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# 2006/42/EC
# Technical Requirement Assesment Report
# EN 60204-1:2018
## Safety of machinery- Electrical equipment of machines - Part 1: General requirements

| | |
|---|---|
| Manufacturer ..... : | **AKOR MAKİNA İMALATI VE DANIŞMANLIK SAN. TİC. LTD. ŞTİ.** |
| Adress..... : | Ramazanoğlu Mah. Sanayi Cad. No:44b İç Kapı No:90, Pendik/İstanbul, Türkiye |
| Product / Model(s) ..... : | **Jiletli Tel Üretim Hattı / AKR-KM-1700**<br>Razor Wire Production Line / AKR-KM-1700 |
| Report Number..... : | TRM-25-3196/01 |
| Date of issue..... : | 06.01.2025 |
| Standard ..... : | EN 60204-1:2018 |
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|---|---|---|---|
| Compiled by..... : | Eng. C. HURSITOGLU | Approved by..... : | Eng. C. TAHIR |
| (+ signature) | | (+ signature) | |
| test case does not applytothe test object..... | | N/A | |
| test object does meet the requirement..... | | P(ass) | |
| test object does not meet the requirement..... | | F(ail) | |
| General Remarks | | | |

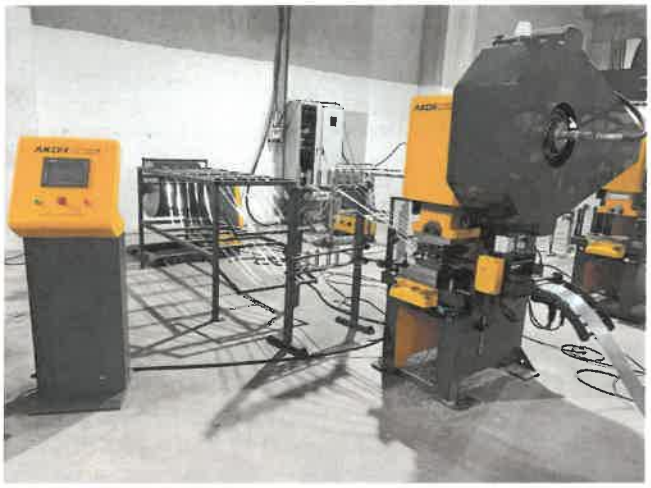
***The variants (AKR-EP2090, AKR-HB-2120, CASTLE JS9000, CASTLE JT9100) were analyzed and verified similar to the tested one (In electrical characteristic, all models mentioned above are similar, the difference among them are appearance and rated input power). The difference has no impact on the safety characteristics, then the result of this test report are valid for all models.***

"(see remark #)" refers to a remark appended to the report.

"(see appended table)" refers to a table appended to the report.

Through out this report a comma is used as the decimal separator.

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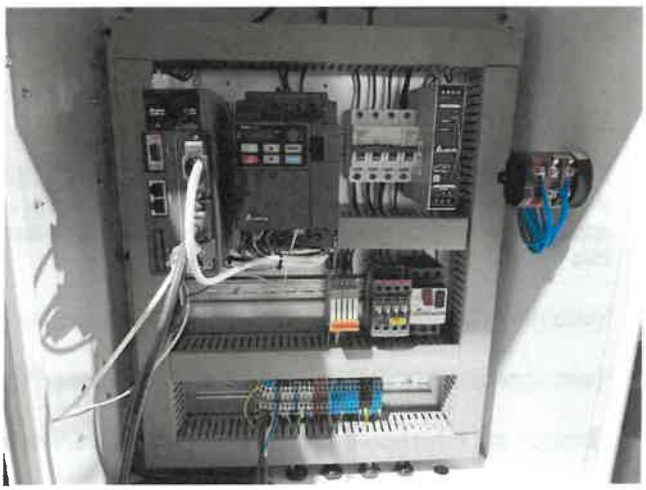












Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| **4.** | ***General requirements*** | | |
| 4.1 | **General**<br>This part of IEC 60204 is intended to apply to electrical equipment used with a wide variety of machines and with a group of machines working together in a co-ordinated manner. | ✓ | PASS |
| 4.2 | **Selection of equipmen** | | |
| 4.2.1 | **General**<br>Electrical components and devices shall:<br>– be suitable for their intended use; and<br>– conform to relevant IEC standards where such exist; and<br>– be applied in accordance with the supplier's instructions. | ✓ | PASS |
| 4.2.2 | **Electrical equipment in compliance with the IEC 60439 series**<br>The electrical equipment of the machine shall satisfy the safety requirements identified by the risk assessment of the machine. Depending upon the machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the machine that are in compliance with EN 60439-1 and, as necessary, other relevant parts of the EN 60439 series (see also Annex F) | ✓<br>The electrical equipment of the machine satisfy the safety requirements identified by the risk assessment of the machine | PASS |
| 4.3 | **Electrical supply** | | |
| 4.3.1 | **General**<br>The electrical equipment shall be designed to operate correctly with the conditions of the supply:<br>– as specified in 4.3.2 or 4.3.3, or<br>– as otherwise specified by the user (see Annex B), or<br>– as specified by the supplier in the case of a special source of supply such as an on-board generator. | ✓ | PASS |
| 4.3.2 | **AC supplies**<br>**Voltage** Steady state voltage: 0,9 to 1,1 of nominal voltage.<br>**Frequency** 0,99 to 1,01 of nominal frequency continuously; 0,98 to 1,02 short time.<br>**Harmonics** Harmonic distortion not exceeding 10 % of the total r.m.s. voltage between live conductors for the sum of the 2nd through to the 5th harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the 6th through to the 30th harmonic is permissible.<br>**Voltage unbalance** Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies exceeding 2 % of the positive sequence component.<br>**Voltage interruption** Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle with more than 1 s between successive interruptions.<br>**Voltage dips** Voltage dips not exceeding 20 % of the peak voltage of the supply for more than one cycle with more than 1 s between successive dips. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 4.3.3 | **DC supplies**<br>From batteries:<br>**Voltage** 0,85 to 1,15 of nominal voltage 0,7 to 1,2 of nominal voltage in the case of battery-operated vehicles.<br>**Voltage interruption** Not exceeding 5 ms. From converting equipment:<br>**Voltage** 0,9 to 1,1 of nominal voltage.<br>**Voltage interruption** Not exceeding 20 ms with more than 1 s between successive interruptions.<br>**Ripple (peak-to-peak)** Not exceeding 0,15 of nominal voltage. | *Not have DC supply* | N |
| 4.3.4 | **Special supply systems**<br>For special supply systems such as on-board generators, the limits given in 4.3.2 and 4.3.3 may be exceeded provided that the equipment is designed to operate correctly with those conditions. | ✓ | PASS |
| 4.4 | **Physical environment and operating conditions** | ✓<br>*The equipment is suitable for the physical environment and operating conditions of its intended use* | PASS |
| 4.4.1 | **General**<br>The electrical equipment shall be suitable for the physical environment and operating conditions of its intended use. The requirements of 4.4.2 to 4.4.8 cover the physical environment and operating conditions of the majority of machines covered by this part of EN 60204. When special conditions apply or the limits specified are exceeded, an agreement between user and supplier (see 4.1) is recommended (see Annex B). | ✓ | PASS |
| 4.4.2 | **Electromagnetic compatibility (EMC)**<br>The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the equipment shall have a level of immunity to electromagnetic disturbances so that it can function in its intended environment. | ✓ | PASS |
| 4.4.3 | **Ambient air temperature**<br>Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation between air temperatures of +5 °C and +40 °C. For very hot environments (for example hot climates, steel mills, paper mills) and for cold environments, additional measures are recommended (see Annex B). | *Specified in the instruction manual* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 4.4.4 | **Humidity**<br>The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities are permitted at lower temperatures (for example 90 % at 20 °C).<br>Harmful effects of occasional condensation shall be avoided by design of the equipment or, where necessary, by additional measures (for example built-in heaters, air conditioners, drain holes). | ✓<br>*The machine design and characteristic Of the machine is suitable for operating Correctly for the given requirements Specified in the instruciton manual capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities are permitted at lower temperatures (for example 90 % at 20 °C).* | PASS |
| 4.4.5 | **Altitude**<br>Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m above mean sea level. | ✓<br>*See instruciton manual* | PASS |
| 4.4.6 | **Contaminants**<br>Electrical equipment shall be adequately protected against the ingress of solids and liquids<br>The electrical equipment shall be adequately protected against contaminants (for example dust, acids, corrosive gases, salts) that can be present in the physical environment in which the electrical equipment is to be installed (see Annex B). | ✓<br>*Electrical equipment is protected against the ingress of solids and liquids e.g accesing the electrical box is used switching* | PASS |
| 4.4.7 | **Ionizing and non-ionizing radiation**<br>When equipment is subject to radiation (for example microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement is recommended between the supplier and the user (see Annex B). | *Not applicable* | N |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

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| 4.4.8 | **Vibration, shock, and bump**<br>Undesirable effects of vibration, shock and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by provision of anti-vibration mountings. A special agreement is recommended between the supplier and the user (see Annex B). | *Not applicable* | N |
| 4.5 | **Transportation and storage**<br>Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of – 25 °C to +55 °C and for short periods not exceeding 24 h at up to +70 °C. Suitable means shall be provided to prevent damage from humidity, vibration, and shock. A special agreement can be necessary between the supplier and the user (see Annex B). | ✓<br>*Specified in the instruction manual how to transportate and storage* | PASS |
| 4.6 | **Provisions for handling**<br>Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment. | ✓ | PASS |
| 4.7 | **Installation**<br>Electrical equipment shall be installed in accordance with the electrical equipment supplier's instructions. | ✓ | PASS |
| 5. | **INCOMING SUPPLY CONDUCTOR TERMINATIONS AND DEVICES FOR DISCONNECTING AND SWITCHING OFF** | | |
| 5.1 | **Incoming supply conductor terminations**<br>It is recommended that, where practicable, the electrical equipment of a machine is connected to a single incoming supply. Where another supply is necessary for certain parts of the equipment (for example, electronic equipment that operates at a different voltage), that supply should be derived, as far as is practicable, from devices (for example, transformers, converters) forming part of the electrical equipment of the machine. For large complex machinery comprising a number of widely-spaced machines working together in a coordinated manner, there can be a need for more than one incoming supply depending upon the site supply arrangements (see 5.3.1).<br>Unless a plug is provided with the machine for the connection to the supply (see 5.3.2 e)), it is recommended that the supply conductors are terminated at the supply disconnecting device.<br>Where a neutral conductor is used it shall be clearly indicated in the technical documentation of the machine, such as in the installation diagram and in the circuit diagram, and a separate insulated terminal, labelled N in accordance with 16.1, shall be provided for the neutral conductor (see also Annex B).<br>There shall be no connection between the neutral conductor and the protective bonding circuit inside the electrical equipment nor shall a combined PEN terminal be provided.<br>**Exception:** a connection may be made between the neutral terminal and the PE terminal at the point of the connection of the power supply to the machine for TN-C systems. | ✓ | PASS |
| 5.2 | **Terminal for connection to the external protective earthing system**<br>For each incoming supply, a terminal shall be provided in the vicinity of the associated phase conductor terminals for connection of the machine to the external protective earthing system or to the external protective conductor, depending upon the supply distribution system. The terminal shall be of such a size as to enable the connection of an external protective copper conductor with a cross-sectional area in accordance with Table<br>Where an external protective conductor of a material other than copper is used, the terminal size shall be selected accordingly (see also 8.2.2).<br>At each incoming supply point, the terminal for connection of the external protective earthing system or the external protective conductor shall be marked or labelled with the letters PE (see IEC 60445). | ✓<br>*Copper is used for protective conductor* | PASS |
| 5.3 | **Supply disconnecting (isolating) device** | | |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 5.3.1 | **General**<br>A supply disconnecting device shall be provided:<br>– for each incoming source of supply to a machine(s);<br>– for each on-board power supply.<br>The supply disconnecting device shall disconnect (isolate) the electrical equipment of the machine from the supply when required (for example for work on the machine, including the electrical equipment).<br>When two or more supply disconnecting devices are provided, protective interlocks for their correct operation shall also be provided in order to prevent a hazardous situation, including damage to the machine or to the work in progress. | ✓<br>*Disconnecting device is used in the box Which is going to be provided with the Machine, not on the machine* | PASS |
| 5.3.2 | **Type**<br>The supply disconnecting device shall be one of the following types: | ✓ | PASS |
| 5.3.3 | **Requirements**<br>When the supply disconnecting device is one of the types specified in 5.3.2 a) to d) it shall fulfil all of the following requirements: | ✓ | PASS |
| 5.3.4 | **Operating means**<br>The operating means (for example, a handle) of the supply disconnecting device shall be easily accessible and located between 0,6 m and 1,9 m above the servicing level. An upper limit of 1,7 m is recommended. | ✓ | PASS |
| 5.3.5 | **Excepted circuits**<br>The following circuits need not be disconnected by the supply disconnecting device:<br>– lighting circuits for lighting needed during maintenance or repair;<br>– plug and socket outlets for the exclusive connection of repair or maintenance tools and equipment (for example hand drills, test equipment);<br>– undervoltage protection circuits that are only provided for automatic tripping in the event of supply failure;<br>– circuits supplying equipment that should normally remain energized for correct operation (for example temperature controlled measuring devices, product (work in progress) heaters, program storage devices);<br>– control circuits for interlocking. | ✓ | PASS |
| 5.4 | **Devices for switching off for prevention of unexpected start-up**<br>Devices for switching off for the prevention of unexpected start-up shall be provided (for example where, during maintenance, a start-up of the machine or part of the machine can create a hazard).<br>Such devices shall be appropriate and convenient for the intended use, shall be suitably placed, and readily identifiable as to their function and purpose (for example by a durable marking in accordance with 16.1 where necessary).<br>Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other locations (see also 5.6).<br>The following devices that fulfil the isolation function may be provided for this purpose:<br>– devices described in 5.3.2,<br>– disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see 3.19).<br>Devices that do not fulfil the isolation function (for example a contactor switched off by a control circuit) may only be provided where intended to be used for situations that include:<br>– inspections;<br>– adjustments;<br>– work on the electrical equipment where:<br>– there is no hazard arising from electric shock (see Clause 6) and burn;<br>– the switching off means remains effective throughout the work;<br>– the work is of a minor nature (for example replacement of plug-in devices without disturbing existing wiring). | ✓<br>*protected by contactors* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 5.5 | **Devices for disconnecting electrical equipment**<br>Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out when it is de-energised and isolated. Such devices shall be:<br>– appropriate and convenient for the intended use;<br>– suitably placed;<br>– readily identifiable as to which part(s) or circuit(s) of the equipment is served (for example by durable marking in accordance with 16.1 where necessary).<br>Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other locations (see also 5.6). | ✓ | PASS |
| 5.6 | **Protection against unauthorized, inadvertent and/or mistaken connection**<br>The devices described in 5.4 and 5.5 that are located outside an enclosed electrical operating area shall be equipped with means to secure them in the OFF position (disconnected state), (for example by provisions for padlocking, trapped key interlocking). When so secured, remote as well as local reconnection shall be prevented. | ✓ | PASS |
| **6.** | **Protection against electric shock** | ✓ | PASS |
| 6.1 | **General**<br>The electrical equipment shall provide protection of persons against electric shock from:<br>– direct contact (see 6.2 and 6.4);<br>– indirect contact (see 6.3 and 6.4).<br>The measures for this protection given in 6.2, 6.3, and, for PELV, in 6.4, are a recommended selection from IEC 60364-4-41. Where those recommended measures are not practicable, for example due to the physical or operational conditions, other measures from IEC 60364-4-41 may be used. | ✓ | PASS |
| 6.2 | **Protection against direct contact** | ✓ | PASS |
| 6.2.1 | **General**<br>For each circuit or part of the electrical equipment, the measures of either 6.2.2 or 6.2.3 and,where applicable, 6.2.4 shall be applied.<br>**Exception:** where those measures are not appropriate, other measures for protection against direct contact (for example by using barriers, by placing out of reach, using obstacles, using construction or installation techniques that prevent access) as defined in IEC 60364-4-41 may be applied (see 6.2.5 and 6.2.6).<br>When the equipment is located in places open to all persons, which can include children, measures of either 6.2.2 with a minimum degree of protection against direct contact corresponding to IP4X or IPXXD (see IEC 60529), or 6.2.3 shall be applied. | ✓<br>*Appliance have barriers to avoid accidental contact*<br>*Equipment is not located in places open to all persons* | PASS |
| 6.2.2 | **Protection by enclosures**<br>Live parts shall be located inside enclosures that conform to the relevant requirements of Clauses 4, 11, and 14 and that provide protection against direct contact of at least IP2X or IPXXB (see IEC 60529).<br>Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD.<br>Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only under one of the following conditions:<br>a) The use of a key or tool is necessary for access. For enclosed electrical operating areas, see IEC 60364-4-41, or IEC 60439-1 as appropriate. All live parts, that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected, shall be protected against direct contact to at least IP2X or IPXXB.<br>Other live parts on the inside of doors shall be protected against direct contact to at least IP1X or IPXXA.<br>b) The disconnection of live parts inside the enclosure before the enclosure can be opened. This may be accomplished by interlocking the door with a disconnecting device (for example, the supply disconnecting device) so that the door can only be opened when the disconnecting device is open and so that the disconnecting device can only be closed when the door is closed. | ✓<br>*Live parts are located inside* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 6.2.3 | **Protection by insulation of live parts**<br>Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions. | ✓<br>*Insulation withstands all requirements* | PASS |
| 6.2.4 | **Protection against residual voltages**<br>Live parts having a residual voltage greater than 60 V after the supply has been disconnected shall be discharged to 60 V or less within a time period of 5 s after disconnection of the supply voltage provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 µC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitances.<br>In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time shall not exceed 1 s, otherwise such conductors shall be protected against direct contact to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example<br>in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning device (for example a warning notice in accordance with 16.1) shall be applied. | ✓<br>*Conductors are protected against direct contact* | PASS |
| 6.2.5 | **Protection by barriers**<br>For protection by barriers, 412.2 of IEC 60364-4-41 shall apply. | ✓ | PASS |
| 6.2.6 | **Protection by placing out of reach or protection by obstacles**<br>For protection by placing out of reach, 412.4 of IEC 60364-4-41 shall apply. For protection by obstacles, 412.3 of IEC 60364-4-41 shall apply.<br>For conductor wire systems or conductor bar systems with a degree of protection less than IP2X, see 12.7.1. | ✓ | PASS |
| 6.3 | **Protection against indirect contact** | ✓ | PASS |
| 6.3.1 | **General**<br>Protection against indirect contact (3.29) is intended to prevent hazardous situations due to an insulation fault between live parts and exposed conductive parts.<br>For each circuit or part of the electrical equipment, at least one of the measures in accordance with 6.3.2 to 6.3.3 shall be applied:<br>– measures to prevent the occurrence of a touch voltage (6.3.2); or<br>– automatic disconnection of the supply before the time of contact with a touch voltage can become hazardous (6.3.3). | ✓ | PASS |
| 6.3.2 | **Prevention of the occurrence of a touch voltage** | ✓ | PASS |
| 6.3.2.1 | **General**<br>Measures to prevent the occurrence of a touch voltage include the following:<br>– provision of class II equipment or by equivalent insulation;<br>– electrical separation. | ✓ | PASS |
| 6.3.2.2 | **Protection by electrical separation**<br>Electrical separation of an individual circuit is intended to prevent a touch voltage through contact with exposed conductive parts that can be energized by a fault in the basic insulation of the live parts of that circuit.<br>For this type of protection, the requirements of 413.5 of IEC 60364-4-41 apply. | ✓ | PASS |

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 6.3.2.3 | **Protection by automatic disconnection of supply**<br>This measure consists of the interruption of one or more of the line conductors by the automatic operation of a protective device in case of a fault. This interruption shall ocur within a sufficiently short time to limit the duration of a touch voltage to a time within which the touch voltage is not hazardous. Interruption times are given in Annex A.<br>This measure necessitates co-ordination between:<br>– the type of supply and earthing system;<br>– the impedance values of the different elements of the protective bonding system;<br>– the characteristics of the protective devices that detect insulation fault(s).<br>Automatic disconnection of the supply of any circuit affected by an insulation fault is intended to prevent a hazardous situation resulting from a touch voltage.<br>This protective measure comprises both:<br>– protective bonding of exposed conductive parts (see 8.2.3),<br>– and either:<br>a) overcurrent protective devices for the automatic disconnection of the supply on detection of an insulation fault in TN systems, or<br>b) residual current protective devices to initiate the automatic disconnection of the supply on detection of an insulation fault from a live part to exposed conductive parts or to earth in TT systems, or<br>c) insulation monitoring or residual current protective devices to initiate automatic disconnection of IT systems. Except where a protective device is provided to interrupt<br>the supply in the case of the first earth fault, an insulation monitoring device shall be<br>provided to indicate the occurrence of a first fault from a live part to exposed<br>conductive parts or to earth. This insulation monitoring device shall initiate an audible<br>and/or visual signal which shall continue as long as the fault persists. | ✓ | PASS |
| 6.4 | **Protection by the use of PELV** | *Not applicable* | N |
| 6.4.1 | **General requirements**<br>The use of PELV (Protective Extra-Low Voltage) is to protect persons against electric shock from indirect contact and limited area direct contact (see 8.2.5).<br>PELV circuits shall satisfy all of the following conditions:<br>a) the nominal voltage shall not exceed:<br>• 25 V AC r.m.s. or 60 V ripple-free DC when the equipment is normally used in dry locations and when large area contact of live parts with the human body is not expected; or<br>• 6 V AC r.m.s. or 15 V ripple-free DC in all other cases;<br>b) one side of the circuit or one point of the source of the supply of that circuit shall be connected to the protective bonding circuit;<br>c) live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer (see IEC 61558-1 and IEC 61558-2-6 );<br>d) conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of 13.1.3 shall apply;<br>e) plugs and socket-outlets for a PELV circuit shall conform to the following:<br>1) plugs shall not be able to enter socket-outlets of other voltage systems;<br>2) socket-outlets shall not admit plugs of other voltage systems. | *Not applicable* | N |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 6.4.2 | **Sources for PELV**<br>The source for PELV shall be one of the following:<br>– a safety isolating transformer in accordance with IEC 61558-1 and IEC 61558-2-6;<br>– a source of current providing a degree of safety equivalent to that of the safety isolating transformer (for example a motor generator with winding providing equivalent isolation);<br>– an electrochemical source (for example a battery) or another source independent of a higher voltage circuit (for example a diesel-driven generator);<br>– an electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in 6.4.1. | *Not applicable* | N |
| **7.** | **Protection of equipment** | | |
| 7.1 | **General**<br>This Clause details the measures to be taken to protect equipment against the effects of:<br>– overcurrent arising from a short circuit;<br>– overload and/or loss of cooling of motors;<br>– abnormal temperature;<br>– loss of or reduction in the supply voltage;<br>– overspeed of machines/machine elements;<br>– earth fault/residual current;<br>– incorrect phase sequence;<br>– overvoltage due to lightning and switching surges. | ✓ | PASS |
| 7.2 | **Overcurrent protection** | ✓ | PASS |
| 7.2.1 | **General**<br>Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be selected are detailed in 7.2.10. | ✓ | PASS |
| 7.2.2 | **Supply conductors**<br>Unless otherwise specified by the user, the supplier of the electrical equipment is not responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment (see Annex B).<br>The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device (see 7.2.10 and 17.4). | ✓ | PASS |
| 7.2.3 | Devices for detection and interruption of overcurrent, selected in accordance with 7.2.10, shall be applied to each live conductor.<br>The following conductors, as applicable, shall not be disconnected without disconnecting all associated live conductors:<br>– the neutral conductor of AC power circuits;<br>– the earthed conductor of DC power circuits;<br>– DC power conductors bonded to exposed conductive parts of mobile machines.<br>Where the cross-sectional area of the neutral conductor is at least equal to or equivalent to that of the phase conductors, it is not necessary to provide overcurrent detection for the neutral conductor nor a disconnecting device for that conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated phase conductors, the measures<br>detailed in 524 of IEC 60364-5-52 shall apply.<br>In IT systems, it is recommended that the neutral conductor is not used. However, where a neutral conductor is used, the measures detailed in 431.2.2 of IEC 60364-4-43 shall apply. | ✓ | PASS |

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 7.2.4 | **Control circuits**<br>Conductors of control circuits directly connected to the supply voltage and of circuits supplying control circuit transformers shall be protected against overcurrent in accordance with 7.2.3.<br>Conductors of control circuits supplied by a control circuit transformer or DC supply shall be protected against overcurrent (see also 9.4.3.1):<br>– in control circuits connected to the protective bonding circuit, by inserting an overcurrent protective device into the switched conductor;<br>– in control circuits not connected to the protective bonding circuit;<br>– where the same cross sectional area conductors are used in all control circuits, by inserting an overcurrent protective device into the switched conductor, and;<br>– where different cross sectional areas conductors are used in different sub-circuits, by inserting an overcurrent protective device into both switched and common conductors of each sub-circuit | ✓<br>*See manual* | PASS |
| 7.2.5 | **Socket outlets and their associated conductors**<br>Overcurrent protection shall be provided for the circuits feeding the general purpose socket outlets intended primarily for supplying power to maintenance equipment. Overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket outlets. | *Not applicable* | N |
| 7.2.6 | **Lighting circuits**<br>All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of overcurrent devices separate from those protecting other circuits. | *Not have lighting appliance* | N |
| 7.2.7 | **Transformers**<br>Transformers shall be protected against overcurrent in accordance with the manufacturer's instructions. Such protection shall (see also 7.2.10):<br>– avoid nuisance tripping due to transformer magnetizing inrush currents;<br>– avoid a winding temperature rise in excess of the permitted value for the insulation class of transformer when it is subjected to the effects of a short circuit at its secondary terminals.<br>The type and setting of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier. | *Not applicable* | N |
| 7.2.8 | **Location of overcurrent protective devices**<br>An overcurrent protective device shall be located at the point where a reduction in the crosssectional area of the conductors or another change reduces the current-carrying capacity of the conductors, except where all the following conditions are satisfied:<br>– the current carrying capacity of the conductors is at least equal to that of the load;<br>– the part of the conductor between the point of reduction of current-carrying capacity and the position of the overcurrent protective device is no longer than 3 m;<br>– the conductor is installed in such a manner as to reduce the possibility of a short-circuit, for example, protected by an enclosure or duct. | ✓<br>*the part of the conductor between the point of reduction of current-carrying capacity and the position of the overcurrent protective device is located in 0,7 m*<br>*Specified in the instruction manual* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

EN 60204-1:2018
Safety of machinery - Electrical equipment of machines – Part 1: General requirements

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 7.2.9 | **Overcurrent protective devices**<br>The rated short-circuit breaking capacity shall be at least equal to the prospective fault current at the point of installation. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (for example from motors, from power factor correction capacitors), those currents shall be taken into consideration.<br>A lower breaking capacity is permitted where another protective device (for example the overcurrent protective device for the supply conductors (see 7.2.2) having the necessary breaking capacity is installed on the supply side. In that case, the characteristics of the two devices shall be co-ordinated so that the let-through energy ($I^2t$) of the two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected by that device (see Annex A of IEC 60947-2).<br>Where fuses are provided as overcurrent protective devices, a type readily available in the country of use shall be selected, or arrangements shall be made for the supply of spare parts | ✓ | PASS |
| 7.2.10 | **Rating and setting of overcurrent protective devices**<br>The rated current of fuses or the setting current of other overcurrent protective devices shall be selected as low as possible but adequate for the anticipated overcurrents (for example during starting of motors or energizing of transformers). When selecting those protective devices, consideration shall be given to the protection of switching devices against damage<br>due to overcurrents (for example welding of the switching device contacts).<br>The rated current or setting of an overcurrent protective device is determined by the current carrying capacity of the conductors to be protected in accordance with 12.4, D.2 and the maximum allowable interrupting time $t$ in accordance with Clause D.3, taking into account the needs of co-ordination with other electrical devices in the protected circuit. | ✓<br>*See manual* | PASS |
| 7.3 | **Protection of motors against overheating** | | |
| 7.3.1 | **General**<br>Protection of motors against overheating shall be provided for each motor rated at more than 0,5 kW.<br>Protection of motors against overheating can be achieved by:<br>– overload protection (7.3.2),<br>– over-temperature protection (7.3.3), or<br>– current-limiting protection (7.3.4).<br>Automatic restarting of any motor after the operation of protection against overheating shall be prevented where this can cause a hazardous situation or damage to the machine or to the work in progress. | ✓<br>*By over temperature protection* | PASS |
| 7.3.2 | **Overload protection**<br>Where overload protection is provided, detection of overload(s) shall be provided in each live conductor except for the neutral conductor. However, where the motor overload detection is not used for cable overload protection (see also Clause D.2), the number of overload detection devices may be reduced at the request of the user (see also Annex B). For motors having single-phase or DC power supplies, detection in only one unearthed live conductor is permitted.<br>Where overload protection is achieved by switching off, the switching device shall switch off all live conductors. The switching of the neutral conductor is not necessary for overload protection. Where motors with special duty ratings are required to start or to brake frequently (for example, motors for rapid traverse, locking, rapid reversal, sensitive drilling) it can be difficult to provide overload protection with a time constant comparable with that of the winding to be protected. Appropriate protective devices designed to accommodate special duty motors or over-temperature protection (see 7.3.3) can be necessary. For motors that cannot be overloaded (for example torque motors, motion drives that either are protected by mechanical overload protection devices or are adequately dimensioned), overload protection is not required. | ✓<br>*See manual* | PASS |

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 7.3.3 | **Over-temperature protection**<br>The provision of motors with over-temperature protection (see IEC 60034-11) is recommended in situations where the cooling can be impaired (for example dusty environments). Depending upon the type of motor, protection under stalled rotor or loss of phase conditions is not always ensured by over-temperature protection, and additional protection should then be provided.<br>Over-temperature protection is also recommended for motors that cannot be overloaded (for example torque motors, motion drives that are either protected by mechanical overload protection devices or are adequately dimensioned), where the possibility of over-temperature exists (for example due to reduced cooling). | ✓ | PASS |
| 7.3.4 | **Current limiting protection**<br>Where protection against the effects of overheating in three phase motors is achieved by current limitation, the number of current limitation devices may be reduced from 3 to 2 (see 7.3.2). For motors having single phase AC or DC power supplies, current limitation in only one unearthed live conductor is permitted. | ✓<br>*current limitation device* | PASS |
| 7.4 | **Abnormal temperature protection**<br>Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures (for example, due to short-time rating or loss of cooling medium) and therefore can cause a hazardous situation shall be provided with suitable detection to initiate an appropriate control response. | ✓ | PASS |
| 7.5 | **Protection against supply interruption or voltage reduction and subsequent restoration**<br>Where a supply interruption or a voltage reduction can cause a hazardous situation, damage to the machine, or to the work in progress, undervoltage protection shall be provided by, for example, switching off the machine at a predetermined voltage level. | ✓ | PASS |
| 7.6 | **Motor overspeed protection**<br>Overspeed protection shall be provided where overspeeding can occur and could possibly cause a hazardous situation taking into account measures in accordance with 9.3.2. Overspeed protection shall initiate appropriate control responses and shall prevent automatic restarting. The overspeed protection should operate in such a manner that the mechanical speed limit of the motor or its load is not exceeded. | ✓ | PASS |
| 7.7 | **Earth fault/residual current protection**<br>In addition to providing overcurrent protection for automatic disconnection as described in 6.3, earth fault/residual current protection can be provided to reduce damage to equipment due to earth fault currents less than the detection level of the overcurrent protection. The setting of the devices shall be as low as possible consistent with correct operation of the equipment. | ✓ | PASS |
| 7.8 | **Phase sequence protection**<br>Where an incorrect phase sequence of the supply voltage can cause a hazardous situation or damage to the machine, protection shall be provided. | ✓ | PASS |
| 7.9 | **Protection against overvoltages due to lightning and to switching surges**<br>Protective devices can be provided to protect against the effects of overvoltages due to lightning or to switching surges. Where provided:<br>– devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device.<br>– devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection. | *Not applicable* | N |
| 8. | **Equipotential bonding** | | |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 8.1 | **General**<br>This Clause provides requirements for both protective bonding and functional bonding. Figure 2 illustrates those concepts. Protective bonding is a basic provision for fault protection to enable protection of persons against electric shock from indirect contact (see 6.3.3 and 8.2).<br>The objective of functional bonding (see 8.3) is to minimize:<br>– the consequence of an insulation failure which could affect the operation of the machine;<br>– the consequences of electrical disturbances to sensitive electrical equipment which could affect the operation of the machine.<br>Normally functional bonding is achieved by connection to the protective bonding circuit, but where the level of electrical disturbances on the protective bonding circuit is not sufficiently low for proper functioning of electrical equipment, it may be necessary to connect the functional bonding circuit to a separate functional earthing conductor (see Figure 2). | ✓ | PASS |
| 8.2 | **Protective bonding circuit** | | |
| 8.2.1 | **General**<br>The protective bonding circuit consists of:<br>– PE terminal(s) (see 5.2);<br>– the protective conductors in the equipment of the machine including sliding contacts where they are part of the circuit;<br>– the exposed conductive parts and conductive structural parts of the electrical equipment;<br>– those extraneous conductive parts which form the structure of the machine.<br>All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit.<br>Where the conductance of structural parts of the electrical equipment or of the machine is less than that of the smallest protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided. This supplementary bonding conductor shall have a cross-sectional area not less than half that of the corresponding protective conductor.<br>If an IT distribution system is used, the machine structure shall be part of the protective bonding circuit and insulation monitoring shall be provided. See 6.3.3 c). Conductive structural parts of equipment in accordance with 6.3.2.2 need not be connected to the protective bonding circuit. Extraneous conductive parts which form the structure of the machine need not be connected to the protective bonding circuit where all the equipment provided is in accordance with 6.3.2.2.<br>Exposed conductive parts of equipment in accordance with 6.3.2.3 shall not be connected to the protective bonding circuit. | ✓<br>*Have PE terminal* | PASS |
| 8.2.2 | **Protective conductors**<br>Protective conductors shall be identified in accordance with 13.2.2. Copper conductors are preferred. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of the allowable copper conductor and such conductors shall be not less than 16 mm2 in cross-sectional area. The cross-sectional area of protective conductors shall be determined in accordance with the requirements of:<br>– 543 of IEC 60364-5-54; or<br>– 7.4.3.1.7 of IEC 60439-1, as appropriate.<br>This requirement is met in most cases where the relationship between the cross-sectional area of the phase conductors associated with that part of the equipment and the crosssectional area of the associated protective conductor is in accordance with Table 1 (see 5.2). | ✓<br>*PE conductors identified*<br>✓<br>*Copper conductor* | PASS |
| 8.2.3 | **Continuity of the protective bonding circuit**<br>All exposed conductive parts shall be connected to the protective bonding circuit in accordance with 8.2.1. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 8.2.4 | **Exclusion of switching devices from the protective bonding circuit**<br>The protective bonding circuit shall not incorporate a switching device or an overcurrent protective device (for example switch, fuse).<br>No means of interruption of the protective bonding conductor shall be provided. | *Not have switching devices which PE Conductor is connected to.* | N |
| 8.2.5 | **Parts that need not be connected to the protective bonding circuit**<br>It is not necessary to connect exposed conductive parts to the protective bonding circuit where those parts are mounted so that they do not constitute a hazard because:<br>– they cannot be touched on large surfaces or grasped with the hand and they are small in size (less than approximately 50 mm × 50 mm); or<br>– they are located so that either contact with live parts, or an insulation failure, is unlikely. This applies to small parts such as screws, rivets, and nameplates and to parts inside an enclosure, irrespective of their size (for example electromagnets of contactors or relays and mechanical parts of devices) (see also 410.3.3.5 of IEC 60364-4-41). | ✓ | PASS |
| 8.2.6 | **Protective conductor connecting points**<br>All protective conductors shall be terminated in accordance with 13.1.1. The protective conductor connecting points shall have no other function and are not intended, for example, to attach or connect appliances or parts.<br>Each protective conductor connecting point shall be marked or labelled as such using the symbol IEC 60417-5019 (DB:2002-10): | ✓<br>*Terminated in accordance with 13.1.1 and marked using the symbol IEC 60417-5019* | PASS |
| 8.2.7 | **Mobile machines**<br>On mobile machines with on-board power supplies, the protective conductors, the conductive structural parts of the electrical equipment, and those extraneous conductive parts which form the structure of the machine shall all be connected to a protective bonding terminal to provide protection against electric shock. Where a mobile machine is also capable of being connected to an external incoming power supply, this protective bonding terminal shall be the connection point for the external protective conductor. | *Not a mobile machine* | N |
| 8.2.8 | **Additional protective bonding requirements for electrical equipment having earth leakage currents higher than 10 mA AC or DC**<br>Where electrical equipment has an earth leakage current (for example adjustable speed electrical power drive systems and information technology equipment) that is greater than 10 mA AC or DC in any incoming supply, one or more of the following conditions for the associated protective bonding circuit shall be satisfied:<br>a) the protective conductor shall have a cross-sectional area of at least 10 mm2 Cu or 16 mm2 Al, through its total run;<br>b) where the protective conductor has a cross-sectional area of less than 10 mm2 Cu or 16 mm2 Al, a second protective conductor of at least the same cross-sectional area shall be provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm2 Cu or 16 mm2 Al;<br>NOTE 3 This can require that the electrical equipment has a separate terminal for a second protective conductor.<br>c) automatic disconnection of the supply in case of loss of continuity of the protective conductor.<br>To prevent difficulties associated with electromagnetic disturbances, the requirements of 4.4.2 also apply to the installation of duplicate protective conductors. In addition, a warning label shall be provided adjacent to the PE terminal, and where necessary on the nameplate of the electrical equipment. The information provided under 17.2<br>b)1) shall include information about the leakage current and the minimum cross-sectional area of the external protective conductor. | *Earth leakage current is less than 10mA* | N |
| 8.3 | **Functional bonding**<br>Protection against maloperation as a result of insulation failures can be achieved by connecting to a common conductor in accordance with 9.4.3.1.<br>For recommendations regarding functional bonding to avoid maloperation due to electromagnetic disturbances, see 4.4.2. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 8.4 | **Measures to limit the effects of high leakage current**<br>The effects of high leakage current can be restricted to the equipment having high leakage current by connection of that equipment to a dedicated supply transformer having separate windings. The protective bonding circuit shall be connected to exposed conductive parts of the equipment and, in addition, to the secondary winding of the transformer. The protective<br>conductor(s) between the equipment and the secondary winding of the transformer shall comply with one or more of the arrangements described in 8.2.8. | ✓ | PASS |
| **9.** | **Control circuits and control functions** | | |
| 9.1 | **Control circuits** | ✓ | PASS |
| 9.1.1 | **Control circuit supply**<br>Where control circuits are supplied from an AC source, control transformers shall be used for supplying the control circuits. Such transformers shall have separate windings. Where several transformers are used, it is recommended that the windings of those transformers be connected in such a manner that the secondary voltages are in phase.<br>Where DC control circuits derived from an AC supply are connected to the protective bonding circuit (see 8.2.1), they shall be supplied from a separate winding of the AC control circuit transformer or by another control circuit transformer.<br>Transformers are not mandatory for machines with a single motor starter and/or a maximum of two control devices (for example interlock device, start/stop control station). | ✓ | PASS |
| 9.1.2 | **Control circuit voltages**<br>The nominal value of the control voltage shall be consistent with the correct operation of the control circuit. The nominal voltage shall not exceed 277 V when supplied from a transformer. | ✓ | PASS |
| 9.1.3 | **Protection**<br>Control circuits shall be provided with overcurrent protection in accordance with 7.2.4 and 7.2.10. | ✓ | PASS |
| 9.2 | **Control functions** | | |
| 9.2.1 | **Start functions**<br>Start functions shall operate by energizing the relevant circuit (see 9.2.5.2). | ✓ | PASS |
| 9.2.2 | **Stop functions**<br>There are three categories of stop functions as follows:<br>– stop category 0: stopping by immediate removal of power to the machine actuators (i.e. an uncontrolled stop – see 3.56);<br>– stop category 1: a controlled stop (see 3.11) with power available to the machine actuators to achieve the stop and then removal of power when the top is achieved;<br>– stop category 2: a controlled stop with power left available to the machine actuators. | ✓ | PASS |
| 9.2.3 | **Operating modes**<br>Each machine can have one or more operating modes determined by the type of machine and its application. When a hazardous situation can result from a mode selection, unauthorised and/or inadvertent selection shall be prevented by suitable means (for example key operated switch, access code).<br>Mode selection by itself shall not initiate machine operation. A separate actuation of the start control shall be required.<br>For each specific operating mode, the relevant safety functions and/or protective measures shall be implemented.<br>Indication of the selected operating mode shall be provided (for example the position of a mode selector, the provision of an indicating light, a visual display indication). | *mode selection is controlled manually* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.2.4 | **Suspension of safety functions and/or protective measures**<br>Where it is necessary to suspend safety functions and/or protective measures (for example for setting or maintenance purposes), protection shall be ensured by:<br>– disabling all other operating (control) modes; and<br>– other relevant means (see 4.11.9 of ISO 12100-2:2003), that can include, for example, one or more of the following:<br>– initiation of operation by a hold-to-run device or by a similar control device;<br>– a portable control station with an emergency stop device and, where appropriate, an enabling device. Where a portable control station is in use, initiation of motion shall only be possible from that control station;<br>– a cableless control station with a device to initiate stop functions in accordance with 9.2.7.3 and, where appropriate, an enabling device. Where a cableless control station is in use, initiation of motion shall only be possible from that control station;<br>– limitation of the speed or the power of motion;<br>– limitation of the range of motion. | *Not applicable* | N |
| 9.2.5 | **Operation** | | |
| 9.2.5.1 | **General**<br>The necessary safety functions and/or protective measures (for example interlocks (see 9.3)) shall be provided for safe operation. Measures shall be taken to prevent movement of the machine in an unintended or unexpected manner after any stopping of the machine (for example due to locked-off condition, power supply fault, battery replacement, lost signal condition with cableless control).<br>Where a machine has more than one control station, measures shall be provided to ensure that initiation of commands from different control stations do not lead to a hazardous situation. | ✓ | PASS |
| 9.2.5.2 | **Start**<br>The start of an operation shall be possible only when all of the relevant safety functions and/or protective measures are in place and are operational except for conditions as described in 9.2.4.<br>On those machines (for example mobile machines) where safety functions and/or protective measures cannot be applied for certain operations, manual control of such operations shall be by hold-to-run controls, together with enabling devices, as appropriate.<br>Suitable interlocks shall be provided to secure correct sequential starting. In the case of machines requiring the use of more than one control station to initiate a start, each of these control stations shall have a separate manually actuated start control device.<br>The conditions to initiate a start shall be:<br>– all required conditions for machine operation shall be met, and<br>– all start control devices shall be in the released (off) position, then<br>– all start control devices shall be actuated concurrently (see 3.6). | ✓ | PASS |
| 9.2.5.3 | **Stop**<br>Stop category 0 and/or stop category 1 and/or stop category 2 stop functions shall be provided as indicated by the risk assessment and the functional requirements of the machine (see 4.1).<br>NOTE The supply disconnecting device (see 5.3) when operated achieves a stop category 0. Stop functions shall override related start functions (see 9.2.5.2). Where required, facilities to connect protective devices and interlocks shall be provided. If such a protective device or interlock causes a stop of the machine, it may be necessary for that condition to be signalled to the logic of the control system. The reset of the stop function shall not initiate any hazardous situation.<br>Where more than one control station is provided, stop commands from any control station shall be effective when required by the risk assessment of the machine. | ✓<br>*Decleration of manufacturer*<br><br>*Stop button carries out stopping function* | PASS |
| 9.2.5.4 | **Emergency operations (emergency stop, emergency switching off)** | ✓<br>*Have an emergency stop.* | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.2.5.4.1 | **General**<br>This part of IEC 60204 specifies the requirements for the emergency stop and the emergency switching off functions of the emergency operations listed in Annex E, both of which are, in this part of IEC 60204, initiated by a single human action. Once active operation of an emergency stop (see 10.7) or emergency switching off (see 10.8) actuator has ceased following a command, the effect of this command shall be sustained until it is reset. This reset shall be possible only by a manual action at that location where the command has been initiated. The reset of the command shall not restart the machinery but only permit restarting. It shall not be possible to restart the machinery until all emergency stop commands have been reset. It shall not be possible to reenergize the machinery until all emergency switching off commands have been reset. | ✓ | PASS |
| 9.2.5.4.2 | **Emergency stop**<br>Principles for the design of emergency stop equipment, including functional aspects, are given in ISO 13850.<br>The emergency stop shall function either as a stop category 0 or as a stop category 1 (see 9.2.2). The choice of the stop category of the emergency stop depends on the results of a risk assessment of the machine.<br>In addition to the requirements for stop (see 9.2.5.3), the emergency stop function has the following requirements:<br>– it shall override all other functions and operations in all modes;<br>– power to the machine actuators that can cause a hazardous situation(s) shall be either removed immediately (stop category 0) or shall be controlled in such a way to stop the hazardous motion as quickly as possible (stop category 1) without creating other hazards;<br>– reset shall not initiate a restart. | ✓<br>*a functional test has been prformed and the results are found in complience with the ISO 13850.*<br><br>*it overrides all other functions and operations in all modes.*<br><br>*power to the machine actuators removed immediately*<br><br>*reset does not initiate a restart* | PASS |
| 9.2.3.4.3 | **Emergency switching off**<br>The functional aspects of emergency switching off are given in 536.4 of IEC 60364-5-53. Emergency switching off should be provided where:<br>– protection against direct contact (for example with conductor wires, conductor bars, slipring assemblies, controlgear in electrical operating areas) is achieved only by placing out of reach or by obstacles (see 6.2.6); or<br>– there is the possibility of other hazards or damage caused by electricity.<br>Emergency switching off is accomplished by switching off the relevant incoming supply by electromechanical switching devices, effecting a stop category 0 of machine actuators connected to this incoming supply. When a machine cannot tolerate this stop category 0 stop, it may be necessary to provide other measures, for example protection against direct contact,<br>so that emergency switching off is not necessary. | ✓<br>*have emergency switch for,*<br>**protection against direct contact*<br>**the possibility of other hazards or damage caused by electricity* | PASS |
| 9.2.5.5 | **Monitoring of command actions**<br>Movement or action of a machine or part of a machine that can result in a hazardous situation shall be monitored by providing, for example, overtravel limiters, motor overspeed detection, mechanical overload detection or anti-collision devices. | ✓<br>*mechanical overload detection*<br>*overtravel limiters* | PASS |
| 9.2.6 | **Other control functions** | | |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.2.6.1 | **Hold-to-run controls**<br>Hold-to-run controls shall require continuous actuation of the control device(s) to achieve operation. | ✓ | PASS |
| 9.2.6.2 | **Two-hand control**<br>Three types of two-hand control are defined in ISO 13851, the selection of which is determined by the risk assessment. These shall have the following features:<br>**Type I**: this type requires:<br>– the provision of two control devices and their concurrent actuation by both hands;<br>– continuous concurrent actuation during the hazardous situation;<br>– machine operation shall cease upon the release of either one or both of the control devices when hazardous situations are still present.<br>A Type I two-hand control device is not considered to be suitable for the initiation of hazardous operation.<br>**Type II**: a type I control requiring the release of both control devices before machine operation can be reinitiated.<br>**Type III**: a type II control requiring concurrent actuation of the control devices as follows:<br>– it shall be necessary to actuate the control devices within a certain time limit of each other, not exceeding 0,5 s;<br>– where this time limit is exceeded, both control devices shall be released before machine operation can be initiated. | *Not Applicable* | N |
| 9.2.6.3 | **Enabling control**<br>Enabling control (see also 10.9) is a manually activated control function interlock that:<br>a) when activated allows a machine operation to be initiated by a separate start control, and<br>b) when de-activated<br>– initiates a stop function, in accordance with 9.2.5.3, and<br>– prevents initiation of machine operation.<br>Enabling control shall be so arranged as to minimize the possibility of defeating, for example by requiring the de-activation of the enabling control device before machine operation may be reinitiated. It should not be possible to defeat the enabling function by simple means. | *Not applicable* | N |
| 9.2.6.4 | **Combined start and stop controls**<br>Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be provided for functions which cannot result in a hazardous situation. | *Not applicable* | N |
| 9.2.7 | **Cableless control** | | |
| 9.2.7.1 | **General**<br>This subclause deals with the functional requirements of control systems employing cableless (for example radio, infra-red) techniques for transmitting commands and signals between a machine control system and operator control station(s).<br>Means shall be provided to readily remove or disconnect the power supply of the operator control station (see also 9.2.7.3).<br>Means (for example key operated switch, access code) shall be provided, as necessary, to prevent unauthorized use of the operator control station. Each operator control station shall carry an unambiguous indication of which machine(s) is (are) intended to be controlled by that operator control station. | *Not have cableless control* | N |
| 9.2.7.2 | **Control limitation**<br>Measures shall be taken to ensure that control commands:<br>– affect only the intended machine;<br>– affect only the intended functions.<br>Measures shall be taken to prevent the machine from responding to signals other than those from the intended operator control station(s).<br>Where necessary, means shall be provided so that the machine can only be controlled from operator control stations in one or more predetermined zones or locations. | *Not have cableless control* | N |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

EN 60204-1:2018
Safety of machinery - Electrical equipment of machines – Part 1: General requirements

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.2.7.3 | **Stop**<br>Cableless control stations shall include a separate and clearly identifiable means to initiate the stop function of the machine or of all the operations that can cause a hazardous situation.<br>The actuating means to initiate this stop function shall not be marked or labelled as an emergency stop device (see 10.7).<br>A machine which is equipped with cableless control shall have a means of automatically initiating the stopping of the machine and of preventing a potentially hazardous operation, in the following situations:<br>– when a stop signal is received;<br>– when a fault is detected in the cableless control system;<br>– when a valid signal (which includes a signal that communication is established and maintained) has not been detected within a specified period of time (see Annex B), except when a machine is executing a pre-programmed task taking it outside the range of the cableless control where no hazardous situation can occur. | *Not have cableless control* | N |
| 9.2.7.4 | **Use of more than one operator control station**<br>Where a machine has more than one operator control station, including one or more cableless control stations, measures shall be provided to ensure that only one of the control stations can be enabled at a given time. An indication of which operator control station is in control of the machine shall be provided at suitable locations as determined by the risk assessment of the machine.<br>**Exception:** a stop command from any one of the control stations shall be effective when required by the risk assessment of the machine. | *Not have cableless control* | N |
| 9.2.7.5 | **Battery-powered operator control stations**<br>A variation in the battery voltage shall not cause a hazardous situation. If one or more potentially hazardous motions are controlled using a battery-powered cableless operator control station, a clear warning shall be given to the operator when a variation in battery voltage exceeds specified limits. Under those circumstances, the cableless operator control station shall remain functional long enough for the operator to put the machine into a nonhazardous situation. | *Not have cableless control* | N |
| 9.3 | **Protective interlocks** | | |
| 9.3.1 | **Reclosing or resetting of an interlocking safeguard**<br>The reclosing or resetting of an interlocking safeguard shall not initiate hazardous machine operation. | ✓ | PASS |
| 9.3.2 | **Exceeding operating limits**<br>Where an operating limit (for example speed, pressure, position) can be exceeded leading to a hazardous situation, means shall be provided to detect when a predetermined limit(s) is exceeded and initiate an appropriate control action. | ✓ | PASS |
| 9.3.3 | **Operation of auxiliary functions**<br>The correct operation of auxiliary functions shall be checked by appropriate devices (for example pressure sensors).<br>Where the non-operation of a motor or device for an auxiliary function (for example lubrication, supply of coolant, swarf removal) can cause a hazardous situation, or cause damage to the machine or to the work in progress, appropriate interlocking shall be provided. | ✓ | PASS |
| 9.3.4 | **Interlocks between different operations and for contrary motions**<br>All contactors, relays, and other control devices that control elements of the machine and that can cause a hazardous situation when actuated at the same time (for example those which initiate contrary motion), shall be interlocked against incorrect operation. Reversing contactors (for example those controlling the direction of rotation of a motor) shall be interlocked in such a way that in normal service no short circuit can occur when switching. Where, for safety or for continuous operation, certain functions on the machine are required to be interrelated, proper co-ordination shall be ensured by suitable interlocks. For a group of machines working together in a co-ordinated manner and having more than one controller, provision shall be made to co-ordinate the operations of the controllers as necessary. Where a failure of a mechanical brake actuator can result in the brake being applied when the associated machine actuator is energized and a hazardous situation can result, interlocks shall be provided to switch off the machine actuator. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.3.5 | **Reverse current braking**<br>Where braking of a motor is accomplished by current reversal, measures shall be provided to prevent the motor starting in the opposite direction at the end of braking where that reversal can cause a hazardous situation or damage to the machine or to the work in progress. For this purpose, a device operating exclusively as a function of time is not permitted. Control circuits shall be so arranged that rotation of a motor shaft, for example manually, shall not result in a hazardous situation. | *Not applicable* | N |
| 9.4 | **Control functions in the event of failure** | | |
| 9.4.1 | **General requirements**<br>Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the machine or to the work in progress, appropriate measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application (see 4.1).<br>The electrical control circuits shall have an appropriate level of safety performance that has been determined from the risk assessment at the machine. The requirements of IEC 62061 and/or ISO 13849-1:1999, ISO 13849-2:2003 shall apply.<br>Measures to reduce those risks include but are not limited to:<br>– protective devices on the machine (for example interlocking guards, trip devices);<br>– protective interlocking of the electrical circuit;<br>– use of proven circuit techniques and components (see 9.4.2.1);<br>– provision of partial or complete redundancy (see 9.4.2.2) or diversity (see 9.4.2.3);<br>– provision for functional tests (see 9.4.2.4).<br>Where memory retention is achieved for example, by battery power, measures shall be taken to prevent hazardous situations arising from failure or removal of the battery. Means shall be provided to prevent unauthorized or inadvertent memory alteration by, for example, requiring the use of a key, access code or tool. | ✓ | PASS |
| 9.4.2 | **Measures to minimize risk in the event of failure** | | |
| 9.4.2.1 | **Use of proven circuit techniques and components**<br>These measures include but are not limited to:<br>– bonding of control circuits to the protective bonding circuit for functional purposes (see 9.4.3.1 and Figure 2);<br>– connection of control devices in accordance with 9.4.3.1;<br>– stopping by de-energizing (see 9.2.2);<br>– the switching of all control circuit conductors to the device being controlled (see 9.4.3.1);<br>– switching devices having direct opening action (see IEC 60947-5-1);<br>– circuit design to reduce the possibility of failures causing undesirable operations. | ✓ | PASS |
| 9.4.2.2 | **Provisions of partial or complete redundancy**<br>By providing partial or complete redundancy, it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous situation. Redundancy can be effective in normal operation (on-line redundancy) or designed as special circuits that take over the protective function (off-line redundancy) only where the operating function fails. Where off-line redundancy which is not active during normal operation is provided, suitable measures shall be taken to ensure that those control circuits are available when required. | ✓ | PASS |
| 9.4.2.3 | **Provision of diversity**<br>The use of control circuits having different principles of operation, or using different types of components or devices can reduce the probability of hazards resulting from faults and/or failures. Examples include:<br>– the combination of normally open and normally closed contacts operated by interlocking guards;<br>– the use of different types of control circuit components in the circuit;<br>– the combination of electromechanical and electronic equipment in redundant configurations.<br>The combination of electrical and non-electrical systems (for example mechanical, hydraulic, pneumatic) may perform the redundant function and provide the diversity. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 9.4.2.4 | **Provision for functional tests**<br>Functional tests may be carried out automatically by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also 17.2 and 18.6). | ✓<br>*Functional test has been carried out manually by inspection* | PASS |
| 9.4.3 | **Protection against maloperation due to earth faults, voltage interruptions and loss of circuit continuity** | | |
| 9.4.3.1 | **Earth faults**<br>Earth faults on any control circuit shall not cause unintentional starting, potentially hazardous motions, or prevent stopping of the machine. | ✓ | PASS |
| 9.4.3.2 | **Voltage interruptions**<br>The requirements detailed in 7.5 shall apply. Where the control system uses a memory device(s), proper functioning in the event of power failure shall be ensured (for example by using a non-volatile memory) to prevent any loss of memory that can result in a hazardous situation. | ✓ | PASS |
| 9.4.3.3 | **Loss of circuit continuity**<br>Where the loss of continuity of safety-related control circuits depending upon sliding contacts can result in a hazardous situation, appropriate measures shall be taken (for example by duplication of the sliding contacts). | ✓ | PASS |
| 10. | **Operator interface and machine-mounted control devices** | | |
| 10.1 | **General** | | |
| 10.1.1 | **General device requirements**<br>This Clause contains requirements for devices mounted outside or partially outside control enclosures.<br>As far as is practicable, those devices shall be selected, mounted, and identified or coded in accordance with relevant parts of IEC 61310. The possibility of inadvertent operation shall be minimized by, for example, positioning of devices, suitable design, provision of additional protective measures. Particular consideration shall be given to the selection, arrangement, programming and use of operator input devices such as touchscreens, keypads and keyboards, for the control of hazardous machine operations. See IEC 60447. | ✓ | PASS |
| 10.1.2 | **Location and mounting**<br>As far as is practicable, machine-mounted control devices shall be:<br>– readily accessible for service and maintenance;<br>– mounted in such a manner as to minimize the possibility of damage from activities suchas material handling.<br>The actuators of hand-operated control devices shall be selected and installed so that:<br>– they are not less than 0,6 m above the servicing level and are within easy reach of the normal working position of the operator;<br>– the operator is not placed in a hazardous situation when operating them. The actuators of foot-operated control devices shall be selected and installed so that:<br>– they are within easy reach of the normal working position of the operator;<br>– the operator is not placed in a hazardous situation when operating them. | ✓ | PASS |
| 10.1.3 | **Protection**<br>The degree of protection (see IEC 60529) together with other appropriate measures shall afford protection against:<br>– the effects of aggressive liquids, vapours, or gases found in the physical environment or used on the machine;<br>– the ingress of contaminants (for example swarf, dust, particulate matter). In addition, the operator interface control devices shall have a minimum degree of protection against direct contact of IPXXD (see IEC 60529). | ✓ | PASS |
| 10.1.4 | **Position sensors**<br>Position sensors (for example position switches, proximity switches) shall be so arranged that they will not be damaged in the event of overtravel. Position sensors in circuits with safety-related control functions shall have direct opening action (see IEC 60947-5-1) or shall provide similar reliability (see 9.4.2). | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 10.1.5 | **Portable and pendant control stations**<br>Portable and pendant operator control stations and their control devices shall be so selected and arranged as to minimize the possibility of inadvertent machine operations caused by shocks and vibrations (for example if the operator control station is dropped or strikes an obstruction) (see also 4.4.8). | ✓ | PASS |
| 10.2 | **Push-buttons** | | |
| 10.2.1 | **Colours**<br>Push-button actuators shall be colour-coded in accordance with Table 2 (see also 9.2 and Annex B).<br>The colours for START/ON actuators should be WHITE, GREY, BLACK or GREEN with a preference for WHITE. RED shall not be used. The colour RED shall be used for emergency stop and emergency switching off actuators. The colours for STOP/OFF actuators should be BLACK, GREY, or WHITE with a preference for BLACK. GREEN shall not be used. RED is permitted, but it is recommended that RED is not used near an emergency operation device. WHITE, GREY, or BLACK are the preferred colours for push-button actuators that alternately act as START/ON and STOP/OFF push-buttons. The colours RED, YELLOW, or GREEN shall not be used (see also 9.2.6). WHITE, GREY, or BLACK are the preferred colours for push-button actuators that cause<br>operation while they are actuated and cease the operation when they are released (for example hold-to-run). The colours RED, YELLOW, or GREEN shall not be used. Reset push-buttons shall be BLUE, WHITE, GREY, or BLACK. Where they also act as a STOP/OFF button, the colours WHITE, GREY, or BLACK are preferred with the main preference being for BLACK. GREEN shall not be used. Where the same colour WHITE, GREY, or BLACK is used for various functions (for example WHITE for START/ON and for STOP/OFF actuators) a supplementary means of coding (for example shape, position, symbol) shall be used for the identification of push-button actuators. | ✓ | PASS |
| 10.2.2 | **Markings**<br>In addition to the functional identification as described in 16.3, it is recommended that pushbuttons be marked, near to or preferably directly on the actuators, with the symbols given in Table 3. | ✓ | PASS |
| 10.3 | **Indicator lights and displays** | | |
| 10.3.1 | **General**<br>Indicator lights and displays serve to give the following types of information:<br>– indication: to attract the operator's attention or to indicate that a certain task should be performed. The colours RED, YELLOW, BLUE, and GREEN are normally used in this mode; for flashing indicator lights and displays, see 10.3.3.<br>– confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colours BLUE and WHITE are normally used in this mode and GREEN may be used in some cases.<br>Indicator lights and displays shall be selected and installed in such a manner as to be visible from the normal position of the operator (see also IEC 61310-1). Indicator light circuits used for warning lights shall be fitted with facilities to check the operability of these lights. | ✓ | PASS |
| 10.3.2 | **Colours**<br>Unless otherwise agreed between the supplier and the user (see Annex B), indicator lights shall be colour-coded with respect to the condition (status) of the machine in accordance with Table 4. | ✓ | PASS |
| 10.3.3 | **Flashing lights and displays**<br>For further distinction or information and especially to give additional emphasis, flashing lights and displays can be provided for the following purposes:<br>– to attract attention;<br>– to request immediate action;<br>– to indicate a discrepancy between the command and actual state;<br>– to indicate a change in process (flashing during transition).<br>It is recommended that higher frequency flashing lights or display be used for higher priority information (see IEC 60073 for recommended flashing rates and pulse/pause ratios). Where flashing lights or displays are used to provide higher priority information, audible warning devices should also be provided. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 10.4 | **Illuminated push-buttons**<br>Illuminated push-button actuators shall be colour-coded in accordance with Tables 2 and 4. Where there is difficulty in assigning an appropriate colour, WHITE shall be used. The colour RED for the emergency stop actuator shall not depend on the illumination of its light. | ✓ | PASS |
| 10.5 | **Rotary control devices**<br>Devices having a rotational member, such as potentiometers and selector switches, shall have means of prevention of rotation of the stationary member. Friction alone shall not be considered sufficient. | ✓ | PASS |
| 10.6 | **Start devices**<br>Actuators used to initiate a start function or the movement of machine elements (for example slides, spindles, carriers) shall be constructed and mounted so as to minimize inadvertent operation. However, mushroom-type actuators may be used for two-hand control (see also ISO 13851). | ✓ | PASS |
| 10.7 | **Emergency stop devices** | | |
| 10.7.1 | **Location of emergency stop devices**<br>Devices for emergency stop shall be readily accessible. Emergency stop devices shall be located at each operator control station and at other locations where the initiation of an emergency stop can be required (**exception**: see 9.2.7.3).<br>There can be circumstances where confusion can occur between active and inactive emergency stop devices caused by disabling the operator control station. In such cases, means (for example, information for use) shall be provided to minimise confusion. | ✓<br>emergency stop is readily accessible.<br><br>emergency stop devices is located at each operator control station | PASS |
| 10.7.2 | **Types of emergency stop device**<br>The types of device for emergency stop include:<br>– a push-button operated switch with a palm or mushroom head type;<br>– a pull-cord operated switch;<br>– a pedal-operated switch without a mechanical guard.<br>The devices shall have direct opening operation (see IEC 60947-5-1, Annex K). | ✓<br>a push-button operated switch with a mushroom head type | PASS |
| 10.7.3 | **Colour of actuators**<br>Actuators of emergency stop devices shall be coloured RED. If a background exists immediately around the actuator, then this background shall be coloured YELLOW. See also ISO 13850. | ✓<br>Actuators of emergency stop devices are coloured RED | PASS |
| 10.7.4 | **Local operation of the supply disconnecting device to effect emergency stop**<br>The supply disconnecting device may be locally operated to serve the function of emergency stop when:<br>– it is readily accessible to the operator; and<br>– it is of the type described in 5.3.2 a), b), c), or d).<br>When also intended for such use, the supply disconnecting device shall meet the colour requirements of 10.7.3. | ✓ | PASS |
| 10.8 | **Emergency switching off devices** | | |
| 10.8.1 | **Location of emergency switching off devices**<br>Emergency switching off devices shall be located as necessary for the given application. Normally, those devices will be located separate from operator control stations. Where it is necessary to provide a control station with an emergency stop device and an emergency switching off device, means shall be provided to avoid confusion between these devices. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 10.8.2 | **Types of emergency switching off device**<br>The types of device for emergency switching off include:<br>– a push-button operated switch with a palm or mushroom head type of actuator;<br>– a pull-cord operated switch.<br>The devices shall have direct opening action (see IEC 60947-5-1, Annex K). The push-button operated switch may be in a break-glass enclosure. | ✓ | PASS |
| 10.8.3 | **Colour of actuators**<br>Actuators of emergency switching off devices shall be coloured RED. If a background exists immediately around the actuator, then this background shall be coloured YELLOW. Where confusion can occur between emergency stop and emergency switching off devices, means shall be provided to minimise confusion. | ✓ | PASS |
| 10.8.4 | **Local operation of the supply disconnecting device to effect emergency switching off** | | |
| 10.9 | **Enabling control device**<br>When an enabling control device is provided as a part of a system, it shall signal the enabling control to allow operation when actuated in one position only. In any other position, operation shall be stopped or prevented.<br>Enabling control devices shall be selected and arranged so as to minimize the possibility of defeating.<br>Enabling control devices shall be selected that have the following features:<br>– designed in accordance with ergonomic principles;<br>– for a two-position type:<br>– position 1: off-function of the switch (actuator is not operated);<br>– position 2: enabling function (actuator is operated).<br>– for a three-position type:<br>– position 1: off-function of the switch (actuator is not operated);<br>– position 2: enabling function (actuator is operated in its mid position);<br>– position 3: off-function (actuator is operated past its mid position);<br>– when returning from position 3 to position 2, the enabling function is not activated. | ✓ | PASS |
| 11. | **Controlgear: location, mounting, and enclosures** | | |
| 11.1 | **General requirements**<br>All controlgear shall be located and mounted so as to facilitate:<br>– its accessibility and maintenance;<br>– its protection against the external influences or conditions under which it is intended to operate;<br>– operation and maintenance of the machine and its associated equipment. | ✓ | PASS |
| 11.2 | **Location and mounting** | ✓ | PASS |
| 11.2.1 | **Accessibility and maintenance**<br>All items of controlgear shall be placed and oriented so that they can be identified without moving them or the wiring. For items that require checking for correct operation or that are liable to need replacement, those actions should be possible without dismantling other equipment or parts of the machine (except opening doors or removing covers, barriers or<br>obstacles). Terminals not part of controlgear components or devices shall also conform to these requirements | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 11.2.2 | **Physical separation or grouping**<br>Non-electrical parts and devices, not directly associated with the electrical equipment, shall not be located within enclosures containing controlgear. Devices such as solenoid valves should be separated from the other electrical equipment (for example in a separate compartment).<br>Control devices mounted in the same location and connected to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.<br>Terminals shall be separated into groups for:<br>– power circuits;<br>– associated control circuits;<br>– other control circuits, fed from external sources (for example for interlocking).<br>The groups may be mounted adjacently, provided that each group can be readily identified (for example by markings, by use of different sizes, by use of barriers or by colours).<br>When arranging the location of devices (including interconnections), the clearances and creepage distances specified for them by the supplier shall be maintained, taking into account the external influences or conditions of the physical environment. | ✓ | PASS |
| 11.2.3 | **Heating effects**<br>Heat generating components (for example heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted limit. | *Not Applicable* | N |
| 11.3 | **Degrees of protection**<br>The protection of controlgear against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e. the location and the physical environmental conditions) and shall be sufficient against dust, coolants, and swarf.<br>**Exceptions:**<br>a) Where an electrical operating area is used as a protective enclosure for an appropriate degree of protection against the ingress of solid bodies and liquids.<br>b) Where removable collectors on conductor wire or conductor bar systems are used and IP22 is not achieved, but the measures of 6.2.5 are applied | ✓ | PASS |
| 11.4 | **Enclosures, doors and openings**<br>Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and other environmental factors that are likely to be encountered in normal service.<br>Fasteners used to secure doors and covers should be of the captive type. Windows provided for viewing internally mounted indicating devices shall be of a material suitable to withstand mechanical stress and chemical attack (for example toughened glass or polycarbonate sheet of not less than 3 mm thickness).<br>It is recommended that enclosure doors be not wider than 0,9 m and have vertical hinges, with an angle of opening of at least 95°. The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical effects of the aggressive liquids, vapours, or gases used on the machine. The means provided to maintain the degree of protection of an enclosure on doors, lids and covers that require opening or removal for operation or maintenance shall:<br>– be securely attached to either the door/cover or the enclosure;<br>– not deteriorate due to removal or replacement of the door or the cover, and so impair the degree of protection | ✓ | PASS |

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 11.5 | **Access to controlgear**<br>Doors in gangways and for access to electrical operating areas shall:<br>– be at least 0,7 m wide and 2,1 m high;<br>– open outwards;<br>– have a means (for example panic bolts) to allow opening from the inside without the use of a key or tool.<br>Enclosures which readily allow a person to fully enter shall be provided with means to allow escape, for example panic bolts on the inside of doors. Enclosures intended for such access, for example for resetting, adjusting, maintenance, shall have a clear width of at least 0,7 m and a clear height of at least 2,1 m.<br>In cases where:<br>– equipment is likely to be live during access; and<br>– conducting parts are exposed,<br>the clear width shall be at least 1,0 m. In cases where such parts are present on both sides of the access way, the clear width shall be at least 1,5 m. | ✓ | PASS |
| 12. | **Conductors and cables** | | |
| 12.1 | **General requirements**<br>Conductors and cables shall be selected so as to be suitable for the operating conditions (for example voltage, current, protection against electric shock, grouping of cables) and external influences (for example ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards) that can exist.<br>NOTE Further information is given in CENELEC HD 516 S2.<br>These requirements do not apply to the integral wiring of assemblies, subassemblies, and devices that are manufactured and tested in accordance with their relevant IEC standard (for example IEC 60439-1). | ✓ | PASS |
| 12.2 | **Conductors**<br>In general, conductors shall be of copper. Where aluminium conductors are used, the crosssectional area shall be at least 16 mm2. To ensure adequate mechanical strength, the cross-sectional area of conductors should not be less than as shown in Table 5. However, conductors with smaller cross-sectional areas or other constructions than shown in Table 5 may be used in equipment provided adequate mechanical strength is achieved by other means and proper functioning is not impaired. | ✓ | PASS |
| 12.3 | **Insulation**<br>The types of insulation include (but are not limited to):<br>– polyvinyl chloride (PVC);<br>– rubber, natural and synthetic;<br>– silicone rubber (SiR);<br>– mineral;<br>– cross-linked polyethylene (XLPE);<br>– ethylene propylene compound (EPR).<br>Where the insulation of conductors and cables (for example PVC) can constitute hazards due to the propagation of a fire or the emission of toxic or corrosive fumes, guidance from the cable supplier should be sought. It is important to give special attention to the integrity of a circuit having a safety-related function. The insulation of cables and conductors used, shall be suitable for a test voltage:<br>– not less than 2 000 V AC for a duration of 5 min for operation at voltages higher than 50 V AC or 120 V DC, or<br>– not less than 500 V AC for a duration of 5 min for PELV circuits (see IEC 60364-4-41, class III equipment).<br>The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts. | ✓ | PASS |
| 12.4 | **Current-carrying capacity in normal service**<br>The current-carrying capacity depends on several factors, for example insulation material, number of conductors in a cable, design (sheath), methods of installation, grouping and ambient temperature One typical example of the current-carrying capacities for PVC insulated wiring between enclosures and individual items of equipment under steady-state conditions is given in Table 6. | ✓ | PASS |

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 12.5 | **Conductor and cable voltage drop**<br>The voltage drop from the point of supply to the load shall not exceed 5 % of the nominal voltage under normal operating conditions. In order to conform to this requirement, it can be necessary to use conductors having a larger cross-sectional area than that derived from Table 6. | ✓ | PASS |
| 12.6 | **Flexible cables** | ✓ | PASS |
| 12.6.1 | **General**<br>Flexible cables shall have Class 5 or Class 6 conductors. Cables that are subjected to severe duties shall be of adequate construction to protect against:<br>– abrasion due to mechanical handling and dragging across rough surfaces;<br>– kinking due to operation without guides;<br>– stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums. | ✓ | PASS |
| 12.6.2 | **Mechanical rating**<br>The cable handling system of the machine shall be so designed to keep the tensile stress of the conductors as low as is practicable during machine operations. Where copper conductors are used, the tensile stress applied to the conductors shall not exceed 15 N/mm2 of the copper cross-sectional area. Where the demands of the application exceed the tensile stress limit of 15 N/mm2, cables with special construction features should be used and the allowed maximal tensile stress should be agreed with the cable manufacturer. The maximum stress applied to the conductors of flexible cables with material other than copper shall be within the cable manufacturer's specification. | ✓ | PASS |
| 12.6.3 | **Current-carrying capacity of cables wound on drums**<br>Cables to be wound on drums shall be selected with conductors having a cross-sectional area such that, when fully wound on the drum and carrying the normal service load, the maximum allowable conductor temperature is not exceeded.<br>For cables of circular cross-sectional area installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with Table 7 (see also Clause 44 of IEC 60621-3). | ✓ | PASS |
| 12.7 | **Conductor wires, conductor bars and slip-ring assemblies** | ✓ | PASS |
| 12.7.1 | **Protection against direct contact**<br>Conductor wires, conductor bars and slip-ring assemblies shall be installed or enclosed in such a way that, during normal access to the machine, protection against direct contact is achieved by the application of one of the following protective measures:<br>– protection by partial insulation of live parts, or where this is not practicable;<br>– protection by enclosures or barriers of at least IP2X (see 412.2 of IEC 60364-4-41).<br>Horizontal top surfaces of barriers or enclosures that are readily accessible shall provide a degree of protection of at least IP4X (see 412.2.2 of IEC 60364-4-41).<br>Where the required degree of protection is not achieved, protection by placing live parts out of reach in combination with emergency switching off in accordance with 9.2.5.4.3 shall be applied.<br>Conductor wires and conductor bars shall be so placed and/or protected as to:<br>– prevent contact, especially for unprotected conductor wires and conductor bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains;<br>– prevent damage from a swinging load. | ✓ | PASS |
| 12.7.2 | **Protective conductor circuit**<br>Where conductor wires, conductor bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation. Therefore, the protective conductor (PE) and the neutral conductor (N) shall each use a separate conductor wire, conductor bar or slip-ring. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (for example, duplication of the current collector, continuity monitoring). | ✓ | PASS |
| 12.7.3 | **Protective conductor current collectors**<br>Protective conductor current collectors shall have a shape or construction so that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 12.7.4 | **Removable current collectors with a disconnector function**<br>Removable current collectors having a disconnector function shall be so designed that the protective conductor circuit is interrupted only after the live conductors have been disconnected, and the continuity of the protective conductor circuit is re-established before any live conductor is reconnected (see also 8.2.4). | ✓ | PASS |
| 12.7.5 | **Clearances in air**<br>Clearances between the respective conductors, and between adjacent systems, of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for at least a rated impulse voltage of an overvoltage category III in accordance with IEC 60664-1. | ✓ | PASS |
| 12.7.6 | **Creepage distances**<br>Creepage distances between the respective conductors, between adjacent systems of conductor wires, conductor bars and slip-ring assemblies, and their current collectors shall be suitable for operation in the intended environment, for example open air (IEC 60664-1), inside buildings, protected by enclosures. In abnormally dusty, moist or corrosive environments, the following creepage distance requirements apply:<br>– unprotected conductor wires, conductor bars, and slip-ring assemblies shall be equipped with insulators with a minimum creepage distance of 60 mm;<br>– enclosed conductor wires, insulated multipole conductor bars and insulated individual conductor bars shall have a minimum creepage distance of 30 mm.<br>The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (for example deposits of conductive dust, chemical attack). | ✓ | PASS |
| 12.7.7 | **Conductor system sectioning**<br>Where conductor wires or conductor bars are arranged so that they can be divided into isolated sections, suitable design measures shall be employed to prevent the energization of adjacent sections by the current collectors themselves. | ✓ | PASS |
| 12.7.8 | **Construction and installation of conductor wire, conductor bar systems and slip-ring assemblies**<br>Conductor wires, conductor bars and slip-ring assemblies in power circuits shall be grouped separately from those in control circuits. Conductor wires, conductor bars and slip-ring assemblies shall be capable of withstanding, without damage, the mechanical forces and thermal effects of short-circuit currents. Removable covers for conductor wire and conductor bar systems laid underground or underfloor shall be so designed that they cannot be opened by one person without the aid of a tool. Where conductor bars are installed in a common metal enclosure, the individual sections of the enclosure shall be bonded together and connected to a protective bonding conductor at several points depending upon their length. Metal covers of conductor bars laid underground or underfloor shall also be bonded together and connected to a protective bonding conductor. The protective bonding circuit shall include the covers or cover plates of metal enclosures or underfloor ducts. Where metal hinges form a part of the bonding circuit, their continuity shall be verified (see Clause 18). Underground and underfloor conductor bar ducts shall have drainage facilities. | ✓ | PASS |
| 13 | **Wiring practices** | | |
| 13.1 | **Connections and routing** | | |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 13.1.1 | **General requirements**<br>All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.<br>The means of connection shall be suitable for the cross-sectional areas and nature of the conductors being terminated.<br>The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective conductor shall be connected to one terminal connecting point.<br>Soldered connections shall only be permitted where terminals are provided that are suitable for soldering.<br>Terminals on terminal blocks shall be plainly marked or labelled to correspond with markings on the diagrams.<br>Where an incorrect electrical connection (for example, arising from replacement of devices) can be a source of risk and it is not practicable to reduce the possibility of incorrect connection by design measures, the conductors and/or terminations shall be identified inaccordance with 13.2.1. The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings. Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose. Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection. Identification tags shall be legible, permanent, and appropriate for the physical environment. Terminal blocks shall be mounted and wired so that the internal and external wiring does not cross over the terminals (see IEC 60947-7-1). | ✓ | PASS |
| 13.1.2 | **Conductor and cable runs**<br>Conductors and cables shall be run from terminal to terminal without splices or joints. Connections using plug/socket combinations with suitable protection against accidental disconnection are not considered to be joints for the purpose of this Subclause. | ✓ | PASS |
| 13.1.3 | **Conductors of different circuits**<br>Conductors of different circuits may be laid side by side, may occupy the same duct (for example conduit, cable trunking system), or may be in the same multiconductor cable provided that the arrangement does not impair the proper functioning of the respective circuits. Where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or shall be insulated for the highest voltage to which any conductor within the same duct can be subjected, for example line to line voltage for unearthed systems and phase to earth voltage for earthed systems. | ✓ | PASS |
| 13.1.4 | **Connection between pick-up and pick-up converter of an inductive power supply system**<br>The cable between the pick-up and the pick-up converter as specified by the manufacturer of the inductive power supply shall be:<br>– as short as practicable;<br>– adequately protected against mechanical damage. | ✓ | PASS |
| 13.2 | **Identification of conductors** | ✓ | PASS |
| 13.2.1 | **General requirements**<br>Each conductor shall be identifiable at each termination in accordance with the technical documentation (see Clause 17).<br>It is recommended (for example to facilitate maintenance) that conductors be identified by number, alphanumeric, colour (either solid or with one or more stripes), or a combination of colour and numbers or alphanumeric. When numbers are used, they shall be Arabic; letters shall be Roman (either upper or lower case). | ✓ | PASS |
| 13.2.2 | **Identification of the protective conductor**<br>The protective conductor shall be readily distinguishable by shape, location, marking, or colour. When identification is by colour alone, the bicolour combination GREEN-ANDYELLOW shall be used throughout the length of the conductor. This colour identification is strictly reserved for the protective conductor.<br>For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15 mm length, one of the colours covers at least 30 % and not more than 70 % of the surface of the conductor, the other colour covering the remainder of the surface.<br>Where the protective conductor can be easily identified by its shape, position, or construction (for example a braided conductor, uninsulated stranded conductor), or where the insulated conductor is not readily accessible, colour coding throughout its length is not necessary but the ends or accessible locations shall be clearly identified by the graphical symbol IEC 60417-5019 (DB:2002- 10) or by the bicolour combination GREEN-AND-YELLOW. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 13.2.3 | **Identification of the neutral conductor**<br>Where a circuit includes a neutral conductor that is identified by colour alone, the colour used for this conductor shall be BLUE. In order to avoid confusion with other colours, it is recommended that an unsaturated blue be used, called here "light blue" (see 3.2.2 of IEC 60446). Where the selected colour is the sole identification of the neutral conductor, that colour shall not be used for identifying any other conductor where confusion is possible. Where identification by colour is used, bare conductors used as neutral conductors shall be either coloured by a stripe, 15 mm to 100 mm wide in each compartment or unit and at each accessible location, or coloured throughout their length. | ✓ | PASS |
| 13.2.4 | **Identification by colour**<br>Where colour-coding is used for identification of conductors (other than the protective conductor (see 13.2.2) and the neutral conductor (see 13.2.3)), the following colours may be used:<br>BLACK, BROWN, RED, ORANGE, YELLOW, GREEN, BLUE (including LIGHT BLUE), VIOLET, GREY, WHITE, PINK, TURQUOISE.<br>It is recommended that, where colour is used for identification, the colour be used throughout the length of the conductor either by the colour of the insulation or by colour markers at regular intervals and at the ends or accessible location.<br>For safety reasons, the colour GREEN or the colour YELLOW should not be used where there is a possibility of confusion with the bicolour combination GREEN-AND-YELLOW (see13.2.2).<br>Colour identification using combinations of those colours listed above may be used provided there can be no confusion and that GREEN or YELLOW is not used except in the bicolour combination GREEN-AND-YELLOW.<br>Where colour-coding is used for identification of conductors, it is recommended that they be colour-coded as follows:<br>– BLACK: AC and DC power circuits;<br>– RED: AC control circuits;<br>– BLUE: DC control circuits;<br>– ORANGE: excepted circuits in accordance with 5.3.5.<br>**Exceptions:** to the above are permitted where:<br>– insulation is used that is not available in the colours recommended; or<br>– multiconductor cable is used, but not the bicolour combination GREEN-AND-YELLOW. | ✓ | PASS |
| 13.3 | **Wiring inside enclosures**<br>Conductors inside enclosures shall be supported where necessary to keep them in place. Non-metallic ducts shall be permitted only when they are made with a flame-retardant insulating material (see the IEC 60332 series). It is recommended that electrical equipment mounted inside enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure (see also 11.2.1). Where that is not practicable and control devices are connected<br>from the rear of the enclosure, access doors or swingout panels shall be provided.<br>Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with 12.2 and 12.6 to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection (see also 8.2.3 and 11.2.1).<br>Conductors and cables that do not run in ducts shall be adequately supported. Terminal blocks or plug/socket combinations shall be used for control wiring that extends beyond the enclosure. For plug/socket combinations, see also 13.4.5 and 13.4.6. Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended. | ✓ | PASS |
| 13.4 | **Wiring outside enclosures** | ✓ | PASS |
| 13.4.1 | **General requirements**<br>The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced (see 11.3). | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 13.4.2 | **External ducts**<br>Conductors and their connections external to the electrical equipment enclosure(s) shall be enclosed in suitable ducts (i.e. conduit or cable trunking systems) as described in 13.5 except for suitably protected cables that may be installed without ducts and with or without the use of open cable trays or cable support means. Where devices such as position switches or proximity switches are supplied with a dedicated cable, their cable need not be enclosed in a duct when the cable is suitable for the purpose, sufficiently short, and so located or protected, that the risk of damage is minimized.<br>Fittings used with ducts or multiconductor cable shall be suitable for the physical environment. Flexible conduit or flexible multiconductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the flexible multiconductor cable, except where the conduit or cable is specifically designed for that purpose. | ✓ | PASS |
| 13.4.3 | **Connection to moving elements of the machine**<br>Connections to frequently moving parts shall be made using conductors in accordance with 12.2 and 12.6. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining, particularly at the fittings.<br>Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp flexing. When this is achieved by the provision of a loop, it shall have sufficient length to provide for a bending radius of the cable of at least 10 times the diameter of the cable.<br>Flexible cables of machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:<br>– being run over by the machine itself;<br>– being run over by vehicles or other machines;<br>– coming into contact with the machine structure during movements;<br>– running in and out of cable baskets, or on or off cable drums;<br>– acceleration forces and wind forces on festoon systems or suspended cables;<br>– excessive rubbing by cable collector;<br>– exposure to excessive radiated heat. | ✓ | PASS |
| 13.4.4 | **Interconnection of devices on the machine**<br>Where several machine-mounted switching devices (for example position sensors, pushbuttons) are connected in series or in parallel, it is recommended that the connections between those devices be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, adequately protected, and shown on the relevant diagrams. | ✓ | PASS |
| 13.4.5 | **Plug/socket combinations**<br>Where plug/socket combinations are provided, they shall fulfil one or more of the following requirements as applicable:<br>**Exception:** The following requirements do not apply to components or devices inside an enclosure, terminated by fixed plug/socket combinations (no flexible cable), or components connected to a bus system by a plug/socket combination | ✓ | PASS |
| 13.4.6 | **Dismantling for shipment**<br>Where it is necessary that wiring be disconnected for shipment, terminals or plug/socket combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage. | ✓ | PASS |
| 13.4.7 | Consideration should be given to providing additional conductors for maintenance or repair. When spare conductors are provided, they shall be connected to spare terminals or isolated in such a manner as to prevent contact with live parts. | ✓ | PASS |
| 13.5 | **Ducts, connection boxes and other boxes** | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 13.5.1 | **General requirements**<br>Ducts shall provide a degree of protection suitable for the application (see IEC 60529). All sharp edges, flash, burrs, rough surfaces, or threads with which the insulation of the conductors can come in contact shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation. Drain holes of 6 mm diameter are permitted in cable trunking systems, connection boxes, and other boxes used for wiring purposes that can be subject to accumulations of oil or moisture. In order to prevent confusion of conduits with oil, air, or water piping, it is recommended that the conduits be either physically separated or suitably identified. Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in such a manner so as to minimize the possibility of damage or wear. In areas where human passage is required, the ducts and cable trays shall be mounted at least 2 m above the working surface. Ducts shall be provided only for mechanical protection (see 8.2.3 for requirements for connection to the protective bonding circuit).<br>Cable trays that are partially covered should not be considered to be ducts or cable trunking systems (see 13.5.6), and the cables used shall be of a type suitable for installation with or without the use of open cable trays or cable support means. | ✓ | PASS |
| 13.5.2 | **Percentage fill of ducts**<br>Consideration of the percentage fill of ducts should be based on the straightness and length of the duct and the flexibility of the conductors. It is recommended that the dimensions and arrangement of the ducts be such as to facilitate the insertion of the conductors and cables. | ✓ | PASS |
| 13.5.3 | **Rigid metal conduit and fittings**<br>Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material suitable for the conditions. The use of dissimilar metals in contact that can cause galvanic action should be avoided. Conduits shall be securely held in place and supported at each end. Fittings shall be compatible with the conduit and appropriate for the application. Fittings shall be threaded unless structural difficulties prevent assembly. Where threadless fittings are used, the conduit shall be securely fastened to the equipment. Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced. | ✓ | PASS |
| 13.5.4 | **Flexible non-metallic conduit and fittings**<br>Flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics similar to those of the sheath of multiconductor cables. The conduit shall be suitable for use in the expected physical environment. Fittings shall be compatible with the conduit and appropriate for the application. | ✓ | PASS |
| 13.5.6 | **Cable trunking systems**<br>Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine. Covers shall be shaped to overlap the sides; gaskets shall be permitted. Covers shall be attached to cable trunking systems by suitable means. On horizontal cable trunking systems, the cover shall not be on the bottom unless specifically designed for such installation. Where the cable trunking system is furnished in sections, the joints between sections shall fit tightly but need not be gasketed. The only openings permitted shall be those required for wiring or for drainage. Cable trunking systems shall not have opened but unused knockouts. | ✓ | PASS |
| 13.5.7 | **Machine compartments and cable trunking systems**<br>The use of compartments or cable trunking systems within the column or base of a machine to enclose conductors is permitted provided the compartments or cable trunking systems are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to damage | ✓ | PASS |
| 13.5.8 | **Connection boxes and other boxes**<br>Connection boxes and other boxes used for wiring purposes shall be accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the machine is intended to operate (see 11.3).<br>Those boxes shall not have opened but unused knockouts nor any other openings and shall be so constructed as to exclude materials such as dust, flyings, oil, and coolant. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 13.5.8 | **Motor connection boxes**<br>Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (for example brakes, temperature sensors, plugging switches, tachometer generators). | ✓ | PASS |
| 14. | **Electric motors and associated equipment** | ✓ | PASS |
| 14.1 | **General requirements**<br>Electric motors should conform to the relevant parts of IEC 60034 series. The protection requirements for motors and associated equipment are given in 7.2 for overcurrent protection, in 7.3 for overload protection, and in 7.6 for overspeed protection. As many controllers do not switch off the supply to a motor when it is at rest, care shall be taken to ensure compliance with the requirements of 5.3, 5.4, 5.5, 7.5, 7.6 and 9.4. Motor control equipment shall be located and mounted in accordance with Clause 11. | ✓ | PASS |
| 14.2 | **Motor enclosures**<br>It is recommended that motor enclosures be chosen from those included in IEC 60034-5. The degree of protection shall be at least IP23 (see IEC 60529) for all motors. More stringent requirements can be needed depending on the application and the physical environment (see 4.4). Motors incorporated as an integral part of the machine shall be so mounted that they are adequately protected from mechanical damage. | ✓ | PASS |
| 14.3 | **Motor dimensions**<br>As far as is practicable, the dimensions of motors shall conform to those given in the IEC 60072 series. | ✓ | PASS |
| 14.4 | **Motor mounting and compartments**<br>Each motor and its associated couplings, belts, pulleys, or chains, shall be so mounted that they are adequately protected and are easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor hold-down means can be removed and all terminal boxes are accessible. Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the limits of the insulation class (see IEC 60034-1). Where practicable, motor compartments should be clean and dry, and when required, shall be ventilated directly to the exterior of the machine. The vents shall be such that ingress of swarf, dust, or water spray is at an acceptable level. There shall be no opening between the motor compartment and any other compartment that<br>does not meet the motor compartment requirements. Where a conduit or pipe is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the conduit or pipe shall be sealed. | ✓ | PASS |
| 14.5 | **Criteria for motor selection**<br>The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environmental conditions (see 4.4). In this respect, the points that shall be considered include:<br>– type of motor;<br>– type of duty cycle (see IEC 60034-1);<br>– fixed speed or variable speed operation, (and the consequent variable influence of the ventilation);<br>– mechanical vibration;<br>– type of motor control;<br>– influence of the harmonic spectrum of the voltage and/or current feeding the motor (particularly when it is supplied from a static convertor) on the temperature rise;<br>– method of starting and the possible influence of the inrush current on the operation of other users of the same power supply, taking also into account possible special considerations stipulated by the supply authority;<br>– variation of counter-torque load with time and speed;<br>– influence of loads with large inertia;<br>– influence of constant torque or constant power operation;<br>– possible need of inductive reactors between motor and converter. | ✓ | PASS |
| 14.6 | **Protective devices for mechanical brakes**<br>Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated machine actuators. | *Not Applicable* | N |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

EN 60204-1:2018
Safety of machinery - Electrical equipment of machines – Part 1: General requirements

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 15. | **Accessories and lighting** | ✓ | PASS |
| 15.1 | **Accessories**<br>Where the machine or its associated equipment is provided with socket-outlets that are intended to be used for accessory equipment (for example hand-held power tools, test equipment), the following apply:<br>– the socket-outlets should conform to IEC 60309-1. Where that is not practicable, they should be clearly marked with the voltage and current ratings;<br>– the continuity of the protective bonding circuit to the socket-outlet shall be ensured except where protection is provided by PELV;<br>– all unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with 7.2 and 7.3 separately from the protection of other circuits;<br>– where the power supply to the socket-outlet is not disconnected by the supply disconnecting device for the machine or the section of the machine, the requirements of 5.3.5 apply | ✓ | PASS |
| 15.2 | **Local lighting of the machine and equipment** | *Not Applicable* | N |
| 15.2.1 | **General**<br>Connections to the protective bonding circuit shall be in accordance with 8.2.2. The ON/OFF switch shall not be incorporated in the lampholder or in the flexible connecting cords.<br>Stroboscopic effects from lights shall be avoided by the selection of appropriate luminaires. Where fixed lighting is provided in an enclosure, electromagnetic compatibility should be taken into account using the principles outlined in 4.4.2. | *Not Applicable* | N |
| 15.2.2 | **Supply**<br>The nominal voltage of the local lighting circuit shall not exceed 250 V between conductors. A voltage not exceeding 50 V between conductors is recommended.<br>Lighting circuits shall be supplied from one of the following sources (see also 7.2.6):<br>– a dedicated isolating transformer connected to the load side of the supply disconnecting device. Overcurrent protection shall be provided in the secondary circuit;<br>– a dedicated isolating transformer connected to the line side of the supply disconnecting device. That source shall be permitted for maintenance lighting circuits in control enclosures only. Overcurrent protection shall be provided in the secondary circuit (see also 5.3.5 and 13.1.3);<br>– a machine circuit with dedicated overcurrent protection;<br>– an isolating transformer connected to the line side of the supply disconnecting device, provided with a dedicated primary disconnecting means (see 5.3.5) and secondary overcurrent protection, and mounted within the control enclosure adjacent to the supply disconnecting device (see also 13.1.3);<br>– an externally supplied lighting circuit (for example factory lighting supply). This shall be permitted in control enclosures only, and for the machine work light(s) where their total power rating is not more than 3 kW.<br>**Exception:** where fixed lighting is out of reach of operators during normal operations, the provisions of this Subclause do not apply. | *Not Applicable* | N |
| 15.2.3 | **Protection**<br>Local lighting circuits shall be protected in accordance with 7.2.6. | *Not Applicable* | N |
| 15.2.4 | **Fittings**<br>Adjustable lighting fittings shall be suitable for the physical environment. The lampholders shall be:<br>– in accordance with the relevant IEC standard;<br>– constructed with an insulating material protecting the lamp cap so as to prevent unintentional contact.<br>Reflectors shall be supported by a bracket and not by the lampholder.<br>**Exception:** where fixed lighting is out of reach of operators during normal operation, the provisions of this Subclause do not apply. | *Not Applicable* | N |
| 16. | **Marking, warning signs and reference designations** | ✓ | PASS |
| 16.1 | **General**<br>Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 16.2 | **Warning signs** | ✓ | PASS |
| 16.2.1 | **Electric shock hazard**<br>Enclosures that do not otherwise clearly show that they contain electrical equipment that can give rise to a risk of electric shock shall be marked with the graphical symbol IEC 60417-5036 (DB:2002-10).<br>The warning sign shall be plainly visible on the enclosure door or cover.<br>The warning sign may be omitted (see also 6.2.2 b)) for:<br>– an enclosure equipped with a supply disconnecting device;<br>– an operator-machine interface or control station;<br>– a single device with its own enclosure (for example position sensor). | ✓ | PASS |
| 16.2.2 | **Hot surfaces hazard**<br>Where the risk assessment shows the need to warn against the possibility of hazardous surface temperatures of the electrical equipment, the graphical symbol IEC 60417-5041 (DB:2002-10) shall be used. | ✓ | PASS |
| 16.3 | **Functional identification**<br>Control devices, visual indicators, and displays (particularly those related to safety) shall be clearly and durably marked with regard to their functions either on or adjacent to the item. Such markings may be as agreed between the user and the supplier of the equipment (see Annex B). Preference should be given to the use of standard symbols given in IEC 60417-<br>DB:2002 and ISO 7000. | ✓ | PASS |
| 16.4 | **Marking of equipment**<br>Equipment (for example controlgear assemblies) shall be legibly and durably marked in a way that is plainly visible after the equipment is installed. A nameplate giving the following information shall be attached to the enclosure adjacent to each incoming supply:<br>– name or trade mark of supplier;<br>– certification mark, when required;<br>– serial number, where applicable;<br>– rated voltage, number of phases and frequency (if AC), and full-load current for each supply;<br>– short-circuit rating of the equipment;<br>– main document number (see IEC 62023).<br>The full-load current shown on the nameplate shall be not less than the running currents for all motors and other equipment that can be in operation at the same time under normal conditions.<br>Where only a single motor controller is used, that information may instead be provided on the machine nameplate where it is plainly visible. | ✓ | PASS |
| 16.5 | **Reference designations**<br>All enclosures, assemblies, control devices, and components shall be plainly identified with the same reference designation as shown in the technical documentation. | ✓ | PASS |
| 17. | **Technical documentation** | ✓ | PASS |
| 17.1 | **General**<br>The information necessary for installation, operation, and maintenance of the electrical equipment of a machine shall be supplied in the appropriate forms, for example, drawings, diagrams, charts, tables, instructions. The information shall be in an agreed language (see also Annex B). The information provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be contained in one document, provided that the document shows all the devices of the electrical equipment and enables the connections to the supply network to be made. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 17.2 | **Information to be provided**<br>The information provided with the electrical equipment shall include:<br>a) A main document (parts list or list of documents);<br>b) Complementary documents including:<br>1) a clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies);<br>2) electrical supply(ies) requirements;<br>3) information on the physical environment ( lighting, vibration, atmospheric contaminants) where appropriate;<br>4) overview (block) diagram(s) where appropriate;<br>5) circuit diagram(s);<br>6) information (as applicable) on:<br>• programming, as necessary for use of the equipment;<br>• sequence of operation(s);<br>• frequency of inspection;<br>• frequency and method of functional testing;<br>• guidance on the adjustment, maintenance, and repair, particularly of the protective devices and circuits;<br>• recommended spare parts list; and<br>• list of tools supplied.<br>7) a description (including interconnection diagrams) of the safeguards, interlocking functions, and interlocking of guards against hazards, particularly for machines operating in a co-ordinated manner;<br>8) a description of the safeguarding and of the means provided where it is necessary to suspend the safeguarding (for example for setting or maintenance), (see 9.2.4);<br>9) instructions on the procedures for securing the machine for safe maintenance; (see also 17.8);<br>10) information on handling, transportation and storage;<br>11) information regarding load currents, peak starting currents and permitted voltage drops, as applicable;<br>12) information on the residual risks due to the protection measures adopted, indication of whether any particular training is required and specification of any necessary personal protective equipment. | ✓ | PASS |
| 17.3 | **Requirements applicable to all documentation**<br>Unless otherwise agreed between manufacturer and user:<br>– the documentation shall be in accordance with relevant parts of IEC 61082;<br>– reference designations shall be in accordance with relevant parts of IEC 61346;<br>– instructions/manuals shall be in accordance with IEC 62079.<br>– parts lists where provided shall be in accordance with IEC 62027, class B.<br>NOTE See item 13 of Annex B.<br>For referencing of the different documents, the supplier shall select one of the following methods:<br>– where the documentation consists of a small number of documents (for example less than 5) each of the documents shall carry as a cross-reference the document numbers of all other documents belonging to the electrical equipment; or<br>– for single level main documents only (see IEC 62023), all documents shall be listed with document numbers and titles in a drawing or document list; or<br>– all documents of a certain level (see IEC 62023) of the document structure shall be listed, with document numbers and titles, in a parts list belonging to the same level. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 17.4 | **Installation documents**<br>The installation documents shall give all information necessary for the preliminary work of setting up the machine (including commissioning). In complex cases, it may be necessary to refer to the assembly drawings for details.<br>The recommended position, type, and cross-sectional areas of the supply cables to be installed on site shall be clearly indicated. The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply conductors to the electrical equipment of the machine shall be stated (see 7.2.2).<br>Where necessary, the size, purpose, and location of any ducts in the foundation that are to be provided by the user shall be detailed (see Annex B).<br>The size, type, and purpose of ducts, cable trays, or cable supports between the machine and the associated equipment that are to be provided by the user shall be detailed (see Annex B).<br>Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment. | ✓ | PASS |
| 17.5 | **Overview diagrams and function diagrams**<br>Where it is necessary to facilitate the understanding of the principles of operation, an overview diagram shall be provided. An overview diagram symbolically represents the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections. | ✓ | PASS |
| 17.6 | **Circuit diagrams**<br>A circuit diagram(s) shall be provided. This diagram(s) shall show the electrical circuits on the machine and its associated electrical equipment. Any graphical symbol not shown in IEC 60617-DB:2001 shall be separately shown and described on the diagrams or supporting documents. The symbols and identification of components and devices shall be consistent throughout all documents and on the machine. Where appropriate, a diagram showing the terminals for interface connections shall be provided. That diagram may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown. Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (for example electricity, air, water, lubricant) and with the machine and its electrical equipment ready for a normal start. Conductors shall be identified in accordance with 13.2.<br>Circuits shall be shown in such a way as to facilitate the understanding of their function aswell as maintenance and fault location. Characteristics relating to the function of the control devices and components which are not evident from their symbolic representation shall be included on the diagrams adjacent to the symbol or referenced to a footnote. | ✓ | PASS |
| 17.7 | **Operating manual**<br>The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the electrical equipment. Particular attention should be given to the safety measures provided.<br>Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, program verification, and additional safety procedures (where required) shall be provided. | ✓ | PASS |
| 17.8 | **Maintenance manual**<br>The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair. Recommendations on maintenance/service intervals and records should be part of that manual. Where methods for the verification of proper operation are provided (for example software testing programs), the use of those methods shall be detailed. | ✓ | PASS |
| 17.9 | **Parts list**<br>The parts list, where provided, shall comprise, as a minimum, information necessary for ordering spare or replacement parts (for example components, devices, software, test equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment. | ✓ | PASS |
| 18. | **Verification** | | |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 18.1 | **General**<br>This part of IEC 60204 gives general requirements for the electrical equipment of machines.<br>The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b) and f) and may include one or more of the items c) to e):<br>a) verification that the electrical equipment complies with its technical documentation;<br>b) in case of protection against indirect contact by automatic disconnection, conditions for protection by automatic disconnection shall be verified according to 18.2;<br>c) insulation resistance test (see 18.3);<br>d) voltage test (see 18.4);<br>e) protection against residual voltage (see 18.5);<br>f) functional tests (see 18.6).<br>When these tests are performed, it is recommended that they follow the sequence listed above.<br>When the electrical equipment is modified, the requirements stated in 18.7 shall apply.<br>For tests in accordance with 18.2 and 18.3, measuring equipment in accordance with the EN 61557 series is applicable. | ✓ | PASS |
| 18.2 | **Verification of conditions for protection by automatic disconnection of supply** | | |
| 18.2.1 | **General**<br>The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.<br>For TN-systems, those test methods are described in 18.2.2; their application for different conditions of supply are specified in 18.2.3.<br>For TT and IT systems, see IEC 60364-6-61. | ✓ | PASS |
| 18.2.2 | **Test methods in TN-systems**<br>Test 1 verifies the continuity of the protective bonding circuit. Test 2 verifies the conditions for protection by automatic disconnection of the supply.<br>**Test 1 – Verification of the continuity of the protective bonding circuit**<br>The resistance of each protective bonding circuit between the PE terminal (see 5.2 and Figure 2) and relevant points that are part of each protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 413.1 of IEC 60364-4-41) having a maximum no-load voltage of 24 V AC or DC. It is recommended not to use a PELV supply since such supplies can produce misleading results in this test. The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective bonding conductor(s).<br>**Test 2 – Fault loop impedance verification and suitability of the associated overcurrent protective device**<br>The connections of the power supply and of the incoming external protective conductor to the PE terminal of the machine, shall be verified by inspection.<br>The conditions for the protection by automatic disconnection of supply in accordance with 6.3.3 and Annex A shall be verified by both:<br>1) verification of the fault loop impedance by:<br>– calculation, or<br>– measurement in accordance with A.4, and<br>2) confirmation that the setting and characteristics of the associated overcurrent protective device are in accordance with the requirements of Annex A. | ✓<br>See Test Report No. TRM-25-3196/01/TI | PASS |
| 18.2.3 | **Application of the test methods for TN-systems**<br>Test 1 of 18.2.2 shall be carried out on each protective bonding circuit of a machine.<br>When Test 2 of 18.2.2 is carried out by measurement, it shall always be preceded by Test 1.<br>The tests that are necessary for machines of different status are specified in Table 9. Table 10 can be used to enable determination of the machine status. | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025 Control: Eng. C. TAHIR 06.01.2025

**EN 60204-1:2018**
**Safety of machinery - Electrical equipment of machines – Part 1: General requirements**

| Clause | Requirement | Result Remark | Verdict |
|---|---|---|---|
| 18.3 | **Insulation resistance tests**<br>When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.<br>**Exception:** for certain parts of electrical equipment, incorporating for example busbars, conductor wire or conductor bar systems or slip-ring assemblies, a lower minimum value is permitted, but that value shall not be less than 50 kΩ.<br>If the electrical equipment of the machine contains surge protection devices which are likely to operate during the test, it is permitted to either:<br>– disconnect these devices, or<br>– reduce the test voltage to a value lower than the voltage protection level of the surge protection devices, but not lower than the peak value of the upper limit of the supply (phase to neutral) voltage. | ✓<br>See Test Report No. TRM-25-3196/01/T2 | PASS |
| 18.4 | **Voltage tests**<br>When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.<br>The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.<br>The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for a period of approximately 1 s. The requirements are satisfied if no disruptive discharge occurs.<br>Components and devices that are not rated to withstand the test voltage shall be disconnected during testing. Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing. | ✓<br>See Test Report No. TRM-25-3196/01/T3 | PASS |
| 18.5 | **Protection against residual voltages**<br>Where appropriate, tests shall be performed to ensure compliance with 6.2.4. | *Not Applicable* | N |
| 18.6 | **Functional tests**<br>The functions of electrical equipment shall be tested.<br>The function of circuits for electrical safety (for example earth fault detection) shall be tested. | ✓<br>*the functions of electrical equipment has been tested manually. the funtional test has been repeated 3 times.*<br><br>*the function of circuits for electrical safety has been tested with positive results.* | PASS |
| 18.7 | **Retesting**<br>Where a portion of the machine and its associated equipment is changed or modified, that portion shall be reverified and retested, as appropriate (see 18.1).<br>Particular attention should be given to the possible adverse effects that retesting can have on the equipment (for example overstressing of insulation, disconnection/reconnection of devices). | ✓ | PASS |

Date/ Engineer: Eng. C. HURSITOGLU 06.01.2025

Control: Eng. C. TAHIR 06.01.2025