IR at Marina Bay Sands

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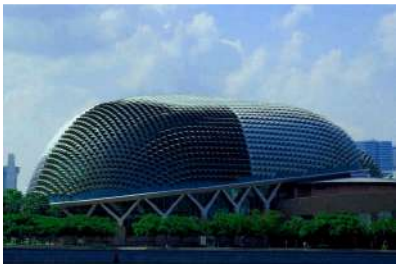


The Esplanade

TECHNICAL HANDBOOK

Series Forti Low Voltage System

Sunlight Power Main Switchboards and Withdrawable Motor Control Centres

Arranged and presented in accordance to IEC 61439

SUNLIGHT

Powering the nation for 40 years

Al-reem Island, Abu Dhabi

DANANG AIRPORT,
Vietnam

Saigon Premier Container Terminal, Vietnam

Released by Design &Engineering Dept., Sunlight Electrical Pte Ltd on Nov 2010

Series Forti Low Voltage System

"Forti" plays on the numerical term "Forty"- 2010 marks Sunlight's 40th year of establishment in Singapore and the year the new series of low voltage switchboards were launched

"Forti" plays on the verb "Fortify"- to strengthen

In its endeavor to strengthen its position as a leading manufacturer of Low voltage switchboards system, Sunlight Electrical is rolling out the Series Forti that comply with the rigorous requirements of IEC 61439 standards and growing industry expectations

TECHNICAL HANDBOOK- Series Forti LV System

Contents

1.0 About Us

Sunlight, with immense support from partners, customers and loyal staff, celebrates 40 years of relentless growth and the birth of its pristine, state-of-the-art new building.

The headquarters cum factory sits over an 85,000 square feet facility at No. 1, Third Chin Bee Road. It represents not only a persistent passion for greater things to come, but a commitment, to partners and investors alike, to continue its spirit for innovation and improvement to product designs and testing standards.

A leading manufacturer of power distribution products to date, this distinction can only ignite Sunlight's drive to become one of the best in Singapore, if not the world.

Sunlight draws upon the latest technology and expertise of renowned brands such ABB, HAGER, Schneider Electric, Siemens, Mitsubishi, amongst many others, with one key focus in mind – To increase production and efficiency to meet and exceed customers' needs and expectations.

"Our mission is to be a leading regional manufacturer of electrical switchgears by providing products with the highest level of technical excellence and reliability, coupled with responsive, flexible and cost-competitive service to continually ensure total customer satisfaction."

2.0 Certification, Performance and Reliability

Series Forti LV System is verified by tests with reference to the specifications and requirements in IEC 61439-1 & 2 by ASTA and KEMA. ASTA Certificates are truly recognized internationally and are available through testing at recognized testing facilities that have been rigorously assessed by Intertek. KEMA Certificates are widely recognized that are only issued if a component is successfully tested in agreement within the relevant international accepted standard.

Sunlight has tested the Series Forti LV System to the following IEC requirements:

LV Switchgear and Controlgear	- IEC 61439-1 & 2: 2009
Degree of Protection	- IEC 60529: 2001
Internal Arc Fault	- IEC TR 61641: 2008

Sunlight has a complete range of tested switchgear and control gear systems. These systems cover the whole spectrum of low voltage applications from the main switchboards to the smallest distribution board and process panels. Series Forti LV System has a proven record of good performance and high level of reliability.

Power Switchboard

Marine Switchboard

Mechanical Switchboard (Air-Con)

Motor control center

PUB Panel

PLC control panel

3.0 Overview of IEC 61439

In January 2009, a new standard was introduced by the International Electro technical Commission (IEC), which governs the safety and performance of electrical switchgear and control gear assemblies. The IEC 61439 – the new IEC standard series is available for low-voltage switchgear and control gear assemblies. The IEC 61439 series replaces the old IEC 60439 standard series following dissatisfaction over the uses of the series which were lacking in several areas:

- Grey area between type tested (TTA) and partially type tested assemblies (PTTA);
- In case of PTTA, it was difficult to check compliance with IEC 60439;
- More and more PTTA assemblies put on the market that do not comply with the standard;
- Manufacturers who have tested and are complying with IEC 60439 are unable to compete with these on-complying assemblies;
- Many manufacturers request partial type tests. It seems that many end customers accept this, but it was not sufficient.

The Structure of Old and New standards

Old	New	Title
IEC 60439-1	IEC 61439-1	General Rules
IEC 60439-1	IEC 61439-2	Power switchgear and control gear assemblies
IEC 60439-2	IEC 61439-6	Bus bar trunking systems
IEC 60439-3	IEC 61439-3	Distribution Boards
IEC 60439-4	IEC 61439-4	Assemblies for Construction Sites
IEC 60439-5	IEC 61439-5	Assemblies for Power Distribution in Public Networks
None	IEC 61439-0	Requirements manual for low-voltage switch gear and control gear assemblies.

In addition to the change in the standard's whole structure, which has been aligned with its new function as a 'General Rules' standard, the main changes to the IEC 61439 compared to its predecessor are as follows:

IEC 61439 series	IEC 60439 series
Deals with Power switchgear and control gear assemblies	Deals with Type-tested and partially type-tested assemblies
Clearly structured and comparable with apparatus standard IEC 60947: IEC 61439-1 General rules IEC 61439-0 Guide for specifying assemblies IEC 61439-2 … -6 Subsidiary parts (product standard)	Mix of different rules and demands in each part
Each subsidiary part is based on the general rules (Part 1) and includes only the specific additional rules for the actual product	Each part is a complete part and can be used by itself
A new approach of three methods of verification: Test, calculation, design rules	Testing each type of combination: Partially type-tested or type-tested
Agreements between Customer and Manufacturer are more detailed and extended	Agreements between Customer and Manufacturer not detailed
Technical changes: Diversity factor is more clearly defined Verification of temperature rise limits has been extended Neutral conductor cross section is raised to a minimum of 50% PEN minimum 50%	

Summary of Series Forti Design Verifications (by tests) in accordance to IEC 61439-1 & 2

The following are the summary of Design verifications done by tests on Series Forti LV System in accordance to IEC 61439-1 & 2:

S/no.	Designation	Incomer Ratings	Reference.	Remarks
1	Series Forti 8A	800A 3 incomers & 2 bus-tie	ASTA's Declaration Letter Laboratory Reference 45002 dated 9th April 2010	IP 4X. Form 3b (Type2)
2	Series Forti 8B	800A 2 incomers & 1 bus-tie	ASTA's Declaration Letter Laboratory Reference 45002/3 dated 21st October 2010	IP 4X Form 3b (Type2)
3	Series Forti 16	1600A LV/Withdrawable Motor Control Center	KEMA Quality's Draft Report 2133222.00-QUQ/INC; 10-1179HKor/ETL dated 25th October 2010 KEMA	50C Ambience IP 44, IP54 Form 4b (Type 7)
4	Series Forti 25	2500A LV/Withdrawable Motor Control Center	KEMA Quality's Draft Report 2133222.00-QUQ/INC; 10-1179HKor/ETL dated 25th October 2010 KEMA	50C Ambience IP 44, IP54 Form 4b (Type 7)
5	Series Forti 32	3200A	ASTA 17709	IP 43 Form 4 (type 7)
6	Series Forti 32A	3200A LV/Withdrawable Motor Control Center	KEMA Quality 2133222.101 dated 25th October 2010	50C Ambience IP 44, IP54 Form 4b (Type 7)
7	Series Forti 40	4000A	ASTA 17708	IP 43 Form 4 (type 7)
8	Series Forti 50	5000A	Panel under Tests Preparation	
9	Series Forti 12	1250A Withdrawable MCC	Testing in Progress	
10	Series Forti 20	2000A Withdrawable MCC	Testing in Progress	
11	Series Forti 24FP	2400A Feeder Pillar	Testing in Progress	
12	Series Forti 63	6300A Withdrawable MCC	Testing in Progress	

3.1 Part-1 General Rules (IEC 61439-1)

Part 1 is General Rules, which refers to the general requirements that cover the various types of low-voltage switchgear and control gear assemblies. It contains the definitions and states the service conditions, construction requirements, technical characteristics and verification requirements for low-voltage switchgear and control gear assemblies. The requirements put down in this part are only applicable if they are referred to in the respective product standard.

The general requirements are divided into two:

- Constructional (3.1.1)
- Performance (3.1.2)

3.1.1 Constructional Requirements (Clause No.8 of IEC 61439-1)

Sunlight Series Forti LV System strictly adheres to all the constructional requirements stated in IEC 61439-1.

3.1.1.1 Strength of materials and parts (Clause No.8.1 of IEC 61439-1)

Sunlight Series Forti LV System is capable of withstanding the mechanical, electrical, thermal and environmental stresses. Our Enclosures and parts of it have thermal stability. Outdoor enclosures and parts are resistant to ultra violet radiation. The insulating materials were tested to be not affected by normal heat, abnormal heat or fire. The Series Forti enclosures and partitions can withstand the stresses during normal and short circuit conditions. Our panels use suitable materials or protective coatings to prevent corrosion, including labeling and markings.

3.1.1.1 The compartment, partition and doors have to withstand the stresses during short circuit conditions

3.1.1.2 Technical specifications of Series Forti LV System

Frames:

The frame consists of rigid sheet steel sections that are inter-connected to one another. Series Forti sturdy frame is available in bolted versions. Frames are made from 2.0mm sheet steel galvanised (G.I) or electro-galvanised (E.G).

Doors:

A flexible door system is provided for all requirements. Door covers are made from 2.0mm E.G. and powder coated. Heavy-duty hinges and spring-loaded locks prevent doors from opening unintentionally.

All round perforation rows with a 25mm whole grid are provided for individual installation.

Busbar:

Busbars are made from 99.99% pure tinned copper. Busbar position is normally arranged at the top and in some instances, middle and bottom. All these different arrangements are tested for temperature rise and short-circuit. Generally, our busbar connection is about 50mm overlap breadth of the busbar without sacrificing the efficiency of the joint. This is substantiated as below:

The resistance of a joint is affected by Streamline effect or spreading resistance R_s, which is the diversion of the current flow through a joint. In the case of an overlapping joint between two flat copper bars with same width, the streamline effect is dependent only on the ratio of the length of the overlap to the thickness of the bars and not on the width. Efficiency of an overlapping joint does not increase as the length of the overlap increases and no advantage gained by unduly long overlap.

The resistance ratio, e, in the graph is the ratio of the resistance of a joint due to streamline effect R_s, to the resistance of an equal length of single conductor R_b,

$e = R_s / R_b = (a*b / \rho*l)\ R_s$

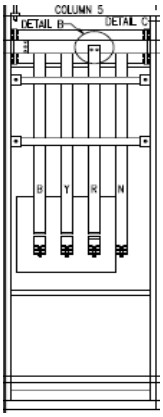
where a = breadth of bar, mm
b = thickness of bar, mm
l = length of overlap, mm
ρ = resistivity of the conductor, μΩmm

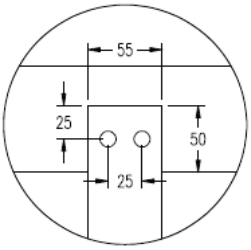
From the graph it is clear that the streamline effect has very little effect when the overlap is greater than 50.

Finishing:

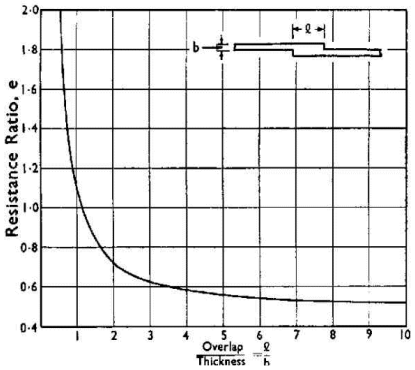
Series Forti LV System is available in powder coated texture finishing to RAL7035 or a wide choice of colours upon request.

3.1.1.2a Suitable materials or protective coatings are used to prevent corrosion, including labeling & markings





3.1.1.2b Joint Overlapping of 50mm



3.1.1.2c The streamline effect has very little effect when the overlap is greater than 50mm

Source from Copper Development Association Publication- 22: 2001

3.1.1.2d Series Forti LV System's sturdy frames are available in bolted versions.

3.1.1.3 Series Forti Cubicle Selection

Our versatile enclosure system allows future extension of busbar and modular cubicles.

Modular dimensions of Series Forti LV System (Dimensions are excluding the door cover):		
Width (mm)	Height (mm)	Depth (mm)
550 750 850 1200	2105 2205 2605	650 750 1050 1250 1450

Customisation of cubicle sizes is possible upon special request.

3.1.1.3 Versatile enclosure system allows future extension of busbar and modular cubicles.

Cubicle dimension for different functional units:

Main Incoming functional unit (Amps) TPN or 4 Pole	Width (mm)	Height (mm)	Depth (mm)*
400 MCCB	550	2105	650 / 750
630 MCCB	550	2105	650 / 750
800 MCCB	550	2105	650 / 750
800 ACB	750	2105	1050 / 1250
1000 ACB	750	2105	1050 / 1250
1600 ACB	750	2105	1050 / 1250
2000 ACB	750	2105	1250
2500 ACB	750	2105	1250
3200 ACB	850	2105	1450
4000 ACB	850	2205	1450
5000 ACB	1200	2205	1450
6300 ACB	1200	2205	1450

*Additional depth of 400,600,800mm available as per requirements

****Compartment dimension for different functional units:**

Main Incoming functional unit (Amps) TPN or 4 Pole	Width (mm)	Height (mm)	Depth (mm)
400 MCCB	550	600	750
630 MCCB	550	600	750
800 MCCB	550	750	750
800 ACB	750	750	1250
1000 ACB	750	750	1250
1600 ACB	750	750	1250
2000 ACB	750	750	1250
2500 ACB	750	750	1250
3200 ACB	850	750	1450
4000 ACB	850	750	1450
5000 ACB	1200	750	1450
6300ACB	1200	750	1450

**Final designs vary with equipment and accessories' dimensional and technical requirements.

3.1.1.4 Degree of protection (Clause No.8.2 of IEC 61439-1)

Series Forti LV System is protected against mechanical impact in accordance with IEC 62262. The degree of protection is indicated by IP (Ingress protection) code according to IEC 60529. The IP Code defines the extent to which the assembly is protected against harmful effects caused by dust or water entering the assembly and the extent to which persons are protected against contact with hazardous parts within the assembly.

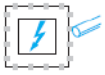
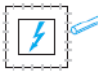
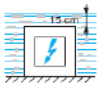
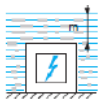
The IP is a measure for this degree of protection denoted in two digits:

- First digit for protection against solid objects.
- Second digit for protection against water ingress.

The degree of protection of an enclosed assembly should be at least IP2X after installation. For outdoor use the degree of protection should be at least IPX3.

First numeral
Protection against solid particles

Second Numeral
Protection against liquid

IP	Illustration	Requirements	Description	IP	Illustration	Requirements	Description
0		No Protection	No Protection	**0**		No Protection	No Protection
1		Protection from solid particles >50mm	Full penetration of 50mm objects not allowed. Contact with hazardous parts not permitted.	**1**		Protection from vertical dripping	Vertically dripping liquids make no harmful effects
2		Protection from solid particles >12.5mm	Penetration of 12.5mm objects not allowed. Fingers or similar parts not permitted.	**2**		Protection from dripping up to 15° from vertical	Vertically dripping liquids make no harmful effects when enclosure is tilted up to 15°
3		Protection from solid particles >2.5mm	Penetration of 2.5mm objects not allowed. Tools or wires of same size not permitted.	**3**		Protection from spraying up to 60° from vertical	Sprays of liquid up to 60° make no harmful effect.
4		Protection from solid particles >1mm	Penetration of 1mm objects not allowed. Wires or strips of same size not permitted.	**4**		Protection from splash from all direction	Splash of liquid from all directions make no harmful effect.
5		Protection from dust particles	Limited ingress of dust only permitted. (No harmful deposit)	**5**		Protection from mild jets	Mild jets of liquid from all directions make no harmful effect.
6		Dust proof	Total protection against ingress of dust	**6**		Protection from strong jets	Strong jets of liquid from all directions make no harmful effect.
				7		Protection from effects of immersion up to 15cm	Temporary immersion in liquid makes no harmful effect.
				8		Protection from long periods of immersion	Continuous immersion under conditions in liquid makes no harmful effect.

3.1.1.5 Clearances and creepage distances (Clause No.8.3 of IEC 61439-1)

The requirements for clearances and creepage distances are based on the principles of IEC 60664-1 and are intended to provide insulation co-ordination within installation. Clearances, the distance from a live conductor to another or earth through air, are sufficient in Series Forti LV System to achieve the rated impulse withstand voltage ($\mathbf{U_{imp}}$) of a circuit. Creepage distances, the distance over the surface of insulating material from a live conductor to another or earth, are determined from the rated insulation voltage ($\mathbf{U_i}$) of the equipment. The clearances and creepage distances apply to phase to phase, phase to neutral, phase to earth and neutral to earth.

Table 1 – Minimum clearances in air [a] (8.3.2)

Rated impulse withstand voltage U_{imp} kV	Minimum clearance mm
≤ 2,5	1,5
4,0	3,0
6,0	5,5
8,0	8,0
12,0	14,0
a) Based on inhomogeneous field conditions and pollution degree 3.	

Table 2 – Minimum creepage distances (8.3.3)

Rated insulation voltage U_i	Minimum creepage distance mm							
	Pollution degree							
	1	2			3			
	Material group[c]	Material group[c]			Material group[c]			
V[b]	I	I	II	IIIa and IIIb	I	II	IIIa	IIIb
32	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
40	1,5	1,5	1,5	1,5	1,5	1,6	1,8	1,8
50	1,5	1,5	1,5	1,5	1,5	1,7	1,9	1,9
63	1,5	1,5	1,5	1,5	1,6	1,8	2	2
80	1,5	1,5	1,5	1,5	1,7	1,9	2,1	2,1
100	1,5	1,5	1,5	1,5	1,8	2	2,2	2,2
125	1,5	1,5	1,5	1,5	1,9	2,1	2,4	2,4
160	1,5	1,5	1,5	1,6	2	2,2	2,5	2,5
200	1,5	1,5	1,5	2	2,5	2,8	3,2	3,2
250	1,5	1,5	1,8	2,5	3,2	3,6	4	4
320	1,5	1,6	2,2	3,2	4	4,5	5	5
400	1,5	2	2,8	4	5	5,6	6,3	6,3
500	1,5	2,5	3,6	5	6,3	7,1	8,0	8,0
630	1,8	3,2	4,5	6,3	8	9	10	10
800	2,4	4	5,6	8	10	11	12,5	a)
1 000	3,2	5	7,1	10	12,5	14	16	
1 250	4,2	6,3	9	12,5	16	18	20	
1 600	5,6	8	11	16	20	22	25	

a) Insulation of material group IIIb is not recommended for use in polluton degree 3 above 630 V.

b) As an exception, for rated insulation voltages 127, 208, 415, 440, 660/690 and 830 V, creepage distances corresponding to the lower values 125, 200, 400, 630 and 800 V may be used.

c) Material groups are classified as follows, according to the range of values of the comparative tracking index (CTI) (see 3.6.17):

- Material group I 600 ≤ CTI
- Material group II 400 ≤ CTI < 600
- Material group IIIa 175 ≤ CTI < 400
- Material group IIIb 100 ≤ CTI < 175

NOTE The CTI values refer to the values obtained in accordance with IEC 60112, method A, for the insulating material used.

Sources taken from IEC 61439-1

3.1.1.6 Protection against electric shock (Clause No.8.4 of IEC 61439-1)

The apparatus and circuits in the Series Forti LV System are arranged in such a way as to do service and maintenance in a safe way. The protection includes basic protection, fault protection and protection during operating and servicing conditions. Series Forti LV System provides basic protection using insulating material and barriers or enclosures. Fault protection is achieved by automatic disconnection, grounding of all the exposed parts of assembly, electrical separation of individual circuits and total insulation. Protection against live parts is maintained during the operation and service by ordinary or authorized persons. A tinned copper earth bar of dimensions not less than 40 x 10mm is provided along the whole length of the switchboard bonding the frame work of all the modular sections of the panel.

3.1.1.6 Barriers are provided to protect personnel when doing terminations or maintenance

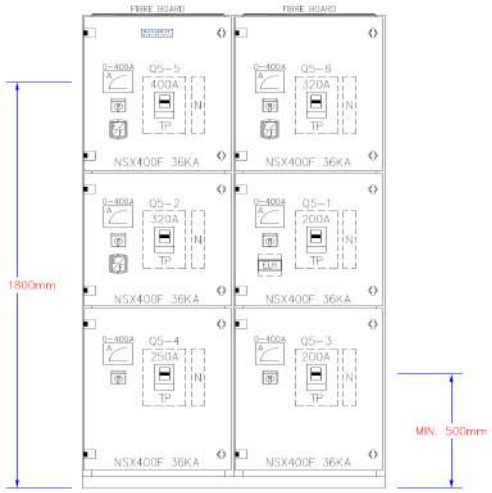
3.1.1.7 Incorporation of switching devices (Clause No.8.5 of IEC 61439-1)

The selection of devices and components must consider the suitability for the application and devices and components must be installed in accordance with the device manufacturers' instructions and with due regard to the accessibility necessary to ensure proper and safe operation in service. The switching devices in Series Forti LV System are incorporated in such a way as to facilitate easy access for adjustments and reset.

Accessibility guide:

Devices and components	**Distance from the Assembly base**
Terminals	At least 0.2m
Indicating instruments	Within 0.2m and 2.2m
Operating devices	Within 0.2m and 2m
Emergency actuators	Within 0.8 and 1.6m

3.1.1.7a Breakers to be installed as per manufacturer's instructions, giving attention to short-circuit conditions

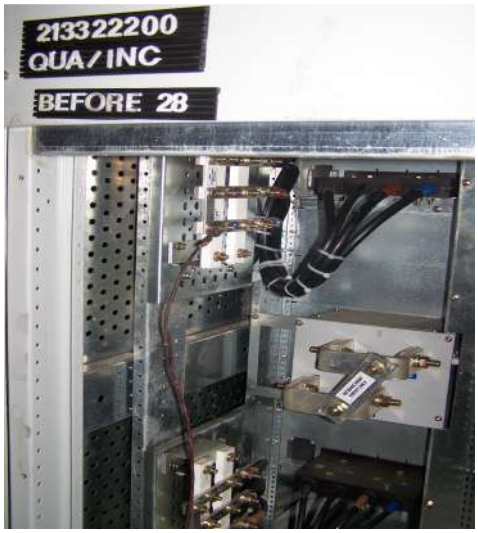


3.1.1.7b Operating devices and indicating instruments are arranged at a max height of 1800mm and min height of 500mm

In Singapore, for example, the operating devices and indicating instruments are arranged in such a way that the topmost row is at 1.8 meter from the floor level and the lowest row is 0.5 meter from the floor level.

3.1.1.8 Internal Electrical circuits and connections (Clause No.8.6 of IEC 61439-1)

The internal electrical circuits and connections are designed to withstand the short circuit stresses limited by the protective devices on the supply side of Series Forti LV System. Special care is taken in arranging the cables and cabling accessories so that it can handle these short circuit stresses. Various widths of cableways are incorporated depending on the number of cables and their sizes. A standard width of 300mm or 450mm is run horizontally throughout the whole length of the board, at the top or bottom as well as vertically beside each function unit section. The minimum cross sectional area of the neutral is maintained to be at least 50% of the phase conductor cross section for circuits with a phase conductor cross section above 16sqmm. Auxiliary circuits are protected against the effects of short circuits. The connections of current carrying parts do not suffer undue alteration as a result of normal temperature rise, ageing of insulating materials and vibrations.

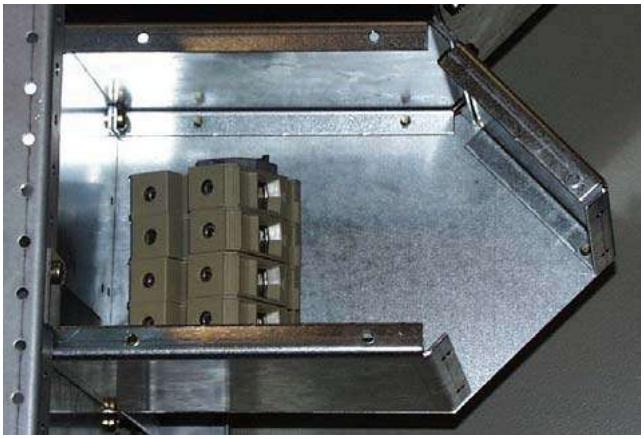


3.1.1.8 Cables and cabling accessories must be arranged to withstand short-circuit stresses and conditions

3.1.1.9 Terminals for external conductors (Clause No.8.8 of IEC 61439-1)

3.1.1.9a Terminal blocks are provided for external cables. Cable support provisions is catered for on the partition plate to secure the external cables

The terminals for external conductors in Series Forti LV System are ensured to have necessary contact pressure. Terminal blocks are provided for external cables. Cable support provisions are catered for, on the partition plate, to secure the external cables. The terminals have proper marking according to IEC 60445. The assembly indicates whether terminals are suitable for the connection of copper or aluminium or both. Verification of the terminals is done via a visual inspection.



3.1.1.9b Terminal blocks provided for external cables in Form4.

3.1.2 Performance Requirements (Clause No.9.0 of IEC 61439-1)

IEC 61439-1 puts forth certain performance requirements for the low-voltage switchgear and control gear assemblies. Sunlight ensures that Series Forti LV System satisfies all these requirements.

3.1.2.1 Dielectric properties (Clause No.9.1 of IEC 61439-1)

Each circuit in the Series Forti LV System is able to withstand temporary over voltages and transient over voltages. A power frequency dielectric test is carried out to verify short-term overvoltage capability. The ability to withstand transient over voltages is verified by impulse withstand voltages.

3.1.2.2 Temperature rise limits (Clause No.9.2 of IEC 61439-1)

The temperature rise of an element or part of the enclosure is the difference in temperature of the same element or part when carrying the rated current with the ambient air temperature outside the assembly. Series Forti LV System is designed in such a way that the temperature rise does not cross the limits which may otherwise cause damage to current carrying or adjacent parts of the assembly. This is achieved by proper ventilation and arrangement of the components inside the panels. The size of top ventilation is designed to 1.1 times the size of the bottom one, which ensures a natural flow of air from bottom-inside to top-outside.

Sunlight has, over the years, accumulated an extensive library of temperature rise data on various breakers' ratings, makes, ambience temperature and its differing configurations.

In recent years, as switch rooms' space allocation is becoming scare, switchboards are increasingly expected to be compact and yet uncompromising in its current carrying capabilities.

This trade-off has seen many circuit breakers arranged in 2-tiers or more within a cubicle. Hence it is especially critical for big current carrying and heat-producing circuit breakers like Air Circuit Breakers (ACBs), to be proven by temperature rise tests, that its stacking will not impede the overall current-carrying capabilities and requirements of the entire switchboard.

3.1.2.2 Sunlight's Series Forti LV System is designed and tested in 2-tier ACB arrangements

Sunlight has considered the below factors that impact the design and the temperature rise conditions of Series Forti LV System:

a. The heat dissipation of various make of breakers, busbars and all other heat-producing components and devices
b. The degree of protection
c. The form of separation
d. The location and the positioning of the boards e.g. wall facing, free standing. Etc
e. The room ambience where the switchboards are installed e.g. air-conditioned room, underground, etc
f. The space of Switchroom

The temperature rise conditions of a switchboard will greatly determine the operating current of the breakers and hence the life span of the switchboard. It is also critical that the insulation of all materials and breakers are not impeded. Great care and design considerations are given to copper busbars for its potential annealing effects when operating under high continuous current and temperature.

Table for temperature rise limits:

Part of assemblies	**Temperature rise (K)**
Built-in components [(a)]	In accordance with the relevant product standard requirements for the individual components or, in accordance with the component manufacturer's instructions [(f)], taking into account the temperature in the assembly.
Terminals for external insulated conductors	70 [(b)]
Busbars and conductors, plug-in contacts of removable or withdrawable parts which connect to busbars.	Limited by [(f)]: • mechanical strength of conducting material [(g)]; • possible effect on adjacent equipment; • permissible temperature limit of the insulating materials in contact with the conductor; • effect of the temperature of the conductor on apparatus connected to it • for plug-in contacts, nature and surface treatment of the contact material
Manual operating means: • of metal • of insulating material	15 [(c)] 25 [(c)]
Accessible external enclosures and covers • Metal surfaces • Insulating surfaces	30 [(d)] 40 [(d)]
Discrete arrangements of plug and socket-type connections	Determined by the limit for those components of the related equipment of which they form a part [(e)]

a) The term "built-in components" means:
• conventional switchgear and control gear;
• electronic sub-assemblies (e.g. rectifier bridge, printed circuit)
b) Parts of the equipment (e.g. regulator, stabilized power supply unit, operational amplifier).
The temperature-rise limit of 70 K is a value based on the conventional test of 10.10. An ASSEMBLY used or tested under installation conditions may have connections, the type, nature and disposition of which will not be the same as those adopted for the test, and a different temperature rise of terminals may result and may be required or accepted. Where the terminals of the built-in component are also the terminals for external insulated conductors, the lower of the corresponding temperature-rise limits shall be applied.
c) Manual operating means within ASSEMBLIES which are only accessible after the ASSEMBLY has been opened, for example draw-out handles which are operated infrequently, are allowed to assume a 25 K increase on these temperature-rise limits.
d) Unless otherwise specified, in the case of covers and enclosures, which are accessible but need not be touched during normal operation, a 10 K increase on these temperature-rise limits is permissible. External surfaces and parts over 2 m from the base of the ASSEMBLY are considered inaccessible.
e) This allows a degree of flexibility in respect of equipment (e.g. electronic devices) which is subject to temperature-rise limits different from those normally associated with switchgear and control gear.
f) For temperature-rise tests according to 10.10 the temperature-rise limits have to be specified by the Original Manufacturer taking into account any additional measuring points and limits imposed by the component manufacturer.
g) Assuming all other criteria listed are met a maximum temperature rise of 105 K for bare copper busbars and conductors shall not be exceeded.

Sources taken from IEC 61439-1

3.1.2.3 Short-circuit protection and short-circuit withstand strength (Clause No.9.3 of IEC 61439-1)

Short-circuit withstand strength is the ability of electrical equipment to withstand the thermal, electrical and mechanical effects produced by short-circuit currents.

The busbar support insulators of Series Forti LV System are manufactured from high grade reinforced glass polyester which can withstand high mechanical and thermal stress.

The following are the summary of details for the short-circuit withstand strength of Series Forti LV System:

S/no.	Incomer Ratings	Short-circuit Withstand	Copper Bars Size	Copper Earth Bars Size
1	400A	36kA 1 sec	4 nos. 30 x10mm	1 nos. 25 x10mm
2	630A	36kA 1 sec	4 nos. 40 x10mm	1 nos. 25 x10mm
3	800A	36kA 1 sec	1 nos. 45 x12.7mm	1 nos. 25 x10mm
4	1000A	36kA 3 sec	1 nos. 80 x 10mm	1 nos. 40 x 10mm
5	1600A	50kA 3 sec	1 nos. 100 x 10mm 2 nos. 55 x10mm	1 nos. 40 x10mm
6	2500A	65kA 3 sec	2 nos. 100 x 10mm	1 nos. 40 x10mm
7	3200A	65kA 3 sec	3 nos. 80 x 10mm	1 nos. 40 x10mm
8	4000A	75kA 3 sec	3 nos. 100 x 10mm	1 nos. 40 x10mm
9	5000A	85kA 3 sec 100kA 3 sec 125kA 1 sec	4 nos. 100 x 10mm	1 nos. 40 x 10mm
10	-	Internal arc fault 75KA	3 nos. 100 x 10mm	

3.1.2.4 Electromagnetic compatibility (Clause No.9.4 of IEC 61439-1)

The EMC performance of an assembly is usually verified via the application of a design rule. This rule requires all components to be themselves compliant with the requirements for the stated environment (Environment A or Environment B). The EMC compatibility can also be verified by Immunity and Emission tests. In Series Forti LV System, we select the components which are compliant to EMC.

3.1.3 Design verification (Clause No. 10 of IEC 61439-1)

Design verification is intended to verify compliance of the design of the assembly with the requirements of the IEC 61439 standards. The tests shall be performed on a clean and new representative sample of an assembly. Design verification shall be achieved by one or more of the following equivalent and alternative methods that are deemed appropriate:

-verification by testing

-verification by calculation

-verification by design rules

Options for Design Verifications of different characteristics (Ref. from IEC 61439-1)

Clause or sub clauses in IEC	Characteristic to be verified	Verification options available		
		Verification by testing	Verification by calculation	Verification by design rules
10.2	Strength of material and parts	Yes	No	No
10.3	Degree of protection	Yes	No	Yes
10.4	Clearances and creepage distances	Yes	Yes	Yes
10.5.2	Effective continuity between parts and PE	Yes	No	No
10.5.3	Effectiveness of the assembly for external faults	Yes	Yes	Yes
10.6	Incorporating of apparatus	No	No	Yes
10.7	Internal electrical circuits and connections	No	No	Yes
10.8	Terminals for external conductors	No	No	Yes
10.9.2	Power frequency withstand voltage	Yes	No	No
10.9.3	Impulse withstand voltage	Yes	No	Yes
10.10	Temperature rise	Yes	Yes	Yes
10.11	Short-circuit withstand strength	Yes	Yes	Yes
10.12	EMC	Yes	No	Yes
10.13	Mechanical operation	Yes	No	No

Small assemblies such as control panels, subject to specific conditions, can take advantage of the alternative routes to verification. Whilst this approach does require the inclusion of the safety margins prescribed in the standard, it can avoid the time and cost associated with conducting many of the design verification tests.

3.2 Part-2 Power switch gear and control gear assemblies (IEC 61439-2)

Part 2 defines the specific requirements of power switchgear and control gear assemblies (PSC), whereby the rated voltage does not exceed 1000 V a.c. or 1500 V d.c. It is the only part that has a dual role, covering power switchgear and control gear assemblies, as well as any assembly not covered by any other product-specific part. This part 2, or any other product-specific part, is to be read in conjunction with part 1. The provisions of the general rules dealt with-in part 1 are only applicable to this part 2 in so far as they are specifically cited. IEC 61439-2 also details 12 characteristics as in 61439-1 that must be verified.

Apart from the general rules mentioned in part-1, this part of IEC 61439 deals with additional requirements specific to PSC assemblies:

3.2.1 Degree of protection of withdrawable parts (Clause No.8.2.101 of IEC 61439-2)

Removable parts of the enclosure effects the degree of protection when removed. Adequate measures are taken to ensure safety in Series Forti LV System while removing the withdrawable parts. The panels are so designed that the degree of protection applying to the withdrawable part in connected position is also maintained in the test and isolated positions and during transfer from one position to another.

3.2.2 Internal separation (Clause No.8.101 of IEC 61439-2)

3.2.2a Each functional device i.e. breaker in Series Forti LV System is compartmentalized i.e. Form 3 and

3.2.2b Outgoing terminal is each compartmentalized and separated- Form 4 b

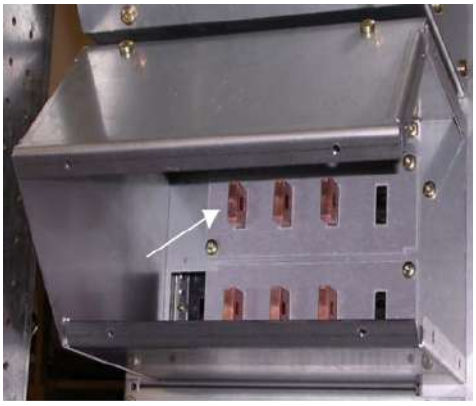
A fault on one circuit must not be permitted to develop into a fault on another. A busbar fault can run from one unit to the next if there is no proper segregation. Any fault produces high degree of ionized gas and ultraviolet light of arcing creates arcs in other regions. A proper segregation is achieved by compartmentalization.

The internal compartmentalization of PSC-assemblies, being a specific characteristic of PSC-assemblies, is dealt with in IEC 61439-2, Sub clause 8.101. This Sub clause is concerned with the ways in which the bus bars and 'functional units' in an assembly may be separated from one another - either by fitting interposing barriers or by locating them in separate compartments, and classifies some typical arrangements into four groups - the so called 'Forms of internal separation'. The separation may be achieved by means of partitions or barriers (metallic or non-metallic), insulation of live parts or the integral housing of the device. The degree of protection shall be at least 2X.

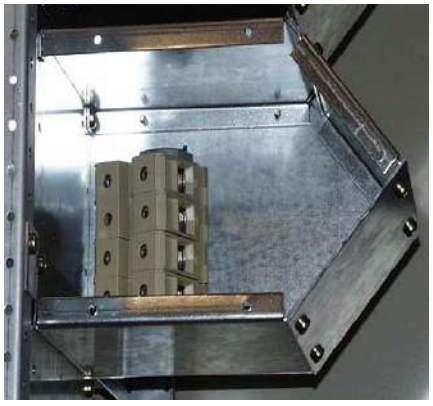
Assembly is a combination of one or more low-voltage switching devices together with associated control, measuring, signaling, protective, regulating equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts.

Functional Unit is a part of an assembly comprising all the electrical and mechanical elements that contribute to the fulfillment of the same function.

Series Forti LV System supports all the four forms of separation. Different types of functional units like fixed, removable and withdrawable can be designed within the same assembly or sections. Electrical equipment from all manufacturers may be fitted in accordance with customer's preferences.



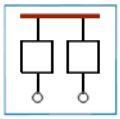
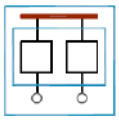
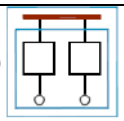
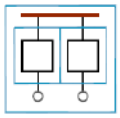
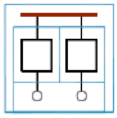
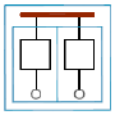
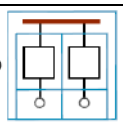
3.2.2c Form4b with connecting bars



3.2.2d Form4b with terminals

3.2.2e Form4b with back cover opened

A general classification for the different forms of separation:

Legend Enclosure with internal separation Busbar Functional unit with terminals	**Busbars separated from functional units**	**Functional units separated from other functional units**	**Terminals external to functional units**	**Terminals are separated from the busbar**	**Terminals are separated from each other**	**Supported by Series Forti LV System**
Form1 						✓
Form 2a 	✓		✓			✓
Form 2b 	✓			✓		✓
Form 3a 	✓	✓	✓			✓
Form 3b 	✓	✓	✓	✓		✓
Form 4a 	✓	✓		✓	✓	✓
Form 4b 	✓	✓	✓	✓	✓	✓

4.0 Series Forti Designs Verified to IEC 61439-1 & 2 by TESTS, Certified by KEMA and ASTA

Series Forti LV System is tested and certified in accordance to IEC 61439-1 & 2 by KEMA & ASTA.

4.1 Strength of materials and parts (Clause No.10.2 of IEC61439-1)

The mechanical, electrical and thermal capability of the materials and parts used in the construction of the assembly has been verified. Series Forti LV System was subjected to various tests like severity test A, salt mist test, ball pressure test and glow wire test and was confirmed that the requirements of the standard are complied.

4.1a Insulation materials subjected to glow-wire test at 960°C.

4.1b Glow wire test

4.2 Degree of protection (Clause No.10.3 of IEC61439-1)

Series Forti LV System was tested for the IP ratings and was found to have complied for IP4X, IP42, IP43, and IP54. A test for forms of separation was conducted on Series Forti LV System and the form of separation was sufficient for the classification of up to Form 4b Type7.

4.2a A panel in a dust chamber preparing for IP5X test

4.2b IP X4 in progress

4.2c Test equipment used for X3 & X4

4.2d IP 4X in progress

4.3 Clearances and creepage distances (Clause No.10.4 of IEC61439-1)

Clearances and creepage distances of Series Forti LV System was verified by ASTA and found to comply with the requirements of IEC.

Rated insulation voltage (U_i) =690V — min.Clearance distance ≥ 14mm (allowable as per IEC)

Rated impulse withstand voltage (U_{imp}) = 12KV — min.Creepage distance ≥ 10mm (allowable as per IEC)

4.4 Protection against electric shock (Clause No.10.5 of IEC61439-1)

The exposed conductive parts of Series Forti LV System were inspected for the effectiveness of the connection to the protective circuit.

The maximum measure value of resistance between exposed conductive parts and the protective circuit was well within the max allowable limit of 0.1Ω.

4.5 Dielectric properties (Clause No.10.9 of IEC61439-1)

Series Forti LV System was able to withstand power frequency withstand voltage and impulse withstand voltage without any disruptive discharges.

Rated insulation voltage (U_i) =690V

Power Frequency withstand voltage = 1890V rms for 5 secs

Rated impulse withstand voltage (U_{imp}) = Up to 9.8KV, 1.2 /50µs

4.5 Rotary handles are tested to withstand over voltages

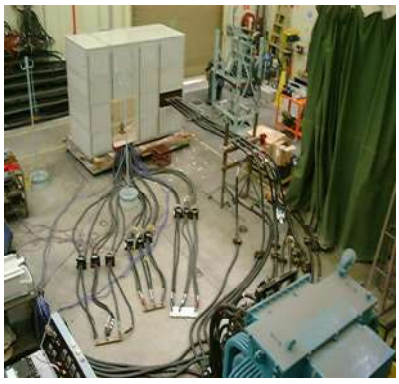
4.6 Temperature rise limits (Clause No.10.10 of IEC61439-1)

The temperature rise limit is verified:

a. On the basis of tests for a specific arrangement of an assembly
b. By derivation(from a tested design) of ratings for similar variants
c. On the basis of power loss calculations in accordance with temperature rise data provided by the enclosure manufacturer or by IEC 60890.

4.6a Series Forti LV System was tested for the temperature rise limits using test currents and was confirmed to comply with the requirements of clause 10.10 of IEC61439-1.

Potential hot spots for a breaker. (Probably found on the top terminals of the breakers.)



Temperature rise conducted in normal environmental condition i.e. average of 35°C up to max of 40°C

This panel is tested under a special environmental condition of 50° C ambient, in a climate controlled-room

4.6b Sunlight has, over the years, accumulated a rich wealth of temperature rise data from various configurations; different makes of breakers, differing busbar and breaker configurations and arrangements, varying IP and form of separation etc. These various technical data allow extrapolations and comparisons of similar arrangements in the Series Forti LV System.

4.6c For assemblies below 1600A there are two methods available on the basis of power loss calculations.
Method 1 (single compartment assembly with the total supply current not exceeding 630A):
The temperature rise within the assembly is determined from the total power loss as provided by data from the enclosure manufacturer or by test.

Method 2 (multiple compartment assembly with the total supply current not exceeding 1600A):
The temperature rise is determined by calculation in accordance with the method of IEC60890.

The remaining assemblies which does not include in any of the above categories are verified for the temperature rise by tests.

4.7 Short circuit withstand strength (Clause No.10.11 of IEC61439-1)

4.7a An outgoing breaker had undergone a conditional short-circuit

Verification of short-circuit withstand can be achieved via test, application of design rules, and/or by calculation, but the use of design rules and calculation is very restricted. Verification by design rules is achieved when comparison of the assembly to be verified with an already tested design shows no deviations.

Factors which testing verifies include:

- Conductor positioning and enclosure strength
- Correct mounting for devices and cables
- The effect of arc emissions of circuit breakers

4.7b After short-circuit, the protective breaker must trip, its metal door cover must remain closed and IP be maintained

4.7c All Protective Covers must remain intact after short-circuit

Series Forti LV System was subjected to short-circuit test and on completion the following found maintained:

- Minimum IP protection
- Creepage and clearance distances
- Insulation integrity and mechanical integrity

4.7d A testing engineer checking the integrity of the busbar system after short-circuit withstand test of Series Forti LV System.

4.8 Electromagnetic compatibility (Clause No.10.12 of IEC61439-1)

As the components used inside our panels are passive and EMC compliant, no special test was required to verify this requirement. The Immunity assessment and Emission assessment are not required as the manufacturer of the components installed in the Series Forti LV System have a valid EMC certificate.

4.9 Mechanical operation (Clause No.10.13 of IEC 61439-1)

Mechanical parts of Series Forti LV System were verified for 200 cycles of operation. Any mechanical interlocks associated were also checked for the proper and safe operation. No difference was discernible in the effort required for operation at the start and end of test.

4.9 A testing engineer performing mechanical operation test.

Having successfully undergone the tests in compliance with IEC 61439-1 & 2, Series Forti LV System proves to be at par with the best in the industry in terms of performance, safety and reliability.

5.0 Internal Arc Fault Tests to IEC TR 61641

Series Forti LV System is subjected to Conditional Short Circuit Current under internal arcing up to 75kA rms at 415V, pf= 0.20 conditions protected by an incomer.

The test is performed in accordance to IEC TR 61641: 2008. The sole purpose of this test is to assess the ability of the assembly to limit the risk of personal injury resulting from an internal arcing fault. If the gases and decomposition products resulting from the faults are capable of bridging the gap between two neighboring phases, an arc will be fired with current intensities of several thousand amperes and temperatures up to 10,000℃. These conditions will result in a strong pressure build up inside the switchgear. The special constructional features like compartmentalization and the arrangement of breakers and busbars prevent and limit the internal arc in Series Forti LV System.

6.0 A Step Forward with IEC 61439 - Many Market Opportunities Ahead

Infrastructure & Iconic Buildings

Public Residential

Private Residential

Public Transport

Industrial Process

Hospital & Medical


Marine Oil & Gas


Pharmaceutical

Renewable Energy

With the introduction of the new Series Forti LV System in full compliance to IEC 61439, Sunlight is now in the ranks of the world's major players to supply low voltage switchgear and controlgear to the latest industrial standards.

Sunlight is proud of her accomplishments both in terms of technical excellence and reliability in all of her projects.

Sunlight draws from her considerable wealth of experience and the unwavering dedication of her employees as she undertakes each new project. Sunlight strives to give each of these endeavors our best in terms of efficiency, time and manpower and looks forward to challenging new opportunities in the future to strengthen and hone her capabilities and to make the Sunlight brand synonymous to excellence.

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