Bosch-Norm

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Delivery instructions for electrical, pneumatic and hydraulic equipment of machines, installations and production equipment (MAE)

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Disclosure	No restrictions

This Bosch-Norm is binding for suppliers if it is part of the order.

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1 Scope

This Bosch-Norm specifies the delivery instructions for electrical, electronic, pneumatic and hydraulic equipment of machines, installations and production equipment (MAE).

2 Binding force

The Bosch-Norm **N51M M23** is binding for all machine types within the EU. The adoption of the **N51M M23** is recommended for all other regions. Country-specific legislations and regulations should be considered during the implementation.

Deviations from the **N51M M23** should basically be coordinated with the respective lead plant.

The supplier is obliged to adhere to these instructions. Deviations from the Bosch-Norm have to be displayed in the offer and have to be documented latest while placing the order. The supplier has to change deviations **that do not have our approval** for us **free of charge**.

The cooperation of the customer in the technical solution or the approval of design characteristics does not relieve the supplier of the sole responsibility for flawless function and do not restrict the assured properties in any way.

3 Definitions

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Remote access: Remote access is, when a person or a service (source), spatially separated, accesses an MAE (target) via a network interface.

Safety-relevant components: Safety-relevant components include the components of an MAE, with which the concept of functional safety is implemented, e.g., programable safety controls, safe actors etc.

4 Voltages and current types

4.1 Control voltage

1. 24 V direct voltage
2. Control circuits have to be grounded on priority. Grounding of control voltage has to be conducted over disconnect terminals and/or terminals with wire straps. This has to be marked clearly in the circuit diagram as well as in the control cabinet. The grounding point in the control unit has to be marked with a yellow advisory sign. Text: "Operate the installation only with control circuit in grounded condition. Separate the bridge only for insulation inspection." If the earthed control circuit poses as a threat for people or machines, then an insulation monitoring has to be installed instead of the earthing.
3. Switch mode power supplies should be used to generate the 24V control voltage.

5 Housing, installation spaces and power supply

5.1 Control cabinet

5.1.1 General

1. Control cabinet in color RAL 7035
2. Stand-alone control cabinets must have transport lugs.
3. Equipment has to be installed on a mounting plate.
4. Rail systems and cable ducts have to be bolted or riveted on the mounting plate. Loose fasteners on the backside of the mounting plate are not permitted.
5. Doors have to be equipped with vertical metal hinges (opening angle ≥ 120°) and be lockable with a rub-in closure size 5.

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6. A rod lock design should be used for doors higher than 1,2 m.
7. All control lines leading to the installation have to be guided on strip terminals, distribution boards or plug systems.
8. The preferred protection class is IP54. In each individual case, another protection class has to be coordinated with the orderer, see DIN EN 60204-1:2019-06 item 11.3.

5.1.2 Equipment arrangement

1. Contactor and control elements are to be mounted in a sequence from left to right so that the designation in ascending numbering is guaranteed.
2. Equipment that needs to be operated (e.g., automatic timer, thermostat) has to be accessible without opening the control cabinet. This equipment has to be protected against unauthorized operation (consider the protection class).

5.1.3 Air conditioning of control cabinet

The increase in temperature within a housing with an electric equipment has to be assessed. The mounting and/or ambient conditions should be coordinated with the orderer. A maximum control cabinet internal temperature of 35°C has to be adhered to. In exceptional cases (e.g., through temporary effects caused by weather), an internal peak temperature of up to 40°C can be agreed upon in coordination with the orderer for a limited period. For this case, an undisturbed operation has to be guaranteed. Measures for the adherence to the limits of the relative humidity should be coordinated with the orderer.

The use of cooling devices controlled by cold water is preferred for the cooling of MAE control cabinets. If this is not practical due to technical reasons or if the plant lacks the infrastructure, then energy-efficient ventilators / air-cooling units with higher cooling efficiency rates should be used, e.g., the models by Rittal, TopTherm Blue e (current cooling efficiency rate up to 2,6) or comparable models with similar performance data.

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5.2 Access and installation spaces

The electric installation spaces cannot contain any other, e.g., mechanical, hydraulic, pneumatic equipment (nor any feed-through).

10% reserve space has to be planned, available at the final inspection, for changes or smaller additions to the control, e.g., for:

- Control cabinet surfaces, installation space and modules
- Strip terminals
- SPS-E/A
- Cable ducts
- Terminal boxes.

5.3 Power supply

5.3.1 General

1. The rated short-circuit current has to be defined for each MAE and has to be documented in the connection data and on the type label.
2. The introduction of the power line into the control cabinet is done on site. For cross sections up to 16 mm^2, conical threaded fasteners have to be used. For larger cross sections, cable clips are applied to achieve cord anchorage. The protection class must not be changed when using cable clips.
3. Terminals as well as the main switch can be used for the connection of the power feed. The power feed must not be on movable parts. The power supply connection in the control cabinet has to be carried out in the five-wire technology (TN-S system).

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4. Besides the external conductor terminal, also suitable terminals for the neutral conductor (N) and the protective conductor (PE) have to be available on the power port. The terminals must be identified with L1, L2, L3 and PE. N needs to be identified only if it is switched. Terminals for external and neutral conductors at least need to be protected against direct contact and marked as live elements (covering, warning sign, lightning arrow).

5.4 Quality

1. The terminal for the protective conductor or, in case of a main switch connection, the N-terminal, have to be arranged near the external conductor terminals.
2. Single-phase consumers, e.g., electrical / electronic devices such as lighting, vibrators, axle reinforcement, heat and receptacles have to be connected to an L and N conductor. The cross section of the power cord must at least measure 0,75 mm^2. Distribute single-phase loads symmetrically.

6 Main switch, mains disconnecting equipment and emergency-stop

6.1 Main switch (switch disconnector)

6.1.1 Requirements

(Application category AC-23B: occasional switching of resistive and inductive loads)

1. Interrupting capacity: $I_A = I_1 + I_{n-1}$ (breaking current)
   I_1 = current of the most powerful motor in blocked condition (normal: 8-fold rated current)
   I_{n-1} = sum of the operating currents of all other consumers
2. Separator property: ≥ 660 V (with 400 V power supply)

6.1.2 Implementation

1. Power supply terminals protected against direct contact and marked as “live” (warning sign lightning arrow).

6.1.3 Installation

1. If the main switch needs to be installed in the door, the selected solution must be considered in the risk assessment. For the risk assessment, the five items from the DKE-note for the norm must be considered [49]).
2. Main switches with door-locking system can only be used if this locking can be deactivated by electrically trained specialists. Switching off has to be possible while the door is open, independent of the arrangement of the main switch.

6.1.4 Plug device

1. Up to 16 A rated current and 3 kW total rated power, a plug device may be used instead of a main switch.
2. Breaking capacity as specified in section 6.1.1.

6.2 EMERGENCY STOP

1. For emergency stops occurring during an automatic working cycle it has to be decided between two options:
   - to finish the current cycle
   - to reset the equipment to the starting position.

   The selected solution has to be agreed with the orderer.

2. Equipment with several emergency stop command devices have to provide the option to display the operating state of each one individually (indicator light, diagnosis system).
3. The emergency stop concept of loosely linked systems has to be agreed with the orderer.

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7 Control technology

7.1 Protection of the control system in case of power failure

1. The entire IT system of the machine must allow for a secure restart of the machine. In case of a spontaneous power failure, remanent data has to be saved and the IT-system has to go to a safe state with the help of a UPS.

7.2 Software

1. In case of function block-oriented programming, the content of the function blocks has to be linked to certain machine functions or installation parts.
2. Source code has to be commented and its function has to be described in a suitable format.
3. The machine flow has to be described as per DIN EN 61131-3:2014-06. Structured text is the preferred programming language.
4. Process sequences shall be built-up according to the step chain principle 1 from n. Sensible deviations have to be agreed with the orderer.
5. The equipment identification from the machine construction has to be adhered to in the software as well and logical symbolic designations have to be selected. These symbols have to be commentated on sufficiently.
6. The whole program has to be documented with comprehensive headlines. Each part of the program, which is assigned to a function block, must have a short description of the contained program.
7. Parameterizable function blocks require precise documentation.

7.3 Diagnosis

1. The error diagnosis comprises safety and control elements as well as chain steps and cycle times.
2. The error diagnosis has to be performed in a way that an occurring error is displayed in clear text. The error is displayed until it is resolved and the disturbance is acknowledged. If multiple errors occur simultaneously, the first error is indicated and not overwritten.
3. Plausibility checks of signal sources must be done (e.g., cyclic query for both switching states).
4. Unexpected malfunctions of a machine have to be intercepted and displayed by the software.

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8 Control, command and signaling devices

8.1 General

1. The installation of command and signaling devices to the control cabinet or separate operator stations as well as the operating concept has to be agreed with the orderer. The designations of these devices have to be in the agreed language and/or symbolism.
2. Designation according to their function in the national language of the factory operator or with symbols according to DIN EN 61310-1:2008-09, DIN EN 61310-2:2008-09, DIN EN 61310-3:2008-09, IEC 61310-1:2007-02, IEC 61310-2:2007-02, IEC 61310-3:2007-02.
3. The function identification of the discrete command and signaling devices are placed above or on the left side of the device.
4. Signal generators must not be used as mechanical stop.
5. If signal elements have an adjustment possibility, unintentional adjustment must be prevented, (e.g., through locking screw, covering). For example, pressure switches, temperature and flow control instruments are also considered signal elements.

8.2 Sensors, switches and indicator lamps

Installation diameter:	22,5 mm (others after consulting with the orderer)
Identification and position:	as per DIN EN 60447:2004-12, preferably on the top or the right
Direction of activation:	as per DIN EN 60447:2004-12

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8.3 Colors of push-button actuators

Table 1 Colors of push-button actuators

Color	Explanation	Application examples
red	emergency	emergency stop
White	on	general ON, START, tapping, control ON, program ON, test ON
black	off	general OFF, STOP
green	normal	drive to initial position
Blue	mandatory	acknowledge, reset
yellow	abnormal	intervention to suppress abnormal condition (upon agreement with the orderer)

1. Additional symbol identification not required.
2. Push button arrangement as per DIN EN 60447:2004-12 figure 4.

8.4 Colors for indicator lights

8.4.1 Signaling of general and value stream-related machine conditions

The indicator lights provide clear information for the operators regarding the status of the machine and the status of the value stream. By signaling upcoming or actual unplanned machine standstill, operators are enabled to take necessary actions quickly. Thereby they improve the overall equipment effectiveness OEE. These objectives shall be considered as the guiding principle when implementing the integration of indicator lights for a given machine by guiding the operator in the necessary interventions.

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Table 2 Colors for indicator lights

Color	Explanation	Application examples
red	emergency, process interruption	warning in case of danger, immediate intervention necessary, stop/further work not permitted, signaling of every unplanned machine standstill, (e.g., through technical interruption, exceeding the limit value, missing material [however not from the predecessor process in the flow of a production line! In this case, use white])
yellow/ orange	warning	early warning about imminent failure (e.g., shortage of parts, refilling of material, oil deficiency,...)
blue	mandatory*)	modification, adjusting, setting etc. by authorized staff. To be used even in case of a standstill through periodically running automatic processes such as e.g., recalibration or hydraulic prospection of a nozzle.
Green	normal	machine produces parts
White	on	control on, machine ready for operation

*) in terms of a manual intervention

The sequence of the colors specified above applies to stacking lamps on top of the installations. All 5 indicator lights shall be used in any case. With alternative signaling solutions (e.g., LED or multicolor stripes), colors shall be used in an analogous manner. Signaling with steady light; only one color is active at any given point of time.

For better accessibility (e.g., red/green color deficiency), several multicolor lights have to be used, which compensate recognition deficiencies through spatial position differences.

For machines, which could fall into a dangerous operating condition with threat to life or physical condition (e.g., activation of a CO2 fire-extinguishing system, gas leak, ...), an additional signaling, e.g., an audio signal, shall be used on entering such operating conditions in addition to the color RED.

The used signaling has to occur consistent with the risk assessment defined in the hazard assessment.

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8.4.2 Signaling additional machine conditions

The additional indicator lights provide clear information for the operators regarding further relevant machine states. They are, for example, used for signaling an active remote access to the machine and thereby make it possible to point out associated risks and regulations applicable in this state to the operator.

Additional indicator lights can be determined for machines and equipment, which are intended for a linked line installation, in coordination with RB (e.g., a central indicator light for remote access for the line network in case of 1:n topologies).

Additional indicator lights should not be fixed close to the signaling column, in order to avoid a mix-up with indicator lights for signaling general and value stream-related machine states and should be labeled significantly (examples, see table 3).

The used signaling has to occur consistent with the risk assessment defined in the hazard assessment.

Table 3 Colors for additional indicator lights

Color	Explanation	Application examples
yellow/ orange	warning	remote maintenance active (e.g., use of Remote Shopfloor Access, ...) labeling of the indicator light with an additional description (e.g., remote maintenance active)
yellow/ orange	warning	laser active in maintenance state (e.g., Trumpf-Laser active, magnetization active, ...) labeling of indicator light with an additional description (e.g., Trumpf-Laser active)

8.5 Signal elements

Signal elements should be easily accessible for the exchange, for adjustment and for monitoring.
They must have an LED-display and should be pluggable if possible. Signal elements have to meet the protection class IP65 for use in wet areas.

8.5.1 Proximity switches

Proximity switches should be secured by mechanical protection against damage by force or against wrong actuation (e.g., chips). Standard dimensions should be used.

8.5.2 Key switch

Suitable secure selectors shall be used for selecting the operating modes, e.g., key switches or RFID chips.

If key switches are used for deactivating the protective function, then those with the lock number SSG21, 2 latching switch positions 0 – I and a switching angle of 90° have to be used for standard MAE. The removal of the key should be possible only in position 0. In order to prevent the key from being permanently inserted on the MAE, it may not be stuck in position 0 (key ejector). The function of the operation type selector switch is described in N54 D2. When using key switches for deactivating protective functions (e.g., a guard door), the automatic operation mode is only allowed with activated protective functions. Key switches with the lock number SSG25 shall be used for special applications (e.g., Laser). Key switches with the lock number SSG30 shall be used for clearing the remote access (Remote Shopfloor Access – RSA).

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9 Cables, lines, wiring

9.1 Cables and lines

9.1.1 General

1. For wiring, only flexible lines may be used. The cross section for connecting motors and other consumers has to be designed in relation to their power. Provide for sufficient mechanical strength.
2. For the introduction of cables, lines or protective sleevings, tension-relieving introductions have to be used. The specified IP degree of protection has to be warranted.
3. Cable introductions preferably come from bottom or sides. If required, turn equipment introductions (e.g., motor terminal boxes).

9.1.2 Colors

1. The wire colors listed in “Table 4 : Wire colors for single-strand lines” have to be used in case of single-strand lines.

Table 4 Wire colors for single-strand lines

Function	Symbol	Color
Protective conductor	PE	green/yellow
Equipotential bonding lines		green/yellow
Mid-point conductor of main current circuits	N	light blue
Main current circuits for alternating voltage or direct voltage		black
Auxiliary circuits for alternating voltage		red
Direct voltage		Blue
Chained voltage (introduced external voltage)		Orange
Central control technology (ZLT)		White

2. The green/yellow strand in multi-strand lines may be used only as protective conductors.
   If a blue strand is missing, a black strand may be used as mid-point conductor.
3. Multi-strand lines have to correspond to DIN EN 50334:2001-10.

9.1.3 Designation

1. Lines that are going out from control cabinet and terminal boxes have to be marked according to chap. 12.2 and 12.3. Protective conductor and N-conductor do not have to be labeled.

9.2 Installations (general provisions)

1. Electrical equipment has to be connected individually. Only systematically-connected users can be fused together.
2. Motors, pumps as well as neighboring aggregates up to 4 kW, of which the connecting parts are difficult to access, have to be designed pluggable.
3. Power rating plates of adjusting elements and driving devices have to be well readable even in installed condition.
4. Metal channels have to be used for the connection between machine and control cabinet and/or other separately placed aggregates.
5. Preferably, all installations, line introductions, threaded connections, terminal boxes and protective sleevings have to correspond to the protection class IP 54. The leak tightness class can be adjusted in coordination with the orderer. These determinations adapt the protection class to the ambient conditions at the installation place.
6. Line introductions have to be permanently strain-relieved.

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7. Design plug connectors always with strain relief (exceptions due to technical reasons are permissible).
8. Sealing material used has to comply with the requirements.
9. In order to connect sensors /actuators, prefabricated pluggable lines should be used preferably. The permissible line length is maximum 1,5 m.
10. For control lines, cables identified by numbers are recommended.
11. In wet areas, valves with cast-on connector and integrated LED have to be used.
12. Strands in fabricated lines must not be twisted.
13. Only cable glands with metric threads as per DIN EN 62444:2014-05 are permissible.
14. Reserve lines have to be put on terminals and to be identified. In case of EMC problems, these lines have to be grounded.

9.3 Protective measures/protection of installations

The following rules have to be observed for the protection against direct and indirect contact with live parts:

1. Small parts to be grounded and fastening angles have to be fixed with good conductivity using toothed contact discs on the grounded installation areas. Good conductivity hast to be ensured.
2. Bus bars for protective conductors have to be connected to each other with good conductivity. The suitable rail profile must be selected for this. Protective conductor terminals arranged on the carrier rail in an insulated manner are not permissible.
3. The protective conductor on the plugs of single-core lines of movable sheathed cables has to be the last to disconnect under a defined load.
4. The protective conductor connections have to be corrosion-resistant and secured against loosening. Fixing screws must not be used for the protective conductor connection.
5. Apply circuit-breakers or motor safety switches to protect current circuits. Electronic fuses are to be preferred for securing 24V circuits. If it is technically required, exceptions are permissible.
6. The power supply from the power outlets with a nominal current not greater than 20 A has to be equipped with a residual current device (RCD) with a release current of not higher than 30 mA.

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9.4 Installations before main switch

1. All parts that are live (supplied with voltage) even when the main switch is off, have to be protected against unintentional direct contact in a finger-safe way (power supply terminals, main switch terminals, feed terminals, receptacles, lighting, etc.). They have to be installed separate from other connections. The corresponding lines are conducted separately or identified preferably with yellow (orange) color.
2. Yellow single cores are not permissible, instead install them e.g., in protective sleeving or as sheathed line.
3. Components situated before the main switch have to be supplied with separate terminals from the power supply terminals (also N terminals).
4. All parts have to be marked as live by pictures (warning sign lightning arrow) and text.

9.5 Distribution board

1. Electric components should be implemented pluggable, if possible. It is preferred to use prefabricated cables.
2. Degree of protection IP 54 (in case of wet processing IP 65).

9.6 Terminal boxes

1. Coverings of terminal boxes have to be fastened with captive screws or hinges and a rub-in closure of size 5.
2. Ensure good accessibility.
3. Only electrical equipment may be installed in terminal boxes.
4. On each clamping point of the terminal block one line may be clamped only. All control lines leaving the control cabinet have to be guided to strip terminals, distribution boards or plug systems. The terminals and/or plug systems are labeled according to terminal plan. The designation is permanent, labeling by hand is not permitted.
5. The designation of the terminal block has to be applied on the covering of the terminal box.

9.7 Plug and terminal equipment

1. If control lines to the control cabinet are pluggable, the connections within the control cabinet can be guided directly to the components (e.g., SPS E/A, contactor, relays etc.).
2. Plug connectors are to be located where they are well accessible and protected largely against damage and dirt. Plug equipment of the same type that may be mismounted, has to be secured against mixing-up.

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3. Plug connectors have to be identified uniquely, permanently and correspondingly.
4. If no plug connectors are planned, all lines have to be guided individually on series terminals.
5. For valves and initiators, the use of three-way terminals is recommended.
6. If the control cabinet cannot be transported together with the machine, the electrical connections between control cabinet and machine are to be designed pluggable. In this case, measuring lines or prefabricated lines have to be conducted over mounting introductions.

10 Electric motors

10.1 General

1. The maximum setpoint for motor protection switches is the nominal motor current.
2. Several motors can be protected with one motor protection switch (motors up to 0,5 kW with connected thermal contact).
3. Redundant aggregates in the installation (e.g., replacement pumps, secondary devices, etc.) have to be put on separate back-up fuses.
4. Motors that are operated with frequency converters have to be equipped with a temperature monitoring. Manufacturer specifications have to be observed.

10.2 Installation

1. Motors with only one direction of rotation have to be permanently labeled with an arrow indicating the direction of rotation. For belt drives this arrow may be omitted, if the direction of transport of the belt is marked.

10.3 Winding layout and starting conditions

1. The locking unit of the star delta switch of motors has to be implemented in hardware only.

10.4 Three-phase AC motors

1.	Operating voltage:	3 x 400 V, 50 Hz (in case of direct start, consult with the orderer)
2.	Efficiency class:	>=IE3 as per DIN EN 60034-30-1:2014-12, mandatorily IE4, where required as per ordinance (EU) 2019/1781
3.	Compensation:	from 30 kVA consultation with the orderer
4.	Protection class:	IP 44 as per DIN EN 60529:2014-09
5.	Connections:	terminals or plug connectors.

10.5 Servomotors

It is preferred that brushless motors are used. A protection class lower than IP 44 is permissible, if the motor installation is suitably protected. Potential thermal problems have to be considered.

11 Electromagnetic compatibility / EMC-conform design

11.1 General

1. The supplier ensures the adherence of the respective valid commitments, which result from the guideline 2014/30/EU for electromagnetic compatibility (short: EMC-guideline).
2. Except the design of the human-machine-interface, planning of installations is done under technical and not aesthetic aspects. Exempted is the design of a human-machine interface.
3. Avoid unnecessary line lengths. Doing so, coupling capacities remain low.
4. Establish a low impedance connection between installation parts, such as control cabinet, machine, cable ducts, auxiliary equipment etc.

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11.2 Electricity feed

1. Filter technology for the energy supply is used to avoid disturbing effects on the installation technology. The filter has to be installed as close as possible to the entry point of the feeder in the control cabinet and must have a good ground connection across the surface. Filters, which can be clamped on the mounting rail, are not permissible.
2. Additional interference filters are placed directly at the source of interference.
3. The filters for converters (e.g., for drives) are placed directly on their entry and wherever necessary at their exit.

11.3 Arrangement of control cabinet

11.3.1 Mechanical arrangement of control cabinet

1. The surface of the mounting plate has to be electrically conductive, e.g., sendzimir-galvanized.
2. Housing parts of mounted equipment and the side walls of the control cabinet must have a ground connection across the surface.
3. Connect the door of the control cabinet with a ground strap.
4. Mounting rails applied on the mounting plate have to provide a good ground connection.

11.3.2 Electrical arrangement of control cabinet

1. Shields and equipotential bonding lines have to be connected to ground near the cabinet inlets across the surface with suitable terminals and/or rails. Any interruption is not permitted. Drain wires are not permitted.
2. If the equipotential bonding between equipment and control cabinet is insufficient, install an equipotential bonding line with a minimum cross section of 10 mm^2.
3. Reserve lines have to be put on terminals and to be identified. In case of EMC problems, these lines have to be grounded.
4. If devices and components with inductive behavior are used (e.g., transformers, throttles, power supply units, drives), then the routing has to be especially short.
5. The interference of inductive loads (e.g., contactor, relay, solenoid-operated valve, motor) has to be suppressed by using RC member, diode or varistor. Interference suppressing may be omitted if these loads can be connected from control elements with suppressed interference, e. g. SPS output.
6. Power components and sensitive sensor technology and/or measurement technology should be arranged at the greatest distance possible. Select the arrangement of equipment and components in a way that the wiring of power and sensor technology can be performed separately.

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11.4 Cable ducts

1. Energy and signal lines (e.g., motor cables, lines between frequency converter and measuring lines, or BUS lines etc.) are laid in separate ducts, otherwise use ducts with separators.
2. Cable ducts between control cabinet and equipment have to be metallic. Exceptions are possible for chemical installations.
3. Cable ducts must have continuous low resistance ground connections (through mechanical screw connections). In special cases in big installations, technical agreements between manufacturer and factory operator have to define how the ground connection is performed. An existing protective conductor connection needs to be integrated into the protective conductor system.

11.5 Installation

1. Run the cable as narrow as possible across a large surface connected to ground.
2. Avoid wound-up cable bundles.
3. Use the maximum possible cross section for the ground balancing line between cabinet and machine (≥ 16 mm^2). If further ground balancing lines are necessary, use cross sections ≥ 6 mm^2.
4. Cable shielding shall be extensively connected to ground (clip on grounding rail).

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12 Identification of machines and equipment

12.1 Identification of control equipment

1. Valves, motors, limit switches etc. have to be identified permanently and correspondingly with the technical documentation. The identification has to be unique and distinctively assigned to the equipment.
2. If any confusion may be possible among the connection cables of pluggable equipment (e.g., valves, pumps, signal generators), a further identification has to be fixed to the cable additionally to the firmly attached identification.
3. Identifications have to be permanent and resistant to heat, oil, light, chemical effects etc.
4. For installations with aggressive media use resistant materials (e.g., plastic with plastic groove pins) and metallic materials (e.g., aluminum) in hot areas.

12.2 Identification inside control cabinets

12.2.1 Identification of machinery and equipment as per DIN EN IEC 81346-2:2020-10

12.2.2 Line identification

Table 5 Line identification

For	Outgoing line
Equipment with relatively long life cycle, such as fuses/automatic circuit breaker, contactors, transformers	Identification **not** required
Pluggable electronic equipment and pluggable SPS-E/A connections	Identification **not** required
Firmly connected electronic equipment Firmly connected safety relays	**Must be** identified with **connecting number**
Output terminals for inside wiring of cabinet	Do **not** identify
Output terminals, not separable to machine and peripheral equipment	**Must** be identified with **connecting number**. Identification **not** required if the **assignment** of lines identified with numbers or color codes in the **circuit diagram** is unique.
Output terminals, separable to machine and peripheral equipment	Cable to machine must be identified
Output plug to machine and peripheral equipment	For cables identified by numbers use logical assignment to plug number. Connector has to be labeled, strands in the same way as output terminals.
Equipment in the control cabinet that is directly connected (without output terminals or plug) from outside	**Must** be identified by the **terminal number** of the equipment.

12.3 Identification during installation and inside the terminal boxes (signal, adjustment and drive elements)

12.3.1 Line and strand identification of machinery and equipment

Table 6 Line and strand identification of machine and equipment

For	Outgoing lines
Pluggable machinery and equipment	**No** identification
Machinery and equipment connected via terminals (e.g., motors, ...)	Identification with terminal number

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12.3.2 Line and strand identification in the terminal box

Table 7 Line and strand identification in the terminal box

For	Outgoing lines
Outgoing lines to the control cabinet	No identification for cables identified by numbers, if assignment is determined in the circuit diagram, otherwise identify with terminal number.
Lines to motors and pluggable signal and adjustment elements (proximity switch, valves)	**No** identification
Connected directly via lines, not pluggable machinery and equipment	**No** identification

13 Documentation of machinery and installation

13.1 Circuit diagram

1. The circuit diagram has to be clearly structured and numbered according to DIN EN IEC 81346-2:2020-10. It must correspond with the installation in all details.
2. The circuit diagram documentation has to include the following items on one or more cover sheets:
    - Name or brand of manufacturer
    - Machine type or catalog number
    - Year of construction
    - Serial number
    - Rated voltage or nominal voltage range
    - Rated current and back-up fuse
    - Rated short circuit current
    - Nominal power
    - Connected load
    - Current type, frequency
    - Project-specific wiring colors
    - Number of circuit diagram with version
    - Table of contents
    - Wiring diagram
    - Numbering systematic of electrical machinery and equipment explained in legend
    - Graphical symbols for diagrams according to DIN EN 60617-2:1997-08 to DIN EN 60617-13:1994-01
    - Necessary electrical power parameters of machinery and equipment needs to be indicated
    - Line wiring of fieldbus systems is to be documented by its order, addressing and length indication
    - Same potentials get the same identification
    - Power circuits not separated by the main switch, have to be identified in the documents
    - The designation of components is supplemented by respective cross references
    - Equipment and equipment combinations can be represented as block diagram with connection designation
    - Cross references to interfaces of purchase equipment
    - Bills of Material
    - Terminal diagrams/connector diagrams
    - Cable lists (upon agreement with the orderer).

DIN EN 60617-13:1994-01

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13.2 Hints for risk assessment and operating instruction

The remote access (and thereby also the remote maintenance access) has to be considered in the risk assessment of the machine. Here, non-mechanical hazards are also relevant (e.g., Laser on/off, ventilation on/off, etc.). During the risk assessment, special attention has to be placed on safety-relevant components, which can be accessed via remote access. For these components it has to be ensured that no manipulation of these components is possible via the remote access. On the whole, the safety concept of the machine may not be corrupted by the remote accesses.

In the operating instruction, the remote access and the boundary conditions under which remote access is possible (e.g., under consideration of the operating modes) have to be explained and, if required, necessary additional measures should be defined.

DIN EN ISO 10218-2:2012-06 should also be considered while using industrial robots.

During the application of components, which contain a radio installation, the risk assessment has to be carried out according to the RED-guideline (guideline 2014/53/EU).

14 Media supply

14.1 Media supply for hydraulics

14.1.1 General

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Hydraulic equipment as single assemblies as well as part of machines, equipment, installations, furnaces and devices have to correspond to DIN EN ISO 4413:2011-04 as well as all currently valid accident prevention regulations of the institution for statutory accident insurance and prevention and the latest findings of technology.
Here, the quality bases for hydraulic installations of DIN EN ISO 4413:2011-04 have to be noted.

If individual requirements of the DIN EN ISO 4413:2011-04 cannot be implemented due to specific boundary conditions of the application domains, e.g., in testing machines, then the deviation should already be indicated in the offer and in the documentation of the equipment.

The following requirements have to be met supplementing and/or deviating from the same.

14.1.2 Requirements

14.1.2.1 Hydropumps and -motors (DIN EN ISO 4413, chap. 5.4.1)

Energy-efficient hydraulic assemblies have to be used in machine tools. Depending on the use case, assemblies should be used with fixed displacement pump and variable speed drive (DvP) or integrated circuit memories and memory charging circuitry (preferred with electric shut-off of the drive motor over two-level controllers in the no charging mode). Components and products from Bosch Rexroth AG should preferably be used.

14.1.2.2 Pre-filling of housings (DIN EN ISO 4413, chap. 5.4.1.5)

Before the first start-up of pumps, the start-up instructions are to be observed, in particular with reference to filling the pump housing and the start-up pressure conditions.

14.1.2.3 Gas-loaded accumulators (DIN EN ISO 4413, chap. 5.4.3)

Nitrogen has to be used as filler gas.

14.1.2.4 Valves (DIN EN ISO 4413, chap. 5.4.4)

The following types of valves have to be used: panel mounting type, distance plate valves (stack mounted) or valves for block mounting (2-port cartridge valves and threaded valves).

Exception: Line mounting is permissible for:

- non-return valves

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- throttle valves
- throttle-type non-return valves
- pressure limiting valves.

Connection hole patterns

- Manifold mounting direction control valves ISO 4401:2005-07
- Manifold mounting pressure, flow control and check valves ISO 6264:1998-03, ISO 6263:2013-04 and ISO 5781:2016-08.

Mounting dimensions

2-port cartridge valves DIN ISO 7368:2018-09

14.1.2.5 Electrical connections (DIN EN ISO 4413, chap. 5.4.4.4.1.1)

According to ISO 4400:1994-09, plug connectors have to be used in valves with electrical connections, except for proportional and control valves. In case of difficult operating conditions, the corresponding protection classes (e.g., "Ex") have to be considered.

14.1.2.6 Manual or other overrides (DIN EN ISO 4413, chap. 5.4.4.4.1.3)

It should be possible to be able to manually actuate electrically actuated direction control valves, except for proportional and control valves, as well. An unintended actuation should not be possible.

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14.1.2.7 Heating systems (DIN EN ISO 4413, chap. 5.4.5.5)

While using immersion heaters or oil heaters, the heat flux of 0,7 W/cm^2 on heating surfaces without circulation flow and 2 W/cm^2 on heating surfaces with circulation flow should not be exceeded.

14.1.2.8 Hose assemblies (as per DIN 20066, DIN EN ISO 4413, chap. 5.4.6.5)

Hose assemblies should be listed in an additional separate hydraulic parts list with the following data (DGUV Rule 113-020:2017-10):

- Manufacturer, type and nominal width of the hose
- Indicator of the hose line manufacturer
- Assembly date (year/month)
- Highest dynamic operating pressure
- Length and connection type (mounting part) of the hose assembly.

The hose assemblies should be marked permanently according to the hydraulics plan, e.g., hanging signs.

14.1.2.9 Hydraulic accumulator (DIN EN ISO 4413, chap. 5.4.7.3)

Automatic shut-off or discharge of the hydraulic accumulators.
Hydraulic accumulators with pressure function (e.g., for tensioning, hydrostatic bearings etc.) have to allow manual discharge.

14.1.2.10 Rinsing (DIN EN ISO 4413, chap. 5.4.7.4.4)

Servo valves can be installed only if the hydraulic system has been cleaned with flushing plates or flush valves (direction control valves).
Is not applicable for proportional and control valves.

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14.1.2.11 Verification of safety requirements and acceptance testing for function test (DIN EN ISO 4413, chap. 6)

The installation has to be tested for its functionality. It is to be verified, whether the function corresponds to the function assured by the supplier. A confirmation should be sent with the delivery.

- Acceptance documents, see "General delivery instructions N51M M20".

14.1.2.12 Final specifications for installations in stationary industrial machines (DIN EN ISO 4413, chap. 7.2)

Circuit diagram as per:

- N51M M20

14.1.2.13 Maintenance information (DIN EN ISO 4413, chap. 7.3.2.2)

Maintenance manuals, see "General delivery instructions N51M M20".

14.1.2.14 Identification and designation (DIN EN ISO 4413, chap. 7.4)

Identification labels have to be attached on the assembly in such a way that they can be easily read by maintenance personnel.

The information on the signs has to contain the controlled function (e.g., "release tightener") along with the identification (e.g., Item-No.) according to the circuit diagram.

The fastening of oil-proof signals happens with the help of adhesives.

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14.2 Hydraulic pumps for machine tools

In case of machine tools with hydraulic leak rates under 1 l/min, hydraulic assemblies with memory charging circuitry and electrical shut-off of the drive motor over two-level controllers in the no charging mode should be used preferably.

In case of machine tools with hydraulic leak rates over 1 l/min due to the design, hydraulic assemblies with constant pump and variable-speed drive (DvP) should be used preferably, as long as it is deliverable.

14.3 High-pressure pumps for cooling lubricant

For generating the high pressure for the cooling lubricant in processing centers, it is preferred to use equipment with screw spindle pumps with frequency-controlled drive. As another alternative, boosters (new approach DC, pressure 10 bar to 150 bar, variable media cleanliness) or radial/axial piston pumps [only at a high media cleanliness (limit value for cleanliness)] are permissible.

14.4 Media supply for pneumatics

14.4.1 General

Pneumatic equipment has to ensure correct functionality at 4,5 bar to 6,0 bar. A deviating operating pressure has to be agreed upon.

The following applies for special machines:

- The pressure air supply in the plant brings at least 5,5 bar inlet pressure to the MAE.
- The inlet pressure at the maintenance unit of the MAE is reduced to 5 bar in order to avoid pressure variations.
- The machine stops at a pressure drop under 4,5 bar - 0,2 bar.
- In each individual case, deviations should be agreed upon in writing.

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Pneumatic equipment as single assemblies as well as part of machines, equipment, installations, furnaces and devices have to correspond to DIN EN ISO 4414:2011-04 as well as all currently valid accident prevention regulations of the institution for statutory accident insurance and prevention and the latest findings of technology.

The **VDMA Standard sheet 66416:2016-01** can be used to help with the interpretation.

If individual requirements of the DIN EN ISO 4414:2011-04 cannot be implemented due to specific boundary conditions of the application domains, e.g., in testing machines, then the deviation should already be indicated in the offer and in the documentation of the equipment.

The following requirements have to be met supplementing and/or deviating from the same.

14.4.2 Requirements

14.4.2.1 Conditions at the installation location and work environment

Irrespective of the energy types available in the pneumatics system (e.g., electric, pneumatic), there should be no danger during switching on and off of the energy supply, in case of energy loss as well as energy return (unexpected or intentional).

Feed valves have to be planned in the maintenance unit in order to avoid drops in pressure and faster, uncontrolled movements while switching on an installation.

If the operating pressure sinks below a permissible value, a switch-off of the energy supply has to take place through adequate measures.

Depending on the conditions of the machine/installation, one of the different options should be discussed with the orderer, e.g.:

- no further automatic cycle
- installation without pressure
- emergency stop.

While using 5/3 direction control valves with blocked center position and analogous circuitry, a manual person release/ventilation has to be planned according to the remaining risks through the blocked compressed air, as long as the person cannot be released by simple means.

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14.4.2.2 Mounting of feed-shut-off valve

All pneumatic installations must have a shut-off valve in the main line. It must be possible to secure this valve, when in the shut-off position (installation vented), against mistaken and unauthorized activation.

14.4.2.3 Compressed-air preparation systems

The conditions for compressed air have to be prepared in accordance with the application and the selected equipment. Contaminants and their aggregate states are listed in the ISO 8573-1:2010-04.

Solids	class 7 with < 5µm particle size
Humidity and water content	Class 4
Oil content	Class 3

14.4.2.4 Design of piping system

The piping system is to be installed in such a way to restrict the number of pipe connections to a minimum
-> Energy efficiency: lines as short as possible.

Threaded connections with taper screw thread must not be used.

Use threaded connections with plug connection.

As connections for metal pipes, see DIN EN 10305-1:2016-08, fittings with cutting ring as per DIN 2353:2013-01 and DIN EN ISO 8434-1:2018-11, in each case the same make in steel, are permissible.

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For plastic pipes (hoses), quick release couplings with fitting piping material PU (polyurethane) and/or for machines with test media (gasoline/diesel) also PA (polyamide) are to be used.

If required, the threaded connections have to be equipped with supporting sleeves.

Plastic pipes of different color should be used as far as possible according to a function code (operating position, normal position, person release/ventilation) in order to reduce the possibility of interchanging during service. If alphanumeric labels are used on the cables, then the color code can be foregone. Exception: The process has to be agreed upon explicitly in case of machines designed to be compatible with ESD.

In case of vacuum installations, suitable screwed connections have to be used so that a vacuum tightness can be guaranteed.

14.5 Vacuum generation

In order to generate vacuum, vacuum pumps have to be used instead of vacuum ejectors, if the volume flow rate > 2 m^3/h and the installation location permits the same and the actuated time (ED) > 25%.

15 Tests

The tests as per DIN EN 60204-1:2019-06 item 18 shall be carried out by the manufacturer and documented with the log. Used BUS systems shall be tested and documented with corresponding log.

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16 Normative references

The following documents are necessary for using this Bosch-Norm. With dated references, solely the edition referred to applies. With undated references, the last edition of the indicated document applies (including all revisions). Intentionally cited historical documents are additionally identified as "H" in the column "Type."

No.	Document number (edition date)	Title	Type
1	N51M M20*N56A 05 M0020	Machine tools, delivery instructions, General delivery instructions for machines, installations and production equipment (MAE)	Z
2	N54 D2	Control engineering, electrical system -electronics; Electrical outfitting of machines, facilities and production equipment; Safety functions	Z
3	DIN EN 60204-1:2019-06	Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2016, modified); German version EN 60204-1:2018	Z
4	DIN EN 60034-30-1:2014-12	Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code) (IEC 60034-30-1:2014); German version EN 60034-30-1:2014	Z
5	DIN EN 60529:2014-09	Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989 + A1:1999 + A2:2013); German version EN 60529:1991 + A1:2000 + A2:2013	Z
6	DIN EN 61310-1:2008-09	Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1:2007); German version EN 61310-1:2008	Z
7	DIN EN 61310-2:2008-09	Safety of machinery - Indication, marking and actuation - Part 2: Requirements for marking (IEC 61310-2:2007); German version EN 61310-2:2008	Z
8	DIN EN 61310-3:2008-09	Safety of machinery - Indication, marking and actuation - Part 3: Requirements for the location and operation of actuators (IEC 61310-3:2007); German version EN 61310-3:2008	Z
9	IEC 61310-1:2007-02	Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals	Z
10	IEC 61310-2:2007-02	Safety of machinery - Indication, marking and actuation - Part 2: Requirements for marking	Z
11	IEC 61310-3:2007-02	Safety of machinery - Indication, marking and actuation - Part 3: Requirements for the location and operation of actuators	Z
12	DIN EN 60447:2004-12	Basic and safety principles for man-machine interface, marking and identification - Actuating principles (IEC 60447:2004); German version EN 60447:2004	Z
13	DIN EN 50334:2001-10	Marking by inscription for the identification of cores of electric cables; German version EN 50334:2001	Z
14	DIN EN IEC 81346-2:2020-10	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 2: Classification of objects and codes for classes (IEC 81346-2:2019); German version EN IEC 81346-2:2019	Z
15	DIN EN ISO 4413:2011-04	Hydraulic fluid power - General rules and safety requirements for systems and their components (ISO 4413:2010); German version EN ISO 4413:2010	Z
16	DIN EN ISO 4414:2011-04	Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010); German version EN ISO 4414:2010	Z
17	DIN 20066:2021-07	Hydraulic fluid power - Hose assemblies - Dimensions, requirements	Z

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No.	Document number (edition date)	Title	Type
18	ISO 4401:2005-07	Hydraulic fluid power - Four-port directional control valves - Mounting surfaces	Z
19	ISO 6264:1998-03	Hydraulic fluid power - Pressure-relief valves - Mounting surfaces	Z
20	ISO 6263:2013-04	Hydraulic fluid power - Compensated flow-control valves - Mounting surfaces	Z
21	ISO 5781:2016-08	Hydraulic fluid power - Pressure-reducing valves, sequence valves, unloading valves, throttle valves and check valves - Mounting surfaces	Z
22	DIN ISO 7368:2018-09	Hydraulic fluid power - Two-port slip-in cartridge valves - Cavities (ISO 7368:2016)	Z
23	ISO 4400:1994-09	Fluid power systems and components - Three-pin electrical plug connectors with earth contact - Characteristics and requirements	Z
24	ISO 8573-1:2010-04	Compressed air - Part 1: Contaminants and purity classes	Z
25	DIN EN 10305-1:2016-08	Steel tubes for precision applications - Technical delivery conditions - Part 1: Seamless cold drawn tubes; German version EN 10305-1:2016	Z
26	DIN 2353:2013-01	Non-soldering compression fittings with cutting ring - Complete fittings and survey	Z
27	DGUV Rule 113-020:2017-10	Hydraulic hose lines and hydraulic fluids – regulations for safe application	Z
28	DIN EN ISO 8434-1:2018-11	Metallic tube connections for fluid power and general use - Part 1: 24° cone connectors (ISO 8434-1:2018); German version EN ISO 8434-1:2018	Z
29	2007-06-03	Ordinance on the protection of workers from the risk of noise and vibration (Industrial Safety Ordinance - Noise and vibration - LärmVibrationsArbSchV	Z
30	2006/42/EG	Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC	Z
31	VDMA Standard sheet 66416:2016-01	Machines and Lines for Handling, Assembly and Testing Technologies - Safety of Machinery for Hazards caused by Moving Machine Parts and Definition of Operating Modes	Z
32	DIN EN 60617-2:1997-08	Graphical symbols for diagrams - Part 2: Symbol elements, qualifying symbols and other symbols having general application (IEC 60617-2:1996); German version EN 60617-2:1996	Z
33	DIN EN 60617-3:1997-08	Graphical symbols for diagrams - Part 3: Conductors and connecting devices (IEC 60617-3:1996); German version EN 60617-3:1996	Z
34	DIN EN 60617-4:1997-08	Graphical symbols for diagrams - Part 4: Basic passive components (IEC 60617-4:1996); German version EN 60617-4:1996	Z
35	DIN EN 60617-5:1997-08	Graphical symbols for diagrams - Part 5: Semiconductors and electron tubes (IEC 60617-5:1996); German version EN 60617-5:1996	Z
36	DIN EN 60617-6:1997-08	Graphical symbols for diagrams - Part 6: Production and conversion of electrical energy (IEC 60617-6:1996); German version EN 60617-6:1996	Z
37	DIN EN 60617-7:1997-08	Graphical symbols for diagrams - Part 7: Switchgear, controlgear and protective devices (IEC 60617-7:1996); German version EN 60617-7:1996	Z
38	DIN EN 60617-8:1997-08	Graphical symbols for diagrams - Part 8: Measuring instruments, lamps and signalling devices (IEC 60617-8:1996); German version EN 60617-8:1996	Z
39	DIN EN 60617-9:1997-08	Graphical symbols for diagrams - Part 9: Telecommunications; Switching and peripheral equipment (IEC 60617-9:1996); German version EN 60617-9:1996	Z

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No.	Document number (edition date)	Title	Type
40	DIN EN 60617-10:1997-08	Graphical symbols for diagrams - Part 10: Telecommunications; Transmission (IEC 60617-10:1996); German version EN 60617-10:1996	Z
41	DIN EN 60617-11:1997-08	Graphical symbols for diagrams - Part 11: Architectural and topographical installation plans and diagrams (IEC 60617-11:1996); German version EN 60617-11:1996	Z
42	DIN EN 60617-12:1999-04	Graphical symbols for diagrams - Part 12: Binary logic elements (IEC 60617-12:1997); German version EN 60617-12:1998	Z
43	DIN EN 60617-13:1994-01	Graphical symbols for diagrams; Part 13: Analogue elements (IEC 60617-13:1993); German version EN 60617-13:1993	Z
44	DIN EN 61131-3:2014-06	Programmable controllers - Part 3: Programming languages (IEC 61131-3:2013); German version EN 61131-3:2013	Z
45	DIN EN 62444:2014-05	Cable glands for electrical installations (IEC 62444:2010, modified); German version EN 62444:2013	Z
46	DIN EN ISO 10218-2:2012-06	Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration (ISO 10218-2:2011); German version EN ISO 10218-2:2011	Z
47	2014/53/EU	Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC	Z
48	2014/30/EU	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility	Z
49	DKE/K_225_Hinweis_zur_Norm_2021-10-15	Note on the standard Installation of manually operated switching devices for protecting and disconnecting main circuits in control cabinet doors according to DIN EN 60204-1:2019, publication 15.10.2021 (German only)	Z

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