IEC 60652

Edition 3.0 2021-07
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

~~Loading Tests on~~ Overhead line structures – Loading tests

IEC 60652:2021-07 RLV(en)

AVA Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2021 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.

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

Tel.: +41 22 919 02 11
info@iec.ch
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
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 It also gives information on projects, replaced and withdrawn publications.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
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - 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: sales@iec.ch.

IEC online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

IEC 60652

Edition 3.0 2021-07
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

~~Loading Tests on~~ Overhead line structures – Loading tests

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.240.20

ISBN 978-2-8322-1010-7

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

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

CONTENTS

FOREWORD....3
1 Scope....5
2 Normative references....5
3 Terms and definitions....5
4 Categories of tests....6
4.1 General....6
4.2 Design tests....6
4.3 Sample tests....6
5 General test criteria....7
6 Acceptability of test station....7
7 Test specification....7
8 Test programme....8
9 Assembly of support....9
10 Load application....9
10.1 General....9
10.2 Combined loads....9
10.3 Precautions for load application....9
10.4 Load levels....9
10.5 Destruction tests....10
10.6 Tolerances on applied loads....10
10.7 Loading rate and holding period....10
11 Measurements....11
11.1 Load and angle measurements....11
11.2 Deflection measurements....11
11.3 Strain measurements....11
12 Sequence of test loading cases....11
13 Video documentation....11
14 Acceptance criteria....11
15 Premature failure....12
15.1 Design tests....12
15.2 Sample tests....12
15.3 Replacement of components....12
16 Material specification....12
17 Test report....13
18 Record and traceability....13

Table 1 – Load tolerances....10

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

INTERNATIONAL ELECTROTECHNICAL COMMISSION

~~LOADING TESTS ON~~ OVERHEAD LINE STRUCTURES – LOADING 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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60652:2002. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

IEC 60652 has been prepared by IEC technical committee 11: Overhead lines. It is an International Standard.

This third edition cancels and replaces the second edition published in 2002. This edition constitutes a technical revision.

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

a) Title modified;

b) Added reference to CIGRE Brochure 399;

c) In Clause 7, added test limitation for wind speed and direction during testing;

d) In paragraph 10.5, added load increments for destruction tests;

e) In paragraph 10.7, added a requirement for an agreement between client and testing station when testing supports made of creep-sensitive materials;

f) In Clause 17, added requirements for sampling procedure to be provided in the test report.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
11/276/FDIS	11/277/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

~~LOADING TESTS ON~~ OVERHEAD LINE STRUCTURES – LOADING TESTS

1 Scope

This document ~~codifies~~ specifies the methods and procedures of testing supports for overhead lines.

It applies to the testing of supports and structures of overhead lines ~~for voltages above 45 kV; it can also serve as reference to the testing of lower voltage supports~~.

There is no restriction on the type of material used in the fabrication of the supports which may include, but not be limited to, metallic alloys, concrete, timber, laminated wood and composite materials. If required by the client, this document ~~may~~ can also be applied to the testing of telecommunication supports, railway/tramway overhead electrification supports, electrical substation gantries, street lighting columns, wind turbine towers, ski-lift supports, etc.

Tests on reduced scale models of supports are not covered by this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-466:1990, *International Electrotechnical Vocabulary (IEV) – Part 466: Overhead lines*
IEC 60050-466:1990/AMD1:2020

ISO/IEC 17025:~~1999~~2017, *General requirements for the competence of testing and calibration laboratories*

CIGRE Brochure 399:2009, *Improvement on the Tower Testing Methodology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-466:1990 and the following apply.

3.1
client
organization which contracts with the testing station and provides the test specification

3.2
design load
load for which the support has been designed

3.3
failure load
~~point~~ limit state loads value at which the support cannot carry any additional load as determined during the destruction test of the support

~~NOTE It is also known as the limit state failure load and is determined during a destruction test on the support.~~

AVA Documents
Document Sharing Hub

3.4
realignment
process used for restoring the original 'vertical' position of the tower after being permanently deformed due to an intermediate loading case testing

Note 1 to entry: This process usually requires release of bolts in connections, pulling back the tower to its original position, and finally re-tightening bolts. This procedure is not recommended.

3.5
test report
document summarizing all the relevant aspects of the tests

4 Categories of tests

4.1 General

The objective of support tests is to verify the design method and inherent assumptions, the method of member detailing and the quality of fabrication, manufacture and material.

With respect to the purpose of the test, the level of instrumentation and the method of execution, this document refers to two categories of tests:

a) design tests;

b) sample tests.

4.2 Design tests

Design tests are normally carried out on full scale prototype supports, with one or more of the following objectives:

a) as part of a research and/or development programme in the design of an innovative support;

b) to verify compliance of the support design with the specifications (also known as type tests on a prototype support);

c) to develop and/or validate a new design standard or methodology;

d) to develop and/or validate new fabrication processes.

When tests are carried out to verify design parameters, the test support shall be identical as far as possible to the serial production supports (see Clause 5, first paragraph). Tests on full scale sections or part of the support may also be undertaken.

Design tests shall be carried out to at least the design load or to failure, especially when testing according to 4.2b) and/or 4.2c).

4.3 Sample tests

These are intended for use either prior to or during the fabrication of the production of a batch of supports to act as a check on the quality of the fabrication, or on the materials being used. The support ~~may~~ shall be taken at random from the serial production supports during manufacture. The test constitutes the acceptance of the production.

Sample tests are taken to a specific percentage of the design load (usually 100 %), as stipulated in the test specification.

Documents
Document Sharing Hub
Full document details: IEC 60652 2021 RLV

5 General test criteria

For a design test (according to 4.2b) or 4.2c)), the material(s) and the manufacturing processes used in the fabrication of the prototype support shall be to the same specifications as those used during the serial fabrication of the ~~production~~ supports. These specifications shall include the member sectional properties, connection details, e.g. bolt or weld sizes, material grades and fabrication processes. Prior to the commencement of the prototype support fabrication, agreement shall be made with regard to the surface coating of the support.

Agreement shall also be made with respect to the organization responsible for the checking of the support prior to the testing.

If a sample test is required on a production support, the components ~~may~~ shall be chosen at random from the batch.

Whether it is for the design test (according to 4.2b)) or the sample test, the support shall successfully withstand the loads specified by the client.

6 Acceptability of test station

If required by the client, the testing station shall be accredited by an external organization to perform this type of test according to the procedures of quality assurance defined by ISO/IEC 17025:2017.

The following minimum requirements shall be fulfilled by the test station:

- the layout of the station is generally safe (e.g. in case of structure collapse the control building and the observation area are not located in the danger zone)
- the station has adequate provision to limit the severity of the collapse of the tower in the event of a failure (e.g. back-stays or others)
- all personnel is provided with adequate personal safety equipment, have received proper training, and all procedures has been validated from the safety point of view
- all lifting equipment has been regularly maintained, tested and certified
- the station pad is clear of loose material during the test
- the rigging equipment is well maintained (e.g. pulley blocks greased), tested and certified
- the load application devices (e.g. winches, hydraulic rams) do not impart dynamic effects when operated
- the equipment employed for the mechanical testing of the steel is calibrated
- the load measuring devices are calibrated against an instrument which itself is calibrated by a recognized independent calibration organization.

7 Test specification

The client shall prepare and transmit to the testing station, at an agreed time prior to the delivery of the support, the following appropriate information:

- Workshop and/or erection drawings of the support.
- The mass of each section of the support.
- Precautions to be observed during the unloading and unpacking.
- Requirements for the support assembly or disassembly, including if necessary details for lifting the support from the horizontal.
- Bolt tightening requirements.

AVA Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

- The tensions for any guys.
- Nominal force to be applied during slip-joining of sections and/or slip-joint length and their respective tolerances.
- Foundation setting tolerances and verticality tolerances of the support.
- The category of the test (design or sample).
- The exact position of the load application points for each loading case.
- ~~The design loads to be applied on the support for each loading case.~~
- (The point of application of the wind loads to be applied on the tower body shall be agreed between the designer and the test station.)
- The loading cases to be used for tower testing as selected from the tower design load cases as well as the detailed tower forces at attachment points and tower body to be applied on the support for each loading case.
- All reactions induced on the foundations of the test support for each loading case to be tested.
- ~~If the support is to be realigned between individual tests.~~
- The location of the deflection measuring points for each loading case.
- The position and the orientation of strain gauges, if applicable.
- The areas of the test support to be filmed during the test.
- Limitation of wind speed and wind direction during the test, if applicable.

8 Test programme

The test programme shall be submitted to the client at an agreed date before the test. This document shall be approved by the client and returned to the testing station within an agreed period.

The test programme shall include but not be limited to the following information:

- The expected test date.
- A description of the proposed foundations for the test support.
- The method of load application.
- A drawing of the test rigging arrangement and attachment details.
- The position of the dynamometers and/or load cells and the position of angle transducers in the case of resultant load applications.
- The position of deflection measurement points.
- The position and orientation of strain gauges if appropriate.
- The tolerances (loads, resultant angles, deflections, strain gauges).
- Details of applied loads as per rigging scheme for each test load case, load increment and holding period.
- Holding period for the final level.
- Loading rate for elastic-plastic materials and creep-sensitive materials. This requirement is not important or required for steel towers, but could be for some support types such as reinforced concrete structures subjected to permanent bending or to fibre reinforced structures.
- The category of the test (design or sample).

Documents
Document Sharing Hub
Full document details: IEC 60652 2021 RLV

9 Assembly of support

~~The test support shall be erected on a footing that simulates the design assumption.~~

Footing(s) on which the test report to be erected shall simulate the design assumption.

The testing station shall proceed with the assembly of the support in accordance with the instructions provided by the client.

In the case where the testing station encounters a difficulty in the assembly or erection of the support, the client shall be informed and shall decide on the modifications required.

If requested by the client, a report of assembly shall be provided by the testing station. This report may include a video of the different phases of the assembly and any particular difficulty encountered.

10 Load application

10.1 General

Loading cases (loads, directions, and load application points) are stated by the client in the test specification.

10.2 Combined loads

If, for practical purposes, certain loads (e.g. due to wind on the support) have to be combined, the value of the resultant, its direction, and its application point shall be shown in the test programme.

10.3 Precautions for load application

The dynamometer/load cells shall be located in the test rigging as close as practical to the load application point on the support. When this cannot be ensured and/or multi-sheave rigging blocks are applied between load cells and load attachment point, allowance shall be made for the friction resistance in the rigging ropes and blocks (refer to Annexes C and D of CIGRE Brochure 399:2009, for further information) as agreed between the test station and the client.

Similarly, it is recommended that the test rigging ~~should~~ shall be arranged so as to minimize any load eccentricity. Fittings of the planned insulator strings shall preferably be used for the load application.

The testing station shall minimize the influence of any contact between the test rigging and the support; where this is not practical, this shall be drawn to the client's attention.

~~Unless otherwise agreed, it is recommended that the difference between the required load and the measured load at any individual load application point and at any time during the test should not exceed 5 %.~~

Loads shall be applied in such a way as to avoid any dynamic effect. However, joint slippage during the support test shall be accepted.

10.4 Load levels

The test loads shall be applied in increments to 50 %, 75 %, 90 %, 95 % and 100 % of the specified loads.

If required by the client, additional load levels may be considered.

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

10.5 Destruction tests

If required by the client, destruction tests shall be performed. These tests are to be applied for normal load cases or anti-cascading loads respectively. For load steps above 100 % of the specified loads, only horizontal loads shall be increased further. For load cases considering ice, both horizontal and vertical loads shall be increased further.

For destruction tests (i.e. for each load level above 100 % of the specified loads), it is suggested that a 5 % load increment be applied for each load step and the load step duration complying with 10.6.

10.6 Tolerances on applied loads

For each load level, the applied load measurements shall be considered acceptable if they are within the limits shown in Table 1.

Table 1 – Load tolerances

~~Load level~~ ~~%~~	~~Acceptable range~~ ~~%~~
~~50~~	~~49 to 51~~
~~75~~	~~74 to 76~~
~~90~~	~~89 to 91~~
~~95~~	~~94 to 96~~
~~100~~	~~100 to102~~

Load level %	Acceptable range for individual load components %	Acceptable range for the average of all loads %
50	48 to 53	48 to 53
75	73 to 78	73 to 78
90	88 to 93	88 to 93
95	93 to 98	94 to 96
100	100 to 105	100 to 102

10.7 Loading rate and holding period

For each load increment, the time taken for the load application depends upon the facilities of the testing station and the time needed for the loads to be adjusted in accordance with ~~9.4~~ 10.5.

~~For the final 100 % level, the loads shall be maintained for a minimum of 1 min and for a maximum of 5 min. The holding period chosen for the final level shall be included in the test programme.~~

For the final 100 % level, the loads shall be maintained for a contractual period of time, usually 1 min (this is the minimum holding period criteria for accepting the test and any longer duration can be agreed upon between the testing station operator and the client prior to testing. Without previous agreement, the holding period criteria shall be the default value of 1 min). In addition to the above holding period criteria, an extended holding period, usually of 4 min beyond the contractual value, can be requested by the client for engineering purposes, but any failure during this extended period shall not be a criterion for rejecting the test. In order to avoid possible disputes regarding acceptance or rejection of testing results, it is recommended that the contractual duration for acceptance of the tests as well as the extended duration be clearly defined prior to testing.

AVA Documents
Document Sharing Hub

Before start counting the holding period, the loads shall be in balance. Balance means that the applied loads are stable.

For supports made of creep-sensitive materials, different loading rates and holding periods may ~~apply~~ be applied subject to client and testing operator agreement.

11 Measurements

11.1 Load and angle measurements

The accuracy of the dynamometers and/or load cells and/or angle transducers shall be such that errors in measurement are not greater than 1 % at full scale ~~(including the effect of the test rigging). The accuracy specified assumes a standard deviation of 3 σ~~.

All dynamometers and/or load cells and/or angle transducers shall be calibrated before and after every test series. ~~The calibration instruments shall be certified at least once a year.~~ The client can specify that at least three load cells shall be calibrated in his presence. This specification requires the client to be present at the station in due time before the test.

All applied loads and/or resultant angles shall be recorded.

11.2 Deflection measurements

At each load level and when the support is stable, support deflection shall be measured in accordance with the test specification. The accuracy of measurements shall be ~~25~~ 10 mm. ~~The accuracy specified assumes a standard deviation of 3 σ.~~

11.3 Strain measurements

If requested by the client, strain measurement shall be obtained in accordance with accepted industry standards. The testing station shall provide the accuracy of measurement of the strain gauges and/or the instrumented members and synchronize the measurements with applied loads.

12 Sequence of test loading cases

The sequence of test loading cases shall be determined by the client and stated in the test specification. It is recommended to choose first those tests having the least influence on the results of the successive tests. If agreed by the client, the testing station may adjust the test sequence to simplify the test operations or to reduce the cost of the test.

13 Video documentation

It is recommended that the entire test should be video recorded and the video cross-referenced with the measurements.

14 Acceptance criteria

The performance of the support shall be considered acceptable if it resists the specified design loads (at 100 %) for the contractual duration period agreed upon in 10.6 (default value of 1 min) without failure of any components or assemblies ~~even though a longer holding period may have been specified~~.

Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV

Permanent local deformations such as bowing or twisting of secondary members and components are acceptable. Ovalization of holes and permanent deformation of bolts shall be accepted as long as the support meets the above contractual duration period.

Additionally, the requirement of Clause 16 shall be fulfilled.

15 Premature failure

15.1 Design tests

In the event of failure at less than 95 % of the specified design load, the failed component(s) ~~may~~ shall be replaced by other component(s). The modified structure shall be retested to resist 100 % of the specified design loads.

In the event of failure between 95 % and less than 100 % of the specified design loads, with the exception of the final load case (frequently the destruction load case), the support shall be modified and retested. If failure occurs in the final load case, the client may elect not to retest the modified support.

In the event of failure at 100 % of the specified design loads but ~~at less than 1 min into~~ before the contractual holding period defined in 10.6 is reached, the client may accept the support without modification.

15.2 Sample tests

In the event of a failure at less than 100 % of the specified design load, the failed component(s) shall be replaced by identical components and the support retested. In the event of a subsequent failure, the client may reject the batch of supports from which the test support has been drawn.

In the event of a failure at 100 % of the specified design load but at less than ~~1 min into~~ the contractual holding period defined in 10.6, the client may accept the batch of supports from which the test support has been drawn.

15.3 Replacement of components

The partial or complete replacement or modification of elements, assemblies and complete sections of the support is the responsibility of the client. In case one or a few members are replaced during testing, previous successful tests do not need to be repeated.

16 Material specification

The selection of materials, manufacturing tolerances and engineering properties (i.e. geometrical and mechanical characteristics) for the support are the responsibility of the client.

The materials used for the fabrication of a prototype support shall be representative of the materials used in serial production structures and within the specified industry standards.

On completion of the test series, it is recommended to take samples from the prototype support and perform tensile tests in order to verify the compliance of the material with the specifications.

The number and location of samples are the responsibility of the client. Minimum five samples shall be taken from the most highly stressed members.

If the components of the support do not fulfil the requirements of the applicable industry standards, the client may declare the test invalid and reject the support.

AVA Documents
Document Sharing Hub

Full document details: IEC 60652 2021 RLV