Protection Against Electric Shock

- Protection against direct contact
- Protection against electric shock in case of indirect contact (fault case)
- Protection through protective extra-low voltage (PELV)
- Protection against residual voltages
Protection Against Direct Contact

**General:**
Energized parts must be protected against direct contact when:

- AC: $U \geq 50 \text{ V}$
- DC: $U \geq 60\text{V}$

**Measures:**

1. Insulation
2. Enclosure
3. Interlocking of enclosures
4. Restricted access to the enclosure
Energized parts must meet the following conditions:

- Complete insulation (only removable through disassembly!)
- Mechanical, chemical, electrical and thermal resistance
- Paints, varnishes and coatings do not offer sufficient protection against electric shock
Protection Against Direct Contact
(2) Enclosures

Enclosures and enclosure openings must comply with the requirements according to:

- UL508
- UL508A
- UL50 or NEMA 250.

**Exception:**
Unapproved enclosures can be checked by means of a test finger; checking of all openings after disassembly of all parts removable without tools

→ Touching of energized parts with the test finger must **not** be possible
Test Finger – NFPA79 6.2.2.1

- Handle
- Stop plate
- Insulating material

SECTION A-A
Cylindrical

SECTION B-B
Spherical

SECTION C-C
Chamber all edges

SIDE VIEW

PART 1
PART 2
PART 3
Protection Against Direct Contact
(3) Interlocking of Enclosures

**General:** Main disconnecting means of enclosures / industrial control panels must be interlocked with the door when energized parts are contained with
- AC $\geq 50$ V
- DC $\geq 60$ V

**Exceptions:**
1. Main disconnecting means for industrial control panel lighting inside the industrial control panel
2. Main disconnecting means for memory elements for the retention of information

**Note:** Qualified persons may implement measures for defeating the interlocking (see NFPA 70E "Standard for Electrical Safety in Workplaces")
Protection Against Direct Contact
(3) Interlocking of Enclosures – Conditions

- The interlocking must be defeatable by means of a tool
- With the door open and the "ON" position, the interlocking must be enabled upon closing
- With the door is open, switch-on must be mechanically blocked; defeat must be possible without tools ("deliberate action")

Caution:
Devices on the inside of industrial control panels must be protected against unintended contact when $U \geq 50$ V; either by means of device characteristics or through barriers in a range of 50 mm (2 inches)
Protection Against Direct Contact
(3) Interlocking of Enclosures – Solutions

Mechanical solutions:
UL-compliant with **UL508A, NFPA 79, JIC and NEC**

**Max-flex drive**
Enclosure type: 1, 3R, 12

**Interlocking module 8UC**
Enclosure type: 1

**Standard references:**
**UL508A:** 30.4 / 66.1.5 / 66.6.3
**NFPA79:** 5.3.3 / 6.2.3 / 6.2.5
Protection Against Direct Contact
(3) Interlocking of Enclosures – mechanical solutions

Examples for mechanical interlocking solutions provided by Siemens
Protection Against Direct Contact
(3) Interlocking of Enclosures – Solutions

Electrical solutions:
- 1 key switch for defeat
- 1 timing relay
- 1 undervoltage release per main disconnecting means
- Diverse auxiliary relays
- 1 limit switch per door, preferably with tumbler
- Motorized operating mechanism

Note:
The electrical interlocking must meet the same conditions as the mechanical interlocking!
When **qualified skilled persons** with respective experience open an industrial control panel **without main disconnecting means**, the following conditions must apply:

- the door can be opened by means of a key or tool,

  or

- the door can be opened without defeat, key or tool when all energized parts are covered or encapsulated in a finger-safe manner
Protection Against Indirect Contact (Fault Case)  

**General:**
Protection against indirect contact is to prevent hazardous states in *case of faults* (e.g. due to insulation faults between energized and exposed parts)

**Measures:**
(1) Protection through double insulation  
(2) Protection through automatic supply disconnection
Protection Against Indirect Contact
(1) Double Insulation

- Double insulation is to prevent the occurrence of hazardous touch voltages due to faults in the basic insulation

- Operating equipment must be *respectively marked*

- Operating equipment either must be *listed or tested in a comparable manner*
Protection Against Indirect Contact
(2) Protection Through Automatic Supply Disconnection

**General:**
Protection through automatic supply disconnection of affected circuits by means of the respective overcurrent protective device in case of faults

**Prerequisites for the safety measure:**
1. Exposed, conductive parts must be grounded
2. Application of overcurrent protective devices for automatic disconnection
Protection Through Protective Extra-Low Voltage – PELV

**General:**
Operator protection for indirect and direct contact in restricted work areas!

**PELV circuits must meet the following conditions:**

1. **Rated voltage**
   a) 30 V AC (RMS) or 60 V DC (ripple-free) with dry locations and when no large contact surfaces for the body are given
   b) 6 V AC (RMS) or 15 V DC (ripple-free) when a.) is not applicable
2. One side of the circuit or one point of the supply must be grounded
3. Energized parts of PELV circuits must be isolated from other energized parts; distance ≥ distance between the primary and secondary side of safety transformers
4. Wires must be routed separately from other circuits as far as possible; option: the dielectric strength of all wires must be given
5. Connectors and receptacles must be coded for PELV circuits
Protection Through Protective Extra-Low Voltage
PELV

Possible devices for infeed:

- Safety transformer
- Current source with identical degree of protection as safety transformer, e.g. motor generator with insulated windings
- Electrochemical supply (e.g. battery)
- Supply via sources which are independent of circuits with higher voltages (diesel-driven generators)
- Electronic power supply unit with protected outputs; internal fault does not lead to voltage overshoot according to the PELV standard voltages
Protection Through Protective Extra-Low Voltage
PELV – Electronic Power Supply Unit with Protected Outputs

**SITOP Select**
6EP1961-2BA00,
setting range 2...10 A
UL, cUL
CCN: NMTR
E197259

**Selectivity module SITOP PSE200U**
6EP1961-2BA10, setting range 0.5...3 A
6EP1961-2BA20, setting range 3...10 A
UL, cUL
CCN: NMTR
E197259
Protection Against Residual Voltages

Note: Residual voltages ≥ 60 V with energized parts must be reduced to U ≤ 60 V within t ≤ 5 sec. after disconnection

Exceptions:
- Components with a stored charge Q ≤ 60 µC
- In case of faults regarding operational functionality; permanent marking on the enclosure with reference to the risk of electric shock and indication of the delay

Note: If the unplugging of connectors leads to exposed conductors (e.g. pins), the discharge time must amount to t ≤ 1 sec.

Exceptions:
- Components with a stored charge Q ≤ 60 µC
- Conductors which are protected against direct contact
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