Fault Location in Electric Low Voltage Cables for Photovoltaic Systems

CASE STUDY

Fault Location in Electric Low Voltage Cables for Photovoltaic Systems

Introduction:

Renewable energy generation plants such as photovoltaic power stations are generally installed using direct-buried low voltage cables interconnecting solar panels to rectifier stations.

Low voltage cables typically used feature polymeric insulation such as XLPE (Crosslinked Polyethylene), PVC (Polyvinyl Chloride) or Polyethylene jackets and they are unshielded with nominal operation voltage of 1.5 kV, maximum 1.8 kV.

On multiple occasions, during the cable installation process or due to actions derived from third parties, jacket aggressions or insulation injuries are caused affecting the constituent elements of the cables, preventing their operation.

Generally, the most frequent aggressions on the jacket originated in the installation process are in the form of breaks or cracks, with or without incidence or deterioration of internal elements such as the insulation or center conductor.

In effect, when laying cables inside trenches, ducts and/or PVC conduit systems, damage may occur due to the inappropriate use of handles, winches, machines that stretch the cable or even laying by hand by inexperienced personnel. Sometimes cracks have been found in the cable affecting not only the jacket but also the insulating material. Inadequate construction of ridges with sharp profiles and sharp angles or laying in areas with rocky prominences that act as blades on the cable sheath when dragging it during laying, aggravating the condition.

This case of study details the technical inspection carried out on the 1.5 kV DC underground power lines of a solar farm located in the Department of Cesar, Colombia.

1. Objective:

The fundamental objective of this work is to show the results of the fault location of the 1.5 kV underground power lines in a solar park, prior to commissioning and report the importance of testing to ensure the correct future operation of buried electrical systems.

2. Inspection Techniques:

The techniques used in the inspection are:

- Jacket or Sheath test using a high voltage (HV) low energy hipot DC source.
- Punctual Fault Location by earth voltage gradient measurement.

3. Inspected Units:

A total of 14 spring boxes were inspected for a total of 28 direct-buried XLPE/PVC aluminum 1.5 kV DC single-core low-voltage cables.

4. Methodology:

- **Verification of the integrity of the Cable Jacket/Insulation**

The tests were carried out by applying hipot DC voltage between the center unground conductor and a grounding reference electrode, which is normally a grounding rod or the substation grounding system. In case of fault, the hipot DC source forces a current through the jacket and surrounding ground back to the source.

The jacket and/or insulation of the cable could be considered safe when the applied voltage remains stable during the test time of 1 minute, and the leakage current is also stable near zero. In order avoid damage in insulation of the cables, it is recommended to apply a DC voltage less than the nominal or operating voltage for a short time duration.

- **Cable fault pinpointing**

The exact location of earth faults in cables due to the jacket is based on the principle of the step voltage or gradient voltage method. To do this, a low energy pulsed hipot DC voltage up to 2 kV is applied cyclically to the cable sheath with a typical on/off rate of 1:3 seconds. The current through the ground creates an earth potential which can be measured by a zero galvanometer and ground stakes; thus, cable sheath fault can be located by capturing the voltage gradient created in the ground. The galvanometer indication increases as it approaches the fault, and changes polarity when one walks beyond the fault. When the galvanometer probes are positioned equal distances from the fault, the indication is zero confirming the real position of the fault. The cable route must be previously known by easily use of an audio-frequency or electromagnetic cable locator.

5. Results:

The result obtained was 9 out of 28 cables tested were faulty. The figure 1 shows the test site and hipot DC equipment during the measurements.

Fig. 1. Hipot DC Test Set. Connections.

It was possible to measure step voltages in the ground with values between 2 mV up to 120 mV around the place where the fault was by using the voltmeter/galvanometer and ground stakes (See figure 2).

Fig. 2. Pinpointing a fault in buried cable.

Voltage gradient measurements were then applied punctually, considering the failure point as found once the voltage was reduced and changed to opposite polarity as shown in the sequence of measurements shows in figure 3.

The figure 4 shows the exact cable fault location.

Fig. 3.Pinpointing a fault in buried cable.

Fig. 4. Pinpointing a fault in buried cable.

6. Conclusions and Recommendation:

Once the jacket tests and fault location have been carried out on the XLPE 1.5 kV cables of a solar farm, we can highlight the following:

- The integrity of the jacket was verified aplying hipot DC up to 1.8 kV.
- All faults were located promptly using the methodology previously described
- It is worth mentioning that most of the damages found after the excavation of the failed cables show cuts, cracks and/or dents that must have been caused by the action of external agents, probably at the time of installation or laying of the cable in trenches. See damages found in figures 5 to 7.

To carry out a proper repair of jacket faults, the following procedure is recommended:

Clean the affected area and scrape the jacket at the fault location with a blunt pointed cutting tool to avoid accidentally causing another fault.

Fig. 5. Damage found in the cable during installation.

Fig. 6. Damage found in the cable during installation.

Fig. 7.Damage found in the cable during installation.

Check the depth of the fault to determine if the damage is only surface or if it has perforated to the center conductor.

In case of surface fault is only on the cable sheath, insulating Tape is applied to the well-cleaned area or vulcanizing tape can be used and covered by insulating tape.

If the damage has reached the center conductor, a new joint or splice must be installed as a final repair following the installation procedures recommended by the manufacturer selected.

It is very important to evaluate the backfill used in the installation. As required by National Electric Code NFPA70 [2], backfill containing large rocks and very angular elements will not be placed to avoid further damage during backfill compaction. Once the cable has been repaired, it should be backfilled with granulated or fine sand and subsequently, it is recommended that the cable sheath be retested according to the procedure initially described in this report.

Solutions:

MFM10

Testing, prelocation and pinpointing of sheath faults. Easy, precise and fast.The intuitive, menu supported operator guidance of the MFM 10 works using the well accepted SebaKMT Easy-Go principle. The fully automatic measurement and evaluation of the measured data gives the operator a fast, easy and reliable tool to test the sheath of cables, and to perform a prelocation and pinpointing of detected faults.

The bipolar prelocation supports the detection of galvanic and thermoelectric influences and increases the prelocation accuracy and quality.

- Test Voltage up to ±10 kV DC
- Up to 750 mA continuous current, also suitable for burning
- Adjustable current limiter
- Bipolar measurement for highest accuracy
- Easy-Go operation via jogdial and touch screen
- Automatic measurement and protocolling

Fault Location in Electric Low Voltage Cables for Photovoltaic Systems

Solutions:

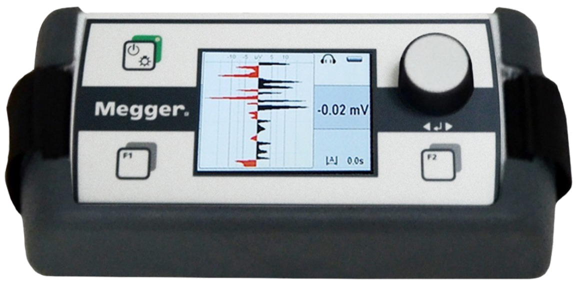
ESG NT

The earth fault locator ESG NT2 is used to pinpointing cable sheath faults with great accuracy. Using a bright, sun readable TFT color display makes it very easy to use.

The displayis by a bargraph, similar to the analogue display or by a history display, which shows the deflections of the last 7 pulses. A fully automatic calibration keeps the display always at zero and the integrated noise suppression eliminates all influences by DC, Railway currents, industrial plants and high resistive soil environment. By two earth rods, the ground step voltage potential is measured and the direction towards the fault is indicated by the display.

The ESG NT2 is also available as combination set with the digiPHONE+ in one unit.

- Automatic adaptation to voltage level
- Automatic filtration of interfering signals
- Automatic zero calibration, no adjustments necessary
- History mode
- High-contrast color display
- 50/60 Hz Mode for fault locating on low voltage cables



References

[1] IEEE Std 1234-2019 IEEE Guide for Fault-Locating Techniques on Shielded Power Cable Systems.

[2] NFPA 70, National Electric Code. 2020 ed.

Megger

For more information please reach out to:

- **Ricardo Puig**
  Applications Engineer LATAM
  ricardo.puig@megger.com
- **Galo Teran**
  Sales Manager LATAM
  galo.teran@megger.com

Megger
4545 West Davis St.
Dallas TX, 75211
USA

csa.megger.com

Fault Location Solar Systems _CaseStudy_EN_V01