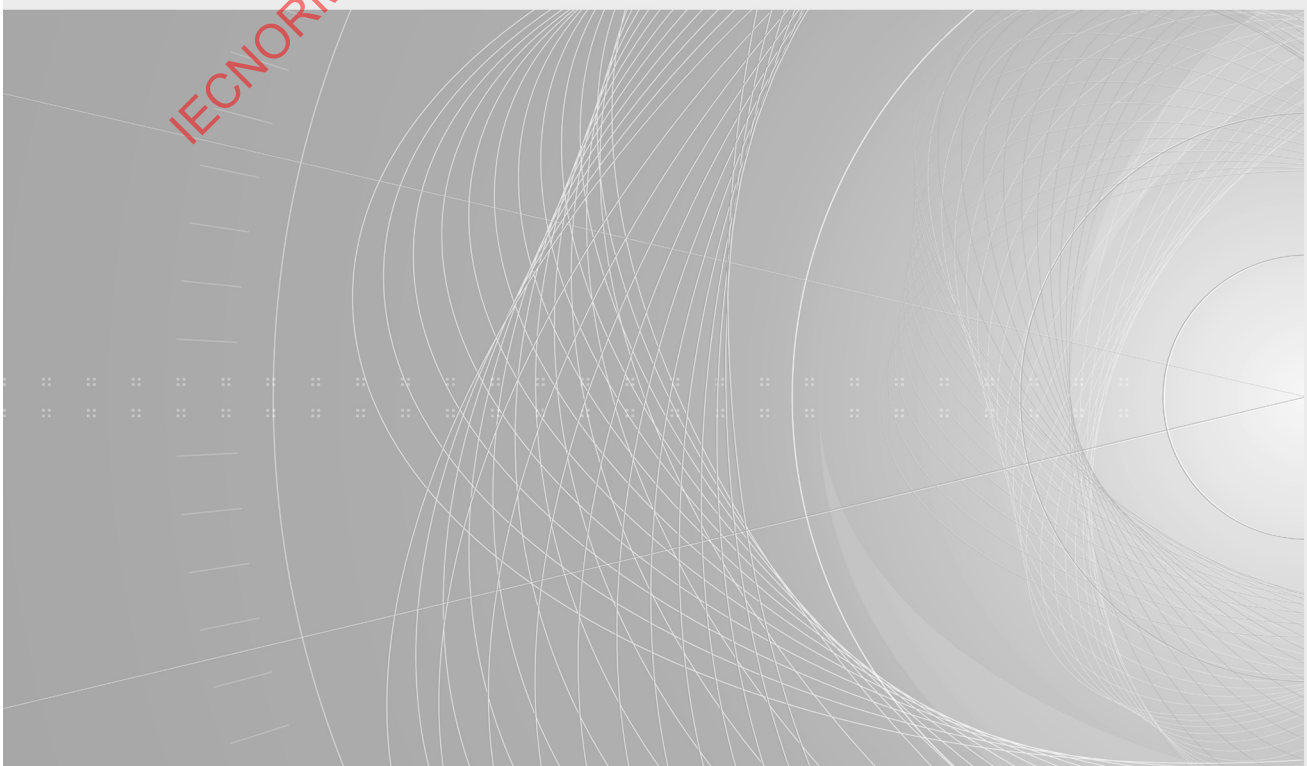
IEC 62912-2

Edition 1.0 2019-08

INTERNATIONAL STANDARD

Railway applications – Direct current signalling monostable relays – Part 2: Spring type relays



IEC 62912-2:2019-08(en)

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 It also gives information on projects, replaced and withdrawn publications.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.

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 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 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 62912-2

Edition 1.0 2019-08

INTERNATIONAL STANDARD

Railway applications – Direct current signalling monostable relays – Part 2: Spring type relays

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 45.060.01

ISBN 978-2-8322-7202-2

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RAILWAY APPLICATIONS – DIRECT CURRENT SIGNALLING MONOSTABLE RELAYS –

Part 2: Spring type relays

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 62912-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

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

FDIS	Report on voting
9/2513/FDIS	9/2532/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.

The existing IEC 62912 will be renumbered as IEC 62912-1 on the occasion of its next revision.

A list of all parts in the IEC 62912 series, published under the general title *Railway applications – Direct current signalling monostabe relays*, can be found on the IEC website.

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.

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

INTRODUCTION

This document gives a set of generic and specific requirements for non-proved direct current signalling relays of the spring type.

This document introduces a set of recommendations and requirements for signalling relay characteristics, construction, magnetic system, contacts and insulation. Requirements are coordinated with current International Standards on all-or-nothing relays.

This document is in addition to IEC 62912:2015. IEC 62912-2 describes the non-proved spring type relay.

All signalling relays are expected to fulfil the requirements of IEC 62425:2007 and their characteristics are given by IEC 62425:2007, Annex C.7.22 which lists two types of physical properties to provide return forces for stability. Of these properties IEC 62912-2 considers only relays with a spring return force alone.

Meeting all the requirements in IEC 62912-2 is sufficient to ensure that further compliance to IEC 62425:2007 need not be evaluated.

IEC 62912-2 has been developed as a standard independent from IEC 62912:2015. It uses the same structure as IEC 62912:2015. IEC 62912-2 does not refer to the IEC 61810 series because the relays defined in it are exclusively used in the signalling system, unlike the electromagnetic type elementary relays defined by IEC 61810.

RAILWAY APPLICATIONS – DIRECT CURRENT SIGNALLING MONOSTABLE RELAYS –

Part 2: Spring type relays

1 Scope

This document gives requirements for direct current relays intended for safety-related applications in railway signalling installations.

This document is applicable to non-proved signalling monostable relays of the spring type, whose return force is generated by elasticity of spring.

The return force can be provided either from a separate spring and/or from the contact springs themselves.

NOTE "Non-proved" means the feature of relays fulfilling all the safety conditions without the aid of other relays or without control of operations in the circuit.

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 62425:2007, *Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling*

IEC 62497-1, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

IEC 62498-3:2010, *Railway applications – Environmental conditions for equipment – Part 3: Equipment for signalling and telecommunications*

IEC 62912:2015, *Railways applications – Direct current signalling monostable relays of type N and type C*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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
all-or-nothing relay
electrical relay, which is intended to be energised by a quantity, the value of which is either within its operative range or effectively zero

Note 1 to entry: "All-or-nothing relays" include both "elementary relays" and "time relays".

[SOURCE: IEC 60050-444:2002, 444-01-02]

3.2
armature
moveable part of a relay that controls contact members

[SOURCE: IEC 62912:2015, 3.2]

3.3
bounce time
for a contact which is closing/opening its circuit, time interval between the instant when the contact circuit first closes/opens and the instant when the circuit is finally closed/opened

[SOURCE: IEC 60050-444:2002, 444-05-04]

3.4
break contact <for elementary relays>
contact which is open when the relay is in its operate condition and which is closed when the relay is in its release condition

[SOURCE: IEC 60050-444:2002, 444-04-18]

3.5
change-over contact
combination of two contact circuits with three contact members, one of which is common to the two contact circuits; such that when one of these contact circuits is open, the other is closed

[SOURCE: IEC 60050-444:2002, 444-04-19]

3.6
contact force
force which two contact members exert against each other at their contact points in the closed position

[SOURCE: IEC 60050-444:2002, 444-04-10]

3.7
contact gap
gap between the contact points when the contact circuit is open

[SOURCE: IEC 60050-444:2002, 444-04-09]

3.8
contact member <for elementary relays>
conductive part designed to co-act with another to close or open the output circuit

[SOURCE: IEC 60050-444:2002, 444-04-05]

3.9
contact point
part of a contact member at which the contact circuit closes or opens

[SOURCE: IEC 60050-444:2002, 444-04-06]

3.10
contact resistance
resistance of a mated set of contacts under specified conditions

[SOURCE: IEC 60050-581:2008, 581-23-08]

3.11
contact wipe
relative rubbing movement of contact points after they have touched

[SOURCE: IEC 60050-444:2002, 444-04-12]

3.12
drop-away current
maximum current through the coil that, starting from the nominal current value, produces the opening of all the make contacts

[SOURCE: IEC 62912:2015, 3.12]

3.13
elementary relay
all-or-nothing relay which operates and releases without any intentional time delay

[SOURCE: IEC 60050-444:2002, 444-01-03]

3.14
forcibly guided contacts
combination of make contacts and break contacts designed in such a way that it is made sure by mechanical means that these make contacts and break contacts can never be in the closed position simultaneously

[SOURCE: IEC 60050-444:2002, 444-04-23]

3.15
maintenance test
test carried out periodically on an item to verify that its performance remains within specified limits, after having made certain adjustments, if necessary

[SOURCE: IEC 60050-151:2001, 151-16-25]

3.16
make contact <for elementary relays>
contact which is closed when the relay is in its operate condition and which is opened when the relay is in its release condition

[SOURCE: IEC 60050-444:2002, 444-04-17]

3.17
monostable relay
electrical relay which, having responded to an energising quantity and having changed its condition, returns to its previous condition when that quantity is removed

[SOURCE: IEC 60050-444:2002, 444-01-07]

3.18
nominal current
current passing through the coil of the relay when the coil is supplied with nominal voltage

[SOURCE: IEC 62912:2015, 3.17]

3.19
opening force
minimum force measured on the relay contact, generated by the relay to open a closed contact

Note 1 to entry: For contacts with double spacing, it is measured upon each individual contact.

3.20
operate condition<for elementary relays>
for a monostable relay, specified condition of the relay when it is energised by the specified energising quantity and has responded to that quantity

[SOURCE: IEC 60050-444:2002, 444-02-02, modified – The last part of the definition concerning a bistable relay has been removed]

3.21
pick-up current <compression>
minimum current through the coil that, starting from a null value, is necessary to move the armature from the release position to the operate position and apply the specified contact force, closing all the make contacts

[SOURCE: IEC 62912:2015, 3.19]

3.22
release condition <for elementary relays>
for a monostable relay, specified condition of the relay when it is not energised; for a bistable relay, one of the conditions, as declared by the manufacturer

[SOURCE: IEC 60050-444:2002, 444-02-01]

3.23
return spring
spring which generates returning force when the relay is de-energized

3.24
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.25
spring elastic limit
minimum stress leading to permanent deformation

3.26
type test
conformity test made on one or more items representative of the production

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

4 Essential requirements of the relays and their construction

4.1 Generic requirements

4.1.1 Generic requirements for spring type signalling relays

The spring type signalling relays in this document shall fulfil (by themselves) all the safety conditions for safety-related signalling systems without the aid of other relays or without control of operations in the circuit. This kind of relay shall be compliant with the safety requirements specified in IEC 62425 and specifically with IEC 62425:2007, B.3.1c).

4.1.2 Forcibly guided contacts

Signalling relays shall be equipped with forcibly guided (mechanically linked) contacts. The forcibly guided (mechanically linked) contacts shall be designed in such a way that it is ensured by mechanical means that make and break contacts can never be in the closed position simultaneously.

If one of the make contacts is closed, none of the break contacts shall be closed. If one of the break contacts remains closed, none of the make contacts shall close (assuming that nominal power conditions apply – see also 4.7.2). Operation of forcibly guided (mechanically linked) contacts means that if, for example, any given make contact fails to open and the relay is de-energised, none of the break contacts shall close. The same principle applies to the failure-to-open of a break contact with energisation of the relay, i.e. in this case, no make contact shall close. (see IEC 62912:2015, 5.1.1)

4.1.3 Forcibly guided operation

The efficiency of forcibly guided (mechanically linked) contact operation shall be maintained as long as the relay operates, even when beyond the specified endurance. This applies both to loaded and unloaded contacts. Forcibly guided (mechanically linked) operation shall be maintained even if individual parts of the relay fail. Under such circumstances, it is irrelevant whether this failure is due to wear or breakage.

Use of change-over contacts is permitted for signalling relays in safety-related circuits.

(see IEC 62912:2015, 5.1.2)

4.1.4 Degradation during service

The spring type relays shall satisfy the product specification during the service life – refer to 4.7.4.

4.2 Specific requirements

4.2.1 Non-welding characteristics

The relays shall be characterised by their non-weldable make contact points, through the use of a suitable contact point material (for example, silver-carbon for which there is no risk of welding above a certain percentage of carbon), or by the introduction of special construction arrangement reducing risks of welding of the contact points (for example, adequate opening force, contacts in series, or fusing) – refer to Clause 5.

4.2.2 Opening of make contacts

The relays shall open the make contacts by the force of contact springs and return springs, when the current is interrupted in the coil.

NOTE The relays that open the make contacts by the falling of the armature under its own weight when the current is interrupted in the coil are not included in this document.

4.2.3 Mounting orientation

The mounting orientation may not depend on gravity. However, the mounting orientation is allowed to be specified with agreement between user and manufacturer.

4.3 Mechanical construction

4.3.1 Connecting device

The connecting devices for relays of the plug-in type (or groups of connectable relays) shall be configured so that it is not possible for any errors in assembly or connection to occur (e.g. coding protection).

(see IEC 62912:2015, 5.3.1)

4.3.2 Materials and arrangement

Sufficient space shall be left between the moving parts of the relays and the detachable case or cover of the relay (or group of relays), to avoid interfering with its operation.

The material, shape, arrangement and control shall be chosen to guarantee normal and safe operation specified in environmental conditions including transport.

(see IEC 62912:2015, 5.3.2)

4.3.3 Prevention of spring breakage

In order to prevent spring breakage, the particular design concept of return springs shall include the following items:

– Design and validation

  a) With regard to all springs including contact members, their maximum outer surface stress shall not exceed 2/3 of the spring elastic limit.

  b) A relay shall operate for twice the predefined maximum number of cycles in the product specification without spring breakage.

  c) Items a) and b) shall be validated by use of a Modified Goodman diagram.

  (See Annex A)

– Production and refurbishing

  - smooth surface and free from defects
  - disassembling and assembling procedures
  - adjustment procedures

– Operation conditions

  - maintenance period

If necessary, springs shall be protected against corrosion.

Fulfilling all the conditions of 4.3.3 is necessary to satisfy the inherent safety requirements of IEC 62425:2007.

4.3.4 Prevention of screw loosening

Screws shall be locked to prevent loosening.

4.4 Environmental conditions

4.4.1 General

The relays shall comply with IEC 62498-3 regarding environmental conditions. Environmental conditions not covered by IEC 62498-3 shall be agreed between user and manufacturer.

4.4.2 Vibrations and shocks

The relays shall comply with vibration and shock condition in IEC 62498-3. Closed contacts shall not open longer than the bounce time and open contacts shall not close on their own, both with the relay de-energised and energised.

If the signalling relays do not comply with these requirements it is allowed to take special measures, for example spring suspension of the relay, groups of relays, or framework.

4.5 Magnetic system

4.5.1 Anti-residual magnetism design

The travel of the moving armature can be limited by means of stops in the energised and de-energised positions. If stops are used these elements shall be made of anti-residual and anti-corrosive material.

During the entire service life prescribed, the air gap, in the energised position of the relay, shall not be less than 0,1 mm, to avoid residual sticking of the armature. A smaller dimension is allowed, if the air gap is completely filled with non-residual material, as long as the service life requirements have been met.

(see IEC 62912:2015, 5.5.1)

4.5.2 Function

The choice of material and the construction shall guarantee the following points through a predefined service life.

- The drop-away current shall not be less than 30 % of the nominal current.
- The pick-up current < compression > shall not be more than 80 % of the nominal current.

NOTE Other values can be agreed between user and manufacturer.

The drop-away current is measured after magnetising of the relays by a current equivalent to 2,5 times the nominal current.

After a current equivalent to 2,5 times the nominal current energises the relay, the reverse pick-up current shall not exceed 110 % of the normal pick-up current. If specified in agreement between user and manufacturer, this residual magnetism test can be eliminated or an alternative test substituted.

4.6 Design of insulation

4.6.1 General

Design of insulation with regard to electrical stress and environmental conditions, as well as insulation tests shall be carried out according to IEC 62497-1. Compliance to IEC 62497-1 shall be satisfied depending on relay application specifications (e.g. connection to outdoor or indoor circuit allowed, working voltage, pollution).

4.6.2 Overvoltage

Overvoltage category 3 (OV3) to IEC 62497-1 shall apply when determining the clearances between the following voltage-carrying, electrically-conducting parts:

- the various windings of a coil,
- the windings of the coil and the other parts of the relay,
- the contacts themselves,
- the contacts and earth,
- the contacts and other parts of the relay.

NOTE Overvoltage category 3 (OV3) applies to equipment in fixed installations, and for cases where a higher degree of availability of the equipment is expected.

4.6.3 Test voltage

Users may decide to choose another overvoltage category keeping as a minimum a test voltage equal to 2 000 V rms at 50 Hz or 60 Hz.

This dielectric strength may, in the case of a supply circuit not connected to earth, also be required for functional combinations (for example, groups of relays), i.e. all the output terminals of a combination are tested against earth by applying a voltage of 2 000 V rms, 50 Hz or 60 Hz.

(see IEC 62912:2015, 5.6.3)

4.6.4 Pollution

Unless otherwise explicitly specified by the manufacturer, Pollution degree 3 (PD3) to IEC 62497-1 shall be assumed for determining the creepage distances between the voltage-carrying, electrically-conducting parts.

NOTE Pollution degree 3 (PD3) designates conductive pollution or dry non-conductive pollution, which can be predicted to become conductive due to condensation.

4.7 Contacts

4.7.1 Spacing (contact gap)

The contacts may comprise:

- single spacing with a single contact point,
- single spacing with double contact points (two contacts points in parallel),
- double spacing (two contacts in series),
- double spacing with double contact points (two set of parallel contacts points in series).

(see IEC 62912:2015, 5.7.1)

4.7.2 Break contact

If a break contact remains accidentally closed, none of the make contacts shall close, even when the relay is energised at 1,5 times its nominal voltage.

(see IEC 62912:2015, 5.7.2)

4.7.3 Contact heating

Adequate construction of the contacts ensures that, when in the closed position and under normal contact force, they shall not become overheated to an inadmissible extend under the effect of the rated current.

(see IEC 62912:2015, 5.7.3)

4.7.4 Service life

Any type of safety-related relay has its physical life limit of use. Service life shall be predefined in the product specification or by agreement between user and manufacturer based on the following points:

- the minimum number of cycles,
- predefined regular replacement time or,
- resultant failure rate in use.

NOTE An example of service life agreement giving these parameters for spring type relays is shown in informative Annex B.

4.7.5 Minimum distance apart of the relay contact elements

The values given below are minimum distances between the contact points of the break contacts when the make contacts close and between the contact points of the make contacts when the break contacts close.

- 0,3 mm when attraction of the moving armature takes place,
- 0,8 mm when attraction of the moving armature ceases.

NOTE Reference standards IEC 62497-1 and former Japanese National Railway Standard (JRS) 22111-11:1973, Line relay (DC, F).

4.7.6 Contact force

The compression force of the contacts on completion of the movement of the moveable armature shall not be less than the following:

- 0,245 N in the case of silver to silver-carbon contact points,
- 0,147 N in the case of silver to silver contact points,
- 0,294 N in the case of silver-carbon to silver-carbon contact points,
- 0,147 N in the case of contact points made of non-corrosive base material.

Lower contact force and different contact materials can be accepted as long as the requirements of 4.4.2 have been met.

For contacts with double contact points, half the contact force suffices per contact point. For double spacing contacts, full force is necessary at each contact point.

Compression force applicable for other combination of contact material shall be specified by the product specification.

4.7.7 Opening force of contacts

Opening force for make contacts shall not be less than 0,490 N.

NOTE The way of measuring is shown in informative Annex C.

4.7.8 Self-cleaning

All contacts shall have necessary and sufficient contact wipe. The minimum contact wipe is 0,1 mm. When no or less contact wipe is available a minimum operating voltage and current shall be specified in the product specification.

4.7.9 Bounce

The maximum bounce time on closing and opening of the contact shall be predefined in the product specification.

NOTE For example, the maximum bounce time is as follows;

- 50 ms in non-proved spring type relay

4.7.10 Contact resistance

Contact resistance shall not exceed the following values (see Table 1):

Table 1 – Contact resistance

Material	Test current (DC) A	Initial value [a] Ω	Field value [b] Ω
Ag-Ag	0,1	0,1	1
AgC-AgC	2	0,5	1
AgC-Ag	0,1	0,3	1,5
[a] new production [b] under operation			

For other contact materials, contact resistance shall be specified by the product specification, unless user and manufacturer agree on different values.

5 Application conditions

Where direct current signalling relays with weldable contact material are used this should be in conjunction with protective devices (e.g. fuse, surge absorber, resistor, etc.) to minimise the residual risks of contact welding.

Each method of over current protection shall be decided in contracts and/or agreements between user and manufacturer, and the manufacturer shall provide detailed operational parameters of the relays (e.g. maximum value and duration of inrush current, value of short circuit current) to the user.

6 Measurement and test methods

Table 2 lists the measurement and test items that shall be used.

Measurement and test methods and other test items listed in the product specification, in the contract and/or in agreement between user and manufacturer shall refer to relevant standards or regulations.

Table 2 – List of measurement and test items

No.	Measurement and test items	Type test	Routine test	Maintenance test
1	Visual inspection	M	M	M
2	Performance test	M	M	M
3	Low temperature test	M	O	NA
4	Dry heat test	M	O	NA
5	Supply overvoltage test	M	O	O
6	Surge test	M	O	O
7	Insulation test	M	M	O
8	Vibration and shock test	M	NA	NA
9	Mechanical switching test	M	NA	NA

M: The execution of measurement and tests items marked with M is mandatory.

O: The execution of measurement and tests items marked with O is subject to contract and/or agreement between user and manufacturer.

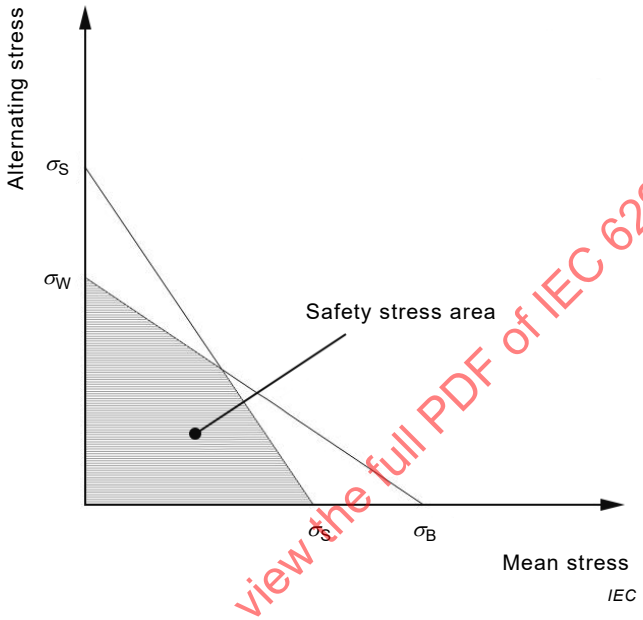
NA: The execution of measurement and tests items marked with NA is not applicable.

Annex A
(normative)

Modified Goodman diagram

A.1 Modified Goodman diagram

The Modified Goodman diagram shows prevention of spring breakage as a safety stress area (see Figure A.1).



Key

σ_S Yield stress

σ_W Fatigue limit stress

σ_B Fracture stress

Figure A.1 – Modified Goodman diagram

A.2 Calculation method for maximum stress of return spring

In this annex, the calculation method concerning the item considered in 4.3.3 is given (see Figures A.2, A.3 and A.4).

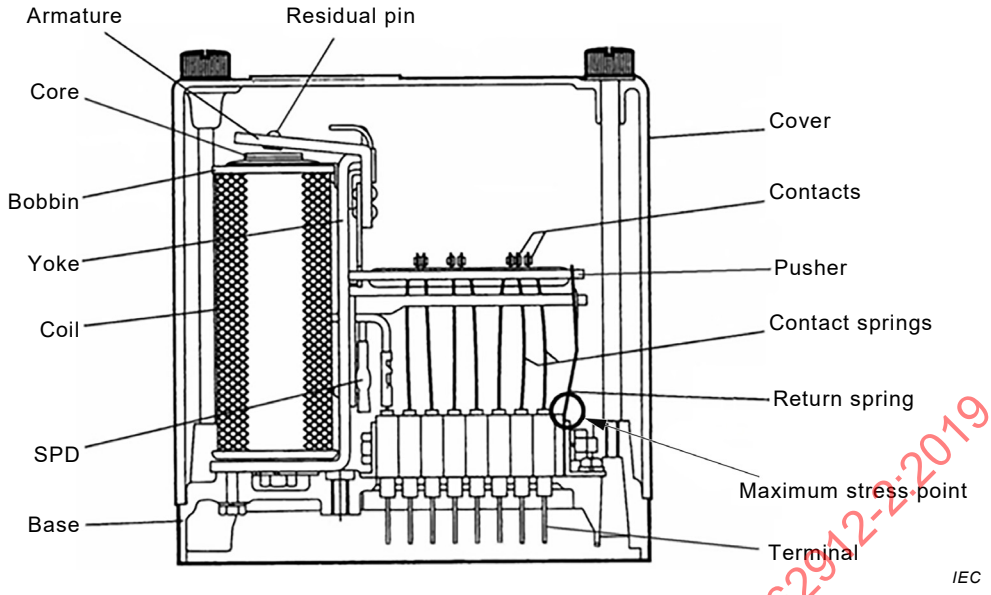
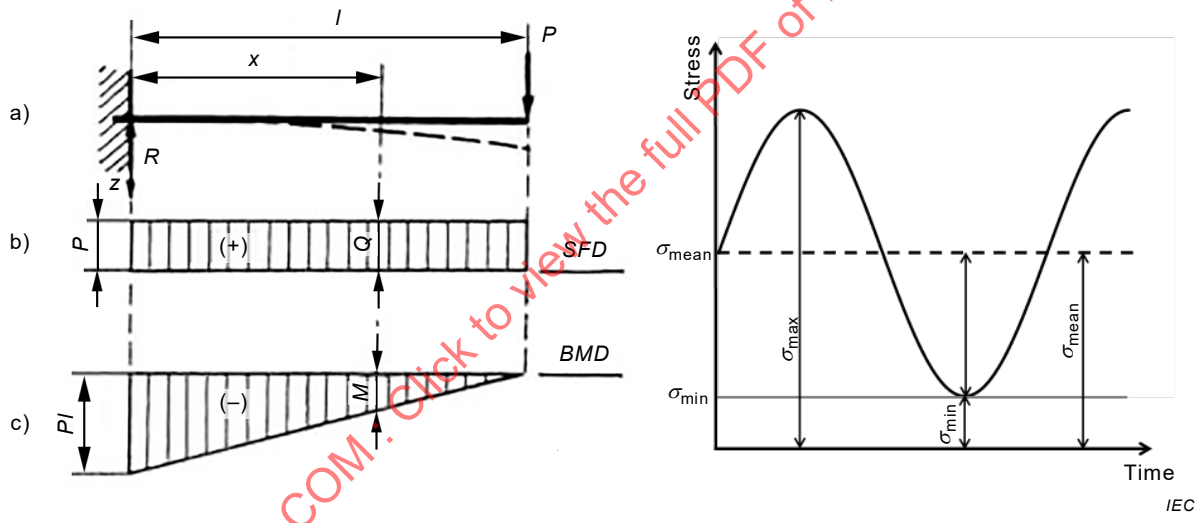


Figure A.2 – Example of railway direct current signalling monostable relay



Key

SFD Shearing Force Diagram

BMD Bending Moment Diagram

Figure A.3 – Stress calculation model of return spring

Application conditions

Configuration: Flat spring, cantilever

b Width of spring blade

t Thickness of spring blade

l Length of spring blade

P Applied force at the end of spring blade

M Bending moment of spring blade

Z Section modulus of spring blade

σ Stress of spring blade

Calculation of stress of spring blade:

$$Z=\frac{bt^2}{6}$$

$$M_{max}=P_{max}\times l$$

$$M_{min}=P_{min}\times l$$

$$\sigma_{max}=\frac{M_{max}}{Z}$$

$$\sigma_{min}=\frac{M_{min}}{Z}$$

A.3 Stress calculation example of return spring

b=7 mm

t=0,2 mm

l=30 mm

$$Z=\frac{7\times 0{,}2^2}{6}=4{,}7\times 10^{-2}\ \text{mm}^3$$

P_{max}=0,5 N

P_{min}=0,24 N

M_{max}=0,5×30 =15 Nmm

M_{min}=0,24×30=7,2 Nmm

$$\sigma_{max}=\frac{15}{4{,}7\times 10^{-2}}=319\ \text{N/mm}^2$$

$$\sigma_{min}=\frac{7{,}2}{4{,}7\times 10^{-2}}=153\ \text{N/mm}^2$$

Stress for plotting on Modified Goodman Diagram:

σ_{Alt} Alternating stress of spring blade:

σ_{max}-σ_{min}=166 N/mm^2

σ_{mean} Mean stress of spring blade:

$$\frac{(\sigma_{max}+\sigma_{min})}{2}=236\ \text{N/mm}^2$$