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REPLACEMENT OR REPAIR OF STOLEN OR DEFECTIVE EARTH TAPES

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PURPOSE AND SCOPE

A correctly designed earthing system is inherently safe under both steady state and transient fault conditions and therefore should present no danger to persons present within its vicinity. If though an earthing system is defective because of theft of part of that system or depleted because of defective or damaged connections, then work should be undertaken in a safe manner to restore the earthing system back to normal.

In order to do the corrective work necessary to restore the earthing system back to normal and because it is not practical to de-energise the network to do so, temporary connections will need to be applied safely and as appropriate prior to the commencement of any permanent repair work.

This Document provides guidance on methods of safely applying these temporary connections and is intended for use within National Grid substations and cable sealing end compounds. This document should also be read in conjunction with NSI 24.

Guidance on how to determine whether there is a break in earth continuity from a overhead line terminal tower to its donor substation and on how to temporarily re-establish this bond safely prior to its permanent repair is detailed within National Grid documents TGN(E)204 and TGN(E)215

PART 1 –PROCEDURAL

1 GENERAL DANGERS

Earth tape theft is normally of the above ground connection to the bases of primary plant but, less commonly, earth tape is also taken from below ground.

Earth tape defects range from the deterioration of welded underground jointed interfaces on an earthing grid to a high resistance bolted connection between a tape and the primary plant.

Both defect types can result in a depleted earthing system that may present danger from electrocution, burns or injury from flying debris to persons in the vicinity.

1.1 Above Ground Earth Tape

Under steady state conditions, the earth tape ensures that the bases of primary plant are at earth potential, thereby preventing significant induced potentials appearing on the support structures. If earth tape is removed from a structure there is a danger of an induced potential appearing on the structure and on the remaining earth tape connected to the base of the primary plant. It is not safe to touch the remaining tape connected to the base of the primary plant or the support structure because the structure will form the lower part of a (both resistive and capacitive) potential divider consisting of the structure and the primary plant. The level of induced potential will be dependent on the environmental conditions, the type of primary plant, and the precise construction and condition of the structure.

In the case of structures supporting shunt connected equipment such as surge arresters and CVTs, or physically large items of primary plant (having a large capacitance) ie power transformers, the likelihood of there being a dangerous potential present on the structure and remaining tape will be greater due to the relatively low impedance path provided by the primary plant.

During poor weather conditions, there will be an increased risk of dangerous induced potentials appearing on the structure and on the remaining earth tape connected to the base of the primary plant. This is because, firstly the surface resistance of the insulation may be reduced (a good indication of this is increased insulator surface activity) and secondly, voltage surges (due to lightning or system faults) may be conducted through shunt connected equipment.

If earth tape is removed from a steel structure, there is little danger of induced potentials appearing on the structure unless the connection between the structure itself and the *Main Earth System* is in doubt, in which case the danger from induced potentials is similar to that for a concrete structure.

Surge arresters present an additional hazard irrespective of whether they are mounted on steel or concrete structures, since for an arrester mounted on a steel structure, the earth tape connection to the base of the arrester will be insulated from the structure to permit connection to a surge counter. Dangerous induced potentials may be present on the remaining tape connecting to the surge arrester during steady state conditions.

In the event of a system fault in the substation, the earth tape which connects the bases of primary plant to the *Main Earth System* provides a safe conducting path for fault current. If the tape is removed, and a fault occurs, the fault current will take an alternative path. A steel switchgear support structure would provide an adequate current path with minimal consequential danger but a concrete structure may conduct the fault through its steel reinforcement members with the result that the structure may rupture catastrophically. In this case there is a danger of being struck by flying concrete or hot metal. There is an increased likelihood of a system fault during poor weather conditions.

1.2 Below Ground Earth Tape

Under steady state conditions, in an earth system in which part of the below ground earth tape has been removed, dangerous induced potentials may be present between sections of earth system which may have become segregated.

In the event of a system fault in the substation, the below ground earth tape serves to reduce step and touch potentials to safe levels. If part of the below ground earth tape has been removed, under fault conditions, there may be dangerous step and touch potentials throughout the substation but more likely in the vicinity of the area from which earth tape has been removed. Additionally, under these conditions, there may be dangerous transferred potentials on the remaining severed tape and any multicore cables present.

Below ground earth tape acts as an earth electrode providing a means of conducting fault currents into the general mass of earth. If a section of tape is removed there will be an increase in the total site impedance to earth. In the event of a system fault in the substation, the substation potential rise will therefore be greater and consequently so will the step, touch and transferred potentials. However, for there to be a significant increase in the total site impedance to earth, there would need to be considerable damage to the below ground earth system, ie the segregation of a significant part of the system

2 APPROACHING AND WORKING ON EARTH SYSTEMS

The safety precautions which must be observed when working on National Grid earth systems are covered within National Grid document NSI 24 - Work on Earth Systems, which draws advice from this document.

Before any work is carried out on an earth **System** it must be adequately planned. The full extent of the work including any equipment required to carry out its repair must be considered and factored into the supporting site specific risk assessment.

Appendix A provides an example of a risk assessment produced to manage the reconnection of a defective substation earthing system, with Type 1 earthing clamps.

2.1 Approaching Main Earth Systems

2.1.1 Approaching intact Main Earth System(s)

There is no restriction when approaching intact Main Earth System(s).

2.1.2 Approaching inadequate Main Earth System(s)

- (a) For concrete structures supporting **Equipment** where the electrical connection to the *Main Earth System* is missing or suspect:
 - (i) No approach is allowed, closer than 10 metres to a structure, where there is an increased risk of a **System** fault. This could include poor weather conditions, construction work taking place in the substation or when water washing of insulators is taking place.

Informative Note: In the event of an emergency involving personal safety, it is permissible to approach within 10 metres, but no closer than 1 metre, to the structure.
 - (ii) Approach up to 1 metre from the structure is permitted where none of the conditions in (i) above exists.
- (b) For metallic structures supporting **Equipment** where the electrical connection from the **Equipment** to the *Main Earth System* is missing or suspect:
 - (i) There is no restriction on approaching any structure if the base of the structure is connected to the *Main Earth System*, except in the case of structures supporting surge arrestors or cable sealing ends. In this case, approach closer than 1 metre is prohibited.

Informative Note: This is due to the surge arrestor base or cable sealing end being independently earthed from the structure.
 - (ii) Where the connection from the base of the structure to the *Main Earth System* is in doubt, approach closer than 1 metre to the structure is prohibited.

- (c) For buried earth tapes:
 - (i) Before approaching closer than 1 metre to any disturbed earth tape the **Senior Authorised Person** must assess the risks and identify the precautions that need to be taken to prevent **Danger**. Where appropriate, further assistance can be obtained from specialists in Asset Management.

2.2 Work on Main Earth System(s)

Making or breaking connections in *Main Earth Systems* must only be carried out after the point of work has been safely bridged out using an **Approved** fault rated earth bond of equivalent current carrying capacity to the tape being worked on.

The application of these **Approved** fault rated earth bonds firstly eliminating dangerous induced potentials which may exist on a depleted earthing system under normal system conditions and secondly manages safely and transfers any dangerous induced or fault currents to earth which may present itself on the local earthing system.

There may though be few instances where it is not possible or it is impractical to use the **Approved** fault rated earth bond to make the system safe prior to the start of any work on the *Main Earthing System*. Examples of when this is likely are listed below:

- a) When the earth tape to be worked upon is of smaller profile to that which can be accommodated by the **Approved** fault rated bond clamp (CE20/2/A/S/RT which ranges 38-50mm tapes).
- b) The earth tapes physical orientation is such that the application of the **Approved** fault rated clamp present unacceptable manual handling issues.

When the **Approved** fault rated earth bonds is not practical for use then there is a responsibility on the person planning the work to fully understand all the issues and additional risks seen by using the **Approved** non-fault rated bond prior to the application of a fully rated bond.

One way of understanding and quantifying the additional risk associated with not using the fault rated bond can be by the use of risk assessment. Appendix A gives an example of when risk assessment can be used to examine these issues locally and in detail.

2.3 Work on Other Earth System(s)

The general principles and the requirement for risk assessment apply, and any *Earth Bond* must be appropriate for the duty it has to perform.

2.4 Work to re-establish the earthing connection between a Substation earthing system and an associated OHL Terminal Tower leg.

It is extremely important that the continuity between a substation earthing system and terminal tower/s are maintained for a number of safety reasons:

- a) Separation of the overhead line earth from the supplying substation earth will result in higher rise of earth potentials being seen under fault conditions both at the substation and on the associated OHL. This is because of the loss of mutual benefit each provides the other when interconnected.
- b) Under both system healthy and fault conditions, dangerous transfer potentials may exist across the point of break in that interconnection.