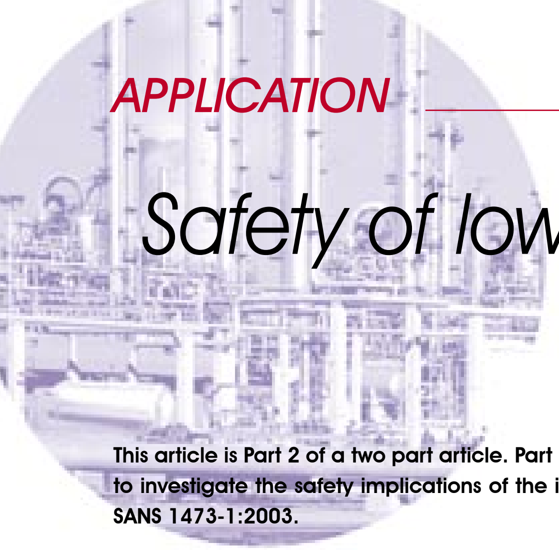

# Safety of low voltage switchgear STAs in South Africa - Part 2

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**This article is Part 2 of a two part article. Part 1 was published in the October 2005 issue of ENERGIZE. A technical analysis was undertaken to investigate the safety implications of the introduction of the category Specially Tested Assembly (STA) into the South African standard SANS 1473-1:2003.**

The aim of this section is to analyze whether the exclusion of four type-tests (for verification as a TTA, in accordance with IEC 60439-1:1999) should be a safety concern, as they are excluded for qualification as a STA, as specified in standard SANS 1473-1:2003 [2]. The type-tests under scrutiny will be the verification of creepage and clearances, effectiveness of the protective circuit, mechanical operation and degree of protection, as shown in Table 1.

### Verification of the effectiveness of the protective circuit

Earthing of an electrical infrastructure can be classified into two categories i.e. protective and system earthing. "Protective earthing is the earthing of a conductive component not forming part of the normal electrical circuit in order to protect personnel from unacceptable touch voltages. System earthing is the earthing of a point in the normal electrical circuit in order that apparatus or systems can be maintained properly" [9]. Correctly sized and connected protective circuits are essential for the safe operation of an assembly. The protective circuit in an assembly consists of either a separate protective conductor or the conductive structural parts, or both. The principal function of the protective circuit in an assembly is to protect personnel from any shock hazards that may result in the non-current carrying part of an assembly accidentally becoming live. This is achieved by interconnecting all exposed conductive parts of the assembly together and to the protective conductor of the supply (or via an earthing conductor to the earthing arrangement). The protective conductors must therefore be correctly sized to carry the prospective short-circuit current of the assembly. The effectiveness of the protective circuit is verified by the following two tests:

The short-circuit withstand test, performed between the protective conductor and the nearest phase, as well as the- resistance measurement of the connection between the exposed conductive parts and the protective circuits. The short-circuit test on the protective circuit verifies that the earthing system is capable of withstanding the thermal and electrodynamic stresses caused by a short-circuit. The resistance measurement confirms that an effective connection between the exposed conductive parts of the assembly and the protective circuit is achieved.

If the assembly is poorly earthed, protection systems may not operate correctly which may cause further damage to the installation. SANS 10142-1:2003 does, however, specify the testing requirements and values for verification of the resistance of earth continuity conductors, but does not specify that the short-circuit withstand strength of the protective conductor be tested [3]. It is, therefore, possible for a conductor to be verified as correctly sized by resistance measurement, but the conductor may in fact be incorrectly sized according to the fault current requirements of the system. The cross-sectional area of the protective conductors in an assembly to which external conductors are to be connected should be calculated using the value of the highest fault current and fault duration that may occur.

These tests are not required for certification as a STA. The safety related concerns from a poorly earthed assembly are self-evident.

### Verification of creepage and clearances

It is not unusual for manufacturers to find that a product fails the creepage and clearance distance test because of miscalculations or simply because the distance between two components was overlooked. Creepage is defined as 'the shortest distance along the surface of an insulating material between two conductive parts, measured along the surface of the insulation' [6]. Clearance is defined as 'the distance between two conductive parts along a string stretched along the shortest distance between the two parts' [2].

The correct creepage distance protects 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 or close to an insulation surface.

Standard IEC 60439-1:1999 specifies the minimum distances in Tables 14 and 16 [1].

These distances are verified by actual measurements. The IEC standard also specifies that both the main and auxiliary circuits shall be verified [1]. However, this test is excluded by default for assembly certification as a STA, since the assembly is specified in the unpopulated state.

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. Should the creepage and clearances of the assembly not be verified, one runs the risk of a flashover, which may generate further effects as severe as an internal arc within the assembly that may cause severe damage or injury. SANS 10142-1:2003 specifies a minimum clearance distance of 8 mm (section 6.6.4.2.4) between phases and between phase and earth [3], which corresponds with Table 14 of IEC 60439-1:1999 up to an impulse voltage level of 8 kV [1]. Should the specified rated impulse withstand voltage be greater than 8kV, the clearances may be incorrectly specified using SANS 10142-1:2003 [3]. Similarly, a minimum creepage distance of 16 mm (section 6.6.4.3.2) is specified in SANS 10142-1:2003 [3] between phases and between phase and earth, but has limited conformity with Table 16 of IEC 60439-1:1999 for various degrees of pollution and material group [1]. Measurement verification of creepage and clearance distances are among the most important parts of all safety standards, and , therefore, it is important for assembly manufacturers to provide verification of this fundamental electrical requirement.

### Verification of the degree of protection

Standard IEC 60439-1:1999 states that 'the degree of protection provided by an assembly against contact with live parts, ingress of solid foreign bodies and liquid is indicated by the designation IP.. in accordance with IEC 60529' [2]. From the above description it is evident that the degree of protection of an assembly does have a safety implication with regards to preventing accidental contact with live parts.

It is not sufficient that an assembly only fulfills the functional requirements that it is designed for, but also to be protected against possible adverse external influences and likewise to ensure that it is not harmful to the user and the environment.

Although the design and construction requirements for protection against electric shock are treated as a separate issue in the standard, verification of protection against electric shock is embedded within the section dealing with degrees of protection.

The degree of protection is generally specified in an agreement between the user and assembly manufacturer, although IEC 60439-1:1999 does specify minimum requirements for assemblies designed for indoor and outdoor use [1]. The type test is required to be done in accordance with IEC 60529 [10] in order for an assembly manufacturer to specify an IP code for the assembly. The current standard SANS 1473-1:2003 does not require that the IP ratings be verified for assemblies [2]. Although the IP rating is specified by the user, an actual verification type test, in accordance with IEC 60529 [10], should be a prerequisite for a declaration of a specified IP rating. The STA is only tested in the unequipped state and, therefore, no IP rating for the assembly can be specified until the assembly is populated. The test is not a requirement for certification as a STA.

**Verification of mechanical operation**

IEC 60439-1:1999 states 'that this type test shall not be made on such devices that have already been type tested according to their relevant specifications provided their mechanical operation is not impaired by their mounting' [1]. The standard specifies that 'the operation of mechanical interlocks associated with these movements shall be checked' [1]. The mechanical operation type test seems at first sight to focus exclusively on the operational aspect of the assembly and its components. This is only true up to the point where, for example, a mechanical interlock failure due to poor workmanship may possibly result in an unsafe condition arising within the assembly for the user due to a mechanical maloperation of a switch or interlock. Verification could detect faulty switchgear operating mechanisms, which may prevent a potential accident, as an electrician may have expected a certain switchgear component to have operated when he turned the handle. Although it is not good practice to perform work on any electrical equipment before verifying isolation, their exists a chance that the electrician can be electrocuted by accessing exposed conductive parts connected to the load side of the switchgear that he thought was successfully isolated. The likelihood of the aforementioned faults occurring are extremely small, nevertheless,

| No. | Characteristics | Subclauses IEC 60439-1 | TTA | PTTA | Subclauses SANS 1473-1 for STA | STA | SANS 1473-1 for STA in accordance with IEC 60439-1 |
|---|---|---|---|---|---|---|---|
| 1 | Temperature-rise limits | 8.2.1 | Verification of the temperature-rise limits by test (type-test) | Verification of the temperature-rise limits by test or exploration | 4.4.1 | Verification of the temperature-rise limits by test (type-test) - Only required for busbar current density values exceeding those specified in 4.4.1.1, or for any busbar material other than copper | NO |
| 2 | Dielectric properties | 8.2.2 | Verification of the dielectric properties by test (type-test) | Verification of the dielectric properties by test according to 8.2.2 or 8.3.2, or veerification of insulation resistance according to 8.3.4 | 4.4.2 | Verification of the dielectric properties by test (type-test) - Only required in the case of an unpopulated assembly | NO |
| 3 | Short-circuit withstand strength | 8.2.3 | Verification of the short-circuit withstand strength by test (type-test) | Verification of the short-circuit withstand strength by test or extrapolation from similar type-tested arrangements | 4.4.3 | Verification of the short-circuit withstand strength by test (type-test) - Only required in the case of an unpopulated assembly | NO |
| 4 | Effectiveness of the protective circuit | 8.2.4 | | Nil | | | NO |
| | Effective connection between the exposed conductive parts of an assembly and the protective circuit | 8.2.4.1 | Verification of the effective connection between the exposed conductive parts of the assembly and the protective circuit by inspection or by resistive measurement (type-test) | Verification of the effective connection between the exposed conductive parts of the assembly and the protective circuit by inspection or by resistive measurement | | | |
| | Short-circuit withstand strength of the protective circuit | 8.2.4.2 | Verification of the short-circuit withstand strength of the protective circuit by test (type-test) | Verification of the short-circuit withstand strength of the protective circuit by test or by appropriate design and arrangement of the protective conductor (see 7.4.3.1.1; last paragraph) | | | |
| 5 | Clearance and creepage distances | 8.2.5 | Verification clearances and creepage distances (type-test) | Verification clearances and creepage distances | Nil | | NO |
| 6 | Mechanical operation | 8.2.6 | Verification of the mechanical operation (type-test) | Verification of the mechanical operation | Nil | | NO |
| 7 | Degree of protection | 8.2.7 | Verification of the degree of protection (type-test) | Verification of the degree of protection | Nil | | NO |

*Table 1*

one can never be too careful when operating any electrical equipment connected to high fault level systems. These examples of potential faults may be exposed when performing the mechanical operation type tests, and rectified prior to installation on site. This will increase the safety of the assembly by assuring that no dangerous failures occur, allowing a greater reliability of the low-voltage distribution network through the assembly. The only mechanical operation type test that can be done to a STA is on the incomer and busbar switches, because the assembly is specified as unpopulated.

**Conclusions**

The proceeding paper highlights that, although not immediately evident, the majority of the type tests specified in IEC 60439-1:1999 are not exclusively related to the performance and constructional aspects of the assembly, but also have safety relevance. Conformity with the standard assures that the assembly will achieve acceptable levels of safety and reliability. The has also exposed the inadequacies of an assembly that is certified as a STA, in accordance with SANS 1473-1:2003, and the potential safety risks associated with this type of assembly classification. It has also been shown that the distinction between TTA and PTTA switchgear and controlgear assemblies has no relevance to the declaration of conformity with standard IEC 60439-1:1999, in so far as the switchboard must comply with this standard. Therefore SANS 1473-1:2003 is fundamentally flawed, by placing TTA, PTTA and STA switchgear and controlgear assemblies on an even keel. The authors are of the opinion that one cannot possibly recognize a TTA and a STA as being equivalent with regards to the aspects of the performance, safety or reliability of the assembly, despite the fact that that they share a common South African standard. A STA is basically a skeleton assembly with a busbar system that has been subjected to a bare minimum amount of tests. A summary of the technical / safety and commercial findings are summarized below:

Standards are written in such a manner that introduces a degree of subjectivity in the interpretation of the document. No matter how one looks at the type tests required for certification as a STA, the deliberate exclusion of a number of type tests by SANS cannot be misconstrued as misinterpretation of IEC 60439-1:1999. With this in mind, the safety related concerns highlighted in this paper expose the STA as a category of assembly, which neglects important safety and performance issues, while not conforming to any internationally accepted standard.

One major downfall of an assembly that is certified as a STA, in accordance with standard SANS 1473-1:2003, is that it is tested in the unpopulated state. It cannot be reasonably assumed that an assembly in the unpopulated state is representative of an assembly in a fully equipped operating form.

The STA was initially introduced to allow smaller manufacturers recognition for complying with some sort of minimum requirement, before which they had few restrictions and standards to comply with. A manufacturer of a STA is at a much greater commercial advantage than a manufacturer of a TTA, should the two categories be acceptable in the same tender document. It is not uncommon for engineering consultants, engineers and designers to make a blanket statement specifying only that the assembly shall conform to SANS 1473-1:2003, due to their limited knowledge of the standard. This leaves the door wide open as to the type of assembly that will be offered to the client. Invariably, the larger corporate companies will specify a TTA or PTTA as the only alternatives on offer, while many of the smaller companies will be at a financial advantage if they can offer a STA as an alternative. Even though the STA manufacturer follows the standard correctly, the assembly cannot be considered safe because it does meet the safety and performance requirements outlined in IEC 60439-1. Type tests are costly to manufacturers, but nevertheless, form a vital part in the assurance of an assembly's performance and safety. There are several reasons highlighted in this paper as to why consumers should choose safety over cost when deciding to opt for a TTA instead of a STA.

With international trade opportunities being accessible to South African companies, it would be sensible for South Africa to conform to recognized international standards with respect to exporting our products. The dilution of the requirements of IEC 60439-1:1999 (applicable to certification as a STA), is harmful to the reputation of our products in the international market.

The remedial work on standard SANS 1473-1:2003 [2] is essential in ensuring that the category STA is both functional and safe, but the method of achieving this will be no straightforward task.

**Recommendations**

*Safety and the OHS Act*

The Occupational Health and Safety Act (85 of 1993) [4], along with the Electrical Installation Regulations and the Electrical Machinery Regulations, govern electrical work, as well as the certification that such work is safe. SANS 10142-1:2003 is referenced herein and is therefore considered a mandatory safety standard It is, therefore, the responsibility of the SANS committee members who compile the electrical standards, to ensure that safety is always considered, and that the standard complies with the requirements specified in the Occupational Health and Safety Act. The removal or incorrect application of type-tests that have safety implications can be viewed as a contradiction of the essence of the Occupational Health and Safety Act.

*Future standard IEC 61439 series*

In principle, the idea to give small manufacturers the possibility to manufacture assemblies, with a lesser amount of testing, is not incorrect. But the smaller the requirements for testing are, the bigger the required safety margins should be. This is also the general philosophy of the future IEC standard for low-voltage switchgear and control gear assemblies. The current series of IEC standards for low-voltage switchgear and controlgear assemblies, IEC 60439, is presently being revised by the IEC. This has been necessitated by the fact that the current series of standards do not cater for customized assemblies, and only allow for TTA or PTTA certification. This fact has also been recognized by SANS, which has possibly resulted in the present STA classification of assembly being included in standard SANS 1473-1:2003 [2]. The proposed new series of standards will expand on the current requirement of design verification by type-test, in the case of an assembly being classified as a TTA, to include alternative design verification methods. The alternative methods include verification by non-destructive measurement, calculation and application of design rules [11]. An increasing conservative design approach will be allowed for as one proceeds through the verification options, from performing actual type tests through to the application of design rules. It is important to note that some actual type testing may still be required as the starting point for design verification of certain categories, for example, short-circuit verification may require a verified and tested reference design upon which design rules may be applied for subsequent designs. The concept of design verification by methods other than verification testing (type tests) is not entirely new. It is similar in many ways to the concept of verification of an assembly as a PTTA (in accordance with standard IEC 60439-1:1999), as some of the tests require a verified and tested design as the starting point. The proposed new IEC series of standards, IEC 61439, seems like a more prudent route to follow than the modification / exclusion of important safety tests as in the case of STA classification. It is strongly recommended that SANS consider the implementation of the new IEC 61439 series upon official publication.

*Suggested immediate measures*

The anomalies exposed in the validity of the type-tests specified for a STA should necessitate a recall of standard SANS 1473-1:2003 [2]. The major question thereafter is what standard should be applied in the interim, while the standard is being revised. Since some of the type tests can be potentially destructive it becomes obvious that for both pragmatic and cost reasons that it would become unreasonable for every assembly to be tested either as a TTA or PTTA. A suggestion may be to remove all references of standard SANS 1473-1:2003 [2] from standard SANS 10142-1:2003[3]. This would effectively make compliance with standard IEC 60439-1:1999 [1] voluntary.

Due to the high forces experienced within an assembly for short-circuits of magnitudes above 20 kA, and the associated safety concerns, it may also be reasonable to consider that all assemblies with rated short-circuit withstand strength above 20 kA be tested for category TTA or PTTA.

**Acknowledgements**

The authors wish to acknowledge the valuable advise from Bill Graham of Graham, Golding & Associates and Dr. Helmut Drebenstedt of Siemens AG, Germany, as well as Eskom (TESP) and THRIP for financial support.

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