Residual current devices basics
RCDs Standards
Objectives

After completing this module, you will be able to

- have a clear overview of the residual current device reference Standards;
- know the Standard differences about the applications and the working limits of residual current devices:
  - household and similar use;
  - industrial use;
- understand every type of residual current device Standards classification.
RCDs Standards introduction

- General requirements for RCDs

  The general requirements for residual current devices are prescribed by the Technical Report IEC 60755

  It gives common Standards guidelines

IEC 60755 apply to residual current operated protective devices with rated voltages ≤ 440V AC
and may be used as a guide also for residual current devices with rated voltages up to 1000V AC.
RCDs Standards definition

- RCD purpose and definition

  RCDs give protection against the risk of electric shocks and provide protection against fire hazards.

  The RCD is intended as a single device which

  - detect the residual current;
  - compare it to a referenced value;
  - open the protected circuit when the residual current exceeds the referenced value;

  or an association of devices, each one of them performing separately one or two functions, but acting together in order to accomplish all three functions.

  Details of how of RCDs should be installed are in the IEC 60364 - Low voltage electrical installations.
### RCDs Standards overview

<table>
<thead>
<tr>
<th>Applications</th>
<th>Standards</th>
<th>Max Voltage</th>
<th>Max Current</th>
<th>Example</th>
</tr>
</thead>
</table>
| Household & similar (uninstructed people) | IEC 61008  
IEC 61009  
IEC 62423 | 440V AC | 125A | RCCB  
RCBO |
| Industrial (instructed people) | IEC 60947-2 Annex B  
IEC 60947-2 Annex M | 1000V AC | - | RCBO  
Tmax+RC |
RCDs for use by uninstructed people

- Residual current devices for use by uninstructed people

  - IEC 61008-1
  - IEC 61008-2-1 and 61008-2-2
    Residual current operated circuit breakers, without integral overcurrent protection, for household and similar uses.

  - IEC 61009-1
  - IEC 61009-2-1 and 61009-2-2
    Residual current operated circuit breakers, with integral overcurrent protection, for household and similar uses.
RCDs for use by uninstructed people

- Residual current devices for use by uninstructed people
  - IEC 61009-1: Annex G
    - RCBOs assembled on site, composed by
      - Residual Current Unit (RCU)
      - Circuit breaker
  - IEC 62423
    - B type residual current operated circuit breakers for household and similar use
RCDs for use by uninstructed people

- Residual current devices for use by uninstructed people

Additional reference Standards:

- IEC 61543: Electromagnetic compatibility of RCDs for household and similar use
  - Low-frequency immunity tests
  - High-frequency immunity tests
  - Electrostatic discharges test

- IEC 62350: Guidance to the correct use of RCDs for household and similar use
RCDs for use by uninstructed people

- IEC 62350: Guidance to the correct use of RCDs

<table>
<thead>
<tr>
<th>Classification from IEC 60364-5-51</th>
<th>Code</th>
<th>External influences</th>
<th>Importance</th>
<th>Standard level</th>
<th>Existing RCD standards</th>
<th>Corresponding standard characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AA</td>
<td>Temperature (°C)</td>
<td>++</td>
<td>AA4</td>
<td>−5 °C +40 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>Temperature and humidity</td>
<td>+++ a</td>
<td>AB4</td>
<td>5% 95%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AC</td>
<td>Altitude (m)</td>
<td>+</td>
<td>AC1</td>
<td>≤ 2000 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AD</td>
<td>Water</td>
<td>++ a</td>
<td>AD1</td>
<td>IPX0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE</td>
<td>Foreign bodies</td>
<td>++</td>
<td>AE1</td>
<td>IP2X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AF</td>
<td>Corrosion</td>
<td>+++ a d</td>
<td>AF1</td>
<td>Negligible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AG</td>
<td>Impact</td>
<td>+</td>
<td>AG1</td>
<td>Low severity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AH</td>
<td>Vibration</td>
<td>+</td>
<td>AH1</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AK</td>
<td>Flora and moulds growth</td>
<td>+</td>
<td>AK1</td>
<td>No hazard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL</td>
<td>Fauna</td>
<td>+</td>
<td>AL1</td>
<td>No hazard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AM</td>
<td>Radiation (EMC)</td>
<td>+++</td>
<td></td>
<td>See IEC 61543</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AQ</td>
<td>Lightning</td>
<td>++</td>
<td>AQ2</td>
<td>Indirect exposure according to IEC 60364-4-44 Clause 443</td>
<td></td>
</tr>
</tbody>
</table>

\[a\] The influence of humidity on the surface of electrical, electronic and mechanical parts of the equipment may impair reliability due to corrosion and influence on insulation.

\[b\] The number of + signs indicates an approximate evaluation of importance of the external influence. The minus sign indicates that there is no influence on the availability of the protection.

\[c\] In some countries, the current standards include a classification according to the ambient temperature:

- −5 °C to +40 °C
- −25 °C to +40 °C

\[d\] An example of an environmental test is the Kesternich test specified in ISO 6988:1985.
RCDs for use by uninstructed people

- Residual current devices for use by uninstructed people

  - RCCBs or RCBOs incorporated in or intended only for association with plugs and socket-outlets or with appliance couplers
    IEC 61008-1 (RCCBs)
    IEC 61009-1 (RCCOs)
    IEC 60884-1: Plugs and socket-outlets for household and similar purposes

  - Portable devices consisting of a plug, an RCD and one or more socket-outlets or a provision for connection, without integral overcurrent protection
    IEC 61008-1
    IEC 61540: Electrical accessories - Portable residual current devices without integral overcurrent protection for household and similar use
RCDs for industrial use

- Residual current devices for industrial use
  - IEC 60947-2 Annex B
    Circuit breakers incorporating residual current protection
  - IEC 60947-2 Annex M
    Modular residual current devices without the integral current breaking device
    The current sensing means and/or the processing device are mounted separately from the current breaking device. They can even have B type detecting features. These devices, for household applications, confirm also the IEC 62020; and can be used only to give a signal alarm.
RCDs Standards classification

- Residual current devices Standards classification

  The Standards classify the RCDs according to many different criteria.

  Main classifications are according to:

  - the method of operation;
  - the behaviour in presence of DC components;
  - the time-delay trip, in presence of a residual current.
RCDs classification: method of operation

- RCDs classification according to the method of operation

  The RCDs classification of the Standards IEC 61008 and 61009

  - Voltage Independent (VI)
    - electromechanical
    - tripping energy supplied by the fault current
    - reliable way to operate

  - Voltage Dependent (VD)
    - electronic
    - tripping energy independent on the fault current
    - does not work without power supply
### RCDs classification: method of operation

- **RCDs classification according to the method of operation**

The classification according to the method of operation

<table>
<thead>
<tr>
<th>4.1.1. functionally independent on the line voltage</th>
<th>4.1.2 functionally dependent on the line voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>4.1.2.1 Opening automatically in case of failure of the line voltage without or with delay</td>
</tr>
<tr>
<td>Danger</td>
<td>4.1.2.2 NOT opening automatically in case of failure of the line voltage</td>
</tr>
<tr>
<td>Out of service</td>
<td>4.1.2.1.a Reclosing automatically when the line voltage is restored</td>
</tr>
<tr>
<td></td>
<td>4.1.2.1.b NOT reclosing automatically when the line voltage is restored</td>
</tr>
<tr>
<td></td>
<td>4.1.2.2.a Able to trip in case of hazardous situation arising on failure of the line voltage</td>
</tr>
<tr>
<td></td>
<td>4.1.2.2.b Not able to trip in case of hazardous situation arising on failure of the line voltage</td>
</tr>
</tbody>
</table>
## RCDs classification: method of operation

- RCDs classification according to the method of operation

<table>
<thead>
<tr>
<th></th>
<th>IEC Standards</th>
<th>EN Standard</th>
<th>Exception: UK National Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RCCBs</strong></td>
<td>IEC 61008-1</td>
<td>EN 61008-1</td>
<td>BS EN 61008-1</td>
</tr>
<tr>
<td></td>
<td>IEC 61008-2-1 (VI)</td>
<td>EN 61008-2-1 (VI)</td>
<td>BS EN 61008-2-1 (VI)</td>
</tr>
<tr>
<td></td>
<td>IEC 61008-2-2 (VD)</td>
<td>Not recognized</td>
<td>BS 61008-2-2 (VD)</td>
</tr>
<tr>
<td><strong>RCBOs</strong></td>
<td>IEC 61009-1</td>
<td>EN 61009-1</td>
<td>BS EN 61009-1</td>
</tr>
<tr>
<td></td>
<td>IEC 61009-2-1 (VI)</td>
<td>EN 61009-2-1 (VI)</td>
<td>BS EN 61009-2-1 (VI)</td>
</tr>
<tr>
<td></td>
<td>IEC 61009-2-2 (VD)</td>
<td>Not recognized</td>
<td>BS 61009-2-2 (VD)</td>
</tr>
</tbody>
</table>

RCDs classification according to the method of operation.
Method of operation: voltage dependent RCD example

- An example of a voltage dependent RCD: DS 271
  1P + solid neutral RCBO

The functional earth permits the device to open the circuit.

The device can be unsafe if the neutral conductor is accidentally broken.
RCDs classification: presence of DC components

- **Technical Report IEC 60755 classification**
  
  Three types of RCDs are defined according to their behaviour in presence of DC components.
  
  RCDs are classified depending on the wave form of the fault current, which they are able to detect:

- **AC type**: sensitive only to alternating current

- **A type**: sensitive to alternating and/or pulsating current with DC component

- **B type**: sensitive to alternating and/or pulsating current with DC component and earth fault currents similar to smooth direct (low ripple) or with high frequency
RCDs classification: presence of DC components

- AC type RCD

In case of earth fault, a linear load (resistance, impedance, capacitor) generates a sinusoidal alternating current, maintaining the frequency of the line current.

AC type is sensitive only to alternating current, whether suddenly applied or slowly rising.
RCDs classification: presence of DC components

- A type RCD

In case of earth fault, a non-linear load (diode, transistor) generates pulsating currents.

A type is sensitive to alternating currents, pulsating direct currents and pulsating direct currents superimposed on a smooth direct current, whether suddenly applied or slowly rising.
In presence of a device that contains a rectifier section, a smooth DC earth fault current can be generated.

Six-pulse bridge

Three-pulse star
In presence of a device that contains an inverter, the case of a fault downstream the inverter generate an earth leakage current with an elevated harmonic content.

RCDs classification: presence of DC components

- B type RCD
RCDs classification: presence of DC components

- B type RCD

Product Standard IEC 62423 has to be used with IEC 61008 and IEC 61009

B type RCDs are sensitive to:
- residual alternating currents at a frequency of 50/60 Hz;
- residual pulsating direct currents with positive or negative half waves;
- residual alternating and/or pulsating currents superimposed on a smooth direct current;
- residual fault currents generated by a rectifier with two or more phases;
- smooth direct earth fault currents;
- residual alternating currents up to a frequency of 1000Hz.
RCDs classification: presence of DC components

- AC, A and B type RCDs

<table>
<thead>
<tr>
<th>Form of residual current</th>
<th>Correct functioning of RCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinusoidal A.C.</td>
<td>AC</td>
</tr>
<tr>
<td>Suddenly applied</td>
<td>+</td>
</tr>
<tr>
<td>Slowly rising</td>
<td></td>
</tr>
<tr>
<td>Pulsating D.C.</td>
<td></td>
</tr>
<tr>
<td>Suddenly applied</td>
<td>+</td>
</tr>
<tr>
<td>With or without 0.06 A</td>
<td></td>
</tr>
<tr>
<td>Slowly rising</td>
<td></td>
</tr>
<tr>
<td>Smooth D.C.</td>
<td></td>
</tr>
</tbody>
</table>

B type is the universal current sensitive residual current device
Presence of DC components: application example

- Application example, B type

Electro-medical equipment

B type
RCDs classification: time-delay

- RCDs classification according to the time-delay

RCD without time-delay: **general type**;
RCD with time-delay for selectivity: **type S**.

<table>
<thead>
<tr>
<th>Type</th>
<th>$I_n$ (A)</th>
<th>$I_{\Delta n}$ (A)</th>
<th>Standard value of break time (s) and non-actuating time (s) at a residual current ($I_{\Delta n}$) equal to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$I_{\Delta n}$</td>
<td>2 $I_{\Delta n}$</td>
</tr>
<tr>
<td>General</td>
<td>Any value</td>
<td>Any value</td>
<td>0,3</td>
</tr>
<tr>
<td>Selective</td>
<td>$\geq 25$</td>
<td>$&gt;0,03$</td>
<td>0,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0,13</td>
</tr>
</tbody>
</table>
RCDs classification: time-delay

- Tripping characteristic of a general RDC

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard value of break time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$I_{\Delta n}$</td>
</tr>
<tr>
<td>General</td>
<td>0.3</td>
</tr>
</tbody>
</table>

![Graph showing tripping time and current values](image)
RCDs classification: time-delay

- Tripping characteristic of a selective RDC

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard value of break time (s) at a residual current (I_r) equal to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I_n</td>
</tr>
<tr>
<td>Selective</td>
<td>0,5</td>
</tr>
<tr>
<td></td>
<td>0,13</td>
</tr>
</tbody>
</table>

![Graph showing tripping characteristic of selective 300mA RCDs]