

UNDERWRITERS LABORATORIES INC. CERTIFICATION REQUIREMENT DECISION

This Certification Requirement Decision is prepared by UL LLC. It is normative for the applicable UL Product Certification Program(s); however, it is currently not part of the UL Standard(s) referenced below.

Product Category (CCN): NMMS/2

Standard Number: UL 61800-5-1

Standard Title: Standard For Safety For Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

Edition Date: June 8, 2012

Edition Number: 1

Section / Paragraph Reference: 5.2.8DV.1.2, Annex DVI, Annex DVJ, Annex DVK

Subject: Requirements for drives used as output conductor protection

DECISION:

5.2.8DV.1.2.1.1 The main output power wire size for the test of a BASIC DRIVE MODULE/ COMPLETE DRIVE MODULE intended for use as output conductor protection shall comply with the requirements of DVI.3.1.2.2.

Annex DVI

(normative)

Output Motor Conductor Protection

DVI D2 Addition of new annex DVI as follows:

DVI.1 General

DVI.1.1 The requirements in this section are applicable only to BASIC DRIVE MODULES/COMPLETE DRIVE MODULE consisting of a single INVERTER SECTION, where each single inverter is intended to control a single motor and provide output motor conductor protection in place of the AC input branch circuit protection.

DVI.2 CONSTRUCTION

DVI.2.1 General

DVI.2.1.1 The construction of a CDM/BDM intended for use as output conductor protection shall comply with the applicable requirements of Section 4 as supplemented and amended by the requirements in this section.

DVI.2.1.2 A CDM/BDM intended for use as output conductor protection shall incorporate SOLID STATE SHORT CIRCUIT PROTECTION that complies with 5.2.3.6.1DV.2,c) – g) and 5.2.9DV.1.

DVI.2.1.3 An overload relay provided within a CDM/BDM intended for output conductor protection shall comply with all applicable requirements in this standard or have been previously evaluated.

DVI.2.1.4 A BDM/CDM that utilizes firmware or software to provide output conductor protection shall additionally comply with the requirements of Annex DVJ, Software for Motor Circuit Conductor Protection.

DVI.2.1.5 A CDM/BDM intended to provide output conductor protection shall additionally comply with the requirements of Annex DVK, Electromagnetic Compatibility (EMC) Requirements for Motor Circuit Conductor Protection.

DVI.3 PERFORMANCE

DVI.3.1 General

DVI.3.1.1 A CDM/BDM intended for use as output conductor protection shall comply with the performance requirements of Section 5 and DVI.3.1.2 - DVI.3.1.7.

DVI.3.1.2 A CDM/BDM intended for use as output conductor protection shall be subjected to the tests specified in Table DVI.1. Where a test specified in Table DVI.1 modifies a test in Section 5, only the modified test shall be required.

DVI.3.1.2.1 A CDM/BDM that includes internal bypass circuitry for motor control shall be tested in all modes of operation.

DVI.3.1.2.2 The output conductors used for all the tests specified in Table DVI.1 shall be the smallest conductor size intended to be protected by the CDM/BDM and in compliance with a) and b):

- a) The main output power wire size shall not be larger than the size marked in accordance with DVI.5.1.1.
- b) The main output power wire shall not be smaller than the minimum size marked in accordance with 6.3.6.4.

DVI.3.1.2.2.1 Conductors smaller than 18 AWG are not permitted, for BDM/CDM complying with 4.4.6DV.1.1, conductors smaller than 14 AWG are not permitted unless the following conditions are met.

- a) For 16 AWG:
 - 1. If CDM/BDM output is rated more than 5.5 A, BDM/CDM in compliance with 4.4.6DV.1.1a) must have a class 10 or 10A overload relay and BDM/CDM in compliance with 4.4.6DV.1.1 b) shall comply with the Solid State Motor Overload Protection Test, except that at 600% the overload shall trip within 10 s, and at 200% the overload shall trip within 4 min.
 - 2. If CDM/BDM output is rated 5.5 A or less, BDM/CDM in compliance with 4.4.6DV.1.1a) must have a class 20, 10, or 10A overload relay and BDM/CDM in compliance with 4.4.6DV.1.1 b) shall comply with the Solid State Motor Overload Protection Test.
- b) For 18 AWG:
 - 1. If CDM/BDM output is rated more than 3.5 A, BDM/CDM in compliance with 4.4.6DV.1.1a) must have a class 10 or 10A overload relay and BDM/CDM in compliance with 4.4.6DV.1.1 b) shall comply with the Solid State Motor Overload Protection Test, except that at 600% the overload shall trip within 10 s, and at 200% the overload shall trip within 4 min.
 - 2. If CDM/BDM output is rated 3.5 A or less, BDM/CDM in compliance with 4.4.6DV.1.1a) must have a class 20, 10, or 10A overload relay and BDM/CDM in compliance with 4.4.6DV.1.1 b) shall comply with the Solid State Motor Overload Protection Test.

Table DVI.1 Test overview						
Std. Ref. Sec.	Test	Explanatory Notes	Sample number ^{a,c}			Seq. 1 Shots
			1	2 ^b	3 ^b	
	Standard Fault					
DVI.3.2	Short Circuit		1			
	A/C ⁴	Apply V _{IN} ⁶ - initiate gating – apply common ¹ fault				1
	C/A ⁵	Apply V _{IN} ⁶ - apply common ¹ fault - initiate gating				1
DVI.3.3	Common Power-up Test	Apply common ¹ fault - Apply V _{IN} ⁶ - initiate gating	2			1
DVI.3.4	Interrupting		3			
	A/C ⁴ Single-Pole	Apply V _{IN} ⁶ - initiate gating – apply single-pole ² fault				3
	C/A ⁵ Single-Pole	Apply V _{IN} ⁶ – apply single-pole ² fault - initiate gating				3
	A/C ⁴ Multiple-Pole ³	Apply V _{IN} ⁶ - initiate gating – apply multiple-pole ³ fault				1
DVI.3.5	Single-Pole Power-up Test	Apply single-pole ² fault - Apply V _{IN} ⁶ - initiate gating		1		
	High Fault					
DVI.3.6	Short Circuit		4			
	A/C ⁴	Apply V _{IN} ⁶ - initiate gating – apply common ¹ fault				1
	C/A ⁵	Apply V _{IN} ⁶ - apply common ¹ fault - initiate gating				1
DVI.3.7	Common Power-up Test	Apply common ¹ fault - Apply V _{IN} ⁶ - initiate gating	5			1
DVI.3.8	Interrupting		6			
	A/C ⁴ Single-Pole	Apply V _{IN} ⁶ - initiate gating – apply single-pole ² fault				3
	C/A ⁵ Single-Pole	Apply V _{IN} ⁶ – apply single-pole ² fault - initiate gating				3
	A/C ⁴ Multiple-Pole ³	Apply V _{IN} ⁶ - initiate gating – apply multiple-pole ³ fault				1
DVI.3.9	Single-Pole Power-up Test	Apply single-pole ² fault - Apply V _{IN} ⁶ - initiate gating			1	
	Verification A	a) No CDM/BDM damage – 1) UL 61800-5-1, 5.2.6.2	7	2	2	

		2) <u>CDM/BDM must operate motor after test</u>				
		b) <u>BCPD cannot open</u>				
	<u>Verification B</u>	c) <u>CDM/BDM damage – consistent with breakdown of components</u> d) <u>BCPD can open</u>	<u>8</u>	<u>2</u>	<u>2</u>	
	<u>Conductor Verification</u>	<u>No output motor conductor insulation damage.</u>				
			<u>Total =</u>			<u>20</u>

^a The verification steps shall be performed last. The other steps are able to be conducted in any order.

^b A different sample is able to be used for each test. Each sample must comply with the verification.

^c All tests or any combination of test sequences are able to be conducted on a single sample when agreeable to those concerned. More than one sample are able to be used when more than one rating is being tested. One sequence is not required to be completed as a prerequisite to the starting of another.

¹ Common Fault – Short-circuit between all motor circuit conductors. Execute one shot.

² Single-Pole Fault - Connect one output motor terminal to one input line terminal. Execute one shot per output motor phase terminal.

³ Multiple-Pole Fault - Simultaneously connect each output motor terminal through a separate contact to a single input line terminal. Execute one shot.

⁴ A/C – Actuate/Close, insert fault while CDM/BDM is running

⁵ C/A – Close/Actuate, insert fault and then start CDM/BDM

⁶ V_{IN} – Apply input voltage with electromechanical switch. Must have step function. No ramping voltage (for example with variac)

Table DVI.2 – Summary of Test Conditions (Individual-Motor, Straight Rating)

<u>Standard Reference Section</u>	<u>Test</u>	<u>Test Circuit Parameter Calibrated?</u>		<u>Can BCPD Open^a</u>	<u>Require Cotton</u>	<u>High Fault Test</u>
		<u>I_{SCA} 3-Ph</u>	<u>PF 3-Ph</u>			
<u>DVI.3.2</u>	<u>Standard Fault Short Circuit Test</u>	Yes	No	No	No	^b
<u>DVI.3.3</u>	<u>Standard Fault Common Power-up Test</u>	Yes	Yes	No	No	^b
<u>DVI.3.4</u>	<u>Standard Fault Interrupting Test</u>	Yes	Yes	No	No	Yes
<u>DVI.3.5</u>	<u>Standard Fault Single-Pole Power-up Test</u>	Yes	Yes	Yes	Yes	Yes
<u>DVI.3.6</u>	<u>High Fault Short Circuit Test</u>	Yes	Yes	No	No	^b
<u>DVI.3.7</u>	<u>High Fault Common Power-up Test</u>	Yes	Yes	No	No	^b
<u>DVI.3.8</u>	<u>High Fault Interrupting Test</u>	Yes	Yes	No	No	Yes
<u>DVI.3.9</u>	<u>High Fault Single-Pole Power-up Test</u>	Yes	Yes	Yes	Yes	Yes

Table DVI.3 – Summary of Test Conditions (Individual-Motor, Straight/Slash Rating)

<u>Standard Reference Section</u>	<u>Test</u>	<u>Test Circuit Parameter Calibrated?</u>				<u>Can BCPD Open^a</u>	<u>Require Cotton</u>
		<u>I_{SCA} 3-Ph</u>	<u>PF 3-Ph</u>	<u>I_{SCA} 1-Ph</u>	<u>PF 1-Ph</u>		
<u>DVI.3.2</u>	<u>Standard Fault Short Circuit Test</u>	No	No	No	No	No	No
<u>DVI.3.3</u>	<u>Standard Fault Common Power-up Test</u>	Yes	Yes	No	No	No	No
<u>DVI.3.4</u>	<u>Standard Fault Interrupting Test</u>	Yes	Yes	Yes	No	No	No
<u>DVI.3.5</u>	<u>Standard Fault Single-Pole Power-up Test</u>	Yes	Yes	Yes	No	YES	Yes
<u>DVI.3.6</u>	<u>High Fault Short Circuit Test</u>	Yes	Yes	Yes	Yes	No	No
<u>DVI.3.7</u>	<u>High Fault Common Power-up Test</u>	Yes	Yes	Yes	Yes	No	No
<u>DVI.3.8</u>	<u>High Fault Interrupting Test</u>	Yes	Yes	Yes	Yes	No	No
<u>DVI.3.9</u>	<u>High Fault Single-Pole Power-up Test</u>	Yes	Yes	Yes	Yes	Yes	Yes

^a The existing requirements specify a series BCPD, sized at a maximum value. If the BCPD does not open, this shows overload function withstand capability does not rely on the BCPD type or rating (group installation) and Sample 1 testing covers group installation for the short-circuit/power-up/interrupting testing.

^b See DVI.3.1.4.

DVI.3.1.3 A CDM/BDM series intended for output conductor protection shall comply with the Standard Faults Tests, DVI.3.2 – DVI.3.5, and High Fault Tests, DVI.3.6 – DVI.3.9, when it is intended to be rated with:

- a) A standard fault current value in accordance with Table 4.3.9DV.1; and
- b) A high fault current value in excess of the standard fault current value

DVI.3.1.4 A CDM/BDM series is in compliance with the High Fault Short Circuit Test, DVI.3.6, without additional testing when:

- a) The CDM/BDM series uses SOLID STATE SHORT CIRCUIT PROTECTION circuitry for compliance with the standard fault current short circuit test; and
- b) The SOLID STATE SHORT CIRCUIT PROTECTION circuitry is used in accordance with DVI.3.1.6.

DVI.3.1.5 A CDM/BDM series is in compliance with the High Fault Common Power-up Test, DVI.3.7, without additional testing when:

- a) The CDM/BDM series uses SOLID STATE SHORT CIRCUIT PROTECTION circuitry for compliance with the standard fault current short circuit test; and
- b) The SOLID STATE SHORT CIRCUIT PROTECTION circuitry is used in accordance with DVI.3.1.6.

DVI.3.1.6 Any model is able to serve as the representative model from a series that uses SOLID STATE SHORT CIRCUIT PROTECTION circuitry for compliance with this test. As an example, for a CDM/BDM series with models rated from 25 hp to 700 hp (18,64 – 521,99 kW), the testing of the 25 hp model at 5 000 A

represents the testing of any models at 10 000 A, 18 000 A, 30 000 A, or 42 000 A when all of the following requirements are met:

- a) The same solid state protection circuitry is used throughout the series;
- b) Any revisions to the protection circuitry requires re-evaluation;
- c) The protection circuitry turns off the output devices (Insulated Gate Bi-polar Transistor IGBT), bi-polar, and similar devices prior to the time in which the devices are damaged by any increase in current. This is based on the manufacturer's rating of the output devices (typically 10 μ s for IGBTs, and 50 μ s for bi-polars);
- d) Any increase in current experienced by the output devices is the result of the DC bus capacitor bank discharging;
- e) The output devices are turned off by the protection circuitry prior to any significant increase in the input current;
- f) In response to a higher standard fault current (for example 42 000 A vs. 5 000 A), the protection circuitry shall react to the higher standard fault current (42 000 A) in the same or shorter time as the lower standard fault current (5 000 A). This may be verified through testing at the higher fault current value or through inspection of the SOLID STATE SHORT CIRCUIT PROTECTION hardware and software circuitry; and
- g) When relying on current sensing (as opposed to output device collector voltage sensing) to actuate the protection circuitry, either the DC bus or all main motor output lines shall be monitored.

DVI3.1.7 The source used to perform the tests specified in Table DVI.1 shall meet the earthing, supply voltage and current requirements of sections 5.2.3.6.2DV.2.1.5 and 5.2.3.6.2.1 through 5.2.3.6.2.1DV.2.1, the power factor requirements of 4.3.9DV.2.4, and the calibration requirements, 5.2.3.6.2.1DV.3.

DVI.3.2 Standard fault short-circuit test

DVI.3.2.1 A CDM/BDM series intended for output conductor protection shall comply with DVI.3.2.2 – DVI.3.2.8.

DVI.3.2.2 The test configuration shall comply with section 5.2.3.6.2 through 5.2.3.6.2DV.4 except for the following differences:

- a) The wire mesh cage and surgical cotton specified in section 5.2.3.6.2, 5.2.3.6.2DV.1.1.2.b), and 5.2.3.6.2DV.5.1.6 are not required.
- b) The branch circuit short circuit protection used for this test shall be of the fastest acting type specified for the CDM/BDM and sized no more than 125% of the CDM/BDM input current rating.

DVI.3.2.3 The short circuit test shall be performed with the CDM/BDM at full load or light load whichever creates the more severe condition.

DVI.3.2.4 As an alternate to providing a full load or light load, a remote circuit may be connected to each CDM/BDM such that the output devices are actuated independent of any loading.

DVI.3.2.5 The location of the short shall comply with 5.2.3.6.3.2 except for the following differences:

- a) Motor power output terminals are the only terminals to be tested.
- b) Motor field winding output terminals are not required to be shorted.

DVI.3.2.6 The input/output wiring connection shall comply with 5.2.3.6.2DV.5. except for the following differences:

- a) The main output power wiring size shall comply with the requirements of DVI.3.1.2.2.

DVI.3.2.7 Test Sequence