Rockwell Automation

Improving Safety with CENTERLINE 2500 IEC Motor Control Centers

Authors: Mark Ossanna, Diego Wilches

Safety philosophy

With over 100 years of motor control experience, the Allen-Bradley® CENTERLINE® 2500 motor control center (MCC) meets safety and reliability expectations. It complies with IEC 61439-1/2 for basic functional safety and is tested in accordance with IEC/TR 61641:2014 for low voltage arc fault containment.

The CENTERLINE 2500 MCC provides improved safety features, including:

- Structural enhancements that help protect against arc flash hazards if a fault occurs
- Advanced diagnostics in IntelliCENTER® software, which provides remote access to data and troubleshooting, minimizing the need for enclosure entry
- Locking provisions that provide additional safety in all four unit positions (connected, test, disconnected and withdrawn)
- SecureConnect™ technology, which allows for closed-door unit released
- Automatic shutters that immediately isolate the vertical bus when a unit is removed
- Machine-torqued, two-bolt fastening system that is used for the horizontal to vertical bus connection, reducing periodic maintenance, minimizing exposure to hazardous voltages
- Rigid structural design with side sheets and solid, non-perforated support plates and solid support plates on all sections to provide better isolation and continuous internal mounting angles, main bus and lifting angle

Type tested

The CENTERLINE 2500 Low Voltage Motor Control Center is subjected to extensive type tests in compliance with specific standards.

The CENTERLINE 2500 MCC complies with IEC 61439 Part 1 and is third-party tested to show compliance with Part 2. Part 1 states General Rules, referring to the specific standards that cover the various types of low-voltage switchgear and controlgear assemblies. It contains the definitions and states the service conditions, construction requirements, technical characteristics and verification requirements for low voltage switchgear and controlgear assemblies.

Part 2 defines the specific requirements of power switchgear and controlgear assemblies and is tested for compliance by a third-party vendor. The CENTERLINE 2500 MCC tests are based on the most critical representative applications of the product or performance range of the switchgear with response to the standard.

IEC 61439-2 standards	Passed	Test results
Strength of material and parts (10.2)	✓	Mechanical integrity was not impaired and seals were not damaged
Degree of protection of Assemblies (10.3)	✓	Degree of protection can be assigned
Clearances and creepage distances (10.4)	✓	Distances verified for: Rated insulation voltage Ui = 690V; Rated impulse voltage Uimp = 12 kV; Pollution degree 3
Protection against electric shock and integrity of protective circuits (10.5)	✓	Verified the effectiveness of connection between protective circuit and exposed conductive parts
Dielectric properties (10.9)	✓	Tests did not produce any punctures or flash-overs
Verification of temperature rise (10.10)	✓	Verified temperature rise limits were not exceeded
Short-circuit withstand strength (10.11)	✓	Unit maintained normal operation – no short circuits, deformation or deterioration
Electromagnetic compatibility (10.12)	✓	Compatibility verified
Mechanical operation (10.13)	✓	No damage or excessive wear was observed on any of the plug-in stabs, other connectors, operating mechanism or interlock

Internal separation

The internal separation is subject to agreement between the manufacturer and user (IEC 60439-1 Annex E 7.7 Internal separation of assemblies by barriers or partitions). Assemblies are divided with partitions or barriers (metallic or non-metallic) into separate compartments or enclosed protected spaces.

Forms of separation					
	Form 1	**Form 2b**	**Form 3b**	**Form 4a**	**Form 4b**
Internal separation	No separation	Separation of busbars including distribution bars from the functional units and terminals for external conductors: Forms 2b, 4a, 3b, 4b	Separation of terminals for external conductors from the functional units: Forms 3b, 4b	Separation of all functional units from another: Forms 4a, 3b, 4b	Terminals not in the same compartment as associated unit: Form 4b
Protection of persons	No protection when doors are open	Helps protect persons against touch of busbars and distribution bars during work on the functional units: Forms 2b, 4a, 3b, 4b	Increased protection during work on the terminals for external conductors: Forms 3b, 4b	Helps protect persons against touch of neighboring functional units during work on a functional unit: Forms 4a, 3b, 4b	Increased protection to terminals of the neighboring functional units: Form 4b
Protection of equipment	No internal protection	Protection against ingress of foreign objects between functional unit into the busbar compartment: Forms 2b, 4a, 3b, 4b	Protection against ingress of foreign objects between functional units and common terminal compartment: Forms 3b, 4b	Protection against ingress of foreign objects into any Neighboring functional unit: Forms 4a, 3b, 4b	Protection against ingress of foreign objects between single terminal compartments: Form 4b
			Achieved by CENTERLINE 2500 MCCs		

Closed-door unit withdrawal

SecureConnect technology for Centerline 2500 units allow the operator to remove a unit without opening its door, a feature that increases the level of personnel safety during servicing while decreasing production downtime.

The unit operating handle is located outside the unit door, which provides movement to all operating positions of the unit without special tools. SecureConnect units meet the requirements of IEC/TR 61641 in the Connected, Test, and Disconnected positions. The ability to remove the unit with the door closed is a specific requirement of IEC 61892, used by the oil and gas industry.

A SecureConnect unit door also features an interlock mechanism for added safety via sequential interlocking and lockout functionality. The interlock operator involves both 180° rotation and depression. The interlock operator must be depressed to achieve any unit position change. You can rotate the interlock operator to either locked or unlocked positions to limit unit positions. You can also lock out the interlock operator to restrict any further unit position change.

Icon	Position	Description
	Connected	Line, load, control, network and PE connections are all engaged. Units can be locked in the connected position.
	Test	Control, network, and PE connections are engaged. Line and load connections are isolated. In this positions, the user can verify control and network wiring along with unit functionality. Units can be locked in the Test position.
	Disconnected	An isolated position where the unit remains housed in the column and the PE connection is engaged, but no other connections are present. Units can be locked in the disconnected position.
	Released	Withdrawable units can be removed from the columns to isolate them from all connections. Released units can be locked to protect against insertion.

Arc fault protection

What is an arc flash?

Defined by the NFPA 70E 2012 (Standard for Electrical Safety in the Workplace), Article 100 defines an Arc Flash Hazard as "a dangerous condition associated with the possible release of energy caused by an electric arc." Equipment damage, personal injury and possible death can be caused by arc flash and arc blast.

An arc flash is a type of electrical explosion that results from a low impedance connection to ground or another voltage phase in an electrical system. An arc flash can cause substantial damage, fire or injury. Temperatures can exceed 19,000 degrees Celsius at the arc terminals. A typical arc flash could be accompanied by a more severe explosion or arc blast. The result of the violent event can cause destruction of equipment, fire, and injury.

An arc blast is an explosive release of pressure, sound, light and shrapnel from an electric arc. When an arc is created across a couple of phases, the temperature goes up. As the air ionizes, the copper begins to be used as fuel. With this conductive plasma, the impedance is much lower than standard air. The light generated intensifies. The bright light can cause temporary or permanent blindness. The expansion rates of metals such as copper can be a factor of 67,000 times when going to a vapor from a solid. With this high expansion rate comes a dangerous energy blast. The most damaging to a human being is the release of a tremendous amount of heat energy. Flying shrapnel from the blast can move at speeds of over 1126 km/h (700 mph) from the arc. Pressure can change up to 29 psi.

Causes of an arc fault

Human error

- Accidentally touching a live conductor
- Dropping or misplacing tools or other parts
- Improper installation practices

Mechanical failure

- Closing into faulted lines
- Loose connections
- Mechanical/electrical dimensioning
- Wire degradation
- Cable insulation
- Dust and impurity buildup

Arc containment solution

To help with safety, Rockwell Automation produces the CENTERLINE 2500 Low Voltage Motor Control Centers with ArcShield™ technology.

Although operators and manufacturers of low voltage systems are becoming more experienced, there is still a risk of internal arc generation. To enhance the protection of personnel and equipment, Rockwell Automation tests the CENTERLINE 2500 Motor Control Centers to IEC/TR 61641 Edition 3.0 2014, which is a standard for testing under conditions of arcing due to internal fault.

The CENTERLINE 2500 Low Voltage Motor Control Center with ArcShield technology was tested against the IEC/TR 61641 standard, and it passed all test criteria at 480V with a rated frequency of 50/60 Hz and arcing time of 300 ms and test current of 65 kA.

The following ignition points were considered on single samples of multiple configurations of the product:

- Load side of the outgoing functional unit
- Supply side of the outgoing functional unit
- Along the distribution busbar
- Along the main busbar
- Load side of the incoming functional unit
- Supply side of the incoming functional unit
- Along the distribution busbar
- Along the main busbar
- Load side of the incoming functional unit
- Supply side of the incoming functional unit

MCC location	Test performed	
Outgoing functional units: (Load side/Supply side)	Withdrawable units: testing completed in multiple module sizes; short across load stabs in vertical wireway and across load terminals of protective device	
Load side	Frame-mount units: testing complete; short across load terminals of protective device	
Supply side	Withdrawable units: arc-free zone* – testing conducted and passed	Frame-mount units: testing complete; short across bracket for vertical bus – cable connection
Distribution busbar: Vertical bus system	Withdrawable units: arc-free zone* – testing conducted and passed	Frame-mount units: arc-free zone* – testing conducted and passed
Main busbar: Horizontal bus system	Horizontal bus compartment: testing complete; short horizontal bus across all 3-phase. Uses top relief plates without the need for additional plenums.	
Incoming functional units: Load side/supply side	Incoming: testing complete in column with air circuit breakers buswork and construction	

*Arc-free zone is used to describe the section within the cubicle consisting of the distribution bars, the main contact and the supply side of the functional unit being the connection to the SCPD.

Ignition point testing

The CENTERLINE 2500 low voltage MCC with ArcShield was tested with third-party validation against the IEC/TR 61641 standard that defines tests under conditions of arcing due to internal fault. Comprehensive tests conducted under Edition 3.0, 2014-1 have passed the requirements for parts 1...5 for the main bus and unit line side, and parts 1...7 for all unit load side tests.

Besides the standard safety features built into every CENTERLINE 2500 MCC, choosing ArcShield provides the following additional benefits:

- Enclosures with specialized front ventilation to help protect personnel in front of the MCC
- Additional structural bracing on both sides of MCC enclosure
- Internal ventilation that directs exhaust gases towards the top of the MCC enclosure and the pressure relief system
- A pressure relief system designed to exhaust gases through the top of the enclosure, away from personnel without the need for additional plenums
- Thicker doors with reinforced hinges and arc-containment door latches that can withstand the high internal pressure of an arc blast and keep the door latched to the MCC during an arcing fault
- Insulating covers on horizontal bus closing plates (on end columns only) that help prevent 'burn through' from arcing faults in the horizontal bus compartment
- Structural bracing (on end columns only) to withstand the high internal pressure of an arc blast

Test criteria

IEC/TR 61641 passes when the following criteria are fulfilled.

1. Correctly secured doors, covers, etc., do not open
2. Parts (of the assembly) which may cause a hazard do not fly off
3. Arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects
4. The indicators arranged vertically do not ignite
5. The protective circuit for accessible parts of the enclosure is still effective
6. The assembly is capable of confining the arc to the defined area where it ignited, and there is no propagation of the arc to other areas with the assembly
7. Assembly protection is achieved when criteria 1-6 are fulfilled.
8. Criterion 7 applies where the assembly is to be suitable for limited continued operation.
9. After clearing the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining assembly is possible. This is verified by a dielectric test with a value of 1.5 times the rated operational voltage during 1 minute

Seismic certification

Earthquakes occur around the world, resulting in hundreds of deaths and widespread damage to structures, buildings and equipment. Public officials have revised building codes to mandate improved seismic design in order to restore function in emergency facilities in these situations. The codes apply not only to the buildings themselves, but also to the electrical and mechanical equipment inside them.

Rockwell Automation has taken action by performing seismic simulation tests on the CENTERLINE 2500 motor control center. The testing was carried out in the presence of a third party in accordance with AC 156 criteria and supports data for the qualification of the 2012, 2015 and 2018 International Building Code (IBC) and of the 2013 and 2016 California Building Code (CBC).

The range of the ICC–ES AC 156 testing enveloped (fulfilled and exceeded) is in the table below.

Throughout the seismic testing, the MCC units were under power and operated before, during, and after the seismic tests. To obtain a UBC or IBC seismic withstandability, each individual CENTERLINE 2500 MCC line-up must be mounted on an adequate seismic foundation. All columns in the MCC line-up must also be bolted together per the requirements in this instruction manual.

In the CENTERLINE 2500 MCC line-up, mounting channels are incorporated in the standard design. As an alternative to boltdown anchoring, these mounting channels may be welded to an adequate seismic foundation.

Test criteria	SDs* (g)	z/h*	Horizontal			Vertical			RP / IP
			AFLEX*	ARIG*	AFLEX/ ARIG	AFLEX*	ARIG*	AFLEX/ ARIG	
ICC-ES-AC156	1.63	1.0	2.608	1.956	1.956	1.092	0.440	2.48	1.0

*Equipment is qualified for SDs and z/h values shown. Qualifications may be valid for higher SDs where z/h is less than 1.0.

Creepage and Clearance

Understanding and calculating the minimum insulation distances for equipment can be critical and should be done early in the design process. It can be used to help protect personnel and property from the effects of electrical voltages or from functional failure of the equipment by providing adequate dimensioning of clearances and creepage distances in equipment.

CENTERLINE 2500 MCCs have a rated insulation voltage of 1000V and a rated impulse withstand voltage of 12 kV. They are rated for material group (overvoltage category) IIIa and a pollution degree of 3.

Description	IEC requirements*	Passed
Clearance:		
Between bus bars	14 mm	✓
Between distribution bars	14 mm	✓
Creepage distance:		
Between bus bars	16 mm	✓
Between distribution bars	16 mm	✓

* IEC 61439-1, paragraphs 8.3.2 and 8.3.3

Clearance:

The shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air. The clearance distance helps prevent dielectric breakdown between electrodes caused by the ionization of air. The dielectric breakdown level is further influenced by relative humidity, temperature and degree of pollution in the environment.

Creepage:

The shortest path between two conductive parts, or between a conductive part and the grounding surface of the equipment, measured along the surface of the insulation. An adequate creepage distance helps protect against tracking, a process that produces a partially conducting path of localized deterioration on the surface of an insulating material as a result of the electric discharges on. The degree of tracking required depends on two major factors: the comparative tracking index (CTI) of the material and the degree of pollution in the environment.

Connect with us.

rockwellautomation.com — expanding **human possibility**®

AMERICAS: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
EUROPE/MIDDLE EAST/AFRICA: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
ASIA PACIFIC: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Publication 2500-WP002A-EN-P – October 2020