Technical Requirements for cable accessories tool.
Date: 09/2021

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Infrastructure & Networks*

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1 DOCUMENT AIMS AND APPLICATION AREA

Enel Global Infrastructures & Network is looking for the design of an instrument or tool able to prepare a cable and automatically install an accessory on MV lines of the distribution networks of Enel Group Distribution Companies.

2 DESCRIPTION

The instrument shall be able to automatically prepare the end of a medium voltage cables and perform the accessory.

The tool shall be easy to handle and transportable as it's foreseen to be used in very different places:

- Excavations in the ground
- At the basis of the poles
- At the top of the poles

The design of the device shall take into account that installation operations are currently carried out in different ways, on the ground or at height (using a lifting basket). Considering the different ways of installation, we are willing to consider all type of solutions: a lightweight device, a device capable of reaching certain heights with an arm or other possible solutions capable of meeting all the requirements listed in this document.

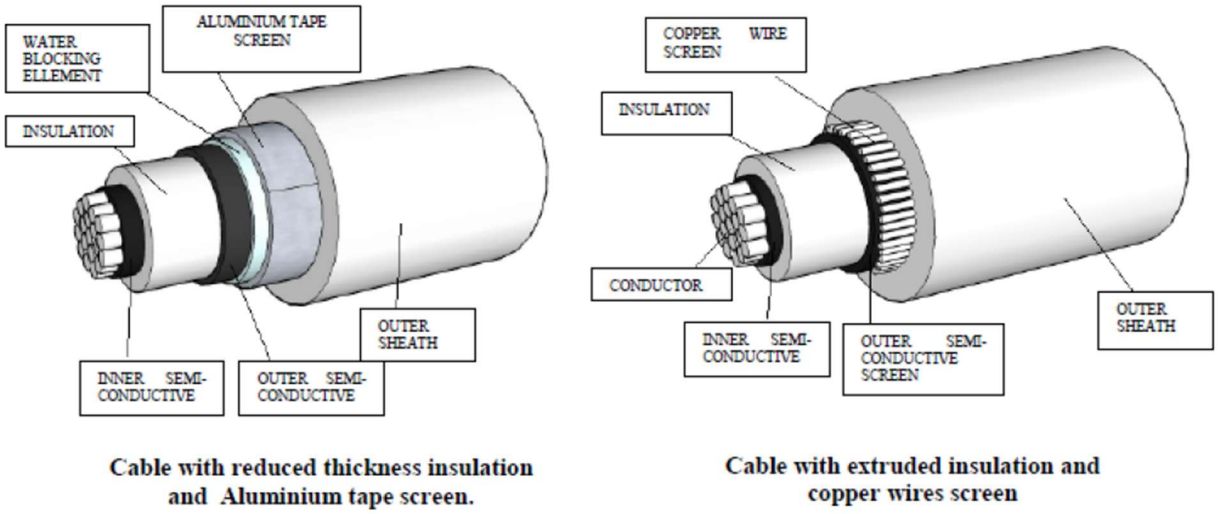
The device shall carry out the necessary operations in the most automated possible way, limiting manual intervention to the minimum necessary in order to minimize possible errors of execution by the operator, who often works in uncomfortable conditions.

The velocity and the easiness of use from the device will be evaluated in a positive way.
Obviously, these parameter shall not influence the component reliability.

2.1 Cable's description

The instrument shall be able to work with the following types of MV cables:

- XLPE Insulated Cables with reduced and full insulation thickness, with aluminum tape or copper wires screen;
- HTPE insulated cables with aluminum tape or copper wire screen;
- EPR insulated cables with copper wire screen;
- Nice to have: Single-core Impregnated Paper insulated cables with lead shield.



Cable with reduced thickness insulation and Aluminium tape screen.

Cable with extruded insulation and copper wires screen

Image 1 General view of a MV cable

The complete range of cable cross sections goes from 35 to 630 mm².

In general, regardless of type, a cable is composed of the following layers of material (from outside in, see image 1):

1) Outer sheath
2) Longitudinal watertightness
3) Metallic earth screen
4) External semiconductor layer (cold peelable or bonded)
5) Insulation layer
6) Inner semiconductor layer
7) Conductor (aluminum or copper)

2.2 Accessory's description

The main types of accessory to be mounted are terminations and splices or joints. The function of these accessories is:

2.2.1 MV Terminations:

A cables termination could be considered as a device able to provide electric stress control for the cable insulation shield, complete external leakage insulation between conductor and ground, a seal to prevent the entrance of the external environment into the cable providing a proper metallic connection (Lug).

2.2.2 MV Joint

A cable joint could be considered as two conductors connected through a suitable mechanical connector, then reinsulated, re-screened and rejacketed with proper material and applied over a suitably prepared surface. Whenever possible, jointing cables is normally avoided. However, splicing is usually often a necessity.

There can be many reasons for installing cable joint splices, such as:

- The supplied length of cable is not sufficient to perform the intended job, e.g., only so much cable can be wound on a Drum (the reel ends), or only so much cable can be pulled through so much conduit, around so many bends, etc.
- Cable failures
- Cables damaged after installation

The tool shall be capable of performing the reconstruction tasks described above (re-insulation, re-screening and re-jacketing), ensuring normal operation of the cable.

3 APPLICABLE LAWS AND REFERENCE STANDARD

Reference documents listed below (amendments included) shall be the edition in-force at the contract date.

3.1 Enel standards

- GSCC004
- GSCC005
- GSCC006
- GSCC015
- GSC001
- GSCC008
- GSCC023

3.2 Laws

Brazil

- NR-10 – Segurança em instalações e serviços em eletricidade.

Chile

- Reglamento de seguridad de las instalaciones eléctricas destinadas a la producción, transporte, prestación de servicios complementarios, sistemas de almacenamiento y distribución de energía eléctrica y todos sus Pliegos Técnicos

Colombia

- RETIE – Reglamento Técnico de Instalaciones Eléctricas.

Perú

- CNE – Código Nacional de Electricidad – Suministro 2011.

Italy

- D.Lgs n. 81 of the 9th of April 2008 and subsequent modifications.
- Nota Operativa PVR001 – Rev. 2 – Ott. 2012 - Gestione Garanzie dei materiali di ENEL Distribuzione.

Spain

- R.D. 614/2001, de 8 de junio, sobre disposiciones mínimas para la protección de la salud y seguridad de los trabajadores frente al riesgo eléctrico.
- R.D. 337/2014, de 9 de mayo, por el que se aprueban el Reglamento sobre condiciones técnicas y garantías de seguridad en instalaciones eléctricas de alta tensión y sus Instrucciones Técnicas Complementarias ITC-RAT 01 a 23.
- R.D. 223/2008, de 15 de febrero, por el que se aprueban el Reglamento sobre condiciones técnicas y garantías de seguridad en líneas eléctricas de alta tensión y sus instrucciones técnicas complementarias ITC-LAT 01 a 09.

Romania

- NTE 001/03/00 – Normativ privind alegerea izolației, coordonarea izolației și protecția instalațiilor electroenergetice împotriva supratensiunilor
- NTE 003/04/00 – Normativ pentru construcția liniilor electrice aeriene de energie electrică cu tensiuni peste 1000 V

4 SERVICE CONDITIONS

The instrument shall be used in all countries where Enel has MV distribution network.

5 TECHNICAL CHARACTERISTICS

The instrument shall be supplied by the following:

12 V DC power supply (either directly or by a 230 V AC/DC converter included in the scope of supply);

Built-in 12 V DC battery with operating autonomy for at least 6 installations and with power and battery status indicator showing the number of installations remaining to be performed.

NOTE: 230 V AC power supply or other solutions are accepted for the development phase.

5.1 Cable preparation

The preparation of the cable requires the different layers listed above to be removed for variable length and thickness depending on the type of cable being processed and according to the installation specifications of the cable accessory (see also GSCC015 for Guidance).

Figure 2 shows an example for a cable with XLPE insulation and aluminum foil earth screen:

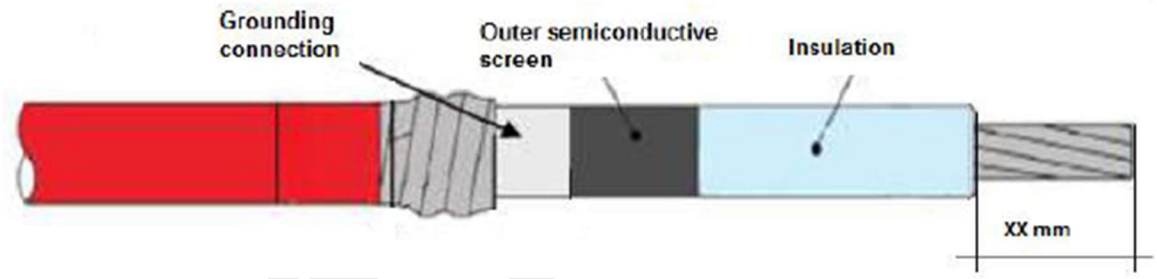


Image 2 Example of prepared XLPE cable with Al tube screen

The instrument shall be firmly positioned at the point of work and shall be equipped with a support that is automatically adjustable in inclination in order to compensate for any unevenness in the ground or the place of installation. Handheld tools could be considered as well, especially for aerial applications.

The cable shall be anchored in a solid manner and in such a way that the cable is kept straight for the entire length involved in the processing. The instrument shall be equipped with intrinsic safety interlocking systems to ensure operator safety at all times. There shall be emergency stop buttons, easily accessible by the operator from every side of the equipment he is working on.

In addition, a minimum degree of protection of IP 53 shall be guaranteed (must be able to operate safely in the rain).

All working phases shall be directly or indirectly monitored (for example with micro-cameras) and must be confirmed by the operator (one by one or also giving cumulative confirmation for all phases)

The instrument shall be equipped with an automatic cable recognition system in order to acquire the information necessary for carrying out the mechanical operations, i.e. the diameters and thicknesses of the different layers of material making up the cable and the lengths that shall be removed for each mechanical operation. Alternatively, the machine could carry out a calibration of the thicknesses to be removed on the initial section of the cable (which will then be removed for final preparation).

The instrument shall be able to automatically select the appropriate accessory to be used for each type of operation (for this reason, the operator shall previously set the type of cable on the machine).

The instrument shall be able to remove the various materials of the cable with an accuracy of 0,1 mm for thicknesses and length to ensure that the thicknesses of the insulating, semiconductor and conductor layers are in accordance with the specification.

During processing, material removed from the instrument shall be disposed of in a specific container.

Processing shall be carried out in such a way as to avoid the entry of dust or other contaminants from the external environment. At the end of each stage of material removal, the instrument shall carry out a surface analysis to check the regularity of the material and remove any residual material.

The instrument shall be equipped with an integrated interface system with the operator (e.g. touch-screen display) and on an external support (smartphone, tablet). It shall also be equipped with a non-volatile memory containing the database with the characteristics of the cables and accessories used by Enel.

The main phases of the process are two: cable preparation and accessory installation.

About cable preparation phases are:

- Positioning and levelling of the instrument by the operator.
- Anchorage of the cable to the instrument by the operator.
- Performing the 90° cut of the cable end.
- Identification of the cable structure (type, dimensions...) by means of an automatic recognition system (e.g. optical). Verification of the data with the database stored in the memory.
- Automatic selection/acquisition of the characteristics of the accessory to be installed: if not present in the database, it must be loaded by the operator.
- Removal of the various layers of material, using laser and/or mechanical tools and checking the surfaces (irregularities, residues, etc.).

- Acquisition of detail and assembly images of the surfaces and interfaces between one material and another.
- Data recording: GPS position, environmental conditions, characteristics of accessories and cables, operator identification.

5.2 MV Cables accessory

As previously described, the tool shall be able to perform not only the cables preparation described in 3.3.1 but also the installation of terminations and joints.

Currently, the accessory installation phases (performed by an operator) are as follow:

5.2.1 Joints:

- Plate for screen connection installation (this phase includes the tape to seal the whole joint and protect the junction of the metallic screen)
- Body parking (preliminary installation of the body on one of the cable to be joint) ;
- Mechanical connector installation (with the correct installation of fuse break screws) ;
- Put the sealing compounds to preserve the screws cavity;
- Body positioning.
- Remove the body support.

5.2.2 Terminals:

- Plate for screen connection installation (this phase includes the tape to seal the whole terminal and protect the junction of the metallic screen)
- Mechanical conductor lug installation (with the correct installation of fuse break screws) ;
- Put the Sealing compounds to preserve the screws cavity;
- Installation of the component to control the electric field and main insulating housing;
- Remove the body support if present.