  | Shut Down Limit                             |
| SELV | Safety Extra-Low Voltage                    |
| STH  | Storage Temperature & Humidity              |
| TC   | Thermocouple                                |
| TE   | Test Equipment                              |
| TTH  | Transportation Temperature & Humidity       |
| TM   | Thermal Module                              |
| USB  | Universal Serial Bus                        |

## 4 Compliance and type tests

### 4.1 Compliance with this standard

Compliance to this standard can be claimed in a number of ways.

1) Complete compliance to this standard:

“compliant to IEC 61131-2”

This means the equipment complies with all clauses.

2) Compliance to a clause or clause(s) statement, for example:

“Compliant to IEC 61131-2:-, Clause 9” or

“Compliant to IEC 61131-2:-, subclause 6.2 and Clause 9”

This means the equipment complies with only the clauses/subclauses stated.

3) Compliance to functionality statement, for example:

“Functionality: Digital Input Type 3 according to IEC 61131-2” and/or

“Ambient temperature range: 0 °C to 60 °C according to IEC 61131-2”

This means the equipment complies with the functionality item stated as defined in this standard.

One exception is Clause 7, Electromagnetic compatibility (EMC) requirements. It is mandatory all equipment complies with this clause.

Where the manufacturer is allowed to select among several options for normal service conditions, catalogues and/or datasheets shall clearly specify which option the equipment has been evaluated against. This applies to e.g. ambient temperature ranges, severity classes of voltage dips (e.g. PS1 or PS2), and types of digital inputs (e.g. Type 1 or Type 3).

## 4.2 Type tests

### 4.2.1 General

The objective of 4.2 is to define how to verify compliance of the control equipment and the associated peripherals with the requirements set forth in this standard. This compliance verification includes:

- a) verification by type tests given in appropriate clauses;
- b) verification by suitable examination, visual inspection or/and measurement.

These tests are qualification tests and not tests related to the ways control equipment is employed. According to the scope of this standard, the above compliance verification may not cover the verification of the ability of the control equipment to satisfy the intended automated control equipment requirements.

NOTE Peripherals, not in the scope of this standard, used in the same environment as the control equipment, can be evaluated to the same requirements as the control equipment.

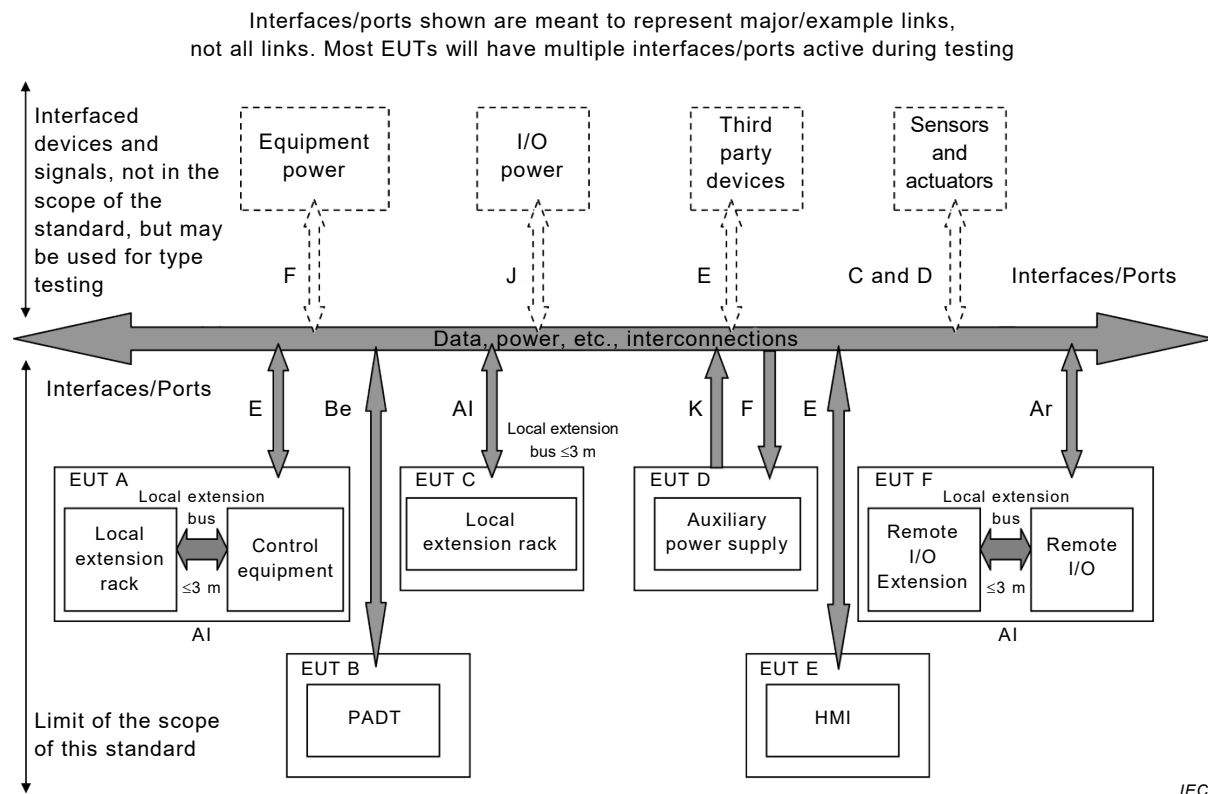
It shall be kept in mind a type test is meant to test a target device, the EUT. But in the type test context EUT can mean the EUT, the single target device, e.g. a module alone or this same single target device as part of a test EUT, e.g. a module, a power supply, a communication module and a rack.

### 4.2.2 Equipment to be tested (equipment under test/EUT)

Control equipment in the scope of this standard is used in a wide variety of applications. The modular designs of most control equipment and the wide range of combinable remote I/O, industrial PCs and HMI lead to an extremely wide variety of system configurations. For obvious practical reasons, in most cases type tests cannot be conducted on EUT identical to user-built systems, and engineering judgement is necessary. Therefore, the manufacturer is required to define the EUTs and document the corresponding test plan and test programmes to meet the following principles.

Combination of tests/EUTs/test programmes shall be such that one may reasonably think that any configuration built by the user according to the manufacturer's specifications and installation instructions would pass satisfactorily the same tests, and will properly function in normal operation, which these tests are intended to reflect.

Unless otherwise specified in this standard, the manufacturer may elect to use various EUTs to achieve the objectives of a given type test.



NOTE Letters used in Figure 2 (e.g. E, F, Be) are defined in the Key of Figure 7.

**Figure 2 – Example EUT configurations**

Each subpart of the EUT as shown in Figure 2 may constitute an EUT represented as EUT A, B, C, D, E and/or F. To exercise different characteristics, capabilities, ports, etc of each EUT, the manufacturer may define subsystems and the different EUTs are tested in turn.

Only one subsystem is under test at any time, the others being considered as auxiliary equipment.

Examples:

- a) to test vibration immunity of the EUT A, equipment of the other EUTs may be connected but are not in the test bed.
- b) to check the electrical interference immunity of the EUT, the manufacturer may choose between the following, as applicable:
  - 1) to build a single global EUT including the PADT/TE/RIOS, and check the whole configuration; or
  - 2) to define a suite of simpler EUTs (for example, a EUT without any PADT/TE/RIOS, and a single PADT and a single RIOS and a single PADT and a single TE, or any other suite of partial combinations of them which make sense) but correspondingly exercise the appropriate ports of each EUT with an equipment part of the test bed (the laboratory equipment necessary to test the EUT) as would do the missing PADT/TE/RIOS. For practical reasons, the manufacturer may elect to use actual PADTs/TEs/RIOS to exercise the EUT ports.

If there are too many families to be included into a single EUT, the manufacturer shall define several EUTs as follows:

- For the type test of a family with very similar modules (family, i.e. modules using the same schematic and basic manufacturing and differing mainly by, for example, the number of

inputs and outputs), the manufacturer may elect to include in the EUT only one arbitrarily chosen member of the family. If the type test is dependent on the differences between the modules, then a single family member shall not be used.

- Appropriate catalogued options, such as power supply units, application memory(ies), processing unit(s) etc. shall be used to build the relevant EUT(s).
- If a local bus extension is part of the EUT and if its maximum cable length cable is less than, or equal to, 3 m, it is considered to be an internal equipment bus. As such, it shall not be considered a port for test.
- If a local bus extension is part of the EUT and is capable of driving cables with a length of > 3 m, then only one end of the link is part of the EUT and it is considered as a communication port.

If an EUT representing a control equipment or a remote I/Os (RIOS) is of modular structure, it shall fulfil the following minimum requirements:

- All types of modules shall be represented in one or several EUT configurations in which any mix of modules is permissible.
- All types of modules shall be configured in the EUTs and tested at least once.

NOTE It can be appropriate to consider statistical criteria based on samples for a large number of I/Os (for example, >100).

At least one of each type or a representative number of I/O ports of the EUT shall be connected and be functional.

A selection of the representative functional modes shall be made considering that only the most typical functions of the equipment can be tested.

The EUT shall be tested according to the manufacturer's installation guideline.

All tests shall be conducted in a well-defined and reproducible manner.

The EUT is located in the specified test e.g. chamber, building, site and any test support equipment shall be located outside the influence of the test environment.

All input/output cables shall be normally looped back for monitoring and testing and/or shall be terminated with a load.

For multi-channel I/O EUT's, the circuit design shall be reviewed to determine the worst case situation for testing. On and off states and the range of allowed loads shall be tested.

Certain tests can be easily targeted at a single item, others are more appropriate to a set of items configured together. Equipment to be tested shall reflect this need. See specific test clauses for recommendations on EUTs.

When new units/modules are introduced after initial release of a control equipment catalogue, which has already been satisfactorily tested according to this standard, EUT(s) simpler than those originally used can be defined. This is only permissible if such EUTs and the associated test programmes provided by the manufacturer allow proper verification as if these new units/modules had been tested within the originally tested EUTs.

Unless otherwise specified in this standard, the manufacturer may elect either that each type test be conducted on a new EUT or that several type tests be performed successively on the same EUT.

It may be determined from consideration of the electrical characteristics and usage of a particular apparatus that some tests are inappropriate and therefore unnecessary. In such cases, it is required that the decision and justification not to test is recorded in the test report.

### 4.2.3 Special features for EMC tests

Communication ports are to be connected as in normal use for ESD testing.

Pass-fail criteria are located in Table 1.

### 4.2.4 Withstand test conditions

In general, a module should be tested alone. Those clauses dealing with withstand tests should be referred to for specifics. See 5.2.1, 5.3.4, 5.4.4, 6.2.2.6, 6.3.2.1, 6.3.2.3, 6.4.4.5.3, 6.4.5.10.4, 6.4.6.10.4 and 6.5.6.6.

### 4.2.5 Climatic tests

Tests are performed on unpackaged equipment.

Temperature-sensitive components that are normally serviced and removed by the service personnel may be removed, if so requested by the manufacturer.

The climatic testing is made on the basis of the applicable standards of the IEC 60068 series.

### 4.2.6 Functionality verification with temperature

#### 4.2.6.1 General method

This test method is utilized for verification of equipment functionality with temperature; e.g. analog I/O characteristics.

It is not required to perform this if it can be proved and documented that temperature range does not have any impact on the equipment.

The equipment shall be mounted in its least favorable position/orientation in an ambient temperature equal to its maximum or minimum rated ambient temperature.

The EUT shall be configured so it is generating its least favorable heat dissipation. It shall be noted that least favorable can be both a hot or cold situation (i.e. highest dissipation or lowest dissipation). This dissipation may be caused by some combination of load current, input voltage, input frequency, I/O duty cycle, etc.

The EUT wiring shall be the smallest size suitable for the maximum current rating of the EUT according to the manufacturer's instructions.

The test room/chamber/box (size is not a test criterion) environment surrounding the EUT shall not be subject to air movement caused by sources not part of the EUT, i.e. it shall be a natural convection environment. See Figure 3.

NOTE 1 To reduce and block forced air movement in a test room or in a climatic chamber around the EUT, the EUT can be placed in a partially or completely closed test box allowing air movement / natural convection only caused by the EUT. Or barriers made of any suitable material could be used around the EUT, to block air movement.

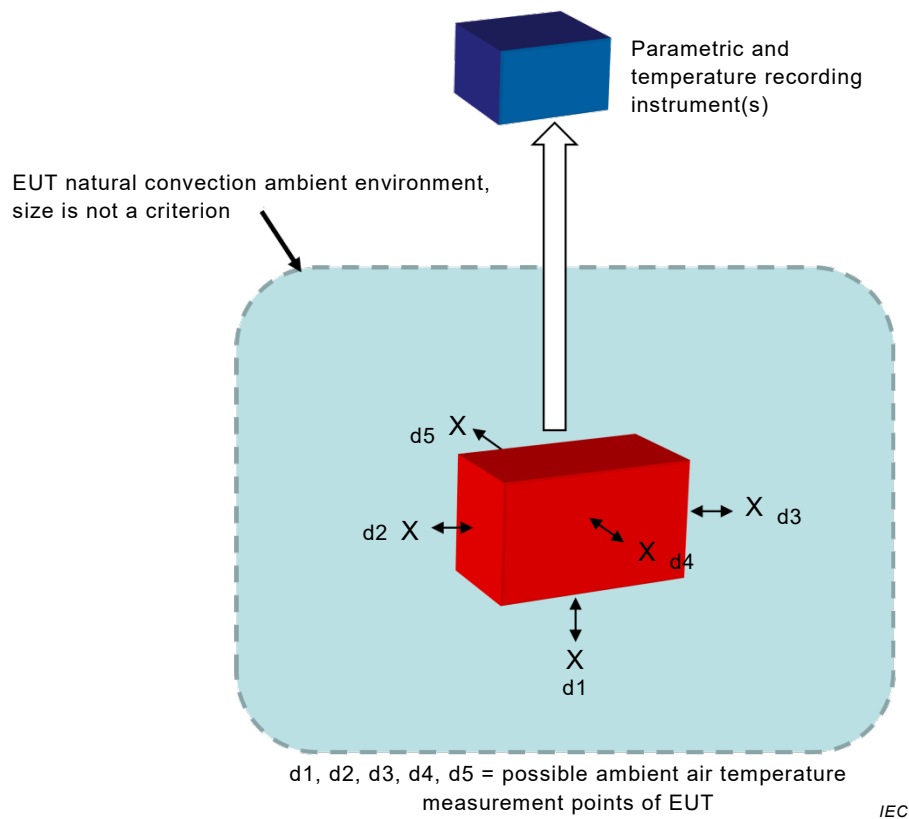


**Figure 3 – General temperature test environment**

Temperatures are measured when steady state has been reached.

If the EUT is meant to function as a standalone unit it shall be tested standalone, e.g. a standalone HMI or communications switch/router. See 4.2.

If the EUT is not meant to function as a standalone unit, e.g. I/O module of a modular equipment system, then a representative EUT shall be utilized for testing. This EUT shall represent a practical least favourable combination of conditions for the EUT. See 4.2.

NOTE 2 Practical least favourable combination of conditions means a realistic situation the EUT can be utilized for in a real world application, not a theoretical combination which would never be used in practice.

This practical least favourable combination shall be, at a minimum, the items necessary for the EUT to function, e.g. power supply, communication module (TM's in Figure 4) and EUT. The EUT shall be surrounded, as permitted by manufacturer's documentation, on both sides with real modules or "simulation module" (thermally representative module, TMs in Figure 4) representing the worst case thermal environment for the EUT, i.e. adding more modules around the EUT does not cause further temperature increase of the EUT. A justification of the configuration for the test shall be provided in the test report.

NOTE 3 An example configuration for testing an I/O module EUT, of a modular system, might be:

- the EUT (I/O module),
- a power supply,
- communication module,
- three of the same type I/O module operating at full load to the left of the EUT,
- three of the same type I/O module operating at full load to the right of the EUT, and
- adding more I/O modules left or right does not cause the EUT's temperature to change.

For vented equipment, cooled by natural air convection, the ambient temperature is the incoming air temperature at a point not more than 50 mm and not less than 25 mm away from the plane of the equipment's air flow entry point. See Figure 4. The points d1, d2 and d3, in Figure 4, are the possible measurement points. The point with the lowest temperature should be utilized as the ambient temperature.

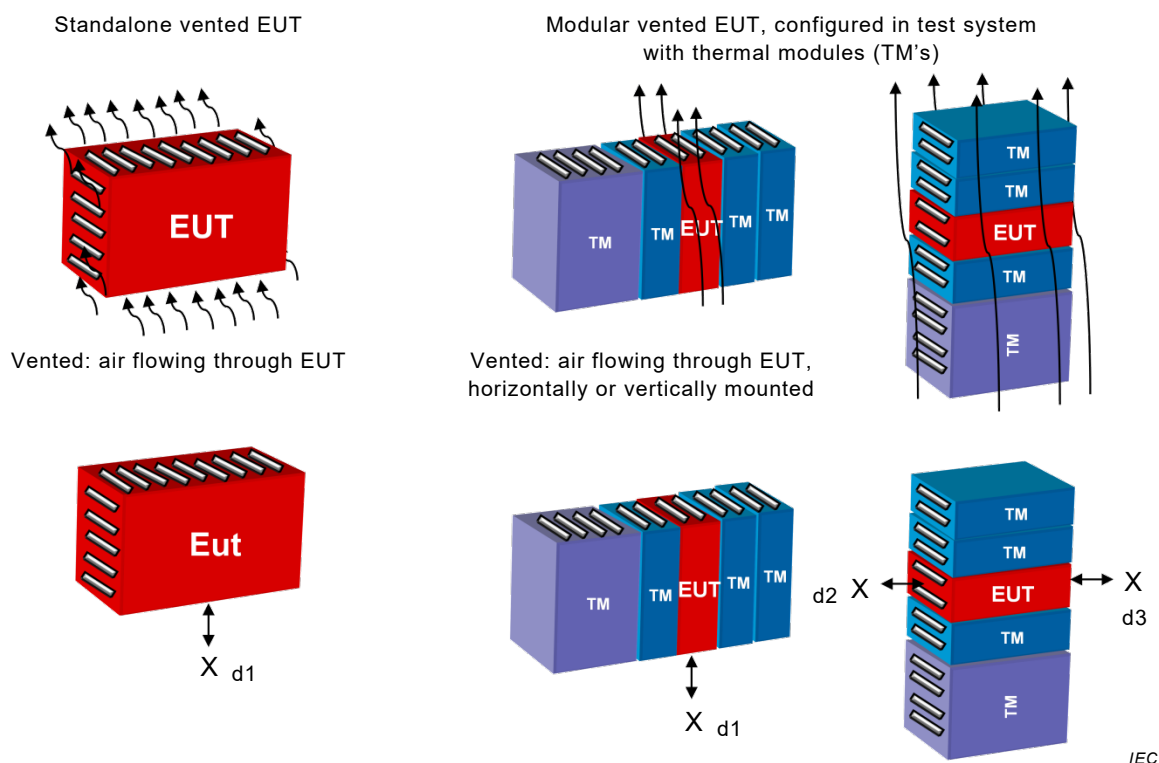


**Figure 4 – Vented equipment**

NOTE 4 Vents are purposeful air openings intended to allow air to pass through the equipment for the purpose of cooling, not incidental vents, e.g. switch shaft or communication jack openings.

For non-vented equipment, cooled by natural air convection, the ambient temperature is the air temperature at a point not more than 50 mm and not less than 25 mm away from the equipment, on a horizontal plane located at the vertical mid-point of the equipment. See Figure 5. The points d2-d5, in Figure 5, are the possible measurement points. The point with the lowest temperature should be utilized as the ambient temperature.

Due to mounting requirements, some of the measurement points may not be practical to utilize.

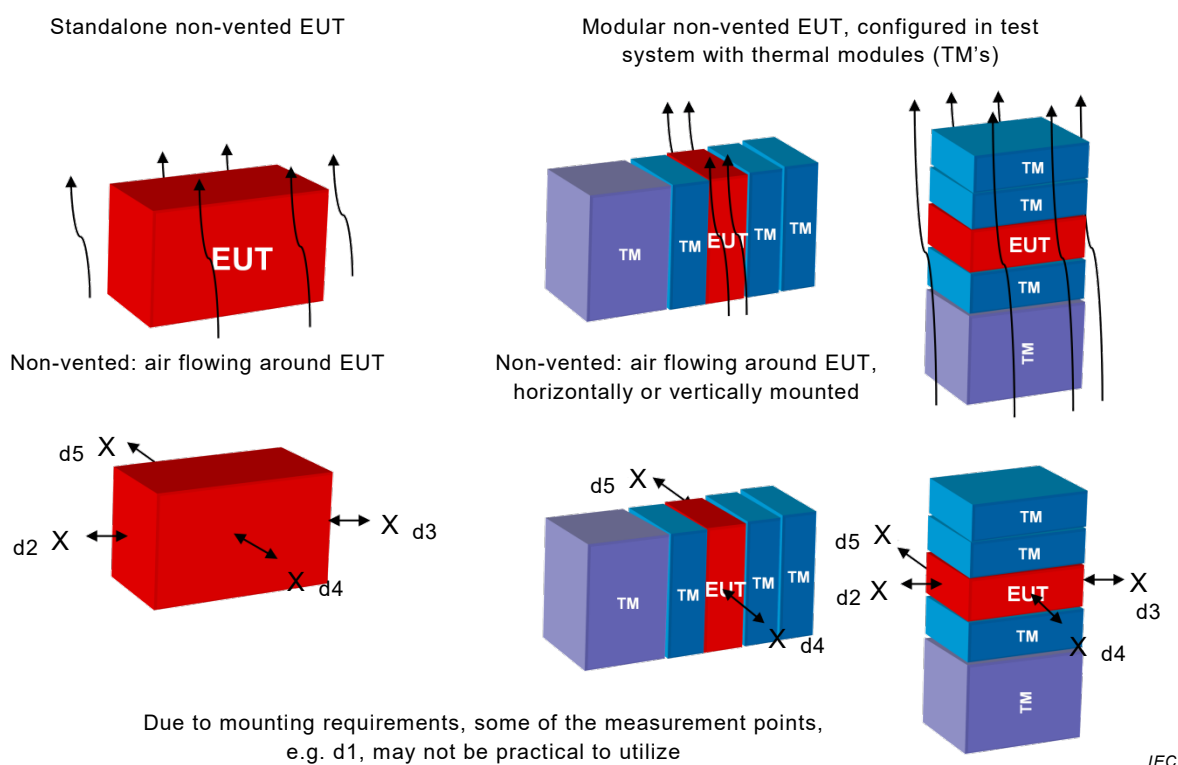


**Figure 5 – Non-vented equipment**

#### 4.2.6.2 Special method, panel mounted equipment

Panel mounted equipment presents some special considerations, see Figure 6.

In this case part of the equipment ( $EUT_a$ ) may be in one ambient environment, e.g. ambient environment #1 and the rest of the equipment ( $EUT_b$ ) may be in another ambient environment, e.g. ambient environment #2. The equipment construction techniques can be quite different, e.g. (referring to Figure 6) open/vented in ambient environment #1 and enclosed/non-vented in ambient environment #2.

It should be kept in mind, it may be necessary that these two different environments be applied simultaneously, to ensure least favourable conditions.

Each part of the equipment ( $EUT_a$  and  $EUT_b$ ) shall be evaluated separately according to its own environment.

The general method described in 4.2.6.1 with regard to test conditions and least favourable EUT configuration, orientation, etc. shall be followed.

Three special methods for testing panel mounted equipment are provided:

- The equipment shall be mounted such that the two portions ( $EUT_a$  and  $EUT_b$ ) of the EUT are subjected to their specific environments.

NOTE 1 This provides the most accurate results, but is the most difficult to create for a test.

- The total EUT ( $EUT_a + EUT_b$ ) shall be mounted in a single environment, which shall be the highest of the two, and the temperatures of the lower temperature EUT portion are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test ambient temperature.

EXAMPLE 1 If EUT<sub>a</sub>'s maximum rated ambient temperature = 60 °C and EUT<sub>b</sub>'s maximum rated ambient temperature = 50 °C, the test will be run with a test ambient temperature = 60 °C. Temperatures taken for EUT<sub>b</sub> would be corrected by –10 °C (50 °C–60 °C).

NOTE 2 This method is not as accurate as a) but will yield conservative results compared to c).

- c) The total EUT (EUT<sub>a</sub> + EUT<sub>b</sub>) shall be mounted in a single environment, which shall be the lower of the two, and the temperatures of the higher temperature EUT portion are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test ambient temperature.

EXAMPLE 2 If EUT<sub>a</sub>'s maximum rated ambient temperature = 60 °C and EUT<sub>b</sub>'s maximum rated ambient temperature = 50 °C, the test will be run with a test ambient temperature = 50 °C. Temperatures taken for EUT<sub>a</sub> would be corrected by +10 °C (60 °C–50 °C).

NOTE 3 This method is not as accurate as a) and will not yield conservative results compared to b).

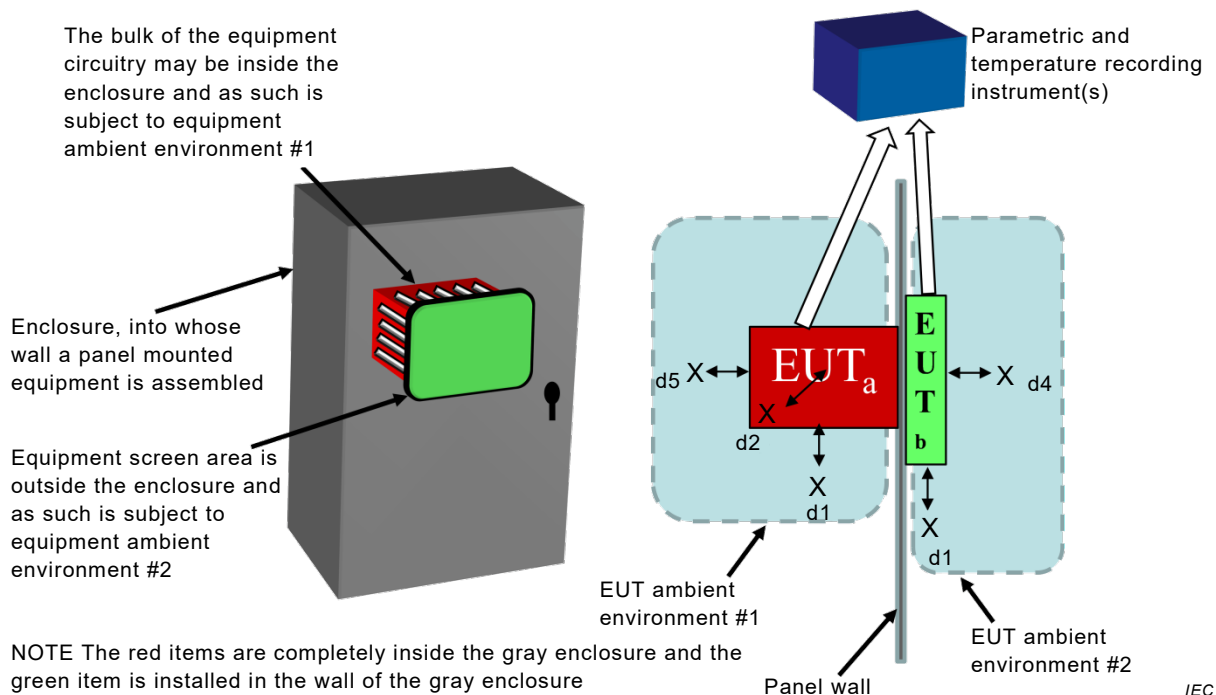


**Figure 6 – Panel mounted equipment extending through the wall of a cabinet**

#### 4.2.6.3 Special method, large or heavy equipment

Equipment too large or too heavy can be tested at room ambient temperature, if the measured temperatures are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test room ambient temperature.

Where this method is applied, rationale shall be provided in the test report.

#### 4.2.7 Verification procedure

Type tests shall be conducted on the EUT(s) defined in 4.2.2 and 4.2.3, unless otherwise specified in this document.

For each test, the manufacturer shall:

- specify the configuration, its arrangement and its external connections;
- provide the test programmes which shall be run during the test;
- provide the proper operation verification procedure, e.g. including the way to measure accuracy and temporary deviations of analog I/Os.

The appropriate test programmes and proper functioning verification procedures provided by the manufacturer shall satisfy the requirements given in 4.2.8.

#### **4.2.8 Requirements for test programmes and proper functioning verification procedures (PFVPs) to be provided by the manufacturer**

During the type tests, there shall be no:

- destruction of hardware;
- modification of the operating system and test programmes and/or alteration of their execution;
- unintended modification of system and application data stored or exchanged;
- erratic or unintended behaviour of the EUT;
- deviation of the analog I/Os out of the limits specified in item 4 of Table 48 and item 3 of Table 52.

All relevant functions and parts of the EUT (i.e. units and modules) shall be functioning in such a way that the information paths to/from these functions and parts are exercised.

All the I/O and communication channels of the EUT shall be exercised.

It is acceptable to apply statistical criteria based on samples, for large number of I/Os, etc. (for example, >100).

The type test is not meant to test every possible operating mode or capability of an EUT. The intent of the type test is to exercise the EUT, at the boundaries of its operating mode(s) and/or capability(ies). Therefore engineering judgement is necessary to define both the configuration of the test and verification, to prove the overall capability. This is without actually testing all possibilities, i.e. a practical set of tests and results.

The following non-exhaustive list contains example items to consider in defining the type tests, with regard to exercise of the EUT.

a) Configuration of the EUT:

- external and internal status information reporting means;
- displays;
- alarm signals,;
- self-test result registers;
- I/O;
- test program length;
- operation modes, e.g. start-up, shut-down, cold/warm/hot restart, normal run;
- performance.

b) The type test shall focus on the least favourable conditions for the EUT, to test its boundaries. Therefore different test set-ups might be needed for testing the EUT boundaries under, for example EMC conditions, climatic conditions.

c) For every EUT there shall be a specification of how and where the limits of proper function can be identified.

#### **4.2.9 EMC Performance criteria**

Verification test method performance criteria.

**Table 1 – Criteria to prove the performance of an EUT against EMC disturbances**

| Performance criterion                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                               |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Criterion                                                 | Operation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                               |
|                                                           | During test                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | After test                                                                                                    |
| A                                                         | The EUT shall continue to operate as intended. No loss of function or performance, according to PFVPs (4.2.8)                                                                                                                                                                                                                                                                                                                                                                              | The EUT shall continue to operate as intended                                                                 |
| B                                                         | Degradation of performance accepted<br>Examples: analog values vary within manufacturer-specified limits <sup>a</sup> , communication delay times vary within manufacturer-specified limits, flickering on HMI display, etc.<br>No change of operating mode<br>Examples: loss of data or uncorrected errors in communication, unintentional state changes of digital I/O which are seen by the EUT or test set-up, etc.<br>No irreversible loss of stored data, according to PFVPs (4.2.8) | The EUT shall continue to operate as intended. Temporary degradation of performance shall be self-recoverable |
| C                                                         | Loss of functions accepted, but no destruction of hardware or software (programme or data)                                                                                                                                                                                                                                                                                                                                                                                                 | The EUT shall continue to operate as intended automatically, after manual restart or power off/power on       |
| <sup>a</sup> See Table 48, item 4) and Table 52, item 3). |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                               |

#### 4.2.10 General facility/laboratory conditions for tests

The tests shall be carried out in accordance with the appropriate test procedure.

The tests shall be carried out under the general test conditions given in Table 2, except for the tests specified with other conditions in this standard, e.g. climatic tests or EMC tests for voltage interruptions.

Unless otherwise specified, no sequence is imposed for type tests.

**Table 2 – General facility/laboratory conditions for tests**

| Test condition      | Range                                    |
|---------------------|------------------------------------------|
| Temperature         | 15 °C to 35 °C                           |
| Relative humidity   | ≤ 75 %                                   |
| Barometric pressure | 86 kPa to 106 kPa (650 mmHg to 800 mmHg) |

#### 4.3 Test report

A test report shall be used to document conformity to this standard or to specific clauses or subclauses within this standard (see 4.1).

The test report shall reference this standard and each clause and/or subclause and their titles, to which conformity is claimed and testing was done.

Where applicable the various tests in a clause and/or subclause and values to which the equipment was tested and/or the measured values shall be identified.

The test report shall contain all necessary information to reproduce the test. At a minimum, the following shall be recorded:

- identification of EUT hardware and any associated equipment (eg. modular parts, cabling, etc.) including versions and/or serial number;
- identification of EUT system software (eg. BIOS), operating system (OS) including versions and/or serial number;
- identification of test equipment including model number, brand, and calibration details;
- climatic conditions including temperature, humidity, and atmospheric pressure;
- rationale for using this combination of hardware and software;
- test results including pass/fail, effects on EUT during/after test;
- any specific conditions required to achieve compliance (e.g. enclosure, shielding, earthing, deratings, etc.).

## 5 Normal service conditions and requirements

### 5.1 General

The equipment is intended to be used in an industrial environment.

Service conditions encompass operating, transport and storage.

### 5.2 Operating conditions and requirements

#### 5.2.1 Ambient temperature and relative humidity

Table 3 provides a recommended set of operating environments for equipment in the scope.

At a minimum, PLC/PAC, if enclosed equipment, shall be suitable for ambient temperature and relative humidity ranges stated as operating environment OTH2 (green highlight in Table 3) and OTH3, if open equipment (blue highlight in Table 3).

**Table 3 – Operating environments, ambient temperature and relative humidity**

| Operating environment | Equipment Type | Minimum ambient temperature | Maximum ambient temperature | Minimum relative humidity | Maximum relative humidity <sup>a</sup> | Comment on application         |
|-----------------------|----------------|-----------------------------|-----------------------------|---------------------------|----------------------------------------|--------------------------------|
| OTH1                  | Enclosed       | 20 °C                       | 25 °C                       | 20 %                      | 75 %                                   | e.g fully air conditioned, DCS |
| OTH2                  | Enclosed       | 5 °C                        | 40 °C                       | 5 %                       | 85 %                                   | e.g. industrial PC             |
| OTH3                  | Open           | 5 °C                        | 55 °C                       | 5 %                       | 85 %                                   | e.g. HMI, PLC, PAC             |
| OTH4                  | Open           | 0 °C                        | 60 °C                       | 10 %                      | 95 %                                   | e.g. PLC                       |
| OTH5                  | Open           | -25 °C                      | 70 °C                       | 10 %                      | 100 %                                  | e.g PLC, field devices         |
| OTH6                  | Enclosed       | -40 °C                      | 70 °C                       | 10 %                      | 100 %                                  |                                |

Air pressure absolute min. 79,5 kPa to max. 101,3 kPa.

NOTE 1 Table based on guidance from IEC 60721-3-3 and historical experience.

NOTE 2 A closely related topic is surface temperature limits. These are specified in 10.1 of IEC 61010-2-201:–.

<sup>a</sup> Under normal operation equipment is not intended to operate with condensation.

Equipment may also be suitable for extended operating environments. Refer to Table 3, for additional environments.

Equipment style (open or enclosed) is not limited to just those operating environments listed, e.g. enclosed = OTH2, open = OTH3. They can be designed for other ranges also, e.g. enclosed = OTH3.

The requirements of 5.2.1 are verified in accordance with the immunity test requirements of Table 4, Table 5, Table 6 and Table 7.

**Table 4 – Dry-heat withstand and immunity tests**

|                                                                                                                                       | Withstand                                                                                                            | Immunity (Not normative: informative / optional)                            |
|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Reference test                                                                                                                        | IEC 60068-2-2, test Bb                                                                                               | IEC 60068-2-2, test Be                                                      |
| Preconditioning                                                                                                                       | According to manufacturer's specifications                                                                           |                                                                             |
| Initial measurement                                                                                                                   | According to PFVP, see 4.2.8                                                                                         |                                                                             |
| Conditioning                                                                                                                          | Power supply unconnected                                                                                             | Power connected and in operation                                            |
| Ambient temperature <sup>b</sup>                                                                                                      | Maximum of<br>STH1, STH2, STH3, STH4 or STH5 °C ± 2 K <sup>d</sup><br>TTH1, TTH2, TTH3 or TTH4 °C ± 2 K <sup>e</sup> | Maximum of<br>OTH1, OTH2, OTH3, OTH4, OTH5 or<br>OTH6 °C ± 2 K <sup>c</sup> |
| Duration of exposure                                                                                                                  | 16 h ± 1 h                                                                                                           | 16 h ± 1 h                                                                  |
| Measuring and/or loading during conditioning                                                                                          | None                                                                                                                 | Yes                                                                         |
| Details of mounting/support                                                                                                           | None                                                                                                                 | See 4.2.6                                                                   |
| Recovery procedure                                                                                                                    |                                                                                                                      |                                                                             |
| Time                                                                                                                                  | 1 h minimum                                                                                                          | -                                                                           |
| Climatic conditions                                                                                                                   | See 4.2.5 and 4.2.9 <sup>a</sup>                                                                                     |                                                                             |
| Special caution                                                                                                                       | No condensation <sup>a</sup>                                                                                         |                                                                             |
| Power supply                                                                                                                          | Power connected and in operation                                                                                     |                                                                             |
| Final measurements                                                                                                                    | According to PFVP, see 4.2.8                                                                                         |                                                                             |
| <sup>a</sup> All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply. |                                                                                                                      |                                                                             |
| <sup>b</sup> Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.                     |                                                                                                                      |                                                                             |
| <sup>c</sup> See Table 3                                                                                                              |                                                                                                                      |                                                                             |
| <sup>d</sup> See Table 13                                                                                                             |                                                                                                                      |                                                                             |
| <sup>e</sup> See Table 14                                                                                                             |                                                                                                                      |                                                                             |

**Table 5 – Cold withstand and immunity tests**

|                                                                                                                                       | Withstand                                                                                                            | Immunity (Not normative: informative / optional)                            |
|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Reference test                                                                                                                        | IEC 60068-2-1, test Ab                                                                                               | IEC 60068-2-1, test Ae                                                      |
| Preconditioning                                                                                                                       | According to manufacturer's specifications                                                                           |                                                                             |
| Initial measurement                                                                                                                   | According to PFVP, see 4.2.8                                                                                         |                                                                             |
| Conditioning                                                                                                                          | Power supply unconnected                                                                                             | Power connected and in operation                                            |
| Ambient temperature <sup>b</sup>                                                                                                      | Minimum of<br>STH1, STH2, STH3, STH4 or STH5 °C ± 3 K <sup>d</sup><br>TTH1, TTH2, TTH3 or TTH4 °C ± 3 K <sup>e</sup> | Minimum of<br>OTH1, OTH2, OTH3, OTH4, OTH5 or<br>OTH6 °C ± 2 K <sup>c</sup> |
| Duration of exposure                                                                                                                  | 16 h ± 1 h                                                                                                           | 16 h ± 1 h                                                                  |
| Measuring and/or loading during conditioning                                                                                          | None                                                                                                                 | Yes                                                                         |
| Details of mounting/support                                                                                                           | None                                                                                                                 | See 4.2.6                                                                   |
| Recovery procedure                                                                                                                    |                                                                                                                      |                                                                             |
| Time                                                                                                                                  | 1 h minimum                                                                                                          | -                                                                           |
| Climatic conditions                                                                                                                   | See 4.2.5 and 4.2.9 <sup>a</sup>                                                                                     |                                                                             |
| Special caution                                                                                                                       | No condensation <sup>a</sup>                                                                                         |                                                                             |
| Power supply                                                                                                                          | Power connected and in operation                                                                                     |                                                                             |
| Final measurements                                                                                                                    | According to PFVP, see 4.2.8                                                                                         |                                                                             |
| <sup>a</sup> All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply. |                                                                                                                      |                                                                             |
| <sup>b</sup> Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.                     |                                                                                                                      |                                                                             |
| <sup>c</sup> See Table 3                                                                                                              |                                                                                                                      |                                                                             |
| <sup>d</sup> See Table 13                                                                                                             |                                                                                                                      |                                                                             |
| <sup>e</sup> See Table 14                                                                                                             |                                                                                                                      |                                                                             |

**Table 6 – Change of temperature, withstand and immunity tests**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    | Withstand test                                                                                         | Immunity test                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------|
| Reference test                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    | IEC 60068-2-14, test Na                                                                                | IEC 60068-2-14, test Nb                |
| Preconditioning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    | According to manufacturer's specification                                                              |                                        |
| Initial measurements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    | According to PFVP, see 4.2.8                                                                           |                                        |
| Conditioning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                    | Power supply unconnected                                                                               | Power connected and in operation       |
| Measurement and/or loading during conditioning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    | None                                                                                                   | Yes <sup>c</sup>                       |
| Details of mounting/support                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                    | None                                                                                                   | See 4.2.6                              |
| Minimum ambient temperature <sup>f</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Open equipment     | STH1, STH2, STH3, STH4 or STH5 °C ± 3 K <sup>g</sup><br>TTH1, TTH2, TTH3 or TTH4 °C ± 3 K <sup>h</sup> | OTH3, OTH4, OTH5 °C ± 3 K <sup>f</sup> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Enclosed equipment |                                                                                                        | OTH1, OTH2, OTH6 °C ± 3 K <sup>f</sup> |
| Maximum ambient temperature <sup>e</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Open equipment     | STH1, STH2, STH3, STH4 or STH5 °C ± 2 K <sup>g</sup><br>TTH1, TTH2, TTH3 or TTH4 °C ± 2 K <sup>h</sup> | OTH3, OTH4, OTH5 °C ± 3 K <sup>f</sup> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Enclosed equipment |                                                                                                        | OTH1, OTH2, OTH6 °C ± 3 K <sup>f</sup> |
| Exposure time at each temperature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    | 3 h ± 30 min                                                                                           |                                        |
| Transport time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    | Less than 3 min                                                                                        | Not applicable                         |
| Temperature variation speed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                    | Not applicable                                                                                         | 3 K/min. ± 0,6 K/min.                  |
| Number of cycles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    | 5                                                                                                      | 2                                      |
| Recovery procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |                                                                                                        |                                        |
| Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    | Less than 2 h                                                                                          | Not applicable                         |
| Climatic conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                    | See 4.2.5 and 4.2.10 <sup>d</sup>                                                                      | Not applicable                         |
| Power supply                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                    | Power connected and in operation                                                                       |                                        |
| Final measurements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    | a                                                                                                      | b                                      |
| <sup>a</sup> PFVP according to 4.2.8 performed after recovery.<br><sup>b</sup> PFVP according to 4.2.8 performed during test.<br><sup>c</sup> Loading per product specifications, including any derating.<br><sup>d</sup> All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply.<br><sup>e</sup> Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.<br><sup>f</sup> See Table 3<br><sup>g</sup> See Table 13<br><sup>h</sup> See Table 14 |                    |                                                                                                        |                                        |

**Table 7 – Cyclic (12 + 12) damp-heat withstand test**

|                                                                                                                                            |                                                                                                                                                    |                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
|                                                                                                                                            | <b>Withstand test</b>                                                                                                                              | <b>Immunity test (Not normative:<br/>informative / optional)</b>                                           |
| <b>Reference test</b>                                                                                                                      | IEC 60068-2-30, test Db<br>Variant 2                                                                                                               | IEC 60068-2-78, test Cab                                                                                   |
| Preconditioning                                                                                                                            | According to manufacturer's specifications                                                                                                         |                                                                                                            |
| Initial measurements                                                                                                                       | According to PFVP, see 4.2.8                                                                                                                       |                                                                                                            |
| Conditioning                                                                                                                               | Power supply unconnected and<br>without packaging container<br><br>EUT at 25 °C ± 3 K stabilized before<br>test starts                             | Power connected and in operation                                                                           |
| Measurement and/or loading<br>during conditioning                                                                                          | None                                                                                                                                               | Yes                                                                                                        |
| Details of mounting/support                                                                                                                | None                                                                                                                                               | See 4.2.6                                                                                                  |
|                                                                                                                                            |                                                                                                                                                    |                                                                                                            |
| Ambient temperature <sup>b, f</sup>                                                                                                        | Maximum <sup>f</sup> of<br>STH1, STH2 °C ± 2 K <sup>d</sup><br>TTH1, TTH2 °C ± 2 K <sup>e</sup><br><br>or<br>Temp. 55°C ± 2 K<br>Rel. Humidity 95% | Maximum of<br>OTH1, OTH2, OTH3 °C<br>± 2 K <sup>c</sup><br><br>or<br>Temp. 30°C ± 2 K<br>Rel. Humidity 93% |
| Number of cycles / time                                                                                                                    | 2 / (12 + 12)h                                                                                                                                     | 1 / 16h                                                                                                    |
| Recovery procedure time                                                                                                                    |                                                                                                                                                    |                                                                                                            |
| Climatic conditions                                                                                                                        | Under controlled conditions prescribed<br>in IEC 60068-2-30 <sup>a</sup>                                                                           | Under controlled conditions<br>prescribed in IEC 60068-2-78 <sup>a</sup>                                   |
| Power supply                                                                                                                               | After recovery: Power connected and in operation                                                                                                   |                                                                                                            |
| Final measurements                                                                                                                         | According to PFVP, see 4.2.8, performed<br>within 30 min after recovery                                                                            |                                                                                                            |
| <sup>a</sup> All external and internal condensation shall be removed by airflow, prior to reconnecting the EUT to a power supply.          |                                                                                                                                                    |                                                                                                            |
| <sup>b</sup> Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.                          |                                                                                                                                                    |                                                                                                            |
| <sup>c</sup> See Table 3                                                                                                                   |                                                                                                                                                    |                                                                                                            |
| <sup>d</sup> See Table 13                                                                                                                  |                                                                                                                                                    |                                                                                                            |
| <sup>e</sup> See Table 14                                                                                                                  |                                                                                                                                                    |                                                                                                            |
| <sup>f</sup> IEC 60068-2-30, test Db specifies two test temperatures. The upper temperature shall be achieved in a period of 3 h ± 30 min. |                                                                                                                                                    |                                                                                                            |

### 5.2.2 Altitude

The equipment shall be suitable for operation up to 2 000 m, see green highlight in Table 8 (minimum 79,5 kPa absolute).

NOTE A closely related topic is clearance distance. This is specified in 6.7.1.2 of IEC 61010-1:2010.

If the equipment is rated for an altitude greater than 2 000 m, the manufacturer shall provide altitude derating information similar to that in Table 8. If the manufacturer does not, Table 8 is applicable.

**Table 8 – Multiplication factors for equipment ambient temperature of operation at altitudes up to 5 000 m**

| Altitude<br>m                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Derating ratio for temperature <sup>a</sup> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| 0 to 2 000 <sup>b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1,0                                         |
| 3 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0,9                                         |
| 4 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0,8                                         |
| 5 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0,7                                         |
| <p>Linear interpolation is allowed between altitudes.</p> <p>NOTE These factors compensate for the reduction in cooling capacity of air at higher altitudes, due to lower density.</p> <p><sup>a</sup> Equipment ambient temperature rating at 2 000 m</p> <p><sup>b</sup> Atmospheric pressure and air density increases with decreasing altitude. Therefore utilization of the derating factor for 0 m to 2 000 m for altitudes below sea level is considered conservative.</p> |                                             |

EXAMPLE 1 If the operating ambient temperature of the equipment is 25 °C at 2 000 m, its operating ambient temperature at 5 000 m = 25 °C \* 0,7 = 17,5 °C.

EXAMPLE 2 If the operating ambient temperature of the equipment is 70 °C at 2 000 m, its operating ambient temperature at 3 000 m = 70 °C \* 0,9 = 63 °C.

The requirements of 5.2.2 are verified by the temperatures tests of Table 4 and by inspection of the equipment manuals for deratings according to Table 8.

### 5.3 Mechanical operating conditions and requirements

#### 5.3.1 General

Experience shows that equipment meeting these requirements are suitable for industrial use.

For the purpose of this standard, the operating conditions are indirectly defined by the following requirements which apply to fixed equipment as well as to unpackaged portable and hand-held equipment. They do not apply to equipment containing assemblies outside the scope of this standard. Fixed equipment is equipment which is part of the permanent installation.

#### 5.3.2 Vibrations

Vibration immunity requirements for equipment in the scope of this document are shown in Table 9.

**Table 9 – Sinusoidal vibration conditions**

|                                                                                                                                                                                                                                                                                                   |                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Displacement                                                                                                                                                                                                                                                                                      | 3,5 mm constant displacement, $5 \leq f < 8,4$ Hz                         |
| Acceleration                                                                                                                                                                                                                                                                                      | 10 m/s <sup>2</sup> (1 g) constant acceleration, $8,4 \leq f \leq 150$ Hz |
| <p>All amplitude figures are peak values.</p> <p>The break point frequency shall be adjusted to yield a smooth cross-over without discontinuity from the constant amplitude displacement requirement to the constant amplitude acceleration requirement.</p> <p>NOTE 1 g = 10 m/s<sup>2</sup></p> |                                                                           |

Vibration is applicable to each 3 mutually perpendicular axes.

The requirements of 5.3.2 are verified in accordance with Table 10.

**Table 10 – Immunity vibration test**

| Reference test                                                                                                                                                                                          | IEC 60068-2-6, test Fc                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Preconditioning                                                                                                                                                                                         | According to manufacturer's specifications                        |
| Initial measurements                                                                                                                                                                                    | According to PFVP, see 4.2.8                                      |
| Details of mounting/support                                                                                                                                                                             | According to manufacturer's specifications                        |
| Motion                                                                                                                                                                                                  | Sinusoidal                                                        |
| Vibration amplitude/acceleration                                                                                                                                                                        |                                                                   |
| $5 \text{ Hz} \leq f < 8,4 \text{ Hz}$                                                                                                                                                                  | $3,5 \text{ mm}_{\text{peak}}$ constant displacement              |
| $8,4 \text{ Hz} \leq f \leq 150 \text{ Hz}$                                                                                                                                                             | $10 \text{ m/s}^2_{\text{peak}}$ constant acceleration            |
| Vibration type                                                                                                                                                                                          | Sweeping, at a rate of 1 octave/min ( $\pm 10 \%$ )               |
| Vibration duration                                                                                                                                                                                      | 10 sweep cycles per axis on each of 3 mutually perpendicular axes |
| Measurement and verification during test                                                                                                                                                                | According to PFVP, see 4.2.8                                      |
| Verification after tests                                                                                                                                                                                | According to PFVP, see 4.2.8                                      |
| The break point frequency shall be adjusted to yield a smooth cross-over without discontinuity from the constant amplitude displacement requirement to the constant amplitude acceleration requirement. |                                                                   |

### 5.3.3 Shock

Shock immunity requirements for equipment in the scope of this document are occasional excursions to  $150 \text{ m/s}^2$  (15 g), 11 ms, half-sine, in each of 3 mutually perpendicular axes.

Electromechanical relays may temporarily respond to  $150 \text{ m/s}^2$  (15 g) shocks. Temporary malfunctioning is allowed during the test, but equipment should be fully functional after the test.

The requirements of 5.3.3 are verified in accordance with Table 11.

**Table 11 – Immunity shock test**

| Reference test                           | IEC 60068-2-27, test Ea                                                                         |
|------------------------------------------|-------------------------------------------------------------------------------------------------|
| Preconditioning                          | According to manufacturer's specifications                                                      |
| Initial measurements                     | According to PFVP, see 4.2.8                                                                    |
| Details of mounting/support              | According to manufacturer's specifications                                                      |
| Type of shock                            | Half-sine                                                                                       |
| Shock severity                           | $150 \text{ m/s}^2$ (15 g) peak, 11 ms duration                                                 |
| Application                              | Three shocks in each direction per axis, on 3 mutually perpendicular axes (total of 18 shocks ) |
| Measurement and verification during test | According to PFVP, see 4.2.8                                                                    |
| Verification after tests                 | According to PFVP, see 4.2.8                                                                    |

### 5.3.4 Free falls (portable and hand-held equipment)

Immunity (during operation) and withstand (non-operational) requirements for falls are as shown in Table 12.

Fall type tests may be combined with the safety evaluation according to IEC 61010-2:2011.

Fall test is for hand-held and portable equipment only. Fixed equipment does not require testing.

The reference standard is IEC 60068-2-31, free fall, procedure 1.

The EUT shall be equipped with manufacturer's standard cable(s) (if any).

Free falls can be on any edge, surface or corner. For free falls the least favourable edge, surface or corner shall be selected for the test.

**Table 12 – Free fall on concrete floor for portable and hand-held equipment**

|                                   | Portable and hand-held (<10kg)<br>(withstand) | Hand-held (<1kg)<br>(immunity) |
|-----------------------------------|-----------------------------------------------|--------------------------------|
| Free falls                        | 100 mm; 2 falls                               | 1 000 mm; 2 falls              |
| Dropping onto an edge or a corner | 30° or 100 mm; 2 falls                        |                                |

The requirements of 5.3.4 are verified, after testing the EUT to Table 12, according to PFVP, see 4.2.8.

The EUT may show signs of physical damage after each test, but shall be fully functional.

With the EUT operating during the fall, erroneous operation can be introduced upon impact. Operator correction/reset is allowed after impact.

It is permitted to use a new sample for each fall.

## **5.4 Transport and storage conditions and requirements**

### **5.4.1 General**

The following requirements apply to control equipment units placed within manufacturer's original packaging.

Transport and storage of unpackaged portable equipment shall not exceed the requirements of 5.4.

When components are included in the equipment, which have particular limitations, e.g. batteries, the manufacturer shall specify the arrangements to be made for transport and storage.

### **5.4.2 Ambient temperature and relative humidity**

Table 13 provides a recommended set of storage environments for equipment in the scope.

**Table 13 – Storage environments, ambient temperature and relative humidity**

| Storage environment                                                        | Equipment Type    | Minimum ambient temperature | Maximum ambient temperature | Minimum relative humidity | Maximum relative humidity <sup>a</sup> | Comment on application                         |
|----------------------------------------------------------------------------|-------------------|-----------------------------|-----------------------------|---------------------------|----------------------------------------|------------------------------------------------|
| STH1                                                                       | Enclosed/<br>Open | 20 °C                       | 25 °C                       | 20 %                      | 75 %                                   | e.g. DCS                                       |
| STH2                                                                       | Enclosed/<br>Open | 5 °C                        | 40 °C                       | 5 %                       | 85 %                                   | e.g. industrial PC, DCS                        |
| STH3                                                                       | Enclosed/<br>Open | -5 °C                       | 60 °C                       | 5 %                       | 95 %                                   | e.g. HMI, industrial PC                        |
| STH4                                                                       | Enclosed/<br>Open | -25 °C                      | 70 °C                       | 10 %                      | 95 %                                   | e.g. PLC/PAC (not recommended for new designs) |
| STH5                                                                       | Enclosed/<br>Open | -40 °C                      | 70 °C                       | 10 %                      | 100 %                                  | e.g. PLC/PAC (recommended for new designs)     |
| NOTE Table based on guidance from IEC 60721-3-1 and historical experience. |                   |                             |                             |                           |                                        |                                                |
| <sup>a</sup> Non-condensing                                                |                   |                             |                             |                           |                                        |                                                |

At a minimum, PLC/PAC equipment shall be suitable for ambient temperature and relative humidity ranges stated as storage environment STH4 (enclosed/open equipment, green highlight in Table 13).

Table 14 provides a recommended set of transportation environments for equipment in the scope.

**Table 14 – Transportation environments, ambient temperature and humidity**

| Transportation environment                                                 | Equipment Type    | Minimum ambient temperature | Maximum ambient temperature | Minimum relative humidity | Maximum relative humidity <sup>a</sup> | Comment on application                         |
|----------------------------------------------------------------------------|-------------------|-----------------------------|-----------------------------|---------------------------|----------------------------------------|------------------------------------------------|
| TTH1                                                                       | Enclosed/<br>Open | 5 °C                        | 40 °C                       | 20 %                      | 75 %                                   | e.g. DCS                                       |
| TTH2                                                                       | Enclosed/<br>Open | -25 °C                      | 60 °C                       | 30 %                      | 75 %                                   | e.g. HMI, industrial PC, DCS                   |
| TTH3                                                                       | Enclosed/<br>Open | -25 °C                      | 70 °C                       | 40 %                      | 95 %                                   | e.g. PLC/PAC (not recommended for new designs) |
| TTH4                                                                       | Enclosed/<br>Open | -40 °C                      | 70 °C                       | 45 %                      | 95 %                                   | e.g. PLC/PAC (recommended for new designs)     |
| NOTE Table based on guidance from IEC 60721-3-2 and historical experience. |                   |                             |                             |                           |                                        |                                                |
| <sup>a</sup> Non-condensing                                                |                   |                             |                             |                           |                                        |                                                |

At a minimum, PLC/PAC equipment shall be suitable for ambient temperature and relative humidity ranges stated as transportation environment TTH3 (enclosed/open equipment, green highlight in Table 14).

Equipment may also be suitable for extended storage environments. Refer to Table 13 and Table 14, for additional environments.

The requirements of 5.4.2 are verified in accordance with the withstand test requirements of Table 4, Table 5, Table 6 and Table 7.

### 5.4.3 Altitude

The design atmospheric pressure for transportation shall be equivalent to 0 m to 3 000 m altitude (minimum 70 kPa absolute).

No verification required.

### 5.4.4 Free falls (in manufacturer's original packaging)

Withstand requirements for control equipment units within manufacturer's original packaging are given in Table 15.

The reference standard is IEC 60068-2-31, procedure 1.

The test is made with each type of manufacturer's original packaging with the heaviest unit using it.

NOTE 1 There are no requirements on the packaging such as e.g. dimensions, material, form, thickness, this test is only to qualify the robustness of the EUT when packaged.

If the EUT is shipped with any manufacturer's standard cable(s) installed and any accessories and documentation in the same package, the test has to be made with the complete filled package.

**Table 15 – Free fall on concrete floor in manufacturer's original packaging**

| Shipping weight with packaging<br>kg | Random free-fall drop height<br>mm                                                                    |                      |
|--------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------|
|                                      | With shipping package                                                                                 | With product package |
| < 10                                 | 1 000                                                                                                 | 300                  |
| 10 – 40                              | 500                                                                                                   | 300                  |
| > 40                                 | 250                                                                                                   | 250                  |
| Number of falls <sup>a, b</sup>      | Once on each face, edge and corner<br>(e.g. for rectangular package, 6 faces, 12 edges and 8 corners) |                      |

<sup>a</sup> The number and type of falls (face, edge or corner) may be limited depending on handling, shipping and transportation requirements / limitations defined by the manufacturer. If the number is limited, it shall be justified in the test report.

<sup>b</sup> Multiple samples are permitted during test execution.

These requirements of 5.4.4 are verified by testing the EUT to Table 15. After unpacking the EUT shall not show evidence of physical damage and by testing the EUT according to PFVP to 4.2.8.

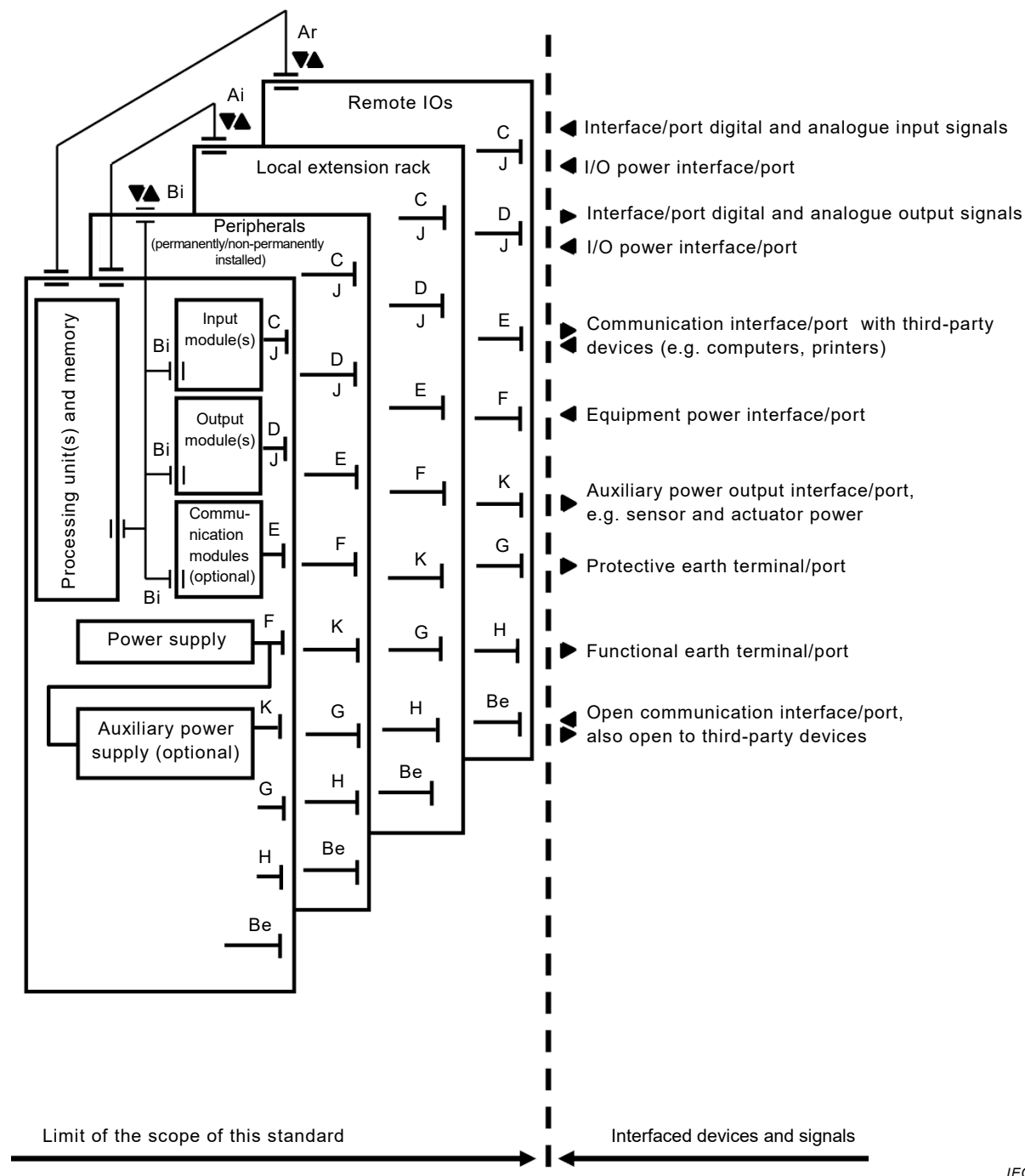
When accessories are to be carried in the same package, they shall be in the package during the fall tests and they shall be checked for damage after unpacking.

Measurement is not required. Vibration sensors may be used at damageable parts or components (e.g. hard disks) to verify compliance with the limits of its data sheet.

## 6 Functional requirements

### 6.1 General

A typical modular control equipment and its interfaces / ports is shown in Figure 7. This type of control equipment provides all types of interfaces and ports that are common for the equipment in the scope of this standard.



IEC

#### Key

AI Communication interface/port for local extension rack

Ar Communication interface/port for remote I/O station, control network, fieldbus

Be Open communication interface/port, open to third-party devices; e.g. PADT, personal computer used for programming

Bi Internal communication interface/port, e.g. backplane bus

- C Interface/port for digital and analog input signals
- D Interface/port for digital and analog output signals
- E Serial or parallel communication interfaces/ports for data communication with third-party devices; e.g. computers, printers
- F Equipment power interface/port. Devices with F ports have requirements on keeping downstream devices intelligent during power up, power down and power interruptions.
- G Protective earth port
- H Functional earth port
- J I/O power interface/port
- K Auxiliary power output interface/port, e.g. sensor and actuators power

**Figure 7 – Typical interface/port diagram of a modular control equipment**

## 6.2 Power input ports

NOTE Power input ports are equipment power port (port F, Figure 7).

### 6.2.1 Requirements

#### 6.2.1.1 Rated values and operating ranges

Incoming power supplies to the control equipment and to the externally powered I/O modules shall be as shown in Table 16.

**Table 16 – Rated values and operating ranges of incoming power supply**

| Voltage                                                                                                                                                                                                                                                                 |                     | Frequency            |                     | Recommended use (R) |             | Normative items and note <sup>c</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------------------|---------------------|---------------------|-------------|---------------------------------------|
| Rated $U_e$                                                                                                                                                                                                                                                             | Tolerance min./max. | Rated $f_n$          | Tolerance min./max. | Power supply        | I/O signals |                                       |
| d.c. 24 V                                                                                                                                                                                                                                                               | –15 %/+20 %         |                      |                     | R                   | R           | a, b                                  |
| d.c. 48 V                                                                                                                                                                                                                                                               |                     |                      |                     | R                   | R           | a                                     |
| d.c. 125 V                                                                                                                                                                                                                                                              |                     |                      |                     |                     |             |                                       |
| a.c. 24 V r.m.s.                                                                                                                                                                                                                                                        | –15 %/+10 %         | 50 Hz<br>or<br>60 Hz | –6 %/+4 %           |                     |             | (NOTE)                                |
| a.c. 48 V r.m.s.                                                                                                                                                                                                                                                        |                     |                      |                     |                     |             | (NOTE)                                |
| a.c. 100 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           |                                       |
| a.c. 110 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           |                                       |
| a.c. 120 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           | (NOTE)                                |
| a.c. 200 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           |                                       |
| a.c. 230 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           | (NOTE)                                |
| a.c. 240 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   | R           |                                       |
| a.c. 400 V r.m.s.                                                                                                                                                                                                                                                       |                     |                      |                     | R                   |             | <sup>d</sup> , (NOTE)                 |
| NOTE The rated voltages are derived from IEC 60038.                                                                                                                                                                                                                     |                     |                      |                     |                     |             |                                       |
| <sup>a</sup> In addition to the voltage tolerances, a total a.c. component having a peak value of 5 % of the rated voltage is allowed. The absolute limits are d.c. 30/19,2 V for d.c. 24 V and d.c. 60/38,4 V for d.c. 48 V.                                           |                     |                      |                     |                     |             |                                       |
| <sup>b</sup> See footnote e) of Table 24 if Type 2 digital inputs are likely to be used.                                                                                                                                                                                |                     |                      |                     |                     |             |                                       |
| <sup>c</sup> For incoming voltages other than those given in the table such as d.c. 110 V etc., the tolerances given in the table and its note apply. These voltage tolerances shall be used to calculate the input limits of Table 24, using the equations in Annex B. |                     |                      |                     |                     |             |                                       |
| <sup>d</sup> Three-phase supply.                                                                                                                                                                                                                                        |                     |                      |                     |                     |             |                                       |

The requirements of 6.2.1.1 are verified in accordance with 6.2.2.1, 6.2.2.2, 6.2.2.3, 6.2.2.4 and 6.2.2.5.

### 6.2.1.2 Improper equipment power supply connection

Equipment shall be designed to withstand a reversal of power supply polarity.

The requirements of 6.2.1.2 are verified in accordance with 6.2.2.6.

### 6.2.1.3 Voltage interruptions power ports

These limits apply to the equipment power interface/port (F) in Figure 7.

For short disturbances of the supply as defined in Table 17, the EUT (including RIOS (see 6.8) and non-permanently installed peripherals) shall maintain normal operation.

For interruptions longer than the maximum interruption time of the supply(ies), the EUT shall either maintain normal operation or go to a predefined state and have a clearly specified behaviour until normal operation is resumed.

NOTE Outputs and fast responding inputs energized by the same supply(ies) can respond to these power supply variations.

**Table 17 – Voltage interruptions (functional requirements)**

| Supply type <sup>e</sup> | Severity level   | Maximum interruption time | Low voltage, $U_{e \min}$ to % $U_e$ <sup>b</sup> |
|--------------------------|------------------|---------------------------|---------------------------------------------------|
| d.c.                     | PS1 <sup>c</sup> | 1 ms                      | 0 %                                               |
| d.c.                     | PS2 <sup>d</sup> | 10 ms                     | 0 %                                               |
| a.c.                     | PS2 <sup>d</sup> | 0,5 period <sup>a</sup>   | 0 %                                               |

NOTE See Annex E.

<sup>a</sup> Any arbitrary phase angle,  $f_n = 50$  Hz or 60 Hz (see 6.2.2.7).

<sup>b</sup>  $U_{e \min}$  is the  $U_e$  at minimum tolerance in Table 16.

<sup>c</sup> PS1 applies to control equipment energized by battery or d.c. supplies which fulfil PS2.

<sup>d</sup> PS2 applies to control equipment energized from a.c. supplies, rectified a.c. supplies and d.c. supplies (with more severe interruption than PS1).

<sup>e</sup> Voltage interruptions are from  $U_{e \min}$ .

The requirements of 6.2.1.3 are verified in accordance with 6.2.2.7.

## 6.2.2 Verification of power input ports (a.c. or d.c.)

### 6.2.2.1 Verification test method for voltage range, voltage ripple and frequency

The test method for voltage range, voltage ripple and frequency is shown in Table 18.

**Table 18 – Voltage ripple and frequency range immunity test**

| Reference test                                    | None                                       |                             |
|---------------------------------------------------|--------------------------------------------|-----------------------------|
| EUT configuration                                 | According to manufacturer's specifications |                             |
| Initial measurements                              | According to PFVP, see 4.2.8               |                             |
| Test description <sup>a</sup>                     | Minimum operational voltage                | Maximum operational voltage |
| a.c. voltage ( $k \times U_e$ ) <sup>b</sup>      | k = 0,85                                   | k = 1,10                    |
| a.c. frequency ( $k \times f_n$ ) <sup>b</sup>    | k = 0,94                                   | k = 1,04                    |
| d.c. voltage ( $k \times U_e$ ) <sup>b</sup>      | k = 0,85                                   | k = 1,20                    |
| Ripple continuous ( $k \times U_e$ ) <sup>b</sup> | k = 0,05                                   | k = 0,05                    |
| Test duration                                     | 30 min                                     | 30 min                      |
| Measurement and verification during tests         | According to PFVP, see 4.2.8               |                             |
| Verification after tests                          | According to PFVP, see 4.2.8               |                             |
| Performance criteria                              | A                                          |                             |

<sup>a</sup> If there are separate equipment power supplies to the EUT, the tests may be carried out on each supply separately.

<sup>b</sup> See precise definitions in Table 16.

#### 6.2.2.2 Shut-down test (sudden supply interruption)

Test description: during shut-down due to the supply interruption, the EUT behaviour shall be observed. The test is repeated twice.

Performance criteria: The requirement given above shall be met. In addition, from the start of interruption to shut-down, there shall be no change not caused by the normal test programme and no erratic or unintended condition of any kind.

The proper functional verification procedure (PFVP) of 4.2.8 shall be performed during tests.

#### 6.2.2.3 Start-up test

When the external supply is applied for a time specified by the manufacturer, the EUT shall start again according to the specifications of the manufacturer (automatic or manual restart, initialization sequence, etc.). During the start-up, there shall be no erratic or unintended condition.

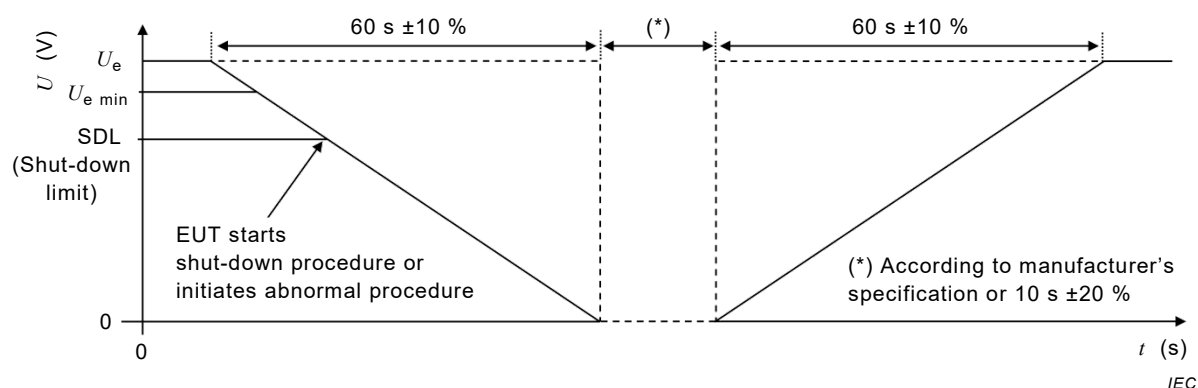
The proper functional verification procedure (PFVP) of 4.2.8 shall be performed during tests.

#### 6.2.2.4 Gradual shut-down/start-up test

Verification test method for gradual shut-down/start-up requirements are shown in Table 19.

**Table 19 – Gradual shut-down/start-up test**

| Reference test                           | None                                                                                                                                                                                |
|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EUT configuration                        | According to manufacture's specifications                                                                                                                                           |
| Initial measurements                     | According to PFVP, see 4.2.8                                                                                                                                                        |
| Test description                         | Gradual shut-down/start-up (see Figure 8)                                                                                                                                           |
| Initial/final conditions                 | Power supply at rated values ( $U_e, f_n$ ), no ripple                                                                                                                              |
| Lowest voltage (V)                       | 0 (zero)                                                                                                                                                                            |
| Waiting time at lowest voltage(s)        | 10 s $\pm$ 20 %                                                                                                                                                                     |
| Number of trials                         | 3                                                                                                                                                                                   |
| Time interval between trials             | 1 s < time interval $\leq$ 10 s                                                                                                                                                     |
| Measurement and verification during test | According to PFVP, see 4.2.8                                                                                                                                                        |
| Voltage shut-down limit (SDL)            | The voltage at which the EUT starts the manufacturer's specified shut-down sequence or initiates a behaviour not in accordance with the PFVP during the decreasing voltage sequence |
| Average SDL ( $SDL_{av}$ )               | The average of 3 measured SDL                                                                                                                                                       |

**Figure 8 – Gradual shut-down/start-up test**

### 6.2.2.5 Supply voltage variation tests

Verification test method for supply voltage variation requirements are shown in Table 20.

**Table 20 – Supply voltage variation tests**

| Reference test                                                                   | None                                                          |                                                  |
|----------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------|
| EUT configuration                                                                | According to manufacture's specifications                     |                                                  |
| Initial measurements                                                             | According to PFVP, see 4.2.8                                  |                                                  |
| Test descriptions                                                                | Fast supply voltage variation<br>(See Figure 9)               | Slow supply voltage variation<br>(See Figure 10) |
| Initial/final conditions                                                         | Power supply at rated values ( $U_{e\ min}, f_n$ ), no ripple |                                                  |
| Lowest voltage ( $U$ )                                                           | 0 (zero)                                                      | 0,9 $SDL_{av} \pm 10\ %^a$                       |
| Waiting time at lowest voltage(s)                                                | 0 (zero)                                                      | 0 (zero)                                         |
| Number of trials                                                                 | 3                                                             | 3                                                |
| Time interval between trials                                                     | 1 s < time interval ≤ 5 s                                     |                                                  |
| Measurement and verification during tests                                        | According to PFVP, see 4.2.8                                  |                                                  |
| <sup>a</sup> $SDL_{av}$ is a result of the gradual shut-down test (see 6.2.2.4). |                                                               |                                                  |

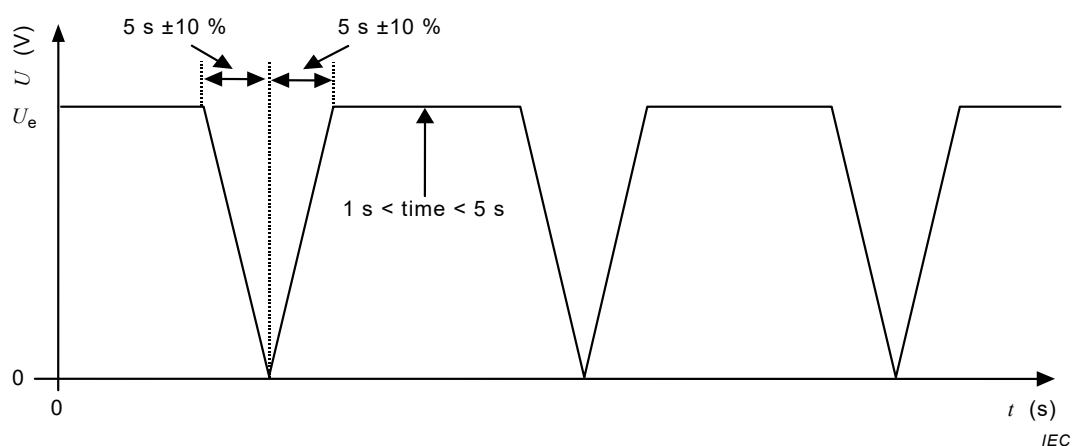


Figure 9 – Fast supply voltage variation test

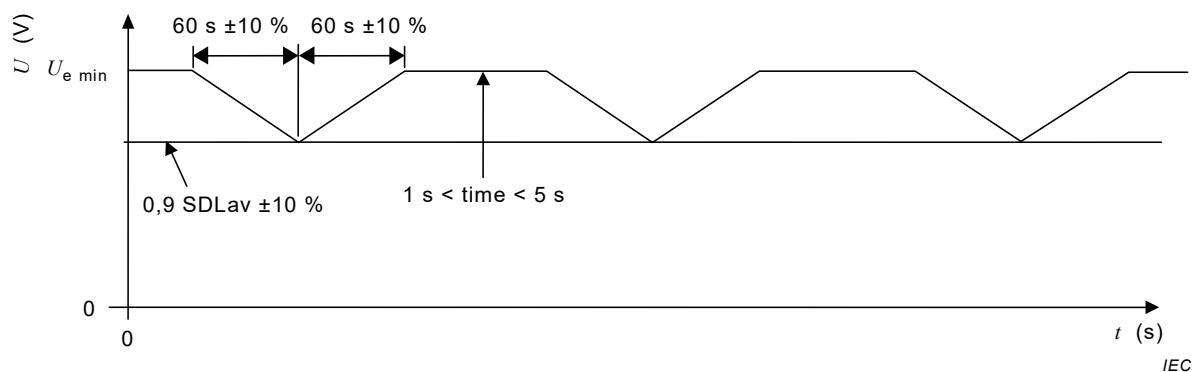


Figure 10 – Slow supply voltage variation test

#### 6.2.2.6 Reversal of d.c. power supply polarity

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of power polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated voltage, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8) after the test.

#### 6.2.2.7 Voltage interruptions verification method

Power ports are equipment power input port, port F, Figure 7. Verification test method for voltage interruptions are shown in Table 21.

**Table 21 – Voltage interruptions immunity test (Functional tests)**

| Reference test                                                                                                                                                                                 | IEC 61000-4-11 <sup>f</sup>                                                                    | IEC 61000-4-29           |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|--------------------------|----------------------|
| EUT configuration                                                                                                                                                                              | According to manufacturer's specifications                                                     |                          |                      |
| Initial measurements                                                                                                                                                                           | According to PFVP, see 4.2.8                                                                   |                          |                      |
| Supply voltage and frequency                                                                                                                                                                   | $U_{e\ min}, f_n^e$                                                                            | $U_{e\ min}^e$           |                      |
|                                                                                                                                                                                                | a.c. supply interruption                                                                       | d.c. supply interruption |                      |
| Duration                                                                                                                                                                                       | 0,5 period, starting at zero-crossing <sup>a, b</sup>                                          | PS1: $\geq 1\ ms^b$      | PS2: $\geq 10\ ms^b$ |
| $U_{e\ min}$ to $\%U_{e\ min}^e$                                                                                                                                                               | 0 (zero) %                                                                                     | 0 (zero) %               | 0 (zero) %           |
| Performance criteria                                                                                                                                                                           | The EUT shall continue to operate as intended. No loss of function or performance <sup>d</sup> |                          |                      |
| Number of trials                                                                                                                                                                               | 20                                                                                             |                          |                      |
| Time interval between trials                                                                                                                                                                   | 1 s < time interval < 10 s                                                                     |                          |                      |
| Measurement and verification during tests                                                                                                                                                      | Normal operation shall be maintained <sup>c</sup><br>According to PFVP, see 4.2.8              |                          |                      |
| Verification after tests                                                                                                                                                                       | The EUT shall continue to operate as intended. According to PFVP, see 4.2.8                    |                          |                      |
| <sup>a</sup> Optionally, the manufacturer may elect to interrupt supply at a random phase angle.                                                                                               |                                                                                                |                          |                      |
| <sup>b</sup> The manufacturer may state longer interruptions.                                                                                                                                  |                                                                                                |                          |                      |
| <sup>c</sup> Outputs and fast responding inputs energized by the same power supply may be affected temporarily during the disturbance but shall resume normal operation after the disturbance. |                                                                                                |                          |                      |
| <sup>d</sup> These criteria are synonymous with Table 1, Criteria A.                                                                                                                           |                                                                                                |                          |                      |
| <sup>e</sup> $U_{e\ min}$ is the $U_e$ at minimum tolerance in Table 16.                                                                                                                       |                                                                                                |                          |                      |
| <sup>f</sup> This test is the same as one portion of the test in 7.3.2, Table 46. A single test may be used to satisfy both requirements..                                                     |                                                                                                |                          |                      |

## 6.3 Memory power back-up

### 6.3.1 Requirements

Power back-up for volatile memories shall be capable of maintaining stored information for at least 300 h under normal use, and 1 000 h at an ambient temperature not greater than 25 °C when the energy source is at rated capacity. (For power back-up needing replacement, the rated capacity is the value used to designate the procedure and time interval for replacement.)

The manufacturer shall specify storage time information relative to volatile memory if different from stated durations.

It shall be possible to change or refresh power back-up without loss of data in the backed-up portions of memory. (See also 5.4, 8.3.5 item h) and 8.3.12 item d).)

Equipment shall be designed to withstand a reversal of memory power back-up polarity.

If a memory back-up battery is provided, a warning of "low battery voltage" shall be provided.

The requirements of 6.3.1 are verified in accordance with 6.3.2.

### 6.3.2 Verification of memory power back-up requirements

#### 6.3.2.1 Back-up duration withstand test

Verification test method for back-up duration requirements.

**Table 22 – Back-up duration withstand test**

| Reference test              | None                                                                                                    |                               |
|-----------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------|
| EUT configuration           | According to PFVP, see 4.2.8                                                                            |                               |
| Duration of preparation     | According to manufacturer's specifications (energy source may require time to be fully charged)         |                               |
| Tests to be performed       | Either Test A or Test B defined below                                                                   |                               |
| Test descriptions           | Test A                                                                                                  | Test B                        |
| Initial conditions          | Energy source fully charged; external energy supply disconnected                                        |                               |
| Ambient temperature         | Open equipment 55 °C<br>Enclosed equipment 40 °C                                                        | General conditions<br>(4.2.9) |
| Duration                    | 300 h                                                                                                   | 1 000 h                       |
| Verification after the test | According to PFVP, see 4.2.8. The EUT shall be fully operational. No loss of retentive data is allowed. |                               |

### 6.3.2.2 Verification of manufacturer's method of changing the energy source

Verification test method for energy storage changing requirements.

The energy source shall be replaced, according to the manufacturer's instructions.

**Table 23 – Change of energy source test**

| Reference test               | None                                                                                                           |
|------------------------------|----------------------------------------------------------------------------------------------------------------|
| EUT configuration            | According to PFVP, see 4.2.8                                                                                   |
| Replacement of energy source | According to the manufacturer's specifications (energy source may require time to be fully charged).           |
| Verification after the tests | According to PFVP, see 4.2.8. The EUT shall be fully operational. No loss of retentive information is allowed. |

No loss of data shall occur.

### 6.3.2.3 Verification of reversal of memory power back-up polarity

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of power polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated voltage, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8).

### 6.3.2.4 Verification of low battery voltage warning requirements

The required warning of "low battery voltage" shall be checked. The energy source shall be removed and the proper controlled voltage shall be applied in place of the energy source.

The low battery voltage warning, as specified by the manufacturer, e.g. LED, software tag, shall change state at or above (above means there is more energy available than necessary) the specified level.

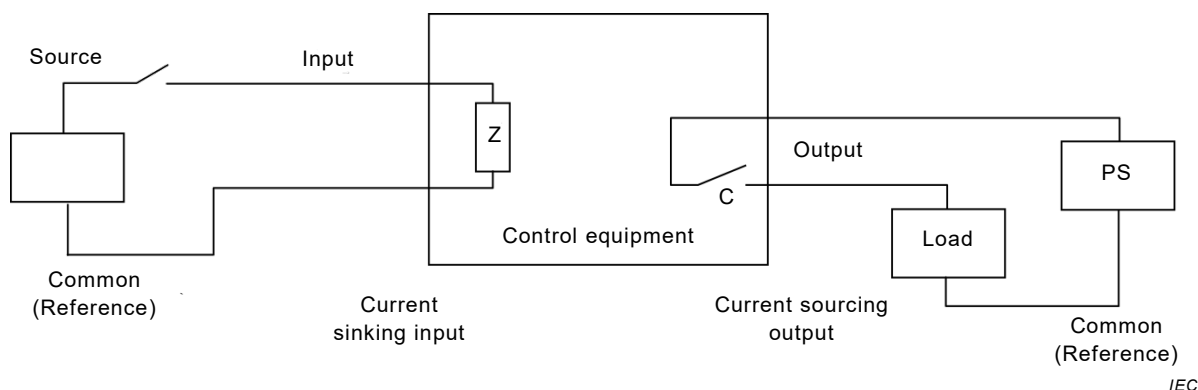
## 6.4 Digital I/Os

### 6.4.1 General

Ports C is the interface/port for digital input signals. Port D is the interface/port for digital output signals. See Figure 7.

### 6.4.2 Positive logic digital I/Os (sinking inputs / sourcing outputs)

Figure 11 gives an illustration of definitions for positive logic I/O parameters.



#### Key

C Output: Mechanical or static contact (e.g. dry relay contact, triac, transistor or equivalent)

Z Input: Input impedance

PS External power supplies

NOTE Some applications may use only one PS common to inputs, outputs and control equipment.

**Figure 11 – Positive logic (sinking inputs / sourcing outputs)**

Digital inputs shall comply with the requirements of the standard voltage ratings given in 6.4.4.2. Non-standard voltage digital inputs shall be in accordance with the design equation given in Annex B.

Digital outputs shall comply with the requirements of the standard ratings given in 6.4.5.1 for a.c. or 6.4.6.1 for d.c.

It shall be possible to interconnect inputs and outputs by means of a correct selection of the above digital I/Os, resulting in proper control equipment operation. Additional external load shall be specified by the manufacturer if necessary.

It shall be possible to feed isolated per channel, multi-channel, modules from different voltage sources. In this case the channels shall comply with the maximum voltage difference occurring between the voltage sources. Example: An a.c. input module having channels attached to different phases of the line. The channels shall then comply with the maximum voltage difference occurring between phases.

### 6.4.3 Negative logic digital I/Os (sourcing inputs / sinking outputs)

Current-sourcing inputs and current-sinking outputs which may be required for certain applications are covered in this standard. See Annex F.