Electrical Specification for Industrial Machinery

Addendum to IEC 60204-1, Edition 6, 2016-10

Global Common

SD-004

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Foreword

This Electrical Specification for Industrial Machinery is issued by Nexteer Automotive. The intent is to provide Nexteer Automotive Plants with safe, well designed, reliable, and productive electrical control systems for industrial machinery, which consistently produce high quality products.

This specification is designed as an addendum to "IEC 60204-1 Safety of machinery – Electrical equipment of machines – Part 1: General requirements; Sixth Edition 2016-10." In order for this addendum to be understood and implemented, a copy of IEC 60204-1 is required.

For clarity, the chapter heading and hence the overall format of IEC 60204-1 has been adopted, even if no additions or changes have been made. All item numbers containing technical content have been identified as to the type of change made from IEC 60204-1. The following convention was used:

- Summary of IEC 60204-1.
- ADD: additional requirements to those stated within IEC 60204-1.
- MODIFY: modified requirements to those stated within IEC 60204-1.
- CLARIFY: informative text added to assist in the understanding of requirements stated within the IEC 60204-1.

This specification was developed by Nexteer Automotive. The mission was to develop a Nexteer Automotive specification based on a globally accepted standard to:

- enhance safety,
- simplify and clarify the specification in order for machinery and equipment builders to comply with minimum costs,
- encourage the common implementation across all Nexteer Sites,
- improve equipment reliability and maintainability,
- incorporate common divisional and Plant specifications into this specification to reduce their size and complexity,
- support lean manufacturing equipment, and
- support design-in safety practices.

This specification is not intended to inhibit new technology in any manner; consequently, Nexteer Automotive would expect and encourage all industrial equipment builders to call to attention any situation which, in their opinion, inhibits the application of new technology. This approach allows any new technology proposal to be evaluated on the merits of its application.

Top priority is given to the enhancement of safety in the operation and maintenance of industrial equipment in conjunction with compliance with Country, State, Provincial, and / or Municipal regulations and safety codes, including international consensus standards and qualified test laboratories standards.

While Nexteer Automotive believes that the specification described in this booklet provides a sound basis for safe electrical control systems for industrial machinery, they are intended only for the use within Nexteer Automotive operations. The specifications were developed based solely on the equipment, operations, processes and facilities of Nexteer Automotive. These specifications should not be relied on for use at non-Nexteer Automotive operations and Nexteer Automotive specifically disclaims any liability should there be use for equipment, operations, processes, and facilities outside their intended purpose.

This specification applies to the purchase of new equipment and major equipment rebuilds. It should not be implied that an existing equipment is required to be retrofitted in order to comply with this specification.

The Forward of IEC 60204-1 includes a list (a-i) of significant technical changes with respect to the previous edition.

ADD: The following (j-cc) significant changes have been made to SD-004 with respect to the previous release.

j) Clause 4.4.2 – Electromagnetic compatibility (EMC); line filters shall be installed ahead of VFD's and Servo Drives to reduce electrical noise.
k) Clause 5.1 – Incoming supply conductor terminations; all supply conductors must be terminated at the supply main disconnect.
l) Clause 7.2.4 – Control circuits; Class 2 power supplies or circuit protection shall be used for devices requiring Class 2 power.
m) Clause 7.2.6 – Lighting circuits; overcurrent device requirements for 120/230V_{AC} lighting circuit applications was removed – all lighting shall be 24V_{DC} (Clause 15.2.2).
n) Clause 7.2.9.2 – Circuit Breakers; circuit breakers shall have Type D trip curve for the primary side of transformers and power supplies.
o) Clause 7.7 – Additional earth fault / residual current protection; residual current protection shall not be implemented for the entire equipment protection due to nuisance trips.
p) Clause 9.2.3.4.2 – Emergency Stop; hardwired circuits must include a safety module for all Nexteer facilities.
q) Clause 9.2.3.8 – Two-hand control; for Nexteer Brazil, two-hand cycle start initiation is required per NR12 requirements.
r) Clause 9.5.4 – Communication (of programmable control devices); Nexteer documents all ethernet based communication protocols in SD-1045; Machine Ethernet Network Specification.
s) Clause 10.1.2 – Location and mounting (of Operator interface and machine-mounted control devices); all operator interface control devices shall be vertically located between 0,9 and 1,65 m above the working surface.
t) Clause 10.2.1 – Colours (of actuators); reset actuators shall be BLUE (BLACK reset pushbuttons are no longer allowed).
u) Clause 10.2.1 – Colours (of actuators); "request to enter" push buttons shall be illuminated YELLOW for full body access and robotic cells.
v) Clause 10.3.4 – Multi-color indicators; additional guidance provided on multi-color indicators for operator load / unload stations as well as multi-color cycle initiation buttons.
w) Clause 10.7.1 – Location of emergency stop devices; machines with identified hazardous motions on the machine risk assessment shall be provided with at least one emergency stop device.
x) Clause 10.7.5 – Emergency stop identification; machines with more than one emergency stop device shall be provided with individual annunciation of their status.
y) Clause 11.2.1 – Accessibility and maintenance (of controlgear); controlgear mounted in enclosures must be mounted no higher than 2,0 m.
z) Clause 11.2.6 – Power Supplies; improved power supply types.
aa) Clause 11.3 – Degrees of protection; requires ancillary equipment, such as torque drivers, also comply to the control system IP rating.
bb) Clause 12.3 – Insulation (of conductors and cables); removed preferred insulation types.
cc) Clause 16.4 – Marking of enclosures of electrical equipment; all electrical enclosures with through-the-door rotary disconnect switches with the handle mounted on the door shall be appropriately labeled.

1. Scope

ADD: The following does not appear in Clause 1:

- Purpose – This specification is to be used for the purchase of equipment for manufacturing at all Nexteer Automotive Plant sites globally.
- Standards – This equipment, and devices on this equipment, shall conform to international common industry standards, such as IEC and ISO.
- Modifications and additions – Equipment designed specifically for Nexteer requirements, including modifications and additions to standard equipment, shall also conform to these standards.
- Mandatory requirements – Mandatory requirements of this specification are indicated by the use of "shall."
- Deviations – Deviations from this standard shall require advanced written approval of the Nexteer Controls Engineer and the Nexteer Purchasing Engineer (Engineer-in-Charge). Any waivers granted shall apply only to the machine in question and shall not be considered permanent.
- Conflicts – The industrial equipment builder (OEM) shall call to attention of the Nexteer Controls Engineer any situation of a conflict between this standard and any other applicable code / regulation.

2. Normative References

ADD: The following Normative References do not appear in IEC 60204-1 Clause 2 and are referenced by Nexteer Automotive.

NFPA 70, National Electrical Code (NEC).

Nexteer Automotive Specification SD-001, General Manufacturing Equipment Specifications.

Nexteer Automotive Specification SD-003, General Drawing and Manuals Specification.

Nexteer Automotive Specification SD-011, Specification for Safety Circuits.

Nexteer Automotive Specification SD-012, Design-In Health and Safety Specification.

Nexteer Automotive Specification SD-017, Design-In Ergonomics Guideline.

Nexteer Automotive Specification SD-1020, Human Machine Interface Application Specification.

Nexteer Automotive Specification SD-1032, Programmable Controller Logic Application Specification.

Nexteer Automotive Specification SD-1045, Machine Ethernet Network Specification.

Local Standards – all equipment shall comply with the latest version of any applicable federal, state, provincial, and local standards for the plant site.

CLARIFY: The Industrial Equipment Supplier is responsible for obtaining copies of all National and International Standards referenced in the specification as needed. Nexteer Automotive specifications are available on the Nexteer Data Exchange website at www.nexteerdataexchange.com under Vendor Documents.

3. Terms, definitions and abbreviated terms

3.1 Terms and definitions

ADD: The following terms and definitions (3.1.66 – 3.1.73) do not appear in Clause 3.1:

3.1.66 Ground Fault Circuit Interrupter (GFCI)

A Residual Circuit Protection Device (RCPD) for the protection of personnel, meeting particular US or Canadian standards, and, as such, is one type of RCPD.

NOTE: GFCI's trip when the leakage current has a value in the range of 4 to 6mA.

3.1.67 In-cycle

The control function that makes a machine capable of producing automatic motion. This is not just an indication, but the command that enables automatic motion for the duration of the cycle.

3.1.68 Ingress Protection (IP)

An IEC ingress protection rating system.

3.1.69 Work lighting

Fixed mounted or portable light, readily accessible and adjustable, located on the outside of a machine, provided to help illuminate the operator area (also known as task lighting).

3.1.70 Machine lighting

Fix mounted (non-adjustable) light located on the inside or outside of a machine, provided to illuminate the general area.

3.1.71 Programmable Electronic System (PES)

Programmable Electronic System, such as a PLC or CNC controller.

3.1.72 Residual Circuit Protection Device (RCPD)

A device which will de-energize a circuit when it senses a difference in the amount of electricity passing through the device and returning through the same device, or a "leak" of current from the circuit, typically when it detects a grounding problem which has caused an unsafe flow of current to ground. These devices commonly are built into outlet-socket or the circuit breaker feeding the outlet socket.

Other industrial terms similar to RCPD include:

- RCD – Residual-Current Device;
- RCCB – Residual-Current Circuit Breaker;
- ELCB – Earth-Link Circuit Breaker;
- ALCI – Appliance Leakage Current Interrupter;
- GFCI – Ground Fault Circuit Interrupter
- Ground fault protection.

NOTE: RCPD trip current differs based on the intended use. Personnel protection should trip at no greater than 30mA, while Equipment protection can be much higher.

3.1.73 TN-C / TN-S

Acronyms for the type of electrical supply system at a facility.

The first letter ("T" or "I") refers to the connection between Earth and the power supply:

- "T" is direct connection point to Earth.
- "I" is no connection point to Earth (isolated).

The second letter ("T" or "N") refers to the connection between Earth and the electrical device (machine):

- "T" is direct connection to Earth (ground rod) independent of any other Earth connection.
- "N" is connection to Earth via supply conductors.

The third letter ("C" or "S") refers to the connections to PE (Earth) and neutral:

- "C" is one common supply wire connected to both PE and neutral.
- "S" is two separate supply wires: a separate PE and neutral.

3.2 Abbreviated terms

ADD: The following abbreviated terms do not appear in Clause 3.2:

GFCI	Ground Fault Circuit Interrupter
HMI	Human Machine Interface
IP	Ingress Protection
PES	Programmable Electronic System
PLC	Programmable Logic Controller
SCCR	Short Circuit Current Rating
SCPD	Short Circuit Protective Device
SCR	Short Circuit Rating
TEFC	Totally Enclosed Fan Cooled

4. General Requirements

4.1 General

Clause 4.1 states safety related requirements pertaining to risks associated with electrical equipment of machines.

CLARIFY: Task-hazards are identified in a Machine Risk Assessment. The following documentation is used to support Nexteer's Machine Risk Assessment Process:

- SD-011, Specification for Safety Circuits
- SD-012, Design-In Health and Safety Specification
- Machine Risk Assessment Toolkit

Clause 4.1 paragraph seven recommends Annex B be used to facilitate the exchange of information between the equipment purchaser and the supplier.

CLARIFY: Nexteer Automotive's Controls System Engineering Approval Process is documented in SD-001, General Manufacturing Equipment Specification.

4.4 Physical environment and operating conditions

4.4.2 Electromagnetic compatibility (EMC)

Clause 4.4.2 states requirements for electromagnetic compatibility including ensuring a machine has a sufficient level of immunity to disturbances.

ADD: Line Filters shall be installed ahead of VFD's and Servo Drives to reduce electrical noise. Manufacturer's installation instructions shall be followed.

4.4.3 Ambient air temperature

Clause 4.4.3 does not require heat dissipation calculations to be performed. However, IEC does state electrical equipment is required to operate in ambient temperatures between +5 °C and +40 °C.

CLARIFY: Control enclosure heat dissipation calculations shall be performed and based on an ambient temperature of +40 °C. It is recommended that Nexteer's standard heat calculation form be used to document the calculations. Heat calculations shall be provided upon request.

5. Incoming supply conductor terminations and devices for disconnecting and switching off

5.1 Incoming supply conductor terminations

Clause 5.1 recommends supply conductors be terminated at the supply disconnect device with exceptions (second paragraph).

MODIFY: All supply conductors (conductors to be disconnected) shall be terminated at the supply disconnect device.

Clause 5.1 states requirements for incoming supply connections for various configurations.

CLARIFY: The number of incoming supply conductors and their wiring configurations for each Nexteer Facility are documented in SD-001, General Manufacturing Equipment Specification.

5.3 Supply disconnecting (isolating) device

5.3.1 General

ADD: The following does not appear in Clause 5.3.1 and are required in addition to those stated within the Clause.

- for each enclosure containing control devices (not including electrical outlets) with an incoming supply voltage greater than 50 volts (AC or DC), a local disconnect shall be provided to isolate all electrical power in the enclosure.
- for each enclosure containing control devices with a supply voltage greater than 50 volts (AC or DC) and a local disconnect is provided, the disconnect shall remove all power to the enclosure.

5.3.2 Type

Clause 5.3.2 (e) allows a plug/socket combination as a disconnect for a flexible cable supply.

MODIFY: The use of a plug / socket combination is not allowed in wet locations. A plug / socket combination shall have a minimum degree of protection of IP 54 or NEMA 3R and shall have a retaining means.

5.3.3 Requirements

Clause 5.3.3 allows the neutral conductor to be disconnected in TN supply systems (first paragraph, fifth item).

CLARIFY: For single-phase supply circuits, the disconnect shall disconnect only the single live conductor(s) (black), sometimes referred to as the "hot conductor," not the grounded conductor (white / current-carrying ground).

5.3.5 Excepted circuits

ADD: The following does not appear in Clause 5.3.5 and are required in addition to those stated within the Clause.

Excepted circuits shall be provided with their own disconnecting device meeting all of the following:

- lockable only in the OFF position;
- mounted adjacent to the enclosure or within the main enclosure, adjacent to the main disconnect;
- all power TO and FROM the excepted circuits disconnecting device shall be separated from other circuits. This separation may be accomplished by running wires in non-metallic flexible conduit or wire wrap identified with the color orange;
- all wiring, including power and control, FROM the excepted circuits disconnecting device shall be orange. Exception: large power conductors can be black wires marked with orange tape.

NOTE: Control interlock wiring (orange wiring) does not need to comply with this separation requirement.

5.4 Devices for removal of power for prevention of unexpected start-up

Clause 5.4 states the selection of a device used for the removal of power is dependent upon the outcome of the risk assessment process (fifth paragraph).

CLARIFY: The Machine Risk Assessment process is documented in SD-012, Design-In Health and Safety Specification. The results of the Machine Risk Assessment process determine when power removal is required and appropriate circuit performance level for the application. The following documentation is used to support Nexteer's Machine Risk Assessment Process:

- SD-011, Specification for Safety Circuits
- SD-012, Design-In Health and Safety Specification
- Machine Risk Assessment Toolkit

6. Protection against electric shock

6.2 Basic protection

6.2.2 Protection by enclosures

Clause 6.2.2 (a) states only devices that are likely to be touched shall be protected to at least IP2x.

MODIFY: All devices located inside enclosures and other live parts on the inside of doors shall be protected against direct contact to at least IP2x or IPXXB.

Clause 6.2.2 states requirements for opening an enclosure under the following conditions:

a) by using a key or tool, or

b) by disconnecting live parts, or

c) by alternate methods from conditions a) and b).

MODIFY: The opening of an enclosure shall only be possible under condition a) using a key or tool, or b) by disconnecting live parts. Condition c), the use of alternate methods, is not permitted.

6.2.5 Protection by barriers

Clause 6.2.5 states protective barriers shall conform to the requirements of IEC 60364-4-41.

MODIFY: All protective barriers provided within a control enclosure shall have a minimum protection of at least IP2x or IPXXB.

6.2.6 Protection by placing out of reach or protection by obstacles

Clause 6.2.6 provides requirements for the protection of live components by placing them out of reach or protecting them by obstacle in accordance with IEC 60364-41-4. Conductor wire or conductor bar systems (controlgear) with a degree of protection less than IP2x must comply with Clause 12.7.1.

MODIFY: All control devices (controlgear) shall be readily accessible; therefore, this Clause is not applicable.

7. Protection of equipment

7.1 General

Clause 7.1 details the measures to be taken to protect equipment against listed effects.

ADD: The following effects shall be taken to protect equipment against in addition to those stated within the Clause:

- considerations for available fault current;
- voltage ratings;
- withstand ratings;
- current limiting characteristics.

7.2 Overcurrent protection

7.2.1 General

Clause 7.2.1 details the requirement to have overcurrent protection be provided where the current in any circuit can exceed either the component or capacity of current in the conductor.

ADD: The equipment's overcurrent protective devices and power distribution devices shall be suitable for use on circuits capable of delivering 50,000 amperes symmetrical (RMS), 50/60 Hz of short-circuit current.

NOTE: For custom-designed systems, the most cost advantageous solution is to use Class-J fuses in the main disconnect. For commodity CNC machinery, the industrial equipment supplier should consider one of the following two common solutions:

- either add a self-enclosed disconnect with Class-J fuses ahead of the CNC system, or
- if a three-phase transformer is provided ahead of the CNC system, verify the system is suitable for (can withstand) the available short-circuit current from the transformer.

7.2.2 Supply conductors

Clause 7.2.2 requires the equipment supplier to state the necessary supply conductor dimensioning and for selecting the overcurrent protective device to the equipment (power distribution system) (second paragraph).

CLARIFY: Nexteer Automotive's Facility Engineering personnel will determine the cross-sectional area of the supply conductor and overcurrent protective device in the power distribution system. The equipment supplier is not required to provide this information.

7.2.4 Control circuits

Clause 7.2.4 includes an exception which states there is no need for a separate overcurrent protective device when the supply unit provides current limiting below the current carrying capacity of the conductors and is below the current rating of the components within the system.

MODIFY: Overcurrent protection is required for all circuits regardless of the supply providing current limiting below the current carrying capacity of the conductors and is below the current rating of the components within the system.

The following does not appear in Clause 7.2.4 and is required.

ADD: Class 2 power supplies or circuit protection shall be used for devices requiring Class 2 power.

7.2.5 Socket outlets and their associated conductors

ADD: Overcurrent protection for remote programming port receptacles (sockets) shall not exceed 10 amperes for $120V_{AC}$ applications and 5 amperes for $240V_{AC}$ applications.

7.2.7 Transformers

Clause 7.2.7 states transformers shall be protected against overcurrent in accordance with manufacturer's instructions.

ADD: Transformers shall be protected in accordance with manufacturer's instructions or with short-circuit protective devices (SCPD's) in accordance with Table 7.2.7 below:

Overcurrent Protection Provided in the:	Primary Current (amperes)	Maximum Primary SCPD	Maximum Secondary SCPD
Primary Only	< 2	300%	-
	< 9	167%	-
	≥ 9	125%	-
Primary and Secondary	< 9	250%	167%
	≥ 9	250%	125%

Table 7.2.7

7.2.9 Overcurrent protective devices

ADD: The following (7.2.9.1 and 7.2.9.2) does not appear in Clause 7.2.9 and are required:

7.2.9.1 SCR

The SCR for the main enclosure shall be shown on the prints (either on the circuit diagrams, or a depiction on the nameplate).

NOTE: Clause 16.4 requires the short-circuit rating (SCR) of the equipment be marked on the nameplate attached to the enclosure. NFPA 70 includes this same requirement; calling it the short-circuit current rating (SCCR).

7.2.9.2 Circuit Breakers

Circuit breakers shall be used as overcurrent protection devices.

Circuit breakers shall have Type D trip curve for the primary side of transformers and power supplies, unless otherwise noted by the device manufacturer.

EXCEPTION: Fuses are permitted where required to meet the SCR rating of the application, such as the use of Class-J fuses in the main disconnect, or where required by device manufacturer's literature.

7.3 Protection of motors against overheating

7.3.2 Overload protection

ADD: The following (7.3.2.1 – 7.3.2.3) does not appear in Clause 7.3.2 and are required:

7.3.2.1 Sizing overloads

Where overload protection is provided, they shall be set at no greater than 115% of motor full-load amperage.

7.3.2.2 Reset of overloads

Resetting of the overload device shall not restart the motor. The overloads are allowed to be connected to the motor starter's energizing circuit or connected to a PLC input.

NOTE: When the overloads are connected to an input, the logic shall be designed to meet this specification item.

7.3.2.3 Motor starter interlock and logic

When a PLC is used to control motors, a normally open auxiliary contact from the motor starter shall be wired as an input. In the logic, this input, in series with a contact from the motor starter's output coil, shall be used to seal in the motor starter's output coil.

NOTE: This interlock is required such that resetting of the overload device does not restart the motor.

7.7 Additional earth fault / residual current protection

Clause 7.7 allows residual current protection to the entire equipment to reduce damage of leakage current (paragraph one).

MODIFY: Residual current protection shall not be implemented for entire equipment protection due to nuisance trips.

7.10 Short-circuit current rating

Clause 7.10 states the short-circuit current rating of electrical equipment shall be determined.

CLARIFY: The UL508A calculation approach is not required but is allowed.

ADD: The following (7.11) does not appear in Clause 7 and is required:

7.11 Resistance heating branch-circuit overcurrent protection

If the branch circuit supplies a single non-motor operated load rating at 16.7 amperes or more, the overcurrent device rating shall not exceed 150% of the load rating.

Equipment employing resistance-type heating elements rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

EXCEPTION: A single sheath-type heating element requiring more than 48 amperes shall be protected at not more than 125% of the load where the element is integral with and enclosed within the machine housing.

8. Equipotential bonding

8.2 Protective bonding circuit

8.2.1 General

Clause 8.2.1 states general requirements for protective conductors.

ADD: In addition to the requirements listed Clause 8.2.1, the secondary of single-phase AC transformers shall be connected to the protective bonding circuit.

Where $240V_{AC}$ and $120V_{AC}$ single-phase voltages are both present within an enclosure, they shall be supplied either from separate transformers, or from the single-phase secondary of a multi-tap transformer as shown in Figure 8.2.1.

Figure: 8.2.1

8.2.2 Protective conductors

Clause 8.2.2 indicates copper conductors are preferred for productive conductors (second paragraph).

MODIFY: Copper conductors shall be used for all protective conductors.

Clause 8.2.2 allows metal enclosures or frames or mounting plates may be used as protective conductors if three requirements are met (third paragraph).

ADD: In addition to the requirements listed, the following is also required:

- connection between the external protective conductor PE terminal and the main enclosure's ground bar through the steel subplate is not permitted, but instead, must be through a conductor.
- galvanized subplates do not require the use of a protective conductor since they meet the three requirements listed in IEC 60204-1 Clause 8.2.2.

Clause 8.2.2 states various methods of a machine and its electrical equipment protective bonding circuit are not to be used as protective conductors (paragraph seven).

CLARIFY: Termination methods of protective conductors are required. The continuity of the ground circuit between enclosures and field devices shall be ensured though conductors only (machine mechanics are not permitted as the grounding path). Equipment grounding conductors shall be terminated in each electrical enclosure on a ground bar bonded to the subplate.

8.4 Functional bonding

Clause 8.4 states protection against maloperation as a result of insulation failures can be accomplished by functionally bonding a common conductor (second paragraph).

ADD: DC controls circuits shall be functionally bonded (connected to the protective bonding circuit).

9. Control circuits and control functions

9.1 Control circuits

9.1.2 Control circuit voltages

Clause 9.1.2 states nominal AC and DC voltage limits for control circuits; including the recommendation of nominal voltage of DC control circuits not to exceed 220V (second and third paragraphs).

MODIFY: All control voltage shall be $24V_{DC}$, grounded.

9.2 Control functions

9.2.2 Categories of stop functions

Clause 9.2.2 states the three categories of stop functions as Stop category 0, 1, and 2. Each category defines the uncontrolled or controlled stop function and power removal requirements.

CLARIFY: All Cycle Stop circuits shall:

- be provided on continuous cycle machines;
- be of Stop category 2 as outlined in IEC 60204-1, Clause 9.2.2; and
- stop the machine at its normal "home" position.

9.2.3 Operation

9.2.3.2 Start

Clause 9.2.3.2 states the start of an operation be possible only when the safety function / protective measures are properly working (second paragraph).

CLARIFY: Machines with multiple start locations where the start function is part of the machine's safety circuit, shall have the start function's circuit performance meet the requirements of SD-011 (Specification for Safety Circuits) and SD-012 (Design-In Health and Safety Specification). Exceptions to IEC 60204-1 Clause 9.2.3.2 are allowed as documented by the Machine Risk Assessment.

9.2.3.3 Stop

Clause 9.2.3.3 states stop categories 0, 1, and 2 stop functions are to be captured in the risk assessment and the functional requirements of the machine (Clause 4.1)(first paragraph).

MODIFY: All servo drive applications shall be stop category 1. All other motions shall be appropriately configured according to manufacturer's recommendations. Stop categories for motions are not required to be captured in the Machine Risk Assessment.

9.2.3.4 Emergency operations (emergency stop, emergency switching off)

9.2.3.4.2 Emergency stop

Clause 9.2.3.4.2 states the following emergency stop function requirements (fourth paragraph):

- must override all functions and operations in any machine mode;
- must stop hazardous motion as quick as possible while not creating additional hazards;
- must not restart with a reset.

ADD: In addition to the requirements listed, the following is also required:

- the emergency stop pushbutton shall be hardwired directly to a safety module;
- the safety module shall perform the required emergency stop function;
- the safety module shall be reset (start) by a contact from the Master Start pushbutton, an Emergency Stop reset pushbutton, or a PLC contact output with logic initiated by an HMI reset button;
- the safety module shall not be reset by pulling out or twist-release of the emergency stop pushbutton; and
- the safety module shall not reset on application of power.

NOTE: Reference Specification SD-011 for additional information.

9.2.3.5 Operating modes

Clause 9.2.3.5 provides general guidelines for operating modes.

ADD: Manual mode operator devices shall be provided with each piece of equipment to perform individual functions. Manual functions shall not operate during automatic mode. The design should minimize interlocks in manual mode to allow maximum freedom of operation without damage to the machine or machine tooling, or hazards to the employee.

NOTE 1: These requirements apply to axis motion as well as fluid power motions.

NOTE 2: Operator devices include, but are not limited to: pushbuttons, momentary selector switches, operator interface keys or keypads, manual pulse generators.

NOTE 3: Direct mechanical operation of a solenoid valve is not considered an operator device.

NOTE 4: A single-step manual function (stepping through the machine sequence) is allowed, but not as a replacement to the individual manual functions required above.

CLARIFY: Manual Control as Safeguards - circuit performance requirements for manual controls implemented as operator safeguarding are detailed in

SD-011 (Specification for Safety Circuits) and SD-012 (Design-In Health and Safety Specification).

Clause 9.2.3.5 does not provide guidance for equipment with multiple Operator control stations.

ADD: When multiple operator stations exist, each operator station shall be provided with a means for selecting and indicating the mode at that station.

9.2.3.6 Monitoring of command actions

Clause 9.2.3.6 states movement or actions of a machine that can result in hazardous situations shall be monitored.

ADD: Proper sequencing, movements, and positioning of equipment and parts in process shall be sensed with position and movement sensors. Where monitoring tooling position is not critical to part processing or part quality, proximity style integral cylinder sensors are permitted. Sensing of time or pressure, in lieu of position and movement, requires Nexteer Automotive Controls approval prior to the issuance of machinery purchase order.

NOTE: Position sensors should be limited to only what is needed. Some processes do not require a position sensor on each end of a motion. As an example, an auto-eject may not need a sensor because if the motion does not occur, the operator can observe it.

9.2.3.8 Two-hand control

Clause 9.2.3.8 states requirements for Type I, II, and III two-hand control.

CLARIFY: Any two-hand control device used to bypass a safeguard (such as a light curtain or interlocked guarding) shall be implemented as Type III.

NOTE: Nexteer Automotive Brazil requires two-hand cycle start initiation implemented in order to meet NR12 requirements. Two-hand cycle start initiation shall be implemented as Type III but does not require continuous concurrent actuation during the hazardous situation when an alternate primary safeguard is in place (i.e. light curtain). Reference SD-011 (Specification for Safety Circuits) and SD-012 (Design-In Health and Safety Specification) for further guidance.

9.2.3.9 Enabling control

Clause 9.2.3.9 provides requirements to enabling control with (2) Subclauses, a) and b).

ADD: The following additional Subclause to enable control:

c) When an enabling device (such as a live-man switch) is used to bypass a safeguard, the enabling device circuit performance level shall be consistent with the safeguard circuit being bypassed.

9.2.4 Cableless control systems (CCS)

Clause 9.2.4 provides requirements for Cableless Control Systems (CCS).

MODIFY: Cableless Control Systems (CCS) are not allowed.

9.4 Control functions in the event of failure

9.4.1 General requirements

Clause 9.4.1 states the requirements for a risk assessment process for safety-related control functions of IEC 62061 and / or ISO 13849.

CLARIFY: Nexteer Automotive's Machine Risk Assessment processes are detailed in SD-012 (Design-In Health and Safety Specification), which are consistent with ISO 13849.

ADD: The following Clause (9.4.4) does not appear in Clause 9.4 and is required.

9.4.4 Control systems incorporating software and firmware-based controllers

Control systems incorporating software and firmware-based controllers performing safety-related functions shall conform to all of the following in the event of any single failure:

- lead to the shutdown of the system in a safe state.
- prevent subsequent operation until the component failure has been corrected.
- prevent unintended startup of equipment upon correction of the failure.
- provide protection equivalent to those control systems incorporating hardwired / hardware components.
- be designed in conformance with an approved standard that provides requirements for systems.

ADD: The following Clause (9.5) does not appear in Clause 9 and is required.

9.5 Programmable control devices

NOTE: Complete Nexteer logic requirements are detailed in SD-1032 (Programmable Controller Logic Application Specification) including reference to logic libraries and routines available for Rockwell Automation (AB) PLC's. Functional logic requirements detailed within this section of SD-004 have been included since they may also include hardware / component implications.

9.5.1 Inputs and outputs

Programmable controller inputs shall be sinking (+24V_{DC} applied to the appropriate input shall cause a false to true transition), and outputs shall be sourcing (+24V_{DC} shall be applied to the load when the output is active).

10% spare I/O space shall be provided. This requirement extends to the I/O image table, which shall have space reserved to accommodate these spare I/O requirements.

9.5.2 Programmable device power

Programmable controllers and human-machine interfaces shall be powered whenever the disconnect switch is on.

NOTE: This typically means they are powered directly from the 24V_{DC} power supply above any control circuits.

9.5.3 Programming equipment

9.5.3.1 Access to programs

Passwords and access codes which prevent the user from altering the machine functional program are not allowed. Passwords and access codes are allowed to protect critical process limits and set points.

9.5.3.2 Application program

Programming equipment shall provide the end user with the ability to enter, alter, view, upload, and download the application program. In addition, the PES shall provide the ability to disable, change, and view all input and output status points as well as data at any memory address.

9.5.3.3 Communication port

The PES system shall be designed such that one communication port is always available for use with the programming equipment. The port shall not require any other system interface be disconnected to use the programming equipment. This programming port shall:

- be on the exterior of a control enclosure, and
- be provided at a readily accessible location, and
- on or near (within 5 meters) of the operator interface.

NOTE: Equipment with multiple stations may require programming ports at multiple stations in order to be readily accessible.

9.5.3.4 Receptacle

A minimum of one (1) receptacle for use by the programming equipment shall be provided, located adjacent to each programming port. The voltage and receptacle type shall be appropriate for the receiving facility.

9.5.4 Communication

All inter-device communications shall be Ethernet based. Complete ethernet network requirements are outlined in Nexteer Automotive Specification SD-1045 (Machine Ethernet Network Specification).

9.5.5 Part quality device interface

Part quality input devices shall be a "Good Part" signal; not a "Reject Part" signal, in order to functionally check both the input and device each cycle. Proper operation of part quality devices shall be verified prior to their use in classifying part status. Complete Nexteer logic requirements are detailed in Nexteer Automotive Specification SD-1032 (Programmable Controller Logic Application Specification).

10. Operator interface and machine-mounted control devices

10.1 General

10.1.1 General requirements

Clause 10.1.1 states general requirements for operator interfaces with consideration given to the selection, arrangement, programming and use of operator input devices. In addition, ergonomic principles are also to be taken into account.

CLARIFY: Operator input device requirements are detailed in SD-1020, Human Machine Interface Application Specification. Ergonomic principles are outlined in SD-017, Design-In Ergonomic Guideline.

10.1.2 Location and mounting

Clause 10.1.2 states hand-operated control devices are required to be located not less than 0,6 m above the servicing level (second paragraph).

MODIFY: All hand-operated control devices shall be located between 0,9 and 1,65 m (35-65 inches) above the service level.

Clause 10.1.2 states requirements for the actuation of foot-operated control devices (third paragraph).

CLARIFY: Ergonomic requirements for hand or foot-operated control devices are detailed SD-017, Design-In Ergonomics Guideline.

10.1.3 Protection

Clause 10.1.3 states operator interface control devices on the outside of an enclosure shall have a minimal ingress protection against contact with live parts of IPXXD (second paragraph).

CLARIFY: Operator interface control devices mounted to the outside of an enclosure shall have a minimum ingress protection against environmental conditions of IP62. Operator interface control devices shall have a minimum degree of protection against contact with live parts of IP2X.

10.2 Actuators

Clause 10.2 does not provide guidance on what types of actuators are allowed to be used within a control system.

MODIFY: Nexteer Automotive does not allow the use of the following devices in the development of a control system:

- push selector switches for start-stop operations;
- time delay push-buttons, selectors, limit switches;
- drum type reversing switches;
- alternate acting push-buttons (requires advanced purchaser approval);
- push / pull buttons for start-stop operations;
- lockable E-Stop buttons;
- maintained position limit switches, except for safety limit switches;

10.2.1 Colours

Clause 10.2.1 states START/ON actuators should be WHITE, GREY, BLACK, or GREEN with a preference for WHITE (second paragraph).

MODIFY: Hardwired START/ON actuators shall be GREEN.

Clause 10.2.1 states the color red shall be used for emergency switching off actuators and if a background exists immediately around the actuator, the color of the background shall be YELLOW (third paragraph).

MODIFY: The background immediately around an emergency stop pushbutton is required and shall be colored YELLOW.

Clause 10.2.1 states STOP/OFF actuators should be BLACK, GREY, or WHITE with a preference for BLACK (fourth paragraph).

MODIFY: Hardwired STOP/OFF actuators shall be RED.

Clause 10.2.1 states the preferred colours for actuators that cause operation while they are actuated and cease operation when released (hold-to-run) to be WHITE, GREY, or BLACK (sixth paragraph).

MODIFY: Hardwired HOLD-TO-RUN actuators shall be BLACK.

Clause 10.2.1 states reset actuators shall be BLUE, WHITE, GREY, or BLACK (seventh paragraph).

MODIFY: Hardwired RESET actuators shall be BLUE.

Clause 10.2.1 states the colour YELLOW is reserved for use in abnormal conditions (eighth paragraph).

ADD: REQUEST TO ENTER actuators shall be illuminated YELLOW for full body access and robotic cells where operators are required to signal a request to enter into the machine or cell.

ADD: The following (10.2.3 – 10.2.7) does not appear in Clause 10.2 and are required:

10.2.3 Hand-operated control devices

All start pushbuttons shall be mounted above or to the left of their associated stop pushbuttons.

10.2.4 Foot-operated control devices

Foot-operated switches used for applications where accidental actuation could create a hazardous situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch.

EXCEPTION: Foot-operated switches used for emergency stop shall not be of the covered or hooded type.

10.2.5 Type

Hardwired pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head type. A YELLOW background shall only be used for red mushroom head pushbutton actuators performing an emergency stop function.

10.2.6 Machine lights and fans

If machine lighting or fans are used, each shall have ON / OFF capability via the operator control panel (either through switches or programmed push buttons on the HMI).

10.2.7 Required hardwired push buttons

All machines with fault displays shall have a hardwired push button for FAULT RESET. This feature is not allowed on the HMI.

10.3 Indicator lights and displays

10.3.1 General

Clause 10.3 does not provide guidance on lamp test features for indicator lights and displays.

ADD: All hardwired indicator lights shall have a lamp test feature. The lamp test feature can be push-to-test or a separate test circuit.

10.3.2 Colours

Clause 10.3.2 provides guidance on the meaning, explanation, and actions required by indicator colour with respect to the condition of the machine (first paragraph and Table 4).

CLARIFY: Nexteer Automotive requires POWER ON indicators to be GREEN.

Clause 10.3.2 recommends indicting towers on machines have applicable colours in a particular order consistent with RED, YELLOW, BLUE, GREEN, and WHITE (second paragraph).

MODIFY: When provided, stack lights shall be mounted in a location clearly visible to the operator. Stack light color arrangement shall be, from top to bottom: RED, YELLOW, and GREEN. The color representation shall be designed as follows:

- RED – machine faulted,
- YELLOW – abnormal condition,
- GREEN – machine running (in-cycle).

10.3.3 Flashing lights and displays

ADD: The following (10.3.4) does not appear in Clause 10.3 and is required:

10.3.4 Multi-color indicators

Multi-color indicators shall be provided at all operator load or unload stations.

The color representation shall be designed as stated below:

- GREEN – good part; shall illuminate at the end of machine cycle and remain on until the part is removed, mode is changed to Manual Mode, or the machine is powered down,
- RED (solid) – reject part; shall illuminate until the reject part has been handled appropriately,
- RED (flashing) – machine faulted; typically indicates an immediate stop fault, however, on continuous cycle machines, it may indicate a cycle stop fault,
- YELLOW – machine-in-cycle; may be used for additional conditions as required.

NOTE: See SD-1032, Programmable Logic Controller Application Specification, for additional guidance.

Manual load or unload stations may be provided with multi-color cycle initiation buttons. When provided, the light shall only illuminate GREEN based on the following conditions:

- ON (flashing) – initial conditions met and the machine is ready for cycle initiation, or
- OFF – initial conditions are not met, or machine cycle has been initiated.

10.7 Emergency stop devices

10.7.1 Location of emergency stop devices

Clause 10.7.1 states emergency stop devices shall be readily accessible (first paragraph).

ADD: Emergency stop devices shall be continuously operable.

Clause 10.7.1 states emergency stop devices shall be provided at each location where an initiation of an emergency stop can be required (second paragraph).

ADD: Machines with hazardous motion as identified in the Machine Risk Assessment shall be provided with at least one emergency stop device.

10.7.3 Operation of the supply disconnecting device to effect emergency stop

Clause 10.7.3 states the supply disconnecting device may serve the function of emergency stop where a stop category 0 is suitable. IEC also provides guidance criteria for implementation.

MODIFY: Nexteer Automotive does not allow the use of the supply disconnect to serve the function of emergency stop.

ADD: The following (10.7.4) does not appear in Clause 10.7 and is required:.

10.7.4 Emergency stop indication

If more than one emergency stop device is used, they shall be individually annunciated.

10.8 Emergency switching off devices

Clause 10.8 states requirements for emergency switching off devices.

MODIFY: Nexteer Automotive does not permit the use of emergency switching off devices. Clause 10.8, and all Subclauses, do not apply.

10.9 Enabling control device

Clause 10.9 states requirements for enabling control device implementation within a control system (paragraph three).

CLARIFY: Enabling control is detailed in SD-011, Specification for Safety Circuits, and SD-012, Design-In Health and Safety Specification. Exceptions to IEC 60204-1 Clause 10.9 are allowed as documented in the Machine Risk Assessment.

ADD: The following (Clause 10.10) does not appear in Clause 10 and is required:

10.10 Arrangement of control station – grouping of automatic and manual controls.

HMI layout and pushbutton arrangement minimum requirements are detailed in SD-1020, Human Machine Interface Application Specification. For machines with additional hardware-controlled motions, the devices shall be arranged so the automatic controls are grouped and separately spaced from the manual controls. Manual controls shall be arranged in logical order in accordance with the sequence of machine operation.

11. Controlgear: location, mounting, and enclosures

11.2 Location and mounting

11.2.1 Accessibility and maintenance

Clause 11.2.1 states the term “terminals” though does not distinguish between terminals on controlgear and terminal bocks (first paragraph).

CLARIFY: The term “terminals” referrals to all locations where conductors are terminated, including terminals located on controlgear and terminal blocks.

Clause 11.2.1 requires all controlgear to be mounted in order to facilitate its operation and maintenance (second paragraph).

CLARIFY: Controlgear shall not be mounted on the subplate behind the disconnect.

Clause 11.2.1 recommends terminals be at least 0,2 m above the servicing level and placed in such a way that conductors and cables can be easily accessed (second paragraph).

CLARIFY: Nexteer identifies all controlgear as requiring access, therefore, all controlgear (including terminals and terminal blocks) shall be mounted at no greater than 2,0 m.

MODIFY: Terminal blocks shall provide unobstructed access to conductors and cables. Stackable, or multi-tier terminal blocks, are permitted with a maximum of two (2) tiers. Terminal blocks shall be mounted to a din-rail, which is mounted to a subplate.

Clause 11.2.1 states no devices, except devices for operation, indicating, measuring, and cooling, be mounted on doors or access covers (third paragraph).

ADD: Remote programming ports and receptacles can be mounted on doors or on normally removable access covers of enclosures. In addition, a disconnect handle can be mounted on the door, but the disconnect shall be mounted to the subplate.

Clause 11.2.1 states requirements for devices connected through plug-in arrangements (fourth paragraph).

ADD: Plug-in devices and assemblies shall be mechanically secured.

Clause 11.2.1 details the location and mounting of controlgear for accessibility maintainability.

ADD: Only devices for operator control, disconnecting, indicating, measuring, cooling, remote programming ports, and receptacles are permitted to be mounted through the side of the control enclosure. All operator and setup controls shall be adjustable without opening the electrical enclosure.

11.2.2 Physical separation of grouping

Clause 11.2.2 provides guidance for the location and mounting of controlgear for physical separation of grouping.

ADD: For cooling considerations, control devices shall be mounted per the manufacturer's recommended clearance (space).

11.2.3 Heating effects

Clause 11.2.3 provides requirements for the location and mounting of controlgear for heating effects.

CLARIFY: To minimize enclosure size and temperature rise, consideration should be given to mounting suitably enclosed heat producing devices, power factor correction capacitors, braking resistors, and transformers outside of the control enclosure.

Clause 11.2 details the location and mounting of controlgear.

ADD: The following (11.2.4 – 11.2.6) does not appear in Clause 11.2 and is required.

11.2.4 Mounting

All enclosure-mounted controlgear, including those in terminal boxes and operator stations, shall be mounted on a steel subplate unless otherwise explicitly permitted within IEC 60204-1, or this document.

Manufacturer's standard mounting details shall not be modified.

Threaded fasteners with machine threads shall be used to attach components to a subplate and shall provide sufficient thread engagement to maintain secure mounting.

A minimum of 10% spare usable subplate space is required in all electrical enclosures.

11.2.5 Line Reactors

Line Reactors shall be used ahead of VFD's and Servo Drives as required by manufacturer recommendations.

11.2.6 Power Supplies

Power supplies shall have an efficiency rating of 90% or greater.

Class 2 power supplies shall be use for devices requiring Class 2 power (see also Clause 7.2.4).

Test equipment power supply ripple shall meet the following requirements:

- Low Power (0-10A); not to exceed 3mV.
- Medium Power (10-50A); not to exceed 100mV.
- High Power (+50A); not to exceed 100mV.

11.3 Degrees of protection

Clause 11.3 (Note 1) details degrees of protection against ingress of water and other liquids.

CLARIFY: Junction boxes shall not be mounted within any coolant spray area of the machine.

Clause 11.3 states enclosures containing controlgear shall have an ingress protection rating of at least IP22 (paragraphs 2 and 3).

MODIFY: All enclosures shall have an ingress protection rating of IP54 or NEMA Type 12 rating at a minimum. To maintain the ingress protection rating of the enclosure(s), all raceways, heat exchange devices, and other devices connected (mounted) to any enclosure require an equivalent rating. Externally mounted transformers do not require this rating, but their connection to an enclosure does need to maintain this rating.

CLARIFY: Ancillary equipment (such as torque drivers, screw driving systems, vibratory feeders, etc.) used within a control system shall follow the requirements of Clause 11.3.

11.4 Enclosures, doors and openings

Clause 11.4 provides recommendations for enclosure doors with vertical hinges not be wider than 0.9 m with an opening angle of at least 95° (fourth paragraph).

MODIFY: All enclosure doors shall have an angle of opening of at least 95°.

Clause 11.4 does not specify a minimum clearance of enclosure doors above the service level.

ADD: All enclosure doors shall have a minimum clearance of 150 mm (6 inches) above the service level.

Clause 11.4 provides several requirements for enclosures, doors, and openings.

ADD: In addition to the stated requirements, all control enclosures containing controlgear shall have vertical hinged doors. All operator interfaces and junction boxes greater than 400cm^2 (60 inches^2) shall have a hinge(s). Hinged doors shall be permanently affixed if control devices are mounted to the door.

11.5 Access to electrical equipment

Clause 11.5 includes requirements for controlgear location, mounting, and enclosures; but does not provide controlgear enclosure layout access detail.

ADD: Access dimensions from the front of all control enclosures which contain controlgear shall be at least 1.1 meter (42 inches).

12. Conductors and cables

12.2 Conductors

Clause 12.2 states copper conductors should be used and aluminum conductors can be used with specific requirements (first paragraph).

MODIFY: All conductors shall be stranded copper (solid core is not permitted).

12.3 Insulation

Clause 12.3 outlines requirements for the insulation of conductors and cables (paragraphs one and two).

ADD: In addition to the requirements listed in Clause 12.3, conductors and cables shall:

- be rated a minimum of 75°C;
- be rated per the application, including voltage, amperage, mechanical strength, and environment;
- (for cords and cables) have an environment rating at least equal to the control enclosure rating requirement of IP54.

NOTE: Mechanical strength applies to cable tray rating and high flex applications.

12.4 Current-carrying capacity in normal service

Clause 12.4 Table 6 contains ampacity ratings for common square millimeter wire sizes . Annex G (Comparison of typical conductor cross-sectional areas) Table G.1 contains a comparison of conductor sizes in American Wire Gauge (AWG) with square millimeters, square inches, and circular mils.

MODIFY: This Specification provides Annex G with the AWG and square millimeter conductor size references with maximum ampacity. The maximum current carrying capacity of conductors shall not exceed the values given in Annex G, which has been derived from Table 310.15(B)(16) of NFPA 70, National Electric Code.

13. Wiring practices

13.1 Connections and routing

13.1.1 General requirements

Clause 13.1.1 states each termination point (terminal block) shall be identified (marked or labeled) to correspond with identification in the diagrams (fifth paragraph).

ADD: Each termination point (terminal block) shall be identified on both sides or in the center of the termination point (terminal block).

13.1.2 Conductor and cable runs

Clause 13.1.2 states an exception to allow splices or joints to be used within junction boxes (exception – second paragraph).

MODIFY: Nexteer Automotive does not allow splices or joints in the wiring. This exception is not allowed.

ADD: The following does not appear in Clause 13.1.2 and is required.

Exception: Crimp-on or pressure connectors may be used for devices which have integral leads (example: motors and valves). Twist-on connectors (typically referred to as a wire-nut) are not allowed.

NOTE: Examples of allowed connectors include crimp-on ring connectors and butt-splices, typically used for wires #4 AWG and smaller, or split-bolts and box-lug ring connectors, typically used for wires larger than #4 AWG.

Support for flexible cables and cords – Cables and cords shall be supported by the equipment or system structure as follows:

- in such a manner that the cable / cord will not be damaged by normal equipment use;
- every 300 mm (~ 12 inches) when suspended in a non-vertical run;
- not attached to removable guarding;
- such that bends in cables / cords do not cause undue stress.

13.1.3 Conductor and different circuits

Clause 13.1.3 states conductors of different circuits may be placed in the same duct (conduit, cable trunking system). Where these circuits operate at different voltage levels, they are to be separated by a suitable barrier or all conductors are to be insulated for the highest voltage exposure contained in the conductors.

MODIFY: Power wiring where the equipment has two or more sources of power, or two or more independent disconnecting means, shall be run in separate raceways, and shall not terminate in, or pass through, common junction boxes, see also Clause 5.3.5, Excepted circuits, for additional requirements.

13.1.4 AC circuits – Electromagnetic effects (prevention of eddy currents)

ADD: The following does not appear in Clause 13.1.4 and is required.

To minimize electromagnetic interference, electronic devices and associated wiring shall be segregated from the electromagnetic control and power wiring, see also SD-1045, Machine Ethernet Network Specification, for additional requirements.

Some methods to minimize electromagnetic interference are:

- field wiring for electronic devices could be contained in a separate metallic raceway from potential sources of interference;
- conductors from AC circuits shall not be run in parallel with conductors from DC circuits nor communication cables and shall cross at 90° angles;
- sensitive devices could be located in separate panel enclosures.

13.2 Identification of conductors

13.2.1 General requirements

Clause 13.2.1 states each conductor is to be identifiable at each termination point (first paragraph).

MODIFY: Each conductor shall be identified by number or by alphanumeric means. Conductor identification by color alone is not permitted.

Exception: the protective conductor is permitted to be identified as GREEN-and-YELLOW as detailed in Clause 13.2.2.

Clause 13.2.1 recommends methods of conductor identification including by number, alphanumeric, colour, or a combination of colour and numbers / alphanumeric means (second paragraph).

MODIFY: Conductor identification for PLC I/O shall have the same identification as the input or output. For non-PLC conductors, the conductor identification shall reference the sheet number, at a minimum, with a preference for using sheet number and line, or column, number.

Clause 13.2.1 does not provide specific guidance for the neutral conductors and industry standard cables, such as serial communication cables.

ADD: The neutral conductor (typically identified by the colour light-blue) shall include the alpha character "N" at a minimum.

ADD: Industry standard cables are not required to have individual conductors identified where the cable is identified by number, alphanumeric, or a combination of colour and numbers or alphanumeric.

13.2.4 Identification by colour

ADD: The following (13.2.4.1 – 13.2.4.2) does not appear in Clause 13.2.4 and are required.

13.2.4.1 Color-coded insulation required

Insulated conductors shall be color-coded. The color-coding recommendation of this Clause shall be followed. In addition, the following colors shall be used:

- WHITE: AC grounded conductor (current carrying ground).
- BLUE: DC grounded conductor (current carrying ground). Exception: any combination of blue and white is permitted for the DC grounded conductor. The color shall be used consistent throughout the equipment.

Exception: Color-coding is not required for multi-conductor cables or cords.

CLARIFY: Color-coded insulation applications. The following are typical Nexteer Automotive applications for insulation color-coding, as required by Clause 13.2.4.1.

- GREEN-and-YELLOW: protective conductor (referred to as PE or ground).
- LIGHT BLUE: neutral conductor (or N) used for single phase $230V_{AC}$ from a 5-wire $400V_{AC}$ utility power (phase to N). This is not a grounded conductor, compared to AC grounded conductor listed below, which shall be WHITE.

- BLACK: AC power circuits, including three-phase utility and distribution circuits, $230V_{AC}$ or $120V_{AC}$ single-phase receptacles, fans, instrumentation power, and AC drive output wiring to the motor.
- WHITE: The grounded conductor (current carrying ground) for the above listed AC power circuits.
- BLACK: DC drive output wiring to the motor.
- RED: AC control circuits are not permitted.
- BLUE: $24V_{DC}$ control circuits including the grounded conductor (current carrying ground).
- ORANGE: excepted circuits as permitted in Clause 5.3.5, such as control interlocks and lighting disconnect circuits.

13.2.4.2 Wire colors for multiple AC power voltage levels

Where 240VAC and 120VAC single-phase are supplied from the single-phase secondary of a multi-tap transformer, the secondary wire insulation colors shall be as shown in Figure 13.2.4.2.

Figure: 13.2.4.2

13.3 Wiring inside enclosures

Clause 13.3 states conductors inside an enclosure are to be supported wherever necessary to keep them in place (first paragraph).

MODIFY: The use of non-metallic / non-flammable ducts (wiring channels) shall be used in enclosures; they shall be mounted on the subplate(s) with a maximum 50% fill.

Clause 13.3 states terminal blocks or plug/socket combinations are to be used for control wiring that extend beyond the enclosure (fifth paragraph).

CLARIFY: Nexteer Automotive considers PES I/O termination points as terminal blocks for control wiring that extends beyond the enclosure.

13.4 Wiring outside enclosures

13.4.5 Plug / socket combinations

Clause 13.4.5 states plug / socket combinations intended to be connected or disconnected under load conditions shall have sufficient load-breaking capacities. Where the plug / socket combination is rated at 30A or greater, the plug / socket combination shall be interlocked (fourth paragraph).

ADD: Plug / socket combinations applied at a voltage greater than 300V (regardless of rated amperage) shall be interlocked with a switching device so that the connection and disconnection is possible only when the switching device is in the OFF position.

CLARIFY: A switch-rated plug / socket combination (such as load-make / load-break or disconnect-rated combination) meets the requirements of Clause 13.4.5.

ADD: the following (f) does not appear in Clause 13.4.5 and is required.

f) All control devices that have quick disconnect cables / connections shall have two labels, one adjacent to the device, and one on the cable. This requirement includes one label for each cable and one label for each connection point on a field mounted On-Machine distributed I/O block.

ADD: The following (13.4.7) does not appear in Clause 13.4 and is required.

13.4.7 Other conductors

Spare conductors shall be provided for all junction boxes, pull boxes, and raceways directly connected to the main enclosure. Spare conductors shall be of sufficient length to reach the extreme points of the enclosure unless terminated. Spare conductors shall be uniquely labeled, such as “SP1” or “SP2.” The number of spare conductors for each junction box or pull box shall be 5% of the total conductors used, or a minimum of two, whichever is greater. Spare conductors in any multiconductor cable shall not be cut off.

13.5 Ducts, connection boxes and other boxes

13.5.1 General requirements

Clause 13.5.1 states ducts shall provide a degree of ingress protection suitable for the application (first paragraph).

MODIFY: Ducts, rigid and flexible conduit, fittings, and connection boxes shall maintain the degree of ingress protection (or NEMA rating) consistent with the enclosure requirements from Clause 11.

13.5.2 Rigid metal conduit and fittings

Clause 13.5.2 states "conduit" in general terms as rigid metal that is galvanized steel or corrosion-resistance material suitable for the conditions (first paragraph).

MODIFY: The use of Electrical Metallic Tubing (EMT), often referred to as "thin wall" conduit, is not permitted.

Clause 13.5.2 provides guidance on fitting installation for rigid metal conduit (third paragraph).

ADD: The selection of fitting type should also be considered when determining the effective internal diameter (percentage fill) of conduit once the fitting is installed.

14. Electric motors and associated equipment

14.2 Motor enclosures

Clause 14.2 states the degree of protection for motor enclosures is dependent on the application and the physical environment (second paragraph).

MODIFY: The degree of protection for motor enclosures shall be at least IP54, or TEFC, for all motors.

ADD: The following (14.7 – 14.8) does not appear in Clause 14 and are required.

14.7 Direction arrow

A direction arrow is required for all 3-phase motors. The arrow shall be adjacent to the motor and plainly visible.

14.8 Motor nameplate

The motor nameplate is required on all 3-phase motors. The nameplate shall include, as a minimum:

- manufacturer's part number
- frame size
- rated frequency(s)
- rated voltage(s)
- full load amperage
- RPM
- horsepower or watts
- CE mark (for Europe)

Special characteristics of AC motors shall be shown on a separate nameplate. Typical examples include special insulation, shaft length, torque, balance, lubrication, and mounting.

15. Socket-outlet and lighting

CLARIFY: Clause 15 also applies to Clause 13.4.5 (Plug / socket combinations) used for accessories and mounting.

15.1 Socket-outlets for accessories

ADD: The following (15.1.1 – 15.1.3) does not appear in Clause 15.1 and are required by Nexteer Automotive.

15.1.1 Residual Circuit Protection Device (RCPD)

All socket-outlets external to the enclosure shall be provided with RCPD, or equivalent, protection. Production critical equipment does not require RCPD protection. See Clause 15.1.3 for further guidance on production critical equipment.

NOTE: Per NEC (NFPA 70), equipment being delivered to Nexteer Automotive North America (US and Mexico) shall be provided with GFCI protection (this meets the RCPD requirements above).

15.1.2 Socket-outlet covers

Auxiliary sockets for service (external to the enclosure) shall be provided with a cover to protect to IP54.

15.1.3 Production critical devices

Power to production critical devices shall be hardwired. Example of production critical devices include items such as bowl feeders, torque guns, uninterruptable power supplies, and other devices used in a normal machine cycle.

15.2 Local lighting of the machine and of the equipment

15.2.2 Supply

Clause 15.2.2 requires lighting circuits not to exceed 250V between conductors and recommends 50V between conductors (first paragraph).

MODIFY: All lighting circuits shall be at the control voltage level (24 V_{DC}).

Clause 15.2.2 provides several methods to supply the lighting circuits (second paragraph).

MODIFY: All lighting circuits shall be supplied downstream of the machine disconnect and directly from a 24V_{DC} power supply above any control circuits.

NOTE: Lighting circuits may be powered from the same 24VDC that supplies the controls circuits, or from a dedicated 24VDC power supply.

15.2.4 Fittings

Clause 15.2.4 states adjustable lighting fittings shall be suitable for the physical environment to which it is installed (first paragraph).

CLARIFY: Work lights exposed to coolants, or other liquids, shall maintain a minimum ingress protection rating of IP65.

16. Markings, warning signs and reference designations

16.2 Warning signs

16.2.1 Electric shock hazard

Clause 16.2.1 states the warning sign (ISO 7010-W012) may be omitted from display when an enclosure has a supply disconnect, on HMI's, or a single device with its own enclosure (third paragraph).

MODIFY: All electrical enclosures shall be marked with the graphic symbol ISO 7010-W012. The symbol is allowed on the visible side of the enclosure if there is not enough room on the door or cover.

16.3 Functional identification

Clause 16.3 requires control devices and visual indicators be clearly and durably marked according to their function.

ADD: Operator interface device identification tags shall be black characters on a white background. Metal tags can be black characters on a light gray background.

16.4 Marking of enclosures of electrical equipment

Clause 16.4 details the required information to be marked on enclosures. IEC recommends this information be displayed adjacent to the main incoming supply.

CLARIFY: The main document number, as described in Clause 16.4, shall be the SD Number of the machine provided with the Purchase Order.

ADD: The equipment short-circuit current rating (SCR or SCCR) shall be provided on the enclosure nameplate. Refer to Clause 7.2.1 for additional guidance.

NOTE: Short-circuit current rating markings are not required for industrial control panels containing only control circuit components.

ADD: The following item does not appear in Clause 16.4 and is required by Nexteer Automotive.

All electrical enclosures with through-the-door rotary disconnect switches with the handle mounted on the door (Clause 11.2.1) shall be labeled with the designated Health & Safety Rotary Disconnect lockout labels.

Figure 16.4 – Through-the-door disconnect identification maintained by the Environmental Health & Safety Team.

17. Technical documentation

17.2 Information related to the electrical equipment

Clause 17.2 requires documentation for the electrical system.

CLARIFY: SD-003, General Drawings and Manuals Specification, documents requirements for the machine (including electrical system diagrams). IEC 60204-1 includes Annex I that provides guidance to numerous other IEC standards for various documentation requirements.

Clause 17.2 (f) provides guidance for maintenance of electrical equipment.

ADD: In addition to the items listed in Clause 17.2 (f), the following are also required:

- electrical circuit diagrams;
- panel and operator layouts;
- inter-device communication diagram(s);
- electronic schematics (where appropriate);
- lubrication diagram (reference only when the equipment has a lubrication system);
- pneumatic diagram (reference only when the equipment has a pneumatic system);
- hydraulic diagram (reference only when the equipment has a hydraulic system);
- miscellaneous system diagrams, such as coolant, water, steam, and test oil (reference only when the equipment has such systems);
- parts list(s);
- program copy; one electronic copy of the as-shipped program (in current media), suitable for direct machine loading with the manufacturer's standard peripheral equipment, or with Nexteer Automotive's specified support system;
- compiled code (for systems running compiled code): one copy of the source code;

NOTE: These program copies and compiled code electronic files shall either be placed in the main electrical enclosure or shipped to the Purchasing Engineer (Engineer-in-charge).

ADD: The following (17.3 – 17.6) does not appear in Clause 17 and are required.

17.3 Electrical circuit diagrams

17.3.1 Device identification

Devices shall be identified by a reference number-device combination using standard designators. Examples:

Control Relay	207CR	2KA1	Located on sheet 2.
Motor Starter	1014M	10KM2	Located on sheet 10.
Limit Switch	735LS	7SQ5	Located on sheet 7.

Non-PLC numbers shall be a unique reference number indicating where the device is located on the drawing. This unique reference can consist of a line , sheet and grid, or sheet and unique number. Similar devices on the same line may require an additional identifier (example on Line 605: 605_1LS and 605_2LS).

17.3.2 Devices connected to PLC's

Device identification for devices connected to a PLC shall have the same identification as the input or output. For example:

Limit Switch	I1.3LS
Pneumatic Valve	O3.0SOLP12
Hydraulic Valve	O:4/11SOLHB

If a single device is connected to more than one input or output, that device shall be assigned a single identification.

17.3.3 Device Function

The functional description for each device shall be shown adjacent to its symbol. For PLC inputs, the functional description shall indicate the state of the device when the input is ON or energized. Functional descriptions shall be in present or past tense. Motion terminology shall have the verb prior to the noun (Raise Press). Functional descriptions shall be consistent throughout the documentation. Further examples are listed in Table 17.3.3 below.

NOTE: Simple control device terms, such as "Extend Cylinder" or "Retract Cylinder," do not describe the actual function of the tooling and therefore are not permitted. Vertical motions are typically described as "Raised" or "Lowered;" they are not "Advanced" or "Retracted."

Motion	Sensor
Lower Press	Press Lowered
Retract Shot Pin	Shot Pin Retracted
Advance Shuttle	Shuttle Advanced
Close Part Clamp	Part Clamp Closed
Open Part Clamp	Part Clamp Opened
Open Collet	Collet Opened
Expand Mandrel	Mandrel Expanded
Lower Front Tooling Slide	Front Tooling Slide Lowered
Rotate Tube to Punch Position	Tube Rotated to Punch Position

Table 17.3.3

17.3.4 Consistency in diagrams

Device identification and functional descriptions shall be consistent throughout all documentation.

17.3.5 Cross-referencing

A cross-referencing scheme shall be used in conjunction with each relay, output device, limit switch, and pressure switch, such that any contact associated with the device can be readily located on the diagram.

17.3.6 Graphical symbols

ANSI based graphical symbols are preferred for Nexteer Automotive US, Mexico, and China facilities. IEC based graphical symbols are preferred for Nexteer Automotive European facilities. Refer to Annex J of this document for cross-reference of ANSI to IEC based graphical symbols. Any symbols shown in Annex J of this document are permitted. Adherence to only one column, either the ANSI symbol or IEC Symbol column is recommended.

17.3.7 Characteristics relating to the function

Functional characteristics which are not evident from the symbol are required. These characteristics include, but are not limited to:

- voltage, current (FLA), and short circuit rating (SCR or SCCR) for supply connections;
- transformer voltages and KVA ratings;
- motor data such as horsepower or kw, frame size, full load amperage, voltage, and speed ;
- fuse and circuit breaker sizes (by manufacture's number);
- wire sizes, identification, and color;
- cable assembly identification number and conductor identification;
- settings for user programmable devices (such as dip switches, jumpers, and rotary switches) ;
- settings for time, temperature, and pressure;
- rack and slot locations of PES cards;
- electrical values and ratings load resistors and potentiometers that are not detailed on the parts list and subplate layout(s);
- special documentation for unique devices.

The information can be documented within the circuit diagrams adjacent to the device or on a chart near the circuits.

17.4 Parts list

The parts list shall be provided in the format detailed in Nexteer Automotive Equipment and Machinery Specification SD-003, General Drawings and Manuals Specification.

Special modifications of any part shall be clearly described in the parts list.

All items on the parts list shall include the original manufacturer's model number.

The parts list (the detail numbers) shall be cross-referenced to all layout drawings.

17.5 Logic and human machine interface (HMI) documentation

Nexteer Automotive's documentation requirements for programmable devices are detailed in SD-1032, Programmable Controller Logic Application Specification, and SD-1020 Human Machine Interface Application Specification.

17.6 Inter-device communication diagram

An inter-device communication diagram (or system communication diagram) shall be included as part of the circuit diagrams. At a minimum the communication diagram shall include cabling schematics and device addresses such as IP addresses.

For Ethernet systems, the Ethernet cable identification shall include device designation, switch, and port. Example: “5905PLC-5102ESWP3”

18. Verification

ANNEX G: AWG/mm ^{2} current-carrying capacity chart (informative)

Derived from NFPA 70 Table 310.15(B)(16) de-rated to 40°C, (formerly Table 310.16), and from IEC 60204-1 Table 6 (already based on 40°C).

AWG	Ampacity	mm^2	
@ 75°C		PVC Insulated – Singe wire in raceway / enclosure	PVC Insulated – Multi-conductor cable in space
18	6		
	7		0.5
16	8	0.75	
	10	1	0.75
	12		1
	13	1.5	
14	15		
	16		1.5
	18	2.5	
12	20		
	22		2.5
	24	4	
10	31	6	4
	37		6
8	44	10	
	52		10
6	57		
	59	16	
	70		16
4	75		
	77	25	
3	88		25
	96	35	
2	102		
	110		35
1	115		
	117	50	
0	132		
	133		50
	149	70	
2/0	154		
	171		70
3/0	176		
	180	95	
4/0	200		
	210	120	95

ANNEX J: Selection from IEC 60617 / ANSI / IEE315 symbol tables (informative)

ANSI SYMBOL	ANSI CODE	IEC 617 SYMBOL	IEC CODE	DESCRIPTION
	CON		KM	CONTACTOR CONTACT OPEN
	CON		KM	CONTACTOR CONTACT CLOSED
	CR		KA	RELAY CONTACT OPEN
	CR		KA	RELAY CONTACT CLOSED
	TR		KT	TIMED CONTACT, N.O. - ON DELAY (TDE)
	TR		KT	TIMED CONTACT, N.C. - ON DELAY (TDE)
	TR		KT	TIMED CONTACT, N.C. - OFF DELAY (TDD)
	TR		KT	TIMED CONTACT, N.O. - OFF DELAY (TDD)
	SS		SA	SELECTOR SWITCH
	PB		SB	PUSHBUTTON N.O.
	PB		SB	PUSHBUTTON N.C.
	PB		SB	PUSHBUTTON MUSHROOM HEAD
	FL		SL	LIQUID LEVEL SWITCH
	FLS	OR	SF	FLOW SWITCH
	PS		SP	PRESSURE SWITCH
	TS		ST	TEMPERATURE SWITCH
	LS		SQ	LIMIT SWITCH
	PRS		SQ	PROXIMITY SWITCH
	FTS	OR	FTS	FOOT SWITCH
A	LT	A	HL	INDICATING LIGHT
	PL		XS	PLUG AND SOCKET

Selection from IEC 60617 / ANSI / IEE315 symbol table (informative)

ANSI SYMBOL	ANSI CODE	IEC 617 SYMBOL	IEC CODE	DESCRIPTION
	CR		KA	CONTROL RELAY COIL
	CON		KM	CONTACTOR COIL
	MS		KM	MOTOR STARTER COIL
TR	TR	OR	KA	TIMER COIL
	SOL	OR	YV	SOLENOID COIL
	CTR		EC	ELECTROMECHANICAL COUNTER
	CB	OR	QF	CIRUCUIT BREAKER
OR	T1	OR	X1 XT	TERMINALS (REFERENCE) FUSED TERMINALS (REFERENCE)
	FU	OR	F	FUSE, PROTECTIVE
	CAP		CAP	CAPACITOR
	DISC	OR	DSC	DISCONNECT SWITCH - NON-FUSED
	DISC	OR	DSC	DISCONNECT SWITCH - FUSED
	GRD OR GND		PE	GROUND (PROTECTIVE EARTH; P.E.)
	OL		OL	OVERLOAD RELAY - THERMAL ELEMENT
	OL	I >	OL	OVERLOAD RELAY - MAGNETIC ELEMENT
	RES		RES	RESISTOR
	T	OR	T	TRANSFORMER

RECORD OF REVISIONS

Revision No	Date	Section	Description
001	31MY09	ALL	Initial release of SD-004-GC – based on Delphi Electrical Specification for Industrial Machinery DA-2004, AP04, and Delphi Steering Addendum to IEC 60204-1, SD104, NO04.
002	06NO09	ALL	Company name update and "GC" removed from specification number. All SD documents are global common.
003	14JL14	ALL	Updated per Central CSE Group Workshop, BPI2013-1.
004	15JN15	Several	Updated Ethernet cable requirements.
005	10DE20	ALL	Adoption of IEC 60204-1 Edition 6.0, 2016-10. Updated per Central CSE Group Workshop.
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