7.4.2 Saturated HAST ............................................................................................. 46
7.4.3 Air-HAST ....................................................................................................... 47
7.4.4 External appearance comparison ................................................................... 48
7.4.5 Use of dark I-V measurement to infer deterioration factors ......................... 50
7.4.6 Use of ion chromatography to quantify residual acetic acid ions ................. 50
7.5 Discussion ............................................................................................................ 51
7.5.1 Environment test method comparisons ......................................................... 51
7.5.2 Power-loss profiles by moisture permeation .................................................. 52
7.5.3 Comparisons by ion chromatography acetic acid quantification ..................... 52
7.6 Conclusion ............................................................................................................ 53
8 Summary .................................................................................................................... 54

Bibliography .................................................................................................................. 55
Figure 31 – Cross-section analysis of 1608R after a humidity test (SEM image) and examples of componential analysis by EDX ................................................................. 38
Figure 32 – Structure of c-Si PV module ................................................................................ 40
Figure 33 – Qualification test sequence in IEC 61215-1 [23] ...................................................... 41
Figure 34 – Appearance of modules ......................................................................................... 42
Figure 35 – EL images after DHT ............................................................................................ 45
Figure 36 – Degradation profiles with DHT ............................................................................. 46
Figure 37 – EL images of HAST 105 °C/100 % RH ................................................................. 46
Figure 38 – EL images after HAST 120 °C/100 % RH .............................................................. 47
Figure 39 – Degradation profiles with HAST .......................................................................... 47
Figure 40 – EL images after air-HAST ................................................................................... 48
Figure 41 – Degradation profiles with air-HAST .................................................................... 48
Figure 42 – Appearance of modules after each test ............................................................... 49
Figure 43 – Dark I-V ............................................................................................................. 50
Figure 44 – Residue of acetate ion and retention of $P_{\text{max}}$ after each test ....................... 51

Table 1 – Test conditions ...................................................................................................... 15
Table 2 – Influence of fluxes and circumstances to whisker growth ....................................... 18
Table 3 – Whisker generation in HAST ................................................................................... 18
Table 4 – Whisker generation in air-HAST ............................................................................ 19
Table 5 – Comparison of coefficients for Equations (5), (6) and (7) ....................................... 24
Table 6 – Details of evaluated samples ..................................................................................... 26
Table 7 – Lead frames composition ........................................................................................ 26
Table 8 – Environmental test conditions ................................................................................ 26
Table 9 – Electrically-conductive adhesives ......................................................................... 30
Table 10 – Testing material .................................................................................................... 31
Table 11 – Test conditions ..................................................................................................... 36
Table 12 – Example of failure modes of PV module via materials .......................................... 40
Table 13 – Specifications of materials used in PV module ..................................................... 42
Table 14 – Test conditions ..................................................................................................... 43
Table 15 – Test conditions and partial pressures .................................................................... 43
DAMP HEAT, STEADY STATE
(UNSATURATED PRESSURIZED VAPOUR WITH AIR)

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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 63141, which is a Technical Report, has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

The text of this Technical Report is based on the following documents:

<table>
<thead>
<tr>
<th>Draft TR</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>104/834/DTR</td>
<td>104/853A/RVDTR</td>
</tr>
</tbody>
</table>

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.
The committee has decided that the contents of this 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

Highly accelerated stress test (HAST), is a high temperature (100 °C or more), high humidity steady test of unsaturated pressurized steam of 85 % RH, and is the original test method that was developed for the evaluation of corrosion of packaged semiconductor wiring. This test method, often referred to as HAST, is applied to primarily non-hermetically sealed small electronic components, and has been standardized as a standard test method for evaluating, in an accelerated manner, the resistance to the deteriorative effect of high temperature and high humidity (IEC 60068-2-66). The equipment used for this test method is a chamber, filled with unsaturated water vapour, called a HAST chamber.

However, in life evaluation test conditions, acceleration cannot be obtained without air from the environment being incorporated into the HAST chamber. This test method is referred to as air-HAST.

Examples of the application of air-HAST are whiskers evaluation of lead-free solder, deterioration life evaluation of conductive paste, and deterioration life evaluation of solar cells and are given in this document in order to provide an understanding of air-HAST with the aim, in future, to standardize air-HAST.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning whisker evaluation given in Clause5.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

ESPEC CORP.
3-5-6, Tenjinbashi, Kita-ku
Osaka, 530-8550
Japan

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

ISO (www.iso.org/patents) and IEC (http://patents.iec.ch) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.
1 Scope

This document describes a new test method to control the volume of air injected into a conventional HAST chamber filled with water vapour. This document provides an overview of the conventional HAST chamber, an overview of the air-HAST equipment where air is incorporated into the HAST chamber, an example of an air-HAST test apparatus, and application examples of air-HAST.

2 Normative references

There are no normative references in this document.