INTEGRATED CABLE TEST FACILITY IN COMPACT MEDIUM VOLTAGE SWITCHGEAR

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ABSTRACT

In modern compact switchgear the accessibility of cable connections is often rather limited and the connections are frequently realized under less than ideal conditions. Nonetheless it remains crucially important to make and keep this vulnerable connection point failure free throughout the lifetime of the switchgear. Cable tests normally require direct interference with this critical connection of operators and test equipment. Such operations are known to be a cause of potentially severe malfunction of cable connectors after the test. This paper describes a recently developed cable test facility (CTF) in two modern medium voltage systems of Eaton Electric, intended to help avoid this type of failure. Basically it consists of test probes and integral cable test ports accessible from the front, fully independent of the cable termination enclosure. The article presents the CTF integrated in RMU-system Xiria and sub-/main station system FMX, and explains how these facilities provide more safety and convenience compared to tests directly on the cable connector. Further it is illustrated how this concept also simplifies, to some degree, the necessary skills of operators to conduct maintenance.

INTRODUCTION

We can state that in today's equipment for electricity distribution there is a growing conflict between the ongoing economical driving force to make MV-switchgear ever smaller in order to save space and costs, and the decreasing possibility this development leaves the technicians to make and maintain the important connection between MV-cables and switchgear free from technical flaws.

There are several aspects to this problem. One is that a switchgear panel, more specifically the cable compartment inside that panel, sometimes has become so small that a person of normal physical size can hardly gain access to the connection interface inside the metal enclosed construction. While on the other hand new cables sometimes tend to be selected in bigger sizes than before, and in such cases are harder to manipulate and bend in the required position. A third factor is that cable terminations, when connected to equipment with small phase distances with respect to the voltage level, necessarily need to be more sophisticated in their dielectric design and hence are more critical to make without any (visually hidden) faults. In remarkable contrast to this it is observed that fully qualified electrical technicians are ever harder to find in many parts of the modern world, and that the level of skills of this important group of professionals tends to drop. While at the same time those who do the job are under increasing time pressure to stay within the budgets of their business.

All these factors together of course present a broad generic picture. The actual situation will vary from user to user, and from station to station within the installed base of one user. In any case it is clear that for one or several of these reasons many users regard connections not just as simple tail ends of the cables in their network, but as an important potential failure source in their grid. A cable connection is recognized as a vulnerable point, to be handled with care. Therefore some customers have asked Eaton to develop a cable test facility integrated in the MV-panel which enables them to test the quality of the cable inclusive that critical connection without having to manipulate or even access it. This paper presents such modern cable test facilities, intended to solve or reduce some of these issues.

CABLE TEST FACILTY IN RMU XIRIA

Figure 1 illustrates how compact a MV-switchgear panel has become compared to the power cables connected to it. Being connected to cable cones at only 110 mm pole

Fig. 1: Cables on 24 kV RMU Xiria

distance, the connectors of the large cables – those in the left and right panels of this CTC-unit- almost touch each other. It is obvious that strict requirements will count for the dielectric properties of these cable connections if the whole switchgear system is to remain failure free. At the same time the illustration shows that although the three cable connections are packed so closely together in a compartment of 350 mm width, they all are well accessible. This user friendly configuration was realized by positioning the points next to each other instead of behind one another, and as high and forward to the front as possible.

Such a configuration enables cable tests to be done directly on the cable connectors, and that procedure in fact is considered feasible by some users, at least with simple connectors. Figure 2 shows an example of such connectors with a conventional earthing knob as interface point for test

Figure 2: Conventional cable test interface on 12 kV cable connector in Xiria

equipment, used here in Xiria at 12 kV rated voltage level. Note that the connector is not equipped with an insulated and earthed housing, as would be required at 24 kV in this small space. Here only a removable thin plastic cap covers the earthing bolt connected to the cable lug inside the housing of the connector.

Functional specification of CTF by utilities

Other users however prefer another procedure, even at 12 kV, because their practice learned that cable connections show an increased risk of failure after testing directly on the connector. South African utility Eskom SA is one of these companies, and they see easy accessible integral cable test facilities as an alternative with benefits. Some of the requirements for such a CTF as defined in [1] are given below.

Integral cable test facilities that are accessible from the front of the ring main unit and independent of the cable termination enclosure shall be provided for the functions (i.e. switch disconnectors, switch-fuse combinations and circuit-breakers).

NOTE Separate cable test facilities that are independent of the cable termination enclosure eliminate the need to access and interfere with the cable terminations for cable testing. Separate cable test facilities are preferred, but if they are not provided, access to the cable termination enclosure is required to test the cable and this may compromise the internal arc classification of the switchgear if the other functions are live. Replacement of separable connectors or their associated test points and caps after testing will require cleaning and re-lubrication.

If separate cable test facilities that are independent of the cable term enclosures are provided, it shall be possible to connect cable test equipment (e.g. pressure testing or fault locating equipment) to the cable under safe earthed conditions via the cable test facility without compromising the IAC of the RMU. Connecting and disconnecting of the cable test leads shall be performed under safe earthed conditions only.

Each cable test facility shall be interlocked with its associated earth switch and be capable of being padlocked to ensure that the test terminals of the cable test facility are not accessible when the cable is energized. The test terminals must be fully earthed under normal service conditions, access must only be possible when the panel is switched ON in earthed position. Access to the test terminals of the cable test facility shall only be possible when the associated earth switch is in the closed EARTH position.

After connecting the test equipment, which must only be possible under safe earthed conditions, the integrated earth connection shall be removed for testing purposes without interfering with the connected test equipment. After completing the test procedure (with pressure testing or fault locating equipment) the integrated earth connection must be reconnected without interfering with the test equipment. The test equipment must be safely removed under full earthed conditions. Under normal service conditions (live cable and busbar) the test connections must be fully earthed.

The protection degree of these connections must be minimal IP3X1D. It must be possible to padlock the function and the access to the test connections in all end position.

Description of the Xiria CTF

To comply with these requirements Eaton has developed a CTF enabling utilities to perform various cable tests in a safe manner and according to their procedures, in particular: cable insulation resistance, cable pressure and phase determination tests. The basic features and operation procedure of this CTF are now presented by means of an excerpt from the Xiria manual.

Optional Cable Test Facility (CTF)

Xiria load break switch panels can be provided with a Cable Test Facility (CTF) as an option. With this option the primary cables can be tested without opening the cable access door by replacing the integrated earth connection with test pin connections on the front.

1. Switch the panel ON to the closed earthed position (as described in …)
2. Remove the padlock (1), see Figure A and open the CTF front cover plate by pulling it off using the front knobs (2). See Figure B.

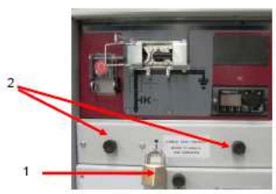


Figure A

Figure B

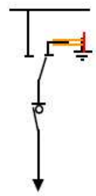


Figure C

The panel is now switched in the position as shown in Figure C with the primary cables connected to earth.

3. Unlock the test connection access holes by turning the interlock knob (3) anti-clockwise in vertical position. See figure D and E.

Figure D Locked position

Figure E Unlocked position

4. Insert the test pin(s) (4) in the test access hole(s) until they are blocked. See Figure F and G. The panel is now switched in the position as shown in Figure H with the test pin(s) in place but they are still safely earthed.

Figure F

Figure G

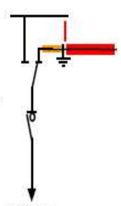


Figure H

5. When the test pin(s) are inserted and the test equipment is connected to the test pin(s), the integrated earth connection can be disconnected by pulling the earth tube (6) to the front. See Figure I and J.

Figure I

Figure J

Figure K

The earth tube(s) must be pulled out until they are blocked and the earth connection with the screen of the test pin(s) (7) is made. See Figure K.

6. The panel is now switched in the position as shown in Figure L with the test pin(s) in place and ready for testing. The test voltage can now be applied to the cable via the test pin(s).

WARNING
DO NOT TOUCH THE TEST PINS AFTER PULLING OUT THE EARTH TUBES.

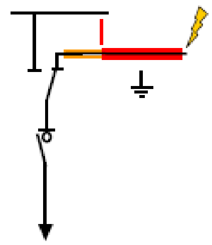


Figure L

7. Shut off the power of the test equipment after finishing the test and push the earth tubes back into the front to the safe earth position. To switch the panel back in operating position after testing: disconnect the test equipment and remove the test pin(s) from the test connection.

8. Lock the access to the test connections by turning the interlock knob (10) clock wise in horizontal position. This is only possible when the earth tubes are fully inserted in the front. See Figure M. Put the CTF front plate back into position and lock it with the padlock. See figure N. This can only be done with the interlock knob (10) fully placed in horizontal position.

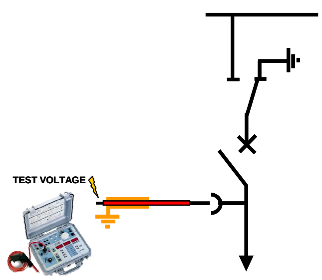
Figure M

Figure N

9. Switch the panel in operating position (as described in …)

CABLE TEST FACILTY IN FMX

FMX is the latest system of Eaton for sub- and main stations in the MV-grid. It also has been equipped with a CTF, and for the same reason as Xiria: to meet the need of customers, first of all in the United Kingdom, who want to be able to test cables without touching it. In this design it turned out to be convenient to position the point of connection of the test probes on the cable side of the circuit breaker, instead of on the side of the change over switch. See figure 3. As in Xiria the operation of the CTF in FMX is integrated in the interlocking system of the operation panel, ensuring the test probes can only be inserted in and removed from the access points under the safe condition that the circuit breaker is closed and the change over switch is in earthed position. The operation is in FMX is somewhat easier because the connection of the CTF to earth is made by normal switching of the circuit breaker instead of removing an earth tube. The alternative configuration in FMX, with the injection point on the cable side of the circuit breaker, has a potential advantage. It requires that the circuit breaker is opened when test voltage is applied on the CTF probe. So this will test the condition of the vacuum interrupters together with that of the cables. And if cables are disconnected from the panel it is possible to test the vacuum condition separately. The test probe for the various cable tests (voltage, fault localization, phase determination) can also be used for a procedure to check CT's and connected electronic protection equipment with a current injection. In addition to that devices are now in development to connect a take over earthing and a proof of earth device via the same CTF access point. All options are planned to be released in the market in 2011.



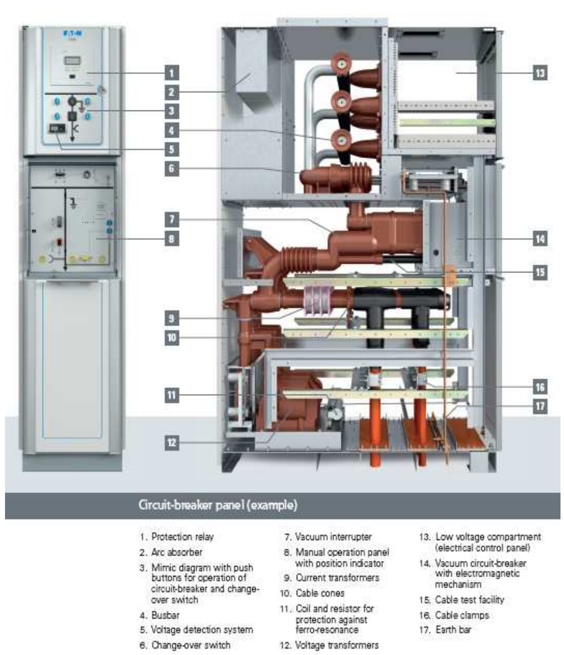


Figure 3: CTF on 24 kV system FMX

CONCLUSION

Eaton has developed an integrated CTF on its two most modern 24 kV MV-systems to meet the requirement of those end users who want to eliminate the need to access and interfere with the cable terminations when testing their cables. The most important benefit of this concept is that it helps to avoid malfunction of cable connections known to be caused by test practices performed directly on cable connectors, in particular ones with an intricate dielectric construction. Further the CTF enables a quality check of the cable connector itself after commissioning. Also the CTF is designed to facilitate the test procedures better than conventional methods. In addition to this the CTF in FMX will be able to test the vacuum integrity of the open interrupters of the circuit breaker. And finally the CTF facilitates a current injection procedure to check CT's and connected protection devices. Practical experience gained in the coming few years by end users in the field will hopefully confirm the expectation that this CTF concept indeed increases the reliability of vulnerable cable connections in modern compact MV-switchgear.

REFERENCES

[1] ESLC / NRS, 2008, LE Draft 5 of NRS 006:2008, "Switchgear– metal-enclosed ring main units for rated voltages above 1 kV up to and including 36 kV"

[2] City Power Johannesburg, 2006, "Procedure for the commissioning of 6,6 kV and 11 kV cables"

[3] W Menheere, F P Schoten, D E Edwards, L MacKay, "Recent trends in the development of Fixed switchgear", *CIRED 2009,* paper 0670