Low Voltage Directive

From:
- 1st June 1989
- 1st January 1997


UK Regulations: The Electrical Equipment (Safety) Regulations 1994

Applies to:
- Electrical equipment
  - 50-1000 VAC
  - 75-1500 VDC
- New and second-hand
- Electrical components
Low Voltage Directive

- Equipment must be **safe** i.e.
- No risk, apart from one reduced to the minimum
- Excludes improper installation, maintenance and misuse
- Constructed to **good manufacturing practice** (complies with a standard)

Low Voltage Directive

- **Electrical equipment should be constructed in accordance with a standard in the following hierarchy**
  - Harmonised standards EN
  - International standards IEC
  - National standards BS
Boy, am I Confused!

Low Voltage Directive  OR  Machinery Directive

Machinery Directive

From:
- 1st January 1993
- 1st January 1995

Directive: 98/37/EC

UK Regulations: The Supply of machinery (Safety) Regulations 1992

Applies to:
- Machinery
- Assemblies of machines
- Interchangeable equipment
- Safety components
Electrical Standards


Presumption of Conformity to
- Low Voltage Directive and
- Machinery Directive

EN IEC 60204-1 Electrical Enclosures

- Door interlock not essential
- Eye bolts for lifting
- High voltage markings
**Electrical Enclosures**

- Door protected with
  - Key locks
  - Door interlocked isolator
- Touch safe components (IP2X)

**Protection of Enclosures**
**IP Rating EN 60529**

**Dust Objects**
- 2X Finger
- 3X Tool
- 4X Wire
- 5X Dust protected
- 6X Dust tight

**Water**
- X2 Rain
- X3 Spraying water
- X4 Splashing water
- X5 Water jets
- X6 Powerful jets
- X7 Temporary immersion
- X8 Continuous immersion
IP Ratings

- IP 54 minimum rating for an enclosure
- IP 5X implies protected against dust
- IP X4 implies protected against splashing water

Enclosures with PLCs

- Access required with panel live
- Key access to enclosure
- High voltage touch safe or in another enclosure
- Isolator within easy reach, but not on door
EN IEC 60204-1 PLC Enclosure

- Touch safe IP2X
- Lexan covers for DC controllers
- 13A socket for programmer on right

EN IEC 60204-1 Supply Disconnect

- Rotary switches
- Insulated contacts
- Black or grey handles
- Red and yellow if used as an emergency stop
EN IEC 60204-1 Cable Entry

- Each cable separately glanded
- Marked at entry point

EN IEC 60204-1 Cable Entry

- Cables secured
- Cables with large radius bends
EN IEC 60204-1 Cable Entry

- Incomer taken directly to the main disconnect

EN IEC 60204-1 Wiring in Enclosures

- Mechanical protection of cables next to door hinge
Neutral and Protective Earth

- Separate terminal must be provided for a **neutral** conductor
- Connections for the **protective earth** (PE) and neutral should be separate.

Cable colours

<table>
<thead>
<tr>
<th>Colour</th>
<th>Used to indicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Protective earth PE</td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
</tr>
<tr>
<td>Light blue</td>
<td>Neutral</td>
</tr>
<tr>
<td>Black</td>
<td>a.c. and d.c. power circuits</td>
</tr>
<tr>
<td>Red</td>
<td>a.c. control circuits</td>
</tr>
<tr>
<td>Blue</td>
<td>d.c. control circuits</td>
</tr>
<tr>
<td>Orange</td>
<td>Interlock control circuits supplied from an external power source</td>
</tr>
</tbody>
</table>
EN 60204-1
New phase colours

<table>
<thead>
<tr>
<th>Colour</th>
<th>Used to indicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>Phase 1</td>
</tr>
<tr>
<td>Black</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Grey</td>
<td>Phase 3</td>
</tr>
</tbody>
</table>

EN IEC 60204-1
Wiring in Enclosures

- Conductors laid side by side in the same duct or in trunking should be insulated to the highest voltage
- Spare terminals must be installed.
- Fill percentages of ducts must allow for additional cables to be installed.
EN IEC 60204-1 Earth Continuity

- Earth straps
- Plated back plate

EN IEC 60204-1 Earth Faults

- An earth fault on a control circuit should not cause **unintentional starting** and not **prevent stopping** of a machine.
- Protection against electric shock must be provided i.e. **RCD** Residual Current Device, Circuit Breakers, **where there is a significant risk** of earth leakage.
**EN IEC 60204-1**

**Overload protection**

- Power circuit breakers complying to *EN60947-3*
- Overload protection for motors above *0.5Kw*
- Miniature circuit breakers (*MCBs*) preferred

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**Machinery Directive**

**1.2 Controls**

1.2.1 Must be safe & reliable

1.2.2 Appropriate & appropriately positioned

1.2.3 Start only by voluntary action

1.2.4 Stops at each work station

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STOP

STOP
EN IEC 60204-1
Start Functions

• The start operation should only be possible when all safeguards are in place and functional
• An immediate switch off stop has priority over a start function;
• Start devices must be mounted to minimise inadvertent operation.

EN IEC 60204-1
Sop Function

• Stop function options
  – Category 0 - power removed immediately
  – Category 1 – machine stops under power and then power is disconnected
  – Category 2 – machine stops under power, power remains connected.
**EN IEC 60204-1**  
*Emergency Stop function*

- Devices must comply with EN 418  
- Function must be either:  
  - **Category 0** - power removed immediately  
  - **Category 1** – machine stops under power and then power is disconnected  
- Function must override all other functions  
- Initiation must remove hazard automatically without creating other hazards

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**EN IEC 60204-1**  
*Emergency Stop function*

- When *reset* is operated the machine is only ready to start i.e. it does not restart automatically  
- No further than **5m** to find a stop
1.2 Controls

1.2.5 Mode Selection – If a mode is required where safeguards are neutralised, it must

- Lockable selector switch
- Hold to run control
- Limited movement or power
- Step by step motion
- Controls near adjustment point

EN IEC 60204-1
Mode Selection

- It should not affect safety levels i.e. immobilise safety protection or interlocking devices;
- If it does alter safety levels, the device must have restricted access e.g. via a key switch or code;
- If it does alter safety levels there must be some other means of decreasing risk e.g. limited speed, limited movement or “hold to run” control.
Machinery Directive

1.2 Controls

1.2.6 No danger after a power failure
1.2.7 No danger after a control failure
1.2.8 Interactive software must be user friendly

Packaging Machine Standards

Shortly to be published
EN 415 Safety of packaging machinery
• Part 5 Wrapping machines
• Part 6 Pallet wrapping machines
• Part 7 Group packaging machines
• Part 8 Strapping machines
EN 415 Series
Electronic Motor Drives

• Inverter drives, rectifier drives, servomotors
• Issue of disconnection of power during a short term intervention
• Fault tolerance requirements
  – Non programmable Category 3 EN 954-1
  – Programmable SIL 2 IEC 61508

EN 415 Series
Electronic Motor Drives

• Galvanic disconnection
  – Cat 2 EN 954-1
• Safe Pulse Blocking
  – SIL 2 IEC 61508
• Position monitoring
  – SIL 2 IEC 61508
• Mechanical braking
  – Cat 3 EN 954-1
Category off control circuits

EN 954-1 Safety of Machinery - Safety related parts of control circuits
EN954-100 explains how to use EN954-1

Ideas are not new to UK. BS5304 had the same categories of control circuit

EN 954-1 Category B

The safety-related parts of control systems shall, as a minimum, be designed, constructed, selected, assembled and combined, in accordance with the relevant standards, using basic safety principles for the specific application so that they can withstand:

Standard components, single circuit
EN 954-1 Category 1

“Well tried” components, in a single circuit
- widely used in the past with successful results in similar applications; or
- made and verified using principles which demonstrate its suitability and reliability for safety-related applications.

The standard form of control circuit used in most machinery since 1974

EN 954-1 Category 2

“Well tried” components, in a single circuit with monitoring of function of components

The check of the safety function(s) shall be performed:
• at the machine start-up
• prior to the initiation of hazardous situation
• periodically if required
• Manual or automatic
• allow operation if no faults have been detected
• Stop machine or warn if a fault is detected
EN 954-1 Category 2

- Self monitoring relay

EN 954-1 Category 3

- A single fault in any of these parts does not lead to the loss of the safety function
- Common mode faults shall be taken into account
- Single fault shall be detected at, or before the next demand upon the safety function.
- Two circuits
- 100% redundancy
EN 954-1 Category 4

- A **single fault** in any of the safety-related parts does not lead to a **loss** of the safety function and
- The **single fault** is detected at or before the next demand upon the safety functions, e.g. **immediately**, at switch on, at end of a machine operating cycle.
- An **accumulation** of faults shall not lead to a loss of the safety function.

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EN 954-1

- **Choose category by risk assessment**
- **The category depends on**
  - Hazard
  - Use
  - Integrity of components
- **There can be more than one category of circuit on a machine**
### Failure of Control Devices

<table>
<thead>
<tr>
<th>Component</th>
<th>Likely failure</th>
<th>How often?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guard switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E - stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brake motor</td>
<td></td>
<td></td>
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<tbody>
<tr>
<td>Guard switch</td>
<td>Mechanical</td>
<td>Likely</td>
</tr>
<tr>
<td>Main relay</td>
<td>Contact wear</td>
<td>Rare</td>
</tr>
<tr>
<td>Safety relay</td>
<td>Component failure</td>
<td>Possible</td>
</tr>
<tr>
<td>E - stop</td>
<td>Mechanical</td>
<td>Possible</td>
</tr>
<tr>
<td>Brake motor</td>
<td>Mechanical wear</td>
<td>Likely</td>
</tr>
</tbody>
</table>
EN 954-1 Category of Circuit

<table>
<thead>
<tr>
<th>Category</th>
<th>S1</th>
<th>S2</th>
<th>F1</th>
<th>F2</th>
<th>P1</th>
<th>P2</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>1</td>
<td>X</td>
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<tr>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Use of Categories

- **B** Machines which cannot cause irreversible injuries
- **1** Most **automatic** machinery protected by interlocked guards
- **2** Automatic machines incorporating **trip devices**
- **3** **Semi-automatic** machines and automatic machines where **access** is **frequent**
- **4** Semi automatic machines where a **single fault** will inevitably lead to an **accident**
EN IEC 60204-1
Markings

- Components in enclosures must be easily identifiable without moving them or the wiring
- Warning signs must be provided

Machinery Directive
1.7 Indicators

1.7.0 The information needed to control machinery must be easily understood
1.7.1 Warnings must be unambiguous
1.7.2 Warn of residual hazards
Signs and Symbols

EN 61310-1 Safety of machinery – Indication marking and actuation – requirements for visual, auditory and tactile signals

EN 61310-2 Safety of machinery – Indication marking and actuation – requirements for marking

ISO 7000 Graphical symbols for use on equipment – index and synopsis

Questions?

www.en-sure.net