ANNEX G - MINIMUM REQUIREMENTS FOR CONSTRUCTION OF MV/HV AERIAL LINE AT WORKSITES

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SECTION 1 – GENERAL INFORMATION

1.1 Forward

The construction of overhead power transmission lines is one of the most complex and difficult engineering activities, both in organizational and operational terms. The multiple interferences that can arise along the power line route (under or over-passing electrical and telephone lines, buildings, roads, waterways, etc.) associated with terrain morphology and weather conditions, significantly increase the specific risks related to this work.

The personnel employed in the works must be highly specialized and trained as well as physically and psychologically fit.

The vehicles, equipment and PPE used must be suitable, efficient and scrupulously checked before and after use. If they show deformations or weak points (cracks, breakages or other defects) they must be replaced immediately.
The main risk for workers is falling from heights, which can be controlled by adopting proper conduct in line with validated work practices and an appropriate use of material and PPE.

The risk of objects falling from heights is always present and must not be overlooked. Hence, it is important to minimize interference between workers operating at heights and those stationed at the base of the support structure. All equipment on the support structure, when not in use, must be secured with straps or chains to prevent accidental knocking over and falling to the ground.

In summary, the safe execution of work on HV overhead lines requires careful planning, diligent task coordination by the supervisors in charge, respect for the operating procedures and the appropriate use of material and PPE.

In order to ensure the correct management of emergencies and considering that HV line construction is generally performed in remote locations far from medical facilities, it is important to always ensure that qualified medical assistance and an equipped ambulance are available nearby.

Moreover, the presence of a rescue stretcher or similar device must be ensured when operations at heights are undertaken.

The main elements that comprise a HV electric power line are: support structures, conductors and insulators.

With regard to Environmental Issues, pay particular attention to all equipment with motor or with the possibility of leaks of lubricating oil, fuel or other chemical components. Provide for leak containment containers. Dispose of any residue by the end of the work, if possible with daily cleaning.

"Support structures" can be pylons (lattice towers) or metal tubular poles. The choice of type of support depends on technical/financial considerations, on the characteristics of the line (voltage, length of spans, the need to reach high elevations to avoid interference with other plant, etc.) and on terrain characteristics (vehicle mobility, access to the line deployment zone by mechanical means, etc.).
The installation of tubular poles is possible only with large hoisting machines (cranes or helicopters) while pylon structures can also be transported in loose sections by simpler means of transport, such as trucks or draught animals (mules).
Moreover, the assembly of lattice trusses can be performed with the use of "gin poles", which can also be transported as loose rod sections.
Generally, the use of pylons in open areas is always possible and therefore they are more commonly deployed.

In cases where lines pass through areas with housing or road interference, the use of tubular poles can be a technically valid solution, since the reduced dimensions of their bases allow them to be installed in confined spaces, such as roadway central reservations or roadside gutters.

As a rule, tubular poles are not used for voltages over 150 KV.
The choice of the type of support structure must be considered beforehand during the design phase to allow for a careful assessment of the risk and avoid construction and safety-related complications during the subsequent construction phase.

Conductors are made of composite aluminum/steel which combines the excellent characteristics of aluminum (weight, conductivity, price) with the mechanical strength of steel.

The most common "insulators" are the bell-shaped type made in glass. Recently, isolators made of

composite material are also being adopted; they are lighter, more robust and more practical to install.

1.2 Purpose of this document

To define the general criteria and measures to be applied during the construction of HV transmission lines in EGP worksites in order to ensure the adherence to appropriate worker safety standards and the correct use of equipment.

SECTION 2 - ASSEMBLING SUPPORT STRUCTURES

2.1 Excavations and foundations

The worksite area must be well defined, marked and of sufficient extension to ensure the manoeuvrability of vehicles in use. Normally, where heavy vehicles are used (excavators, trucks, cement mixers, etc.) it is important to ensure that the access routes to the worksite are of sufficient size for the transit of vehicles. It is also necessary to verify that the ground is firm enough to support the weight of heavy vehicles:

- On-site personnel must pay the utmost attention to moving vehicles;

- People must pay particular attention as concrete mixer trucks approach the excavation area, since the excessive weight of the vehicle could cause ground subsidence. At this stage, it is advisable for the personnel engaged in the concrete casting to keep at a safe distance from the excavation until completion of the operations, with the mixer truck stationary in a stable position;

- The work area must be well marked and kept in an orderly manner. Personnel working near the excavation must be secured with the appropriate PPE against the risk of falling;

- In the case of excavations with depths > 1.5 metres, the risk of ground subsidence and the consequent risk of workers being buried must be considered. The excavation should be dug with inclined walls or fitted with safety shoring, depending on the nature of the terrain;

- Avoid the accumulation of waste material near the excavation, paying particular attention to rocks and stones.

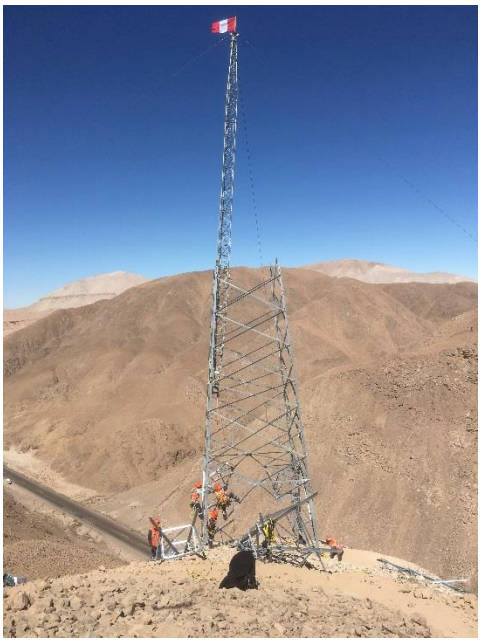
2.2 General remarks

In the assembly phase, regardless of the type of support used, the following general measures must be taken into account:

- Assess possible interference from works and services external to the worksite (public roads, power or telecommunications lines, etc.) and organise the work areas to minimise them;

- Inside the worksite, manage any interference between operations at heights and those on the ground. As far as possible, ensure that people do not transit or remain directly under places where work at height is underway;

- Use of steel tie rods and special rope winches for the fixing and control of the "Falcon", in order to facilitate the movement of the "Falcon";



- Only suitably qualified personnel may climb on the support structure and they must be equipped with appropriate PPE that will allow them to perform the climb and remain at the elevated workplace in safety;

2.3 Tubular pole supports

When climbing on the support structure, workers must always be harnessed to the structure itself with the appropriate PPE. It is forbidden to fasten the safety hook to ropes or other extensions that may compromise the functionality of the fall-arrest device;

- Before hoisting the pole sections, consult the load tables to ensure that the load capacity is suitable for the weight to be lifted;
- Hoisting gear (cables and slings) must be suitable for the load to be lifted and visually checked before use;

- During the hoisting of the various sections, all personnel not strictly engaged in the task must move away to a safe position;
- Before hoisting the pole sections, check that the rungs to be used for future ascents are fully tightened;

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- Connect two ropes of adequate length to the pole section being hoisted to allow the control of swinging from the ground and facilitate the coupling of the sections to each other;

- Before hoisting the second pole section, check that the first section is fully upright (in plumb) and that its climbing rungs are tightly fastened. The final tightening must be performed with a torque wrench or other device which ensures that sufficient force is applied;

- Check that the pole sections are perfectly coupled together before proceeding to climb on the pole to unhook the crane slings from the raised section;

2.4 Pylons

- Workers at height on the pylon must always be secured to the structure with the appropriate fall-arrest PPE;

- It is forbidden to fasten the safety hook to ropes or other extensions that may compromise the functionality of the fall-arrest device. In such circumstances it is preferable to directly install a dedicated safety line;

- The fall-arrest device must be anchored to a rod of the pylon truss (preferably a horizontal one) and not to the lateral rungs fitted to assist climbing;

- Where possible, if mechanical equipment can access the worksite, it is preferable to assemble the pylon sections at ground level and then hoist them into position by crane;

- Before hoisting by crane, the sides or lateral sections pre-assembled on the ground must be secured with ropes of adequate length to allow any swinging of the load to be controlled from the ground and to guide the sections as they are coupled together.

- All tools and equipment used by workers at height must be secured to the pylon or tied to the operator to avoid accidental object falls;
- In the event of assembly using a gin pole, take all the necessary precautions during the installation and movement of the gin pole itself along the pylon structure;

- Depending on the chosen assembly method (by sections, sides or loose rods), the gin pole may be installed inside or outside the pylon frame. For safety, personnel assigned to the work must remain inside the pylon frame if the gin pole is installed externally and vice versa;

- Check the tightness of the gin pole bolts before use; if necessary, brace it with pegs, ballast or other dead centre struts.
- Check that the capacity of the gin pole is adequate for the maximum load to be lifted.
- During assembly work, all personnel not directly involved must move away to a safe position. Within the worksite, manage any interference between operations at heights and those on the ground until all moving parts have been fastened;

SECTION 3 - INSTALLATION OF THE BUNDLE ASSEMBLY AND INSULATORS

Hoisting of the bundle assembly and insulator gear must normally be carried out with the service cable and the return pulley. If the weight of the elements to be lifted is compatible with the strength of the operators, this task may be carried out directly by hand, in this case, specify the specific implementation procedures and risks involved in the work processes. In the case of heavier elements, a motorized winch with adequate load capacity should be used. Another suitable method for hoisting these elements is by crane. It is forbidden to use hoisting solutions other than those listed above. Should unexpected unavailability prevent the use of traditional hoisting equipment and other methods must be used, specific work procedures must be drafted taking into account all possible risks for the operators and the relevant operations must be organized in such a way as to minimize them. In particular, in the exceptional case of use of moving vehicles, it will be necessary to:

- define the worksite area encompassing the maneuvering spaces;
- assess the general conditions of the terrain (excessive slopes, presence of holes, wet areas with the risk of loss of grip and poor vehicle control);
- avoid interference between workers at height and those on the ground and between the latter and the moving vehicle;
- use a rope to control any swinging of the load from the ground;
- ensure the presence of an operator near the vehicle to facilitate communication between the personnel at height and the driver;

- organise the activity so as to avoid vehicles and personnel passing directly under the element being hoisted until it has been firmly secured to the pylon structure.

- Use of pilot cable pre-installed during the assembly of the towers to avoid further maneuvers of operators at high altitude during the tightening phase, thus limiting the risk of falling;

SECTION 4 - STRINGING THE HV LINE

- Before starting the stringing operations, inspect the area to identify all potential interferences (power and telecommunication lines, road crossings, waterways, houses, etc.) and assess the operational options that will ensure the safest possible execution.
- In the vicinity of road crossings with traffic, provide suitable means of protection to restrict the fall of the conductor in case of accidental collapse. Where necessary, deploy someone to control traffic.
- In case of other power line crossing or parallel segments, assess the option of putting the interfering line out of service by contacting the utility that operates it. Before starting work, directly ascertain the actual disconnection in situ according to the 5 golden rules;

- Deploy some operators along the entire section to be strung and, in particular, at the points where the conductor is subject to greater stress (acute angles, particularly long spans, underpass crossings with vertical upward pull, etc.);
- Ensure radio contact between the winch and engine brake operators and those positioned along the line. The radio link must always be tested before starting stringing operations;

- The winch and engine brake must be placed in stable positions and anchored with sufficient strength to counteract the line tension (concrete blocks or other ballast). The same consideration applies to the systems anchoring the conductor.

- Having defined the supports that limit the extremities of the section to be strung, the winch and the brake are positioned respectively in front of and behind the aforementioned anchors.
- As a rule, do not use conductors that have not yet been definitively fastened as fall-arrest anchorage points, it is preferable to anchor to elements designed for this purpose, (crossbar, hanging ladder) or a crane with operator basket. The adoption of alternative measures must be supported by drafting work procedures that include a careful risk assessment.

- The temporary anchoring of the conductors (prior to the final tension stringing of the line) must be performed with a self-tightening double-clamp safety system or with a single system with a bolt clamp.

- The conductor reels must be positioned upstream of the brake and installed on reel-lift stands with braking devices to control the conductor pay-off and ensure sufficient mechanical tension at the brake inlet. During the stringing phase, in as far as possible, everyone should remain at a safe distance from the conductor and the moving reel. If available, it is preferable to use a hydraulic brake with remote control.
  It is forbidden to perform manual braking on the reels or to use improper devices such as wooden planks or other objects;

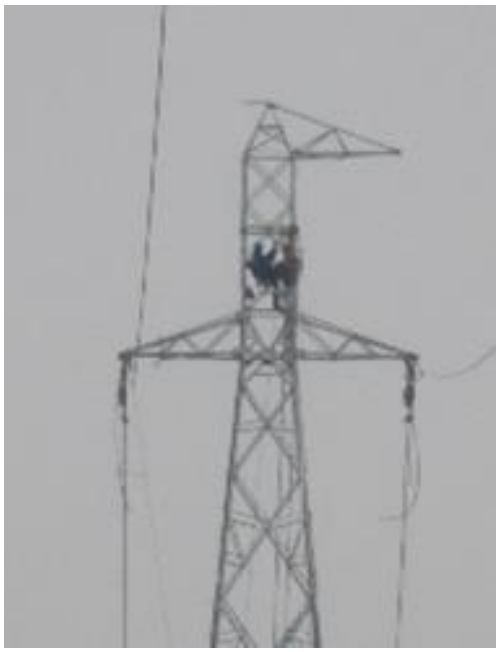
- It is forbidden to act manually on the conductor while it is being pulled between the winch and the engine brake. The uncontrolled release of the conductor could cause serious damage to operators and structures. If it is necessary to access the conductor at significant elevation above ground level, use suitable hoisting means such as a mobile elevating work platform, ladders supported by some element other than the conductor, or scaffolding;

- Before starting the stringing operations, ground all the metal chassis of the mechanical equipment employed (winch, brake, crane, metallic or conducting cable). For effective grounding via a good contact with the chassis of any metal equipment, use the earthing bolt fitted precisely for this purpose where available. In cases where there is no grounding bolt, the grounding cable may be directly connected to a bare metal part of the chassis (free of paint or rust) with a clamp;

- Tighten clamps or bolts firmly and sink the ground rods firmly into the soil (depth > 50 cm). With regard to the conductor or the pull rope (if metal), grounding must be performed with the special mobile roller device positioned both on the winch side and on the brake side;

- It is good practice to position the winch and the brake on a metallic mesh grounded at the ends and connected to the same ground rod used for grounding the mechanical equipment. The mesh must extend for at least 1.5 metres beyond the footprint of the mechanical equipment to ensure equipotentiality between the operator and the equipment itself;

- During the stringing operations, while the conductor is in motion, operators must remain inside the pylon structure to avoid being accidentally struck by a possible loosening of the conductor (whiplash);



- Before starting the stringing operations, evaluate the stresses to which the pylon is subject; if necessary, providing adequate reinforcements (bracing, support tie-rods for crossbars or other);

- In event of temporary suspension of activities (e.g. lunch breaks or bad weather), the worksite must be safely secured, with particular attention to the anchoring of the conductors and the segregation of areas where access is forbidden to non-authorised persons.

SECTION 5 - MANAGING INTERFERENCE WITH OVER OR UNDER-PASSING LIVE POWER LINES

In EGP worksites (particularly in Central/South America), when laying new HV overhead lines, it is normal to intercept other live power lines which force an under or over-pass. In these situations, the first objective should be to disconnect the interfering line, should this not be possible, the electrical risk for personnel engaged in the work is particularly high. This risk is related to the possibility of contact or proximity induction, between the element being strung (pull rope, conductor or shield wire) and the intercepted live line. In both cases, the risk of electrocution for the workers on site is real and must be handled by adopting measures that mitigate the risk of contact or the excessive proximity between elements being strung and the conductors of the intercepted live line. In order to perform this work in safety, it will therefore be necessary to implement specific work procedures on a case by case basis. These must take into account the electrical risk involved, provide for the use of highly qualified personnel and the use of dedicated vehicles and tools (insulated ropes, special equipment, etc.). For the optimal control of electrical risk, it is essential to ensure the condition of equipotentiality between the operators and the mechanical equipment or structures (pylon or tubular poles) in contact with the element being strung. This chapter lists the general safety criteria to be adopted for the execution of crossings with live lines, from the design phase to practical implementation:

- DESIGN: Starting at the design phase, assess the possibility of minimizing interference with external services (roads, power and telecommunications lines, other). Should it become inevitable that other live power lines will be crossed, provide for an adequate length of the crossing segment and an intersection angle as close as possible to 90° (this to minimize interference between the lines);
- REQUEST A POWER SHUTDOWN FOR LINE STRINGING OPERATIONS: When crossing other live power lines, before carrying out the work, assess the possibility of a power shutdown on the interfering line. This requires that arrangements be made in advance with the Owner/Network Manager. If it favors the concession of a power shutdown by the Owner/Network Manager, consider the possibility of performing the work during night-time. In fact, should it come to a choice between the two options (daylight crossing work with a live interfering line or a night-time crossing with the interfering line disconnected) the second option is preferable because, even if the work is done at night, operations can proceed in greater safety and there is less risk to workers;
- REQUEST FOR POWER SHUTDOWN FOR THE ASSEMBLY OF PROTECTION STRUCTURES: If it is not possible to put the HV line out of service for the time necessary to implement the crossing, consider the possibility of a short power shutdown, possibly also at night-time, to allow at least

for the construction of protective structures capable of preventing contact/proximity between elements being strung and the live interfering line;

- WORK PROGRAMMING: It should be kept in mind that crossings with existing lines must always be carried out against agreements with the Owner/Network Manager which may require notice times of weeks or months. This also applies if the interfering line remains in service. In consideration of the above, it is advisable to make the crossings as autonomous as possible with respect to the construction of the rest of the power line. In this sense, it may be convenient to anticipate the implementation of the supports of the crossing span with respect to the work on the rest of the line. Being ready and being able *to* ask for authorization with considerable advance can facilitate the power shutdown on the interfering line and avoid delays in the construction of the power line, with rapid connection times to the network and production possibilities of the plant. Finally, and more importantly, it must be considered that, planning work in advance, allows a better assessment of the organization of the activity and greatly reduces the risks for workers;
- DISABLING OF AUTOMATIC RECLOSERS: Despite the above assessments, should it not be possible to obtain a power shutdown of the interfering line, an agreement should be determined with the relevant owner/manager to disable the automatic reclosing mechanisms. This condition is essential both for the assembly of protection structures and the stringing of the new power line. Automatic re-closers must remain disabled for the duration of the works. It is quite normal that these stringing phases will last for a number of days; in such cases, if requested by the Owner/Manager, the interfering line re-closers may be reset to automatic standby at the end of the working day and disabled again when work restarts. In any case, the disabling of automatic re-closers must always be checked before work begins. Failing this verification, work must not be allowed to start;
- WEATHER CONDITIONS: rain, humidity and strong winds can significantly reduce air-insulation clearance. Also fog and haze can worsen electrical risk, since good visibility is a basic requisite for safety in this type of work. Therefore, before starting the activity and during the work, assess the prevailing weather conditions and how they are changing. In the event of poor weather conditions, the works supervisor may decide to suspend operations if deemed appropriate. In this case, the worksite must be secured in safety, adequately positioning suspended elements and blocking the stringing machinery. Furthermore, all areas with access forbidden to unauthorized persons must be properly segregated;
- PROTECTIVE MEASURES AGAINST DIRECT CONTACT: Given the presence of an interfering live power line, for safe execution of the crossing phase, it is advisable to install some means of protection that ensures adequate clearance, also in the event of the strung line going slack. The preparation of such a protective structure requires the drafting of a Technical Report which describes the characteristics of the elements constituting the structure itself (cranes, scaffolding, wooden poles, steel tie-rods, ropes, insulated ropes, other) and the relevant assembly procedure (work methods, number of assigned workers, list of vehicles and equipment), as well as the grounding system for metal parts, where applicable. A detailed drawing should be included in the Technical Report, indicating the dimensions of the structure (height, width, protective mesh gauge, other) and the clearances with respect to the live interfering line. The Technical Report must also include the Design Calculations which ascertain the stability and strength of the structure in the event of accidental fall of a conductor during handling. It should be noted that the protective structure has the purpose of avoiding accidental proximity of the elements being strung with the conductors of the live interfering line. Therefore, the structure cannot be used as a support base for the elements being strung, which must always be kept at a distance to avoid direct contact. In some cases, the assembly of a protective structure can be excessively complex and laborious. In these cases, the solution for protection against direct contacts may consist of an insulated net, equipped with sliding rings fitted to a load-bearing cable which is anchored to the support structures straddling the crossing section;
- PROTECTIVE STRUCTURES FOR GUARDING AGAINST DIRECT CONTACTS IN MULTIPLE CROSSINGS WITH LIVE UNDERPASSING HV AND MV LINES: In cases where a number of live HV and MV lines are being crossed, it may be necessary to create specific protection structures for each interfering line. In these cases, the structures will probably have various dimensions and may be made from different materials. Nevertheless, all protective structures must be compatible

with each other and adequate in terms of height, clearance and mechanical resistance in the event of a fall of the conductor being strung.

- LINES HAVING MORE THAN ONE CONDUCTOR PER PHASE: In the case of lines with two or more conductors per phase, always assess the possibility of handling one conductor at a time as this facilitates the control of stringing operations and reduces the risks;
- USE OF DUAL CLAMPS FOR TEMPORARY ANCHORING: For safety purposes, temporarily strung conductors should be fastened by means of dual clamps. This condition must be enforced until all operations are completed, i.e. until the strung conductor has been definitively anchored and connected to its chain of insulators;
- STRINGING WITH POWERED WINCH AND ENGINE BRAKE: Always consider the option of completing the crossing by using a powered winch and an engine brake, as this method is safer than manual stringing. In fact, the use of mechanical means allows for a better control of the pull and facilitates the establishment of equipotential bonding between the workers and equipment in use (a basic condition for the management of electrical risk when working on overhead lines);
- MANUAL STRINGING: After a careful assessment, if the type of crossing does not allow for the use of winch and brake (e.g. difficult access or problems in positioning mechanical equipment due to lack of adequate space), then manual stringing remains the only option. In this case a procedure must be defined that excludes the risk of contact or proximity between workers and the element to be strung. In fact, with manual stringing, the control of the pull is less effective and there is greater difficulty in ensuring equipotentiality for the workers;
- EQUIPOTENTIAL BONDING FOR WORKERS OPERATING MECHANICAL EQUIPMENT: As previously mentioned, equipotential bonding is a crucial safety criterion for the mitigation of electric risk for workers on HV lines, especially when crossing live interfering lines. For effective equipotentiality, the mechanical equipment must be placed on a suitably grounded metallic mesh, to which the chassis of the equipment must be connected via the movable grounding device. This applies to machinery such as the winch, brake and reel-lift stands as well as the element being strung (pull rope, conductor, and shield wire) – see SECTION 4. The mesh pitch must be sufficient to ensure effective contact with the operator's feet (50x50 mm). Should the mesh have a greater pitch (maximum 100x100 mm), two overlapping meshes must be laid to ensure closer grid spacing. Furthermore, the grounding mesh must over-extend by at least 1.5 meters along the entire perimeter of the vehicle/equipment footprint so that an operator touching the mechanical equipment is always standing on the equipotential mesh. The mesh deployed in this manner must be grounded at its four corners and at the center with grounding rods sunk to at least 50 cm. Also the reel-lift stand should rest on a grounded metal mesh which is equipotentially bonded to the brake's ground mesh. All ground connections (clamps, connectors, terminals, etc.) must be clean, free of oxide or paint and tightened securely to ensure an effective connection (see SECTION 4). Workers who are not strictly involved in the task at hand must move away to a safe position. The approach of personnel not directly involved in the work underway will be allowed only on the express authorization of the works supervisor once the latter has ordered the necessary precautions (suspension of stringing operations, blocking of mechanical equipment, etc.). Also the crane, which is normally equipped with pulleys, must be properly grounded. To ensure proper equipotential bonding between the crane and the operators engaged in handling operations, an equipotential metal resting surface must be provided, with a structure similar to that envisaged for the winch and brake. For large cranes, a partial ground mesh covering is allowed; it need not occupy the entire footprint of the crane provided it ensures adequate protection to metal surfaces typically in contact with the operators (control panel, cockpit access points, any other parts of the chassis) with a 1.5 meters over-extension. Furthermore, the pulleys fitted to the crane must be insulated to a rating appropriate for the voltage level of the interfering line;
- EQUIPOTENTIAL BONDING FOR WORKERS OPERATING ON SUPPORT STRUCTURES: As a rule, the presence of operators on the support structures is required during stringing operations so that they may give assistance as required. Operators working on the support structures straddling the crossing section must take up positions at a safe distance from the element being strung. Should it be necessary to come into contact with the same, it is always mandatory to establish equipotential connection with the support structure before touching the element being strung with the hands. For this purpose, the operator may use the equipotential device (ground terminal and

insulating stick) or the movable roller device if it has been previously connected between the element being strung and the support structure;

- INTERFERENCE WITH WORKS ON OTHER SUPPORT STRUCTURES ON THE SAME LINE SEGMENT: When work is underway on the crossing span, operations planned on other support structures of the same section should be suspended. In fact, if the support structures straddling the crossing span are connected with other support structures of the same line (via shield wire, metal pull rope and/or conductor on pulleys), a hazardous voltage could be transferred to all the interconnected support structures of a given section, with increased electrical risk for all operators working on the line. In the above described conditions, it is therefore necessary to avoid scheduled operations on the section until all crossing-related work has been completed and all the conductors and shield cables have been definitively anchored or blocked with a dual clamp if the fastening is temporary. The same requirements as above must be adopted (EQUIPOTENTIAL BONDING FOR WORKERS OPERATING ON SUPPORT STRUCTURES) if it is strictly necessary to work simultaneously on the crossing span and on other support structures of the same section.