



TECHNICAL REPORT



Environmental conditions – Vibration and shock of electrotechnical equipment – Part 5: Equipment during storage and handling

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.040

ISBN 978-2-8322-2815-9

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

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references.....	7
3 Data source and quality.....	8
3.1 Container handling measurements by Hoppe and Gerock	8
3.2 Intermodal container handling by Association of American Railroads.....	9
3.3 Intermodal container handling at Swedish container terminal	9
3.4 Handling of air cargo pallet at Stockholm and New York airports	10
3.5 Forklift handling	11
3.6 Movement of unsuspended trolleys.....	11
3.7 Supplementary data	12
4 Intra data source comparison	12
4.1 General.....	12
4.2 Container handling measurements by Hoppe and Gerock	13
4.3 Intermodal container handling by Association of American Railroads.....	13
4.4 Intermodal container handling at Swedish container terminal	14
4.5 Handling of air cargo pallet at Stockholm and New York airports	14
4.6 Forklift handling	15
4.7 Movement of unsuspended trolleys.....	16
5 Inter data source comparison	16
6 Environmental description	19
7 Comparison with IEC 60721	20
8 Recommendations	21
Bibliography	56
Figure 1 – Vibrations loading and unloading of container on to US rail car using overhead crane [2]	25
Figure 2 – Vibrations loading and unloading of container on to US rail car using side loader [2]	25
Figure 3 – Vibrations from handling an ISO container at a port – Axial [3]	27
Figure 4 – Vibrations from handling an ISO container at a port – Transverse [3].....	27
Figure 5 – Vibrations from handling an ISO container at a port – Vertical [3]	28
Figure 6 – Amplitude probability density from handling an ISO container at a port – Vertical [3]	28
Figure 7 – Amplitude probability density from handling an ISO container at a port – Transverse [3].....	29
Figure 8 – Amplitude probability density from handling an ISO container at a port – Axial [3]	29
Figure 9 – Shocks from handling an ISO container at a port – Axial [3]	30
Figure 10 – Shocks from handling an ISO container at a port – Transverse [3].....	30
Figure 11 – Shocks from handling an ISO container at a port – Vertical [3].....	31
Figure 12 – Air pallet vibration severities due to aircraft movement – Vertical [4].....	32
Figure 13 – Air pallet vibration severities due to aircraft movements – Axial/transverse [4]	33
Figure 14 – Bandpass vibration amplitudes from four forklift trucks – Vertical [5].....	33

Figure 15 – Bandpass vibration amplitudes from four forklift trucks – Lateral [5].....	34
Figure 16 – Bandpass vibration amplitudes from four forklift trucks – Axial [5].....	34
Figure 17 – Shock response spectra from 1 000 Kg forklift truck [5].....	35
Figure 18 – Shock response spectra from 1 500 Kg forklift truck [5].....	35
Figure 19 – Shock Response Spectra from 2 000 Kg Forklift Truck [5].....	36
Figure 20 – Shock response spectra from 3 500 Kg forklift truck [5].....	36
Figure 21 – Vibration at wheels of small trolley – Vertical [6].....	37
Figure 22 – Vibration at wheels of small trolley – Lateral [6].....	37
Figure 23 – Vibration at wheels of small trolley – Axial [6].....	38
Figure 24 – Vibration at wheels of medium trolley – Vertical [6].....	38
Figure 25 – Vibration at wheels of medium trolley – Lateral [6].....	39
Figure 26 – Vibration at wheels of medium trolley – Axial [6].....	39
Figure 27 – Vibration at wheels of large trolley – Vertical [6].....	40
Figure 28 – Vibration at wheels of large trolley – Lateral [6].....	40
Figure 29 – Vibration at wheels of large trolley – Axial [6].....	41
Figure 30 – Amplitude distribution at wheels of small trolley – Vertical [6].....	43
Figure 31 – Amplitude distribution at wheels of small trolley – Lateral [6].....	43
Figure 32 – Amplitude distribution at wheels of small trolley – Axial [6].....	44
Figure 33 – Shock response spectra at wheels of small trolley – Vertical [6].....	44
Figure 34 – Shock response spectra at wheels of small trolley – Lateral [6].....	45
Figure 35 – Shock response spectra at wheels of small trolley – Axial [6].....	45
Figure 36 – Comparison of acceleration and derived velocity for largest impacts [1].....	46
Figure 37 – Comparison of acceleration and derived drop height for largest impacts [1].....	46
Figure 38 – IEC 60721-3-2– Stationary vibration random severities.....	47
Figure 39 – IEC 60721-4-2– Stationary vibration random severities.....	47
Figure 40 – IEC 60721-3-2– Shock severities.....	48
Figure 41 – IEC 60721-4-2– Shock severities for IEC 60068-2-29 test procedure.....	48
Figure 42 – IEC 60721-4-2 – Shock severities for IEC 60068-2-29 test procedure.....	49
Figure 43 – Comparison of Hoppe & Gerock [1] derived shocks with IEC 60721-3-2.....	49
Figure 44 – Comparison of unsuspended trolley [6] shocks with IEC 60721-3-2.....	50
Figure 45 – Comparison of US forklift [5] shocks with IEC 60721-3-2.....	50
Figure 46 – Comparison of Swedish port [3] shocks (dockside crane) with IEC 60721-3-2.....	51
Figure 47 – Comparison of Swedish port [3] shocks (mobile crane) with IEC 60721-3-2.....	51
Figure 48 – Comparison of Swedish port [3] shocks (straddle carrier) with IEC 60721-3-2.....	52
Figure 49 – Comparison of Swedish port [3] shocks (transport tug) with IEC 60721-3-2.....	52
Figure 50 – Comparison of Swedish air transport [4] vibrations with IEC 60721-3-2.....	53
Figure 51 – Comparison of unsuspended trolley [6] vibrations with IEC 60721-3-2.....	53
Figure 52 – Comparison of Swedish port [3] vibrations (transport tug) with IEC 60721-3-2.....	54
Figure 53 – Comparison of Swedish port [3] vibrations (dockside crane) with IEC 60721-3-2.....	54
Figure 54 – Comparison of Swedish PORT [3] vibrations (mobile crane) with IEC 60721-3-2.....	55

Figure 55 – Comparison of Swedish port [3] Vibrations (straddle carrier) with IEC 60721-3-2..... 55

Table 1 – Maximum vibration accelerations and displacements occurring during handling of ISO containers at container terminal [1] 22

Table 2 – Largest shocks occurring during handling of ISO containers by straddle carrier [1] 23

Table 3 – Largest shocks occurring during transfer of ISO containers on to rail cars [1] 23

Table 4 – Largest shocks occurring during transfer of ISO containers on to ships [1]..... 24

Table 5 – Largest shocks occurring during transfer of ISO containers on to US rail cars [2]..... 24

Table 6 – Summary of vibration r.m.s. during port movements of ISO containers [3]..... 26

Table 7 – Summary of peak shock severities during port movements of ISO containers [3]..... 26

Table 8 – Summary of shock levels from air cargo pallet ground operations [4] 31

Table 9 – Summary of peak vibration levels from air cargo pallet ground operations [4]..... 32

Table 10 – Summary of overall vibration severities [6] 42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ENVIRONMENTAL CONDITIONS – VIBRATION
AND SHOCK OF ELECTROTECHNICAL EQUIPMENT –****Part 5: Equipment during storage and handling**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. 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 62131-5, 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:

Enquiry draft	Report on voting
104/620A/DTR	104/639/RVC

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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 62131 series, under the general title *Environmental conditions – Vibration and shock of electrotechnical equipment*, can be found on the IEC website.

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

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

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

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

ENVIRONMENTAL CONDITIONS – VIBRATION AND SHOCK OF ELECTROTECHNICAL EQUIPMENT –

Part 5: Equipment during storage and handling

1 Scope

IEC TR 62131-5, which is a technical report, reviews the available dynamic data relating to the handling of electrotechnical equipment. The intention is that from all the available data an environmental description will be generated and compared to that set out in the IEC 60721 series.

For each of the sources identified, the quality of the data is reviewed and checked for self consistency. The process used to undertake this check of data quality and that used to intrinsically categorize the various data sources is set out in IEC TR 62131-1.

This technical report primarily addresses data extracted from a number of different sources for which reasonable confidence exist in its quality and validity. The report also reviews some data for which the quality and validity cannot realistically be verified. These data are included to facilitate validation of information from other sources. The report clearly indicates when utilising information in this latter category.

This technical report addresses data from a number of data gathering exercises. The quantity and quality of data in these exercises varies considerably as does the range of conditions encompassed.

Not all of the data reviewed were made available in electronic form. To permit comparison to be made, in this assessment, a quantity of the original (non-electronic) data has been manually digitized.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068 (all parts), *Environmental testing*

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

IEC 60068-2-29¹, *Environmental testing – Part 2-29: Tests – Test Eb Bump*

IEC 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 60721-3-2:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

¹ Withdrawn and now incorporated into IEC 60068-2-27.

IEC TR 60721-4-2, *Classification of environmental conditions – Part 4-2: Guidance for the correlation and transformation of environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Transportation*

IEC TR 62131-1, *Environmental conditions – Vibration and shock of electrotechnical equipment – Part 1: Process for validation of dynamic data*

IEC TR 62131-2, *Environmental conditions – Vibration and shock of electrotechnical equipment – Part 2: Equipment transported in fixed wing jet aircraft*

IEC TR 62131-3, *Environmental conditions – Vibration and shock of electrotechnical equipment – Part 3: Equipment transported in rail vehicles*

IEC TR 62131-4, *Environmental conditions – Vibration and shock of electrotechnical equipment – Part 4: Equipment transported in road vehicles*