



UL 347A

STANDARD FOR SAFETY

Medium Voltage Power Conversion Equipment

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UL Standard for Safety for Medium Voltage Power Conversion Equipment, UL 347A

First Edition, Dated September 8, 2015

Summary of Topics

This is the first edition of the Standard for Medium Voltage Power Conversion Equipment, UL 347A.

The new requirements are substantially in accordance with Proposal(s) on this subject dated March 20, 2015..

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UL 347A

Standard for Medium Voltage Power Conversion Equipment

First Edition

September 8, 2015

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 347A as an American National Standard (ANSI) occurred on September 8, 2015. ANSI approval for a standard does not include the Cover Page, Transmittal Pages and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

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APPENDIX A

INTRODUCTION

1 Scope

1.1 These requirements cover enclosed medium voltage power conversion equipment, such as variable frequency controllers, that control and transfer power to motors. These requirements also cover power-supply modules, input/output modules, and electronic assemblies, for use in or with power conversion equipment.

1.2 These requirements cover equipment rated above 1500 volts to 38kV.

1.3 These requirements do not cover equipment for use in hazardous locations as defined by the National Electrical Code, NFPA 70.

1.4 These requirements do not cover solid state reduced voltage motor controllers (soft starters).

1.5 These requirements do not cover low voltage power conversion equipment rated 1500 volts and below. This type of equipment is covered by the Standard for Power Conversion Equipment, UL 508C or the Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy, UL 61800-5-1.

2 Glossary

2.1 For the purpose of this document, the following definitions apply.

2.2 AMBIENT TEMPERATURE – The temperature of the air medium into which the heat of the equipment is dissipated. See 30.1.3.

2.3 BUS – A conductor, or group of conductors, that serve as a common connection for two or more circuits.

2.4 BUS, HORIZONTAL – A bus that extends through a vertical section, that is intended to connect to another vertical section, that may be provided in the future.

2.5 BUS, VERTICAL – A bus that connects one or more controllers in a vertical section together. Where the assembly also contains a horizontal bus, the vertical bus connects the controllers in a vertical section to the horizontal bus.

2.6 BYPASS CIRCUIT – A circuit, typically consisting of a switch or contactor, that when closed, creates an alternate path for current flow in parallel with the circuit being bypassed, allowing the original circuit to be turned off while maintaining current flow to the load.

2.7 CONTACTOR – A two-state (ON-OFF) device for repeatedly establishing and interrupting an electric power circuit.

2.8 CONTACTOR, AIR-GAP – A contactor that introduces a gap (in air) between contacts to interrupt a circuit.

2.9 CONTACTOR, SOLID-STATE – A contactor that introduces a high impedance to interrupt a circuit. Typical solid-state contactors use silicon controlled rectifiers (SCR) or insulated gate bipolar transistors (IGBT) as the switching device(s).

2.10 CONTACTOR, VACUUM – A contactor that introduces a gap between contacts (located in a vacuum) to interrupt a circuit.

2.11 CONTROL CIRCUIT – A circuit that carries the electric signals directing the performance of a controller, and that does not carry the main power circuit. A control circuit is generally limited to 15 amperes or less.

2.12 CONTROLLER – A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

2.13 COVER – An unhinged portion of an enclosure that covers an opening.

2.14 DOOR – A hinged portion of an enclosure that covers an opening, that is intended to be opened during routine maintenance, operations and adjustments.

2.15 ENCLOSURE – A surrounding case designed to protect:

a) Personnel against injury due to accidental contact with electrical or moving mechanical parts of the enclosed device(s), and

b) Internal device(s) against specified external conditions.

2.16 FAULT CURRENT – A current that results from the loss of insulation between conductors or between a conductor and ground.

2.17 GALVANICALLY ISOLATED SECONDARY CIRCUIT – A circuit having no direct electrical connection to a medium voltage circuit, with isolation between the circuits obtained by the use of transformers or optical isolation.

2.18 INTERLOCK – A device that prevents operation of some other device with which it is directly associated under specific conditions. Interlocks may be electrical, mechanical, or a combination of both.

2.19 INTERLOCK, MECHANICAL – An interlock that performs its function solely by mechanical means.

2.20 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolating source (such as a transformer, optical isolator, voltage divider or electro-mechanical relay) and having no direct connection back to the primary circuit.

2.21 ISOLATING MEANS – A mechanical switching device that provides, in the open position, isolating distance in the main circuit, from the source of power.

2.22 LOW VOLTAGE – Voltage of 1500 V or less.

Note: The National Electrical Code, NFPA 70 defines low voltage to be voltages of 1000 V or less.

2.23 LOW VOLTAGE SECTION (of a voltage divider) – That portion of a voltage divider where a small fraction (no greater than 1500 V total) of the input voltage is present during normal operation.

2.24 MEDIUM VOLTAGE – Voltage greater than 1500 V, up to and including 38 kV.

Note: National Electrical Code, NFPA 70 defines any voltage above 1000 V as High Voltage.

2.25 OVERCURRENT – Overcurrent is a current in excess of the continuous rated current.

2.26 PANEL, HINGED – A portion of an enclosure that has hinges, but no hand-operable latching system, secured in the closed position by multiple bolts or other hardware requiring a tool other than a key to operate.

Note: Hinged panels are not intended to be opened during normal operation, routine adjustment or simple maintenance operations such as replacement of fuses.

2.27 PHASE LEAST LIKELY TO STRIKE GROUND – A phase that is referenced to ground or by virtue of its position, potential, or both, relative to other phases of the device is defined as less likely than any other phase to strike ground. In a three phase device, this phase is usually the center phase. It is possible for several phases to be equally likely to strike to ground.

2.28 POLLUTION DEGREE 1 – No pollution or only dry, nonconductive pollution occurs. The pollution has no influence.

2.29 POLLUTION DEGREE 2 – Normally, only nonconductive pollution occurs; however, temporary conductivity is expected when equipment is out of operation.

2.30 POLLUTION DEGREE 3 – Conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation that is expected.

2.31 PRIMARY CIRCUIT – A circuit in which the wiring and components are conductively connected to the branch circuit.

2.32 PRIMARY SECTION (of a voltage divider) – That portion of a voltage divider where a large fraction of the input voltage is present during normal operation.

2.33 PROTECTION, OVERLOAD – A protective device or circuit that detects excessive current, (not necessarily short-circuit current) and functions to cause interruption or limitation of the flow of current through the protected device or circuit.

2.34 PROTECTION, OVERVOLTAGE – A protective device or circuit that detects excessive voltage and functions to interrupt power or reduce voltage to the protected device or circuit.

2.35 RATING – A designated limit of operating characteristics based on definite conditions. Operating characteristics such as current, voltage, frequency, and other characteristics comprise the rating.

2.36 RELAY, OVERLOAD – A relay that functions at a predetermined value of overcurrent to provide a signal or to result in disconnection of the load from the power supply, or both. An overload relay is intended to protect the motor branch circuit conductors, the motor control apparatus, and the motor against overcurrent. It does not necessarily protect itself.

2.37 REVERSING – Reversing is a control function that provides for changing operation of the controlled motor from one direction to the other.

2.38 ROUTINE MAINTENANCE – Maintenance that involves simple tasks such as changing of filters, adjustment of controls, replacement of fuses, or resetting of protective functions or devices. Routine maintenance does not include repair or replacement of components other than fuses or filters.

2.39 SOLID STATE MOTOR OVERLOAD PROTECTION – Circuitry integral to the power conversion equipment that acts to protect a motor under overload conditions by reducing current flow to the motor output terminals. This protection is typically achieved through an algorithm based on the I^2t of the current to the motor. The protection circuitry is usually comprised of hardware, firmware and software components.

2.40 SOLID STATE SHORT CIRCUIT PROTECTION – Circuitry integral to power conversion equipment that acts to suspend current flow to the motor output terminals upon sensing a preset or predetermined condition such as a rapid rate of change in output current or bus voltage. The protection circuitry may be comprised of hardware, firmware and software components.

2.41 SWITCH, ISOLATING – A switching device intended for isolating an electric circuit from the source of power. It does not have an interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

2.42 SWITCH, LOAD BREAK – A switch that has an interrupting rating equal to or greater than the circuit that it controls, and is intended for control of the particular load type to which it is connected.

2.43 TRIP CURRENT – Current above rated output motor current at which the motor overload protection circuitry will function. May be provided as a percent of motor current or as an actual stated current value. Typical values are 125 percent of full load motor current or less.

2.44 VOLTAGE DIVIDER – A combination of components intended to produce an output voltage that is a fraction of the voltage input to the combination.

3 Components

3.1 Other than where specifically referenced in this standard, or as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in products covered by this standard.

3.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

3.3 An unevaluated component, such as a capacitor, resistor, or inductor, is not required to comply with a specific requirement when the system incorporating the component complies with the requirement.

3.4 A low voltage subassembly located in low voltage circuitry, that is both physically and electrically isolated by a transformer, electromechanical relay, or other isolation device, from medium voltage equipment shall be investigated in accordance with the Standard for Industrial Control Panels, UL 508A. Any protection circuitry shall be evaluated with the controller to the requirements of this standard.

3.5 Printed wiring boards shall be suitable for direct support of live parts in accordance with the Standard for Printed Wiring Boards, UL 796.

4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

RATING

5 General

5.1 Power conversion equipment shall be rated according to:

- a) Input.
 - 1) Voltage.
 - 2) Maximum current.
 - 3) Number of phases.
 - 4) Frequency.
- b) Output.
 - 1) Voltage.
 - 2) Full load current or maximum horsepower.
 - 3) Number of phases.

4) Base frequency and frequency range (applies only to alternating current outputs).

5.2 Power conversion equipment shall also be rated with the following:

- a) Short circuit current rating.
- b) Maximum voltage.
- c) Control voltage.
- d) Impulse test voltage (expressed in kilovolts).
- e) Dielectric withstand voltage.

5.3 Ratings of equipment covered by this standard are based on normal service conditions as defined in Section 2.1 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347. Section 2.2 of UL 347 provides additional guidance when equipment is used in special service conditions.

CONSTRUCTION

6 General

6.1 Equipment covered by these requirements shall be constructed as to provide for compliance with the rules for installation and use of such equipment as given in the National Electrical Code, NFPA 70.

7 Enclosure

7.1 General

7.1.1 The requirements of Section 5.102.201 through 5.102.205 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347, apply.

7.2 Ventilation openings

7.2.1 When provided, ventilation openings shall comply with 7.2.2 – 7.2.10.

7.2.2 A ventilating opening shall not be employed in an enclosure unless the conditions of use necessitate such ventilation and the equipment complies with all the tests in this standard when the equipment under test includes the specified ventilation openings.

7.2.3 Any ventilation opening in the top of the enclosure shall be covered by a hood or protective shield spaced above the opening to prevent the entry of water or objects falling vertically downward, both with and without any cooling system or fans operating.

7.2.4 Ventilation openings, including perforations, louvers, and openings protected by means of wire screening, expanded metal, or a perforated cover, shall comply with the rod entry test specified in Clause 6.207 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347.

7.2.5 Barriers shall be provided behind all ventilating openings into medium-voltage compartments. The barrier shall be effectively secured in place and shall be positioned such that a straight line (of zero diameter) may not be drawn from any point outside of the equipment, through the ventilation opening, to any insulated or uninsulated live part. Removable ventilation filters shall not be considered as barriers to meet this requirement.

7.2.6 The diameter of the wires of a screen shall not be less than 1.3 mm (0.050 in) if the screen openings are 320 mm² (0.497 in²) or less in area, and shall be not less than 2.06 mm (0.081 in) thick for larger openings.

7.2.7 Perforated sheet steel and sheet steel employed for expanded metal mesh shall be not less than 1.07 mm (0.042 in) thick for mesh openings or perforations 320 mm² (0.497 in²) or less in area, and shall be not less than 2.03 mm (0.080 in) thick for larger openings.

7.2.8 When ventilation is accomplished by one or more blowers within the enclosure that provide a positive intake and exhaust, the ventilation openings shall be located such that the exhaust air is not directed toward the area occupied by the equipment operator. The area occupied by the operator is defined to be an area 30 in (762 mm) wide, centered on any operator control, display, or disconnect handle, and extending from the bottom of the equipment to a height of 78 in (2 m).

7.2.9 When equipment incorporates a blower motor, it shall comply with 37.3.

7.2.10 When provided with filter(s) for ventilation openings, the construction shall comply with 37.4 and with (a) or (b) below:

a) The filter(s) shall be located such that it cannot be replaced without opening an interlock in accordance with Section 14, Interlocking, or

b) The filter(s) shall be located so that the filters may be replaced without operating an interlock. During any period of filter replacement, including with a filter access cover open and no filter installed, the construction shall comply with 7.2.2 through 7.2.7.

7.3 Environmental rating related enclosure requirements

7.3.1 The requirements of Section 5.102.210 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347, apply to all enclosures intended for outdoor use. When provided with forced ventilation, the driven rain test shall be conducted with the ventilation system operating, and repeated with the ventilations system off. When an enclosure is marked with an enclosure type number, it shall comply with 7.3.2.

7.3.2 Other than as noted in 7.3.3, when marked with an enclosure type number, an enclosure shall comply with the requirements of the Standard for Electrical Equipment, Environmental Considerations, UL 50E, as they apply to the type number or numbers that are marked on the enclosure. When provided with forced ventilation, the environmental tests required for the type number(s) marked on the enclosure shall be conducted with the ventilation system operating, and repeated with the ventilation system off.

7.3.3 An enclosure complying with the Driven Rain Test of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347, is not required to comply with the Rain Test of the Standard for Electrical Equipment, Environmental Considerations, UL 50E, but shall comply with all other requirements for the enclosure type number that is marked on the enclosure.

7.4 Protection against corrosion

7.4.1 The requirements of 5.102.207 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347 apply.

8 Arrangement of Components

8.1 Arrangement of devices in assemblies shall be such that individual components can perform their intended function without adversely affecting the operation of other components in the assembly.

8.2 Gas discharged during operation of interrupting devices shall be so directed as not to endanger personnel or impinge on other components of a controller.

8.3 The requirements of 5.102.208 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347 apply.

9 Guarding and Accessibility of Live Parts

9.1 When access is required to a compartment that contains energized medium-voltage parts, barriers shall be provided to:

- a) Prevent unintentional contact with energized parts;
- b) Prevent tools or other equipment from being dropped on energized parts; and
- c) Protect against contact with live parts of adjacent functional units.

9.2 Any barrier intended to be removed during routine maintenance or servicing (such as barriers required to be removed for replacement of fuses or the examination of contacts) shall be marked in accordance with 42.25.

10 Grounding and Bonding

10.1 The requirements of Section 5.3 of the Standard for Medium Voltage AC Contactors, Controllers, and Control Centers, UL 347, apply.

10.2 Within the low voltage compartment, a wire binding screw intended for the connection of a field-installed equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both.

10.3 Within the low voltage compartment, a pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be plainly identified, such as being marked "G," "GR," "GRD," "Ground," "Grounding". The symbol $\oplus$ (IEC Publication 417, Symbol 5019) shall not be used alone unless the symbol is defined in the installation instructions provided with the equipment.

10.4 Insulated grounding and bonding conductors shall be identified by the color green with or without one or more yellow stripes. Insulated grounding and bonding conductors 6 AWG or larger may have black insulation, if the conductor is identified by green paint or tape applied at each end of the conductor. No other leads shall be so identified.

11 Protective Devices

11.1 Other than as noted in 11.5, equipment shall include coordinated protection that automatically interrupts overcurrents occurring in the driven motor, and in the motor-circuit conductors, both internal and external to the equipment itself.

11.2 Motor overload protection shall be provided over the rated operating frequency range of the equipment by one of the following means:

- a) Mechanical or electronic overload relay that complies with Section 12, Overload Relays; or
- b) Solid state overload protection that complies with the Solid State Motor Overload Protection Test, Section 36.1 and is subjected to the requirements in Section 48, Burn-In and Diagnostic Tests.

11.3 Other than as noted in 11.5, in addition to the motor overload protection required by 11.2, branch circuit overcurrent protection shall be provided in the input circuit by one of the following:

- a) A circuit breaker of suitable type and ratings. The circuit breaker may sense the fault current by means of integral or external sensing elements.
- b) Fuses of suitable type and rating, placed in each ungrounded conductor.

11.4 The branch circuit overcurrent protection required by 11.3 shall not automatically reclose the circuit.

11.5 The branch circuit overcurrent protection required by 11.3 may be omitted when the equipment is marked, in accordance with 42.7, to indicate the specific overcurrent protection that shall be provided in the installation.

11.6 Polyphase controllers shall be provided with input phase loss protection. This protection shall prevent the controller from providing a single phase output to the motor terminals for more than 30 seconds. This protection shall comply with the single phase test requirements of Section 37.2.

11.7 Equipment shall comply with one of the following:

- a) Be provided with motor load and speed sensitive overload protection with thermal memory retention, that complies with 36.2, 36.3, and 36.4,
- b) Be provided with a means to accept and act upon a signal from a thermal sensor or switch imbedded in the motor or from an external protective relay, and be marked in accordance with 43.7, or
- c) Have no provisions for motor overtemperature protection and be marked in accordance with 43.8.

11.8 When equipment is provided with current limiting protection that causes the output current to be limited to a specific current regardless of any increase in loading of the controlled motor, the protection shall comply with 37.5.

11.9 Equipment shall be provided with over speed protection. When a controller is provided with overspeed protection incorporating feedback, the protection shall operate to prevent over-speed upon loss of the feedback signal.

11.10 When equipment is provided with phase reversal protection, the protection shall operate on the reversal of the phase rotation in a polyphase circuit to cause and maintain the interruption of power in all of the circuit until the protection has been manually reset.

11.11 Equipment for controlling a synchronous AC motor shall not incorporate over current protection in a motor field supply circuit, unless such protection also operates to remove all power from the motor.

11.12 Equipment for controlling a DC motor shall not be provided with field supply circuit protection unless the equipment incorporates a detector that senses loss of field current or voltage and prevents over-speed upon field loss.

11.13 Protective devices shall open all ungrounded conductors of the protected circuit. When fuses are provided, there shall be a fuse in each ungrounded conductor of the circuit.

11.14 Opening of a single fuse in a three phase circuit shall not result in application of single phase conditions to the motor for more than 30 seconds.

11.15 Fuses may be used in parallel in medium voltage circuits when all of the following conditions are met:

- a) The fuses in parallel have identical ratings;
- b) The fuses are installed in a common mounting with electrical connections that divide the current equally; and
- c) The equipment is marked in accordance with 42.31.

12 Overload Relays

12.1 Section 12 applies only when equipment is provided with a discrete overload relay.

12.2 The overload relay shall be of the ambient compensated type and shall comply with the requirements for overload relays as detailed in the Standard for Industrial Control Equipment, UL 508.

12.3 Equipment that incorporates an overload relay with removable overload relay current elements that is used with a current transformer shall be marked in accordance with 42.9, unless it is so interlocked that the motor cannot be energized with the overload relay current element either removed or open.

12.4 Equipment incorporating an overload relay with removable overload relay current elements shall be provided with instructions for selection of the proper element.

12.5 Equipment incorporating an adjustable overload relay shall be provided with instructions for such adjustment.

13 Isolating Means

13.1 Other than as noted in 13.9, a controller shall be provided with an externally-operable, gang-operated, medium-voltage, power circuit isolating means with position indication that complies with 13.2 – 13.8. The isolating means can be any one of the following:

- a) Three-pole isolating switch;
- b) Three-pole isolating switch in mechanical combination with medium-voltage motor circuit fuses;
- c) Three-pole load break switch;
- d) Draw out three-pole contactor (with or without fuse assembly); or
- e) Draw out three pole circuit breaker.

13.2 The isolating mechanism, indicated in 13.1, shall be arranged to be operated from a location where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. The disconnecting means shall not disconnect a permanently grounded conductor, unless the disconnecting means is so constructed that the pole in the grounded conductor cannot be opened without disconnecting all conductors of the circuit in the same operation.

13.3 The isolating means shall provide visible evidence of an isolating gap in the circuit adequate for the operating voltage.

13.4 To comply with 13.3, the isolation gap or a mechanically operated indicator shall be visible through a viewing pane or by opening a door when the isolating gap is open. The mechanical operator shall be actuated by the movement of the actual isolating switch assembly, the shutter of a draw-out assembly, or the like. The action of the mechanical indicator shall not be dependent on the movement of the operating handle or mechanism alone.

13.5 The power-circuit isolating means shall be interlocked as indicated in Interlocking, Section 14.

13.6 The power-circuit isolating means shall have provision for being padlocked in the open position.

13.7 Other than as noted in 13.8, all switch blades shall be de-energized when the switch is in the open position.

13.8 Switches that are intended to be energized from both sides (for example, bus tie, loop sectionalizing) shall not have energized blades in the open position unless:

a) Barriers or enclosures are installed over the switches for protection against contact with the energized switch blades; and

b) The switch is marked in accordance with 42.9.

13.9 Equipment that is not provided with the isolating means noted in 13.1 shall comply with (a) – (d) below:

a) The equipment shall be marked in accordance with 42.8;

b) The equipment shall be provided with specific instructions indicating the specific external isolating means that shall be provided;

c) The equipment shall be provided with means for interlocking with the specified external isolating means. This requires a portion of the interlock system to be installed on the equipment, and the remaining portion (that will be installed on the external isolating means) to be provided in the form of a kit, that is shipped with the equipment. This kit shall include all the necessary parts of the interlock, all hardware required to install the interlock, and specific instructions detailing the installation of the interlock on the isolating means; and

d) When the interlock is properly installed on the external isolating means, the resulting assembly shall comply with all the requirements of 13.2 – 13.8 and the requirements of Interlocking, Section 14.

14 Interlocking

14.1 Interlocking shall be provided by a solely mechanical means and shall provide the following features:

a) Prevent opening or closing the isolating means if the controller is providing current to the load, unless the isolating means is a load break type switch.

b) Prevent the opening of a door when the isolating means is closed, if the door provides access to a compartment containing medium-voltage energized parts or medium-voltage wiring.

c) Prevent closing the isolating means when any medium-voltage- compartment door of the controller is open.

d) Prevent opening the isolating means while current is flowing in the secondary of a control transformer unless the isolating means has been made the subject of an investigation to determine its acceptability for this type of operation. See 32.4.