User’s manual
Emergency stop, stop category 0 (option +Q951) for ACS880 multidrives
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<td>ACS880-307 (+A003) diode supply units hardware manual</td>
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<tr>
<td>ACS880-307 (+A018) diode supply units hardware manual</td>
<td>3AXD50000011408</td>
</tr>
<tr>
<td>ACS880-907 regenerative rectifier units hardware manual</td>
<td>3AXD50000020546</td>
</tr>
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<td>ACS880 IGBT supply control program firmware manual</td>
<td>3AUA0000131562</td>
</tr>
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<td>ACS880 diode supply control program firmware manual</td>
<td>3AUA0000103295</td>
</tr>
<tr>
<td>ACS880 regenerative rectifier control program firmware manual</td>
<td>3AXD50000020827</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Inverter unit manuals and guides</th>
<th>Code (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS880-107 inverter units hardware manual</td>
<td>3AUA0000102519</td>
</tr>
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<td>ACS880 primary control program firmware manual</td>
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</tr>
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<td>ACS880 primary control program quick start-up guide</td>
<td>3AUA0000098062</td>
</tr>
</tbody>
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<tr>
<th>PC tool manuals</th>
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</tr>
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<tr>
<td>Start-up and maintenance PC tool Drive composer user’s manual</td>
<td>3AUA0000094606</td>
</tr>
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<td>Functional safety design tool user’s manual</td>
<td>3AXD10000102417</td>
</tr>
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</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td>3AUA0000085685</td>
</tr>
<tr>
<td>Functional safety; Technical guide No. 10</td>
<td>3AUA0000048753</td>
</tr>
<tr>
<td>Safety and functional safety; A general guide</td>
<td>1SFC001001080201</td>
</tr>
<tr>
<td>ABB Safety information and solutions</td>
<td><a href="http://www.abb.com/safety">www.abb.com/safety</a></td>
</tr>
<tr>
<td>Manuals and quick guides for I/O extension modules, fieldbus adapters, etc.</td>
<td></td>
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</tbody>
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You can find manuals and other product documents in PDF format on the Internet. See section Document library on the Internet on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.
User’s manual

Emergency stop, stop category 0 (option +Q951) for ACS880 multidrives

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Introduction to the manual

Contents of this chapter

This chapter describes the manual in short and gives some general information for the reader. The chapter also contains a quick reference for implementing a safety system.

Applicability

The manual applies to ACS880 multidrives which have the option: Emergency stop, stop category 0 with main contactor/breaker, with safety relays (option +Q951).

Safety instructions

Only a qualified electrician who has appropriate knowledge on functional/machine/process safety is allowed to install, start up and maintain the safety circuit.

WARNING! After making additions to the drive safety circuit or modifying it, or changing circuit boards inside the drive, always test the functioning of the safety circuit according to the acceptance test procedure. Any changes in the electrical installations of the drive may affect the safety performance or operation of the drive unexpectedly. All customer-made changes are on the customer’s responsibility.

WARNING! Read and obey all safety instructions given for the drive in ACS880 multidrive cabinets and modules safety instructions (3AUA0000102301 [English]). If you ignore them, injury or death, or damage to the equipment can occur.

This manual does not repeat the complete safety instructions of the drive but it only includes the instructions related to the scope of this manual.
Target audience

The manual is intended for people who install, start up, use and service the safety option of the drive. Read the manual before working on the drive. You are expected to know the fundamentals of electricity, wiring, electrical components, electrical schematic symbols, and functional safety.

Contents

The chapters of this manual are briefly described below.

Introduction to the manual (this chapter) introduces this manual.  
Option description and instructions describes the safety option and instructs how to wire, start up, test, validate, use and maintain it.

Related documents

- Product manuals (see the inside of the front cover)
- Circuit diagrams delivered with the drive
- Part lists delivered with the drive
- Safety data report

Abbreviations

Abbreviations used in this manual are listed below.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
</table>
| Cat.         | Category  
1. Stop category according to EN/IEC 60204-1  
The stop categories are: 0 (uncontrolled stop) and 1 (controlled stop)  
2. Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability.  
The categories are: B, 1, 2, 3 and 4. | EN/IEC 60204-1, EN ISO 13849-1 |
| DI           | Digital input                                                               |                                     |
| DIIL         | Digital input interlock                                                     |                                     |
| E-stop       | Emergency stop                                                              |                                     |
| HFT          | Hardware fault tolerance                                                    | IEC 61508, EN/IEC 62061            |
| IGBT         | Insulated gate bipolar transistor                                           |                                     |
| PFH          | Average frequency of dangerous failures per hour                            | IEC 61508                           |
| PL           | Performance level (levels are: a, b, c, d and e). Corresponds to SIL.        | EN ISO 13849-1                      |
| SIL          | Safety integrity level                                                      | IEC 61508, IEC 61511, EN/IEC 62061, EN/IEC 61800-5-2 |
Exclusion of liability

ABB is not responsible for the implementation, verification and validation of the overall safety system. It is the responsibility of the system integrator (or other party) who is responsible for the overall system and system safety.

The system integrator (or other responsible party) must make sure that the entire implementation complies with all relevant standards, directives and local electrical code, and that the system is tested, verified and validated correctly.
Quick reference guide for implementing a safety system

<table>
<thead>
<tr>
<th>Task</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the appropriate functional safety standard for the implementation: EN ISO 13849-1, EN/IEC 62061, IEC 61511 or other.</td>
<td></td>
</tr>
<tr>
<td>If you select EN/IEC 62061 or IEC 61511, make a safety plan. See EN/IEC 62061 or IEC 61511.</td>
<td></td>
</tr>
<tr>
<td>Assess safety: analyze and evaluate risks (estimate SIL/PL) and define risk reduction strategies. Define the safety requirements.</td>
<td></td>
</tr>
<tr>
<td>Design the safety system. The part of the design made by ABB is described in chapter Option description and instructions on page 11.</td>
<td></td>
</tr>
<tr>
<td>Verify the achieved SIL/PL with, for example, FSDT-01 Functional safety design tool or similar. See Functional safety design tool user's manual (3AXD10000102417 [English]).</td>
<td></td>
</tr>
<tr>
<td>Connect the wiring. See section Wiring on page 15.</td>
<td></td>
</tr>
<tr>
<td>Set the parameters. See section Parameter settings Note: ACS880 primary control program controls the inverter unit by default. There are dedicated control boards for the supply and inverter units.</td>
<td></td>
</tr>
</tbody>
</table>
| Validate that the implemented system meets the safety requirements:  
  • Do the acceptance test. See section Start-up and acceptance test on page 16. |   |
| Write the necessary documentation. |   |
Option description and instructions

Contents this chapter
This chapter describes the +Q951 emergency stop option and instructs how to wire, start up, test, validate, use and maintain it.

Overview
Option +Q951 corresponds to an uncontrolled stop in accordance with stop category 0 (EN/IEC 60204-1). After the emergency stop command has been given, the drive trips the main contactor/breaker which cuts off the input power of the drive. The motor(s) coasts to a stop.

The design principles of the option +Q951 comply with EN ISO 13850.

For a list of related standards and European directives, see section Related standards and directives on page 24.
Operation principle

This figure shows a simplified operation principle. For a more detailed description, see the circuit diagrams delivered with the drive.

-1) To other inverter units
-2) Reset circuit
-A41 Control board (inverter unit)
-A51 Control board (supply unit)
-A61 Emergency stop safety relay
-F61 Protection switch
-S61 Emergency stop button (optional or user-defined)
-S62 Emergency stop reset button (optional or user-defined)
-P62 Emergency stop indication lamp (optional or user-defined)
-Q2 Main contactor
-K64 Feedback relay to reset circuit
-K65 Auxiliary safety relay
-K66 Auxiliary relay
-T01 Supply module
-T11...TXX Inverter module(s)
-T61 24 V power supply

The dash-dot line (---) in the figure indicates a user-defined installation.
Initial status: The drive is in operation and the motor is running.

<table>
<thead>
<tr>
<th>Step</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The user activates emergency stop by pushing the emergency stop button [S61].</td>
</tr>
<tr>
<td>2.</td>
<td>The emergency stop safety relay [A61] switches off the DI input of the inverter unit control boards [A41]. The auxiliary relay [K66] switches off the DIIIL input of the supply unit control board [A51]. The auxiliary safety relay [K65] de-energizes the main contactor [Q2]. The main contactor [Q2] switches off the power supply to the supply unit and inverter units.</td>
</tr>
<tr>
<td>4.</td>
<td>The motors coast to zero speed and remain at zero speed while the emergency stop is active.</td>
</tr>
</tbody>
</table>
| 5.   | Normal operation resumes after the user:  
|      | • releases the emergency stop button [S61] to normal (up) position  
|      | • resets the emergency stop circuit with the emergency stop reset button [S62]  
|      | • closes the main contactor [Q2] with the operating switch  
|      | • makes sure that the inverter units have received the start signals (depends on the configuration, see the firmware manual). |

Fault reaction function

**Definition:** A safety function requires a “fault reaction function” that attempts to initiate a safe state if the safety function's diagnostics detect a fault within the hardware/software that performs the safety function.

The fault reaction function of the emergency stop safety relay [A61] trips if it detects a failure (short circuit between signals, open circuits, redundancy fault when the emergency stop button is pushed) in the safety circuit. The fault reaction function shifts the drive immediately into the safe state by switching on the drive emergency stop command, opening the main contactor, and keeping them on until the detected fault has been repaired. The indication lamp [P62] of the reset button [S62] is on until the fault has been repaired.

The emergency stop reset circuit must be open when the user releases the emergency stop button. The emergency stop safety relay [A61] detects if the reset circuit is closed and the relay does not close.

**Parameter settings**  
*Note: ACS880 primary control program controls the inverter unit by default. There are dedicated control boards for the supply and inverter units. The inverter unit parameter settings in ACS880 primary control program:*

- **Parameter 10.24 RO1 source** is set to value P.10.1.3-
- **Parameter 21.04 Emergency stop mode** is set to value Coast stop (Off2)
- **Parameter 21.05 Emergency stop source** is set to value DI4 (delivery-specific, refer to the circuit diagrams)
- **Parameter 31.22 STO indication run/stop** is set to value Warning/Warning (recommended).
The supply unit parameter settings in the ACS880 supply control programs:

- parameter 121.04 Emergency stop mode is set to value \textit{Stop and warning}.
- parameter 121.05 Emergency stop source is set to value \textit{DIIL}.

For more information, see the firmware manuals.
Hardware settings

Appropriate hardware settings have been preset at the factory for the safety function.

The settings in the emergency stop safety relay [A61] are:
- cross fault detection is set to value On,
- manual reset is set to value On.

Note: If the cross fault detection is not On, it decreases the fault diagnostics of the wiring.
For more information, see the circuit diagrams delivered with the drive.

Wiring

If option +G331 has been selected one emergency stop button and one reset button are installed on the cabinet door and wired to the drive at the factory. There are double contacts in the emergency stop button and double wiring (two-channel connection) between the button and the emergency stop safety relay [A61]. The safety relay detects cross faults and faults across one contact from the emergency stop button. This function must be used in a redundant manner, that is, the emergency stop button must be connected to both terminals with a separate contact.

If needed, install additional emergency stop buttons on site and wire them to the appropriate terminal block inside the drive cabinet. See the circuit diagrams delivered with the drive. Follow the rules below:

1. Use only double-contact buttons approved for the emergency stop circuits.
2. Connect the emergency stop buttons with two conductors (two-channel connection).
   Note: Keep the channels separate. If you use only one channel, or if the first and second channels are connected together (for example, in a chain), the cross fault detection of the emergency stop safety relay trips and activates the emergency stop command of the inverter unit as it detects a redundancy fault.
3. Use a shielded, twisted pair cable. We recommend a double-shielded cable and gold-plated contacts in the emergency stop button.
4. Ensure that the sum resistance for one channel (loop resistance) from the field to the safety relay does not exceed 70 Ohm.
5. Follow the general control cable installation instructions given in the drive hardware manual.

You can also install additional reset buttons and indication lamps for the emergency stop circuit on site. We recommend gold-plated contacts in the reset button. Wire the buttons to the appropriate terminal block inside the drive cabinet. See the circuit diagrams delivered with the drive. Follow the rules below:

1. Sum resistance of the external reset circuit may not exceed 70 Ohm.
2. Follow the general control cable installation instructions given in the drive hardware manual.
**Start-up and acceptance test**

You need the Drive composer PC tool or a control panel to perform the start-up and acceptance test.

Initial status: Make sure that the drive is ready for use, that is, you have done the tasks of the drive start-up procedure. See the hardware manual.

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WARNING!</strong> Obey the <em>Safety instructions</em>, page 7. If you ignore them, injury or death, or damage to the equipment can occur.</td>
</tr>
</tbody>
</table>

### Checks and settings with no voltage connected

If any connections of the emergency stop circuit have been done on site (such as wiring of additional emergency stop buttons, connection of shipping splits of large drives, etc.), check the connections against the appropriate circuit diagrams.

Check that the hardware settings relevant to the safety function are set as defined in section *Hardware settings* on page 15.

### Settings with voltage connected

Check that the parameters relevant to the safety function are set as defined in section *Parameter settings*. Note: ACS880 primary control program controls the inverter unit by default. There are dedicated control boards for the supply and inverter units, on page 13.

### Acceptance test

Ensure that the motors can be run and stopped freely during the test.

We recommend that you monitor these signals with the Drive composer PC tool:

- 01.01 Motor speed used (rpm)
- 01.02 Motor speed estimated (rpm)
- 01.07 Motor current (A)
- 01.10 Motor torque (%)
- 23.01 Speed ref ramp input (rpm)
- 23.02 Speed ref ramp output (rpm)
- 90.01 Motor speed for control (rpm)
- 90.10 Encoder 1 speed (rpm) (if you use an encoder)

Start the inverter units and ensure that the motors are running. If possible, use a motor speed close to the maximum speed of the application.

Push the emergency stop button [S61].

Ensure that the inverter units stop the motors by coasting and display the related warning. See section *Emergency stop indications* on page 18.

Ensure that the indication lamp [P62] switches on.

Ensure that you cannot switch the power on with the operating switch.

Ensure that you cannot start the inverter units and motors from any control location: Ensure that the motors do not start even if you switch the start signal off and on or push the start key of the panel.

Turn the emergency stop button [S61] until it releases and returns to the up position.

Push the emergency stop reset button [S62]. Ensure that the indication lamp [P62] switches off.

Switch off the start signals of the inverter units.
<table>
<thead>
<tr>
<th>Action</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power up the drive (see the hardware and firmware manuals).</td>
<td>✔</td>
</tr>
<tr>
<td>Restart the inverter units and motors and check that they operate normally.</td>
<td></td>
</tr>
<tr>
<td>Repeat the test from each operating location (every emergency stop button and reset button).</td>
<td></td>
</tr>
<tr>
<td>Fill in and sign the acceptance test report which verifies that the safety function is safe and accepted to operation.</td>
<td></td>
</tr>
</tbody>
</table>
Use of the safety function

Activating

1. Push the emergency stop button [S61]. The emergency stop activates and the button locks in “ON” (open) position.

Resetting

1. Turn the emergency stop button [S61] until it releases.
3. Reset the inverter units if necessary.
4. If necessary, close the main contactor with the operating switch (see the hardware and firmware manuals).
   The main contactor/breaker closes and the drive is powered up.
5. Make sure that the inverter units have received the external start signals (depends on the configuration, see the firmware manual).
6. You can now restart the inverter units.

Note: You have to reset the emergency stop circuit with the reset button [S62] also after you have powered up the drive.

Emergency stop indications

When the emergency stop is on:

• the inverter unit control program has the warning Emergency stop active,
• the emergency stop reset button [S62] on cabinet door is illuminated (indication lamp [P62]).

Fault tracing

This table describes the status LEDs of the emergency stop safety relay [A61].

<table>
<thead>
<tr>
<th>LED</th>
<th>LED is lit and steady</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netz</td>
<td>Power supply is connected.</td>
</tr>
<tr>
<td>K1</td>
<td>Relay K1 is energized.</td>
</tr>
<tr>
<td>K2</td>
<td>Relay K2 is energized.</td>
</tr>
</tbody>
</table>

To reset the emergency stop safety relay [A61] after fault situations, switch off the external power supply of the safety relay.

For more fault tracing possibilities, see the hardware and firmware manuals of the drive.
Maintenance

After the operation of the safety function is tested at start-up, it does not need any scheduled maintenance, excluding the main contactor which has a limited lifetime. Replace the contactor before the end of its lifetime. See the contactor data sheet or manual. Repeat the acceptance test for the function after the replacement. See section \textit{Start-up and acceptance test} on page 16.

In addition to proof testing, it is a good practice to check the operation of the function when other maintenance routines of the machinery are carried out. Do the acceptance test described in section \textit{Start-up and acceptance test} on page 16.

If you change any wiring or component after the start up, or restore parameters to their default values:

- Use only ABB approved spare parts.
- Register the change to the change log for the safety circuit.
- Test the safety function again after the change. Obey the rules given in section \textit{Start-up and acceptance test} on page 16.
- Document the tests and store the report into the logbook of the machine.

\textbf{Proof test interval}

After the operation of the safety function is validated at start-up, the safety function must be maintained by periodic proof testing. In high demand mode of operation, the maximum proof test interval is 20 years. In low demand mode of operation, the maximum proof test interval is 1 year (high or low demand as defined in IEC 61508, EN/IEC 62061 and EN ISO 13849-1). Regardless of the mode of operation, it is a good practice to check the operation of the safety function at least once a year. Do the test as described in section \textit{Start-up and acceptance test} on page 16.

The person responsible for the design of the complete safety function should also note the Recommendation of Use CNB/M/11.050 published by the European co-ordination of Notified Bodies for Machinery concerning dual-channel safety-related systems with electromechanical outputs:

- When the safety integrity requirement for the safety function is SIL 3 or PL e (cat. 3 or 4), the proof test for the function must be performed at least every month.
- When the safety integrity requirement for the safety function is SIL 2 (HFT = 1) or PL d (cat. 3), the proof test for the function must be performed at least every 12 months.

This is a recommendation and depends on the required (not achieved) SIL/PL. For example, safety relays, contactor relays, emergency stop buttons, switches etc. are typically safety devices which contain electromechanical outputs.

\textbf{Competence}

The maintenance and proof test activities of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6.

\textbf{Residual risk}

The safety functions are used to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. Therefore the warnings for the residual risks must be given to the operators.
Intentional misuse
The safety circuit is not designed to protect a machine against intentional misuse.

Decommissioning
When you decommission an emergency stop circuit or an inverter unit, make sure that the safety of the machine is maintained until the decommissioning is complete.
Safety data

- **Safety data values**
  Each multidrives delivery is unique. If included in the customer order, ABB calculates the safety data for the safety function, and delivers the data separately to the customer.

- **Safety component types**
  Safety component types as defined in IEC 61508-2:
  - emergency stop button: type A
  - emergency stop safety relay: type A
  - auxiliary safety relay: type A
  - contactor(s): type A
  - circuit breaker: type A.
Safety block diagrams
Each multidrives delivery is unique. If included in the customer order, ABB defines the safety block diagram for the safety function, and delivers the diagram separately to the customer.

Relevant failure modes
- The main contactor does not open when requested. (All contactor failures are considered dangerous.)
- Internal failures of safety relays and the emergency stop button. These failures are included in the PFH value of the function.

Fault exclusions
Fault exclusions (not considered in the calculations):
- any short and open circuits in the cables of the safety circuit
- any short and open circuits in the cabinet terminal blocks of the safety circuits.

Operation delays
Emergency stop total delay: less than 250 ms
General rules, notes and definitions

- Validation of the safety functions

You must do an acceptance test (validation) to validate the correct operation of safety functions.

Validation procedure

You must do the acceptance test using the checklist given in section Start-up and acceptance test on page 16:
• at initial start-up of the safety function
• after any changes related to the safety function (wiring, components, safety function related parameter settings etc.)
• after any maintenance action related to the safety function.

The acceptance test must include at least the following steps:
• you must have an acceptance test plan
• you must test all commissioned functions for proper operation, from each operation location
• you must document all acceptance tests.

Acceptance test reports

You must store the signed acceptance test reports in the logbook of the machine. The report must include, as required by the referred standards:
• a description of the safety application (including a figure)
• a description and revisions of safety components that are used in the safety application
• a list of all safety functions that are used in the safety application
• a list of all safety related parameters and their values
• documentation of start-up activities, references to failure reports and resolution of failures
• the test results for each safety function, checksums, date of the tests and confirmation by the test personnel.

You must store any new acceptance test reports performed due to changes or maintenance in the logbook of the machine.

Competence

The acceptance test of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.
24 Option description and instructions

- **Ambient conditions**
  For the environmental limits for the safety functions and the drive, refer to the hardware manual of your drive.

- **Reporting problems and failures related to safety functions**
  Contact your local ABB representative.

**Related standards and directives**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60204-1:2016</td>
<td></td>
</tr>
<tr>
<td>EN 61800-5-2:2007</td>
<td>Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional</td>
</tr>
<tr>
<td>IEC 61800-5-2:2016</td>
<td></td>
</tr>
<tr>
<td>IEC 62061:2015</td>
<td></td>
</tr>
<tr>
<td>EN ISO 13849-1:2015</td>
<td>Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design</td>
</tr>
<tr>
<td>IEC 61511-1:2016</td>
<td>Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements</td>
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<tr>
<td>IEC 61326-3-1:2008</td>
<td>Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications</td>
</tr>
<tr>
<td>2006/42/EC</td>
<td>European Machinery Directive</td>
</tr>
<tr>
<td>Other</td>
<td>Machine-specific C-type standards</td>
</tr>
</tbody>
</table>

- **Compliance with the European Machinery Directive**
  The drive is an electronic product which is covered by the European Low Voltage Directive. However, the drive internal safety function of this manual (option +Q951) is in the scope of the Machinery Directive as a safety component. This function complies with European harmonized standards such as EN/IEC 61800-5-2. The declaration of conformity is delivered with the drive.
Further information

Product and service inquiries
Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/searchchannels.

Product training
For information on ABB product training, navigate to new.abb.com/service/training.

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