

ESSENTIAL CHANGES IN THE PRODUCT STANDARD FOR LOW VOLTAGE MCC AND SWITCHGEAR

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Abstract - Since the main objective of a product standard is to ensure the safety of the equipment during its operational life, new editions of such a standard are expected to advance the general safety. This is done by adding requirements where the former standard ran short and by narrowing down the ways to interpret the text in order to make the specified properties of assemblies from different manufacturers comparable.

The restructuring of the former document, IEC60439-1, started in 1999. While the interpretation of TTA was stretched by manufactures in a way that is hard to recognise for the user, the committee decided to abandon the terms TTA and PTTA. In general, type testing is replaced by design verification. Particularly for temperature rise testing it implemented exact ways for temperature rise verification three new methods are developed: Testing with current; Derivation (from a tested design) of ratings for similar variants; Calculation.

This paper gives a qualitative overview of the improvements of the new IEC 61439-1 and -2 that has been published beginning this year, compared to the former standard. The new 61439 series is intended to be extended with a specifiers guide to enable the user to make a comprehensive specification of the switchgear he requires. To cover also internal arcing the in 2008 published technical report for testing under conditions of internal arcing, document IEC/TR 61641, is also incorporated in this paper.

Index Terms — MCC; LV Switchgear Assembly; Design Verification

I. INTRODUCTION

When you read the 60439 series in general, you can conclude that these are merely written to the use for manufacturers. The terms and definitions are mainly technical and do hardly address the user. The constructional requirement and performance requirements are interweaved and therefore unclear for the non frequent user of it. A summary of items that are to be addressed by the purchasing party is lacking. The methods for verification can be interpreted in more than one way.

The motive to remove TTA and PTTA from the standard is that these terms left too much room for interpretation. In particular systems that would qualify as PTTA in many cases manufactures pretended it to be more than in fact was. For example, there are little rules for sizing internal conductor or rating the current capability of a device for PTTA design. While the quality and the

quantity of the type testing for the end user is hard to verify. Of course this would influence the competition on the market for there are manufacturers that do apply the rules in the standard that price wise have a problem to compete with the parties that take the standard more lightly.

The proposal of the British national committee was supported by the majority of the countries. In 1999 the working group started their work. This resulted in January of this year in two new parts of the IEC 61439 series.

II. DEFINITIONS

design verification: verification made on a sample of an assembly or on parts of assemblies to show that the design meets the requirements of the relevant ASSEMBLY standard.

original manufacturer: organization that has carried out the original design and the associated verification of an assembly in accordance with this standard and the relevant assembly standard.

assembly manufacturer: organization taking the responsibility for the completed assembly.

TTA: type tested assembly (definition from the old standard IEC 60439-1).

PTTA: partially type tested assembly (definition from the old standard IEC 60439-1).

diversity factor: simultaneous load factor designated by the manufacturer to a group of functional units in an assembly.

SCPD: short circuit protection device.

III. NAVIGATING THROUGH THE NEW STANDARD

A. Navigating through the new series

The above resulted in three alterations to the documents:

1. 439-series have been changed (see table 1)
2. 439-series contents have changed (see table 2)
3. Terms and requirements in the document have been refined and where necessary extended.

TABLE 1

New 439-series	
IEC 61439 part 1	General rules
IEC 61439 part 2	PSC-Assemblies
IEC 61439 part 3	Distribution boards
IEC 61439 part 4	Ass ^s . for construction sites
IEC 61439 part 5	Ass ^s . for power distribution
IEC 61439 part 6	BBT

BBT = Busbar Trunking Systems
PSC = Power switchgear and controlgear assemblies

As you can read from the table 1 the new 61439-series is to consist of 6 parts. A short explanation on the new parts:

Part 1, General rules, is to be used in combination with one of the other parts dedicated for specific assemblies. Note that in the scope of this part it is indicated that, *Supplementary requirements for assemblies forming part of a machine are covered by the IEC 60204 series of standards.*

Parts 2 particular requirements for Power switchgear and controlgear assemblies. This was formerly integrated in part 1. Part 1 and 2 have been published January 2009.

Parts 3 to 6, particular requirements for *specific assemblies*, will undergo the same restructuring and potentially have technical changes and are planned for publication 2011.

B. Navigating through the parts

The numbering of clauses has been extended in the restructured document to make it more accessible to all stakeholders, and therefore expected to be used more than is the case now. All parts follow the same order for the clauses

TABLE 2

Content of IEC 60439	Content of IEC 61439
1. General (scope + norm. Ref.)	1. Scope
	2. Normative references
2. Definition	3. Definitions
	4. Symbols and abbreviations
3. Classifications	<i>moved to clause 5.5</i>
4. Characteristics	5. Characteristics
5. Information	6. Information
6. Service conditions	7. Service conditions
7. Design and construction	8. Constructional requirements
	9. Performance requirements
8. Test specifications (inc.routine tests)	10. Design verification
	11. Routine verification

C. Part 2: power switchgear and controlgear

This part particularly sets the requirements for Power Switchgear and Controlgear that also covers MCC (Motor Control Centers). This requires that for this type of product part 2 of the series is referenced in the specification of the user and on the nameplate of the assembly.

Typical features of PSC-assemblies are withdrawable units and forms of separation are defined in this part. Furthermore

IV. INTERESTING ITEMS FROM THE NEW STANDARD

A number of new definitions are introduced; the most interesting will be reviewed:

A. Definitions regarding protection against electric shock

The relevant definitions from the wiring rules (IEC 60364 series) are incorporated and used throughout this document.

B. Definitions of ways of verification

There are three definitions involving verification: *design verification*: referring to an assembly or part of an assembly; *verification test*: referred to in case where verification actually involves a test; and *verification assessment*: referring to those verifications that were done based on calculations and/or design rules.

It is important for the user to distinguish the terms *verification test* and *verification assessment* while these will tell him whether the design verification of the switchgear assembly is primarily based on physical measurements or calculations.

C. Definitions of manufacturer

The new standard distinguishes the original manufacturer and the assembly manufacturer. This enables to make distinct responsibilities for both parties.

The original manufacturer bears design responsibility, therefore he has to implement the constructional design rules and carry out the verification. The assembly manufacturer may be a completely other company, he is expected to follow the instructions of the original manufacturer assembling the switchgear and carry out the routine tests.

A comprehensive list with symbols and abbreviations is added in clause 4. So one can easily trace the terms referred to throughout the document.

D. Characteristics and information

It was recognized that the number of interface characteristics required additional items to be more precise on the various ratings of voltages ($U_n; U_e; U_i; U_{imp}$), current of the assembly (I_{nA}), current of a circuit (I_{nc}), various short circuit currents ($I_{cw}; I_{cc}; I_{pk}$) of the assembly or circuit.

E. Constructional requirements

IEC 61439 series is a product standard that defines requirements that the manufacturer has to meet and prove by verification. How he meets these requirements is up to him. This allows innovations and bringing the technology for this equipment up to a high level. More involvement from the UL oriented countries introduced also rules for those markets.

TABLE 3

Purpose of test	Clause	Verification
Construction	10.2	Strength of materials and parts
	10.3	Degree of protection of enclosures
	10.4	Clearances and creepage distances
	10.5	Protection against electric shock and integrity of protective circuits
	10.6	Incorporation of switching devices and components
	10.7	Internal electrical circuits and connections
	10.8	Terminals for external conductors
Performance	10.9	Dielectric properties
	10.10	Temperature rise
	10.11	Short-circuit withstand strength
	10.12	Electromagnetic compatibility
	10.13	Mechanical operation

The new terms for protection against electric shock from the IEC 60364-4-41, basic protection and fault protection and the constructional requirements and solutions have been incorporated.

The constructional requirements only apply to general applications. This means there are no special requirements for environments containing particles of corrosive chemicals.

F. Design verification

Where the IEC 60439-series speaks of type testing the new document speaks of design verification. The standard now distinguishes verification of the assembly construction and the performance. The new rules regarding constructional design verification distinguishes verifications of the enclosure depending on its material and application, indoor or outdoor. Other main alterations involve well detailed clauses on the various methods of verification for temperature rise and short circuit withstand strength. The design verification in general is a responsibility of the original manufacturer.

1) *New introduced verifications:* A detailed clause regarding *Strength of materials and parts* for enclosures and internal parts is added to address verification of all constructional parts against corrosion (mainly ferrous parts are addressed) and for insulating materials the thermal stability, resistance to UV radiation, resistance of heat and resistance of abnormal and fire e.g. the glow wire test. The majority of these tests already existed in the standard for *Empty enclosures*. Therefore they already existed as requirements for assembly manufacturers that built their switchboard from empty enclosures.

A verification of *Incorporation of switching devices and components, Internal electrical circuits and connections, Terminals for external conductors* where routine tests, now these have become part of the design verification.

2) *Verification of temperature rise:* There are three verification methods for temperature rise verification.

- Verification shall be made by:
- a) testing with current;
 - b) derivation (from a tested design) of ratings for similar variants;
 - c) calculation

The above three methods of verification can be conducted in one or more ways.

Verification according to method a) comprises the following:

- 1) Selection of critical variants and the most onerous arrangement(s);
- 2) Temperature rise verification in accordance with one of the methods:
 - a. The complete assembly (DF=1);
 - b. Individual functional units separately and the complete assembly;
 - c. considering individual functional units and the main and distribution busbars separately as well as the complete assembly.
- 3) When the assembly tested are the most onerous variants out of a larger product range then the test results can be used to establish the ratings of similar variants without further testing (by application of method b).

Method b) derivation from a tested design of ratings for similar variants, involves a assessment of similarity of functional units, construction, dimensions, cooling and power losses, internal separation and number of outgoing

circuits.

The assembly being verified may comprise all or only part of the electrical circuits of the assembly previously verified. Alternative arrangement(s) of functional units within the assembly or section compared to the tested variant is allowed as long as the thermal influences of the adjacent units are not more severe.

For verification according to method c) two calculation methods are provided:

- a) Single compartment assembly with rated current not exceeding 630 A;
 - b) Multiple compartment assembly with rated current not exceeding 1600 A.
- Over 1600 A verification by test is required!

Both determine the approximate air temperature rise inside the enclosure, which is caused by the power losses of all circuits, and compare this temperature with the limits for the installed equipment. The methods differ only in the way the relationship between the delivered power loss and the air temperature rise inside the enclosure is ascertained.

Verification of the temperature-rise of a multiple compartment assembly with the total supply current not exceeding 1600 A and for rated frequencies up to and including 60 Hz, may be made by calculation in accordance with IEC 60890.

The latter is also allowed under the current standard. The difference is that the rules regarding the loading of devices and internal wiring are more explicit.

3. Example

Example for a temperature rise verification test on an assembly comprising a main incoming feeder, a main busbar, a single compartment outgoing feeder and a panel with a distribution busbar and multi compartment outgoing feeders as in figure 1.

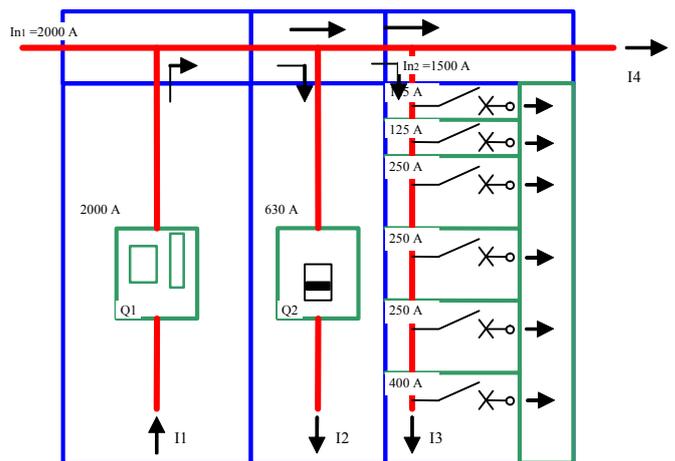


Figure 1

a) *Verification of the complete assembly:* Test method a) tells, one should test the rated values for all functional units and the busbars altogether. Assuming that all the individual functional units are loaded to there maximum capacity and the busbar and incoming feeder (I1) are not loaded up to there maximum capacity one

shall add current to the distribution busbar (I_3) and or main busbar (I_4) to prove that all parts are able to carry there rated current.

The outcome of the test is the maximum current capacity of each functional unit and applying $DF=1$ it is there rated current under all operating conditions.

b) *Considering individual functional units and the main and distribution busbars separately as well as the complete assembly.* Test method c). Several separate test on busbars and on the individual functional units will be conducted prior to the verification test of the complete assembly.

i) First the main busbar is tested. The current (I_4) is supplied form one end of the assembly and lead to a star connection of the three phase on the other end and the temperature rise is verified to the rated limits. The outcome of the test is the rated current of the main busbar. In this case while the incoming unit has the same rating one can do a combined test as long as the length of the section of the main busbar that is tested is $2\text{ m}\pm 0,4$.

ii) Next is the distribution busbar. While there is a main busbar in the system one shall test the distribution busbar in conjunction with the main busbar. Current supply may be done from the incoming unit ($I_1 = 2000\text{ A}$), going out through the distribution busbar ($I_3 = 1500\text{ A}$) the remaining current ($I_4 = 500\text{ A}$) has to flow to the end of the main busbar.

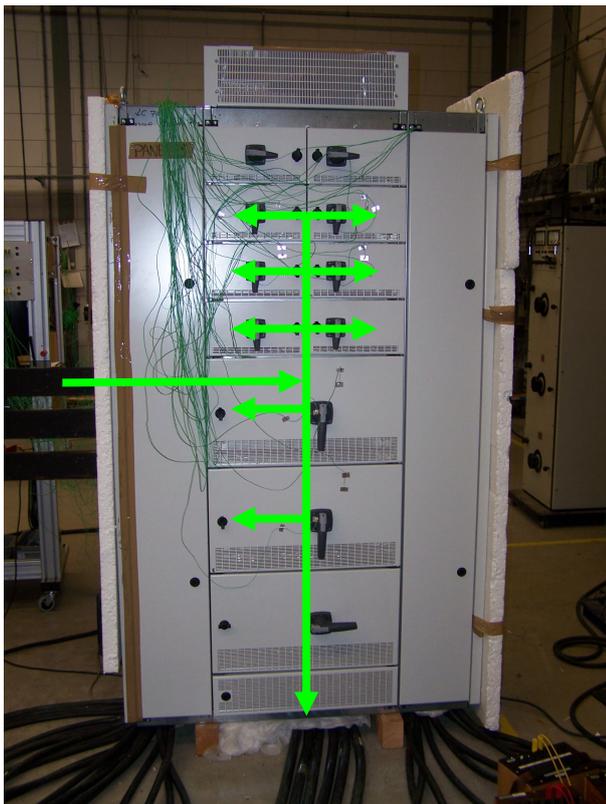


Figure 2

iii) Next are the individual units (only the critical variants in the most onerous positions). These also have to be tested in conjunction with the busbars. The 630 A circuit breaker (I_2) must be tested with the main busbar supplied with its rated current (I_1). The current capacity (I_2) complying with the rated temperature rise limits with a maximum of 630 A will be the rated current of the

functional unit. The rest current flows to the end of the main busbar (I_4).

The individual units in the compartmented panel also have to be tested in conjunction with the distribution busbar. This requires a supply current (I_1) of the rated value in the main busbar, current of the rated value in the distribution busbar, current in the individual unit and rest current to the end of the distribution busbar (I_3) and rest current to the end of the main busbar (I_4). The current capacity complying with the rated temperature rise limits not exceeding the rated current of the device is the rated current of the functional unit.

iv) Ultimately the complete assembly has to be tested as described under method a), this time a diversity factor (DF) can be applied. The main incomer will have a DF of 1 as well as the busbars. The outgoing units however may have a DF lower than 1. For MCC's the DF is often 0,9 for distribution it may be 0,8 or less.

The new method of verification with current is quite complex and involves many equipment and cables to control the current through all the current paths that need to be addressed. The photo of figure 2 shows the test conductors for such test. The green arrows show the current paths.

4. Verification of short circuit withstand

Verification of the short circuit withstand strength may be by the application of design rules, by calculation or by test.

Verification by the application of design rules is undertaken by comparison of the assembly to be verified with an already tested design. A check list is used for this method.

The assessment of the short-time withstand strength by calculation is done by a comparison of a construction already verified by test. The assessment shall be in accordance with IEC 61117 and the check list that has been introduced in the standard.

Verification by test distinguishes the following situations:

1. Not dependent upon a SCPD. The test duration in this case usually is 1s or 3s;
2. Dependent upon an incoming SCPD included upstream or within the assembly;
3. When an SCPD is part of the main circuit, then operation of the SCPD shall be verified.

The SCPD may reduce either the peak value or the duration of the short circuit current. The short circuit current for outgoing units usually is limited by a SCPD.

The test now required at item 3 above is new, the old standard was not clear on this item and often lead to discussions between the manufacturer and the test laboratory.

G. Device substitution

Herewith is meant substitution a certain device within the verified assembly with another device (brand and or series) fulfilling the same function without additional testing. This is practiced more often than the user may be aware of. Particularly substitution of circuit breakers in applications with a prospective short circuit current greater than 10 kArms this can pose a serious risk for the user, while he is not operating on a tested design anymore! Behaviour of the switchgear under short circuit conditions

and temperature rise when reaching higher operating current levels can result in dangerous situations.

The committee has addressed the item device substitution by adding specific items that shall be assessed for applying device substitution. Still this will not be the end of the discussion.

V. WHAT ARE THE CONSEQUENCES

A. For the test laboratories and CB's

Laboratories can apply the new standard from the day it is published, however doing a complete verification applying all aspect of the new standard involves more effort and consideration. CB's (certification bodies) have to come up with generally accepted schemes that cover all tests. The latter is necessary for international recognition of certificates between CB's and is a process that takes time.

For example: Although the standard gives detailed rules for verification by calculation an official certificate from a laboratory or CB is a complete new feature of this standard. So labs and CB have to adjust to that way of verification.

B. What is the impact to the market

In the European Union the EN version of the standard applies. The EN version of the standard will due to the parallel voting procedure contain the same content and publication will follow a few months after the IEC version. Till the date of withdrawal (DOW) it is acceptable to refer to the old standard. It takes time for manufacturers to change their product certification to the new standard, for reasons of product compliance but also for the process that the CB's have to go through.

The answer to the question: Can the user require a particular way of verification of the assembly he intends to buy? Probably **NOT!** For example: The assembly manufacturer aims for a certain market segment with his product and on that base choose a method of verification. The user searches the market for the type of assembly he requires. If he specifies for an assembly to be verified by test and sends his requisition to a manufacturer that aim on the market that does not require that he can expect quotation that does not comply with that spec (if he gets one at all).

However one can imagine that in cases where a user requires a number of similar assemblies, he is in the position to specify the method of design verification. In such case he will be more in control of the design verification that normally is decided by the manufacturer. Then the user is less dependant of the manufacturers interpretation of test results (inter- and extrapolation), calculated values etc. it will become less obscure for the end user. A manufacturer will be sensitive to the users' requirements.

VI. HOW TO SPECIFY A LV SWITCHGEAR WITH IEC 61439 SERIES

As IEC 61439-1 and -2 define uniform safety and service requirements and verifications for switchgear assemblies, the end user might have numerous other requirements.

The IEC Committee attempted to catch both in a future Specifiers Guide for LV Switchgear and Control Gear

Assemblies, the future part 0.

However still under construction, annex A of that document will show most of the considerations for specifying your LV MCC and Switchgear. Starting with the electrical system characteristics through installation environment and storage and handling to Maintenance & Upgrade Capabilities it covers most aspects of the general requirements.

Still a few topics are missing, i.e. Arc Flash Protection and Arc Flash Containment. Further, the choice in standard options could be extended to simplify completion of the specification.

Benefit of a standardized specifier guide is a level playing field for both manufacturer and user (specifier). Confusing issues and incomplete specs, as in the past, can be avoided.

VII. TESTING OF ARC PROTECTION OF LV SWITCHGEAR ASSEMBLIES

Testing the switchgear under conditions of internal arcing is not a requirement in the product standard unlike the product standard for medium voltage switchgear. For the majority of the LV switchgear there is no necessity to do this test because of the limited short circuit energy that is available. However switchgear connected to a large main transformer does pose a danger to the operator and persons in the vicinity when an internal arc occurs.

Since January 2008 there is a new Technical Report (TR) to guide Laboratories conducting internal arc tests on LV switchgear. This new TR compared to the former document has been extended in several ways. A new feature of this document is the classifications for assemblies with the *ability to limit the risk of personal injury* and of *damage of assemblies resulting from an internal arcing fault* in order to be fit for further operation. It also states that recommendations of the report are not acceptable in the USA, Canada and the United Kingdom. USA and Canada have other ways for assessing the danger resulting from an internal arcing fault in an Assembly.

New definitions are added to define areas of an assembly that are specially designed to avoid arcing or to cope with the effects of internal arcing.

For example, the *arc free zone* is (part of) a circuit where it is not possible to apply an ignition wire without destroying the insulation material on conductors. This is with respect to the wire sizes defined for the various ranges of the *permissible current under arcing conditions*.

The *arc proof zone* is defined as part of a circuit where an ignition wire can be applied and fulfilling all relevant criteria for the assessment of the test. The *arc proof ASSEMBLY* can consist of both type of zones combined.

VIII. MCC ACCORDING TO IEC 61439 VS IEC 60204

IEC 60204 recognizes the 439 standard as an acceptable standard to design and test Motor Control Centers. Moreover if you compare the two documents you'll find that with regards to safety of constructional requirements and performance testing the IEC 61439 is much more extensive and detailed and therefore provides rules for safer equipment to the user.

So how to distinguish whether to go with the IEC 60204 or when to base the design and design verification on IEC 61439-2. Maybe the answer can best be found in the

methods and rules for verification as provided in the new IEC 61439 series.

For instance, with regards to verification of short circuit withstand this standard exempts specific levels of short circuit current from testing. Every design for operation on a supply with a short circuit level below 10 kA_{rms} or below 17 kA_{pk} need not be tested. That is a clear criterion. Secondly the rules for temperature rise verification by calculation have also limits: Assemblies with an operating current over 1600 A shall be tested with current. This is also a clear criterion that can be followed deciding on whether for safety matters one should specify: Verification by test; or verification based on calculation. The latter is acceptable according IEC 60204 although little rules are provided.

IX. CONCLUSIONS

1. IEC 61439, including its specifiers and users guide, will give user and manufacturer an equal base of understanding and it will ease the product comparison of the various manufacturers;

2. Verifications according to the new standard are more extensive and rigid than under the former standard;

3. Arc protection is still kept out of the standard and will have to be addressed separately by the user or specifier;

4. Criteria for deciding when to turn to IEC 61439 series with regards to requirements for construction and verification of an MCC can now be derived from the new standard.

X. REFERENCES

- [1] IEC 60439 series.
- [2] IEC 61439 part 1 and part 2
- [3] IEC committee draft for part 0

XI. VITA

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