WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Company Directive

STANDARD TECHNIQUE : TP21K/1

Relating to Substation Compound Fence Earthing

Policy Summary

This document defines how substation compound fences shall be earthed and constructed so as to control electric shock hazards. Requirements concerning metalwork within 2m of such fences (ie metal lighting columns, security beam towers/cameras, external fences, noise enclosures and stays) are also covered.

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Implementation date: March 2014

Approved by:

Policy Manager

Date: 28 March 2014

Implementation Plan

Introduction

The document defines how substation compound fences shall be earthed so as to control hazards.

Main Changes

Branding changes only.

Impact of Changes

None, the content remains the same.

Implementation Actions

None.

Implementation Timetable

Immediate.

Document Revision & Review Table		
Date	**Comments**	**Author**
March 2014	• Brand changes to incorporate the Midlands area and remove references to SWEB.	Graham Brewster

1.0 INTRODUCTION

This document defines how substation compound fences shall be earthed and constructed so as to control electric shock hazards. Requirements concerning metalwork within 2m of such fences (ie lamp posts, detection/surveillance systems, external fences, noise enclosures and stays) are also covered.

2.0 SCOPE

This policy applies specifically to all 132kV and 33kV compound substation fences (including PVC covered chain-link).

The requirements of this policy also apply to other metal substation fences if supported on conducting posts or otherwise earthed.

This ST shall be read in conjunction with ST:TP21B and POL:SP5 and associated STs.

3.0 POLICY

3.1 Earthing of Fences

Substation compound fences shall be effectively earthed using one of two arrangements:-

independently earthed (ie electrically separate from the substation earth electrode)

earthed via direct connection to substation earth electrode.

Refer to the Technical Policy Manager where it is required to have a combination of these two methods.

3.1.1 Independently Earthed Fence

A substation compound fence may only be independently earthed if specific criteria are satisfied:-

the fence is electrically separate from the substation earth electrode (ie no direct connections)

there is no hand-to-hand touch hazard. That is, there is a minimum 2m separation above ground between conducting parts which can attain different potentials and could be touched simultaneously (eg between the fence connected to earth and other independently earthed conducting parts such as metalwork connected to the substation earth electrode, other independently earthed fences and stays).

there is a minimum 2m separation below ground between conducting fence posts/fence earth electrodes and conducting parts common with the substation earth electrode.

Care is required to achieve effective separation. Special consideration shall be given to:-

earth electrode and cables passing under the compound fence

stay wires within 2m of the fence

metal gates/doors

all modifications to the substation involving the fence and within 2m of it.

Measures to achieve effective separation include:-

insulating cables and electrodes passing under the fence for 2m either side (eg wrapped insulation or installed in plastic duct).

positioning stay wires so that they pass no closer than 2m from the fence above ground or, where not possible, insulating them to achieve the same effect

ensuring a minimum 2m separation from the fence with the swing arc of gate and door conducting parts earthed via the substation earth electrode

insulating metalwork to remove touch hazards

providing the bond between insulated lighting columns and the substation earth electrode using insulated copper to ensure 2m separation below ground is not compromised.

Figure 1 summarises separation requirements. Note that this shows above-ground metalwork (eg security beam column) connected to the substation earthing system outside of the earth 'grid'. This may create touch hazards. Refer to ST:TP21B.

3.1.1.1 **Earthing Requirements**

Earthing for an independently earthed fence shall comprise 3m earth rods installed vertically:-

at each fence corner

at each gate-post

below the outer phase conductors of each overhead line where it crosses the fence

with a maximum spacing along the fence perimeter of 50m

such that no section of fence remains unearthed. See 3.4 for exceptions.

Where such a fence is electrically discontinuous and the separation between sections is less than 2m, continuity bonding or insulation shall be added to control possible touch hazards. Specific requirements for gates are given in 3.2.

Figure 2 shows an example installation.

Where ground conditions are difficult and prevent a 3m driven rod, it is permissible to install the two 1.5m rods each to a depth of 1.5m provided that:-

they are horizontally separated by 1.5m or more (eg to next post)

the combined fence earth resistance achieved is a maximum of 100 ohms (ie additional rods may be required along the fence).

It is assumed that metal fences are electrically continuous with low resistance joints. If this is not the case, (eg due to corrosion or construction) continuity bonding may be required to meet the requirements above.

3.1.1.2 **Connections**

Fence earthing conductor, connecting the fence to its earth electrode, shall be a minimum of 70mm^2 in copper in accordance with ST:TP21B.

For jointing requirements and methods, see ST:TP21B and ST:TP21L, respectively.

3.1.2 **Fence Earthed Via Direct Connection To Substation Earth Electrode**

3.1.2.1 **Criteria**

The permitted alternative method of fence earthing is to effectively connect the fence to the substation earth electrode. A perimeter potential grading electrode is required to control the higher touch voltage which can arise on the fence. However, if it can be demonstrated that the maximum possible touch voltage which could arise on the fence will not exceed permitted levels, then no potential grading electrode is required. Guidance can be obtained from the Technical Manager.

3.1.2.2 **Earthing Requirements**

The fence shall be connected to the substation earth electrode:-

at each gate-post

below each overhead line where it crosses the fence

with a maximum spacing along the fence perimeter of 50m

such that no section of fence remains unearthed.

In addition, earth rods shall be installed and connected to the gate-posts as per 3.1.1.2 above.

The perimeter potential grading electrode shall be installed 0.5m below finished surface level, 1m out from the fence. An arc shall be formed at corners to maintain the 1m separation exactly. This electrode shall be of bare copper tape or bare stranded copper conductor with cross-sectional area equal to or greater than the main substation earth electrode. A minimum of 70mm^2 in copper shall apply in accordance with ST:TP21B.

Figure 3 shows an example installation.

It is assumed that metal fences are electrically continuous with low resistance joints. If this is not the case, (eg due to corrosion or construction) continuity bonding may be required to meet the requirements above.

3.1.2.3 **Connections**

Fence earthing conductor, connecting the fence to its earth electrode, shall be a minimum of 70mm^2 in copper in accordance with ST:TP21B.

For jointing requirements and methods, see ST:TP21B and ST:TP21L, respectively.

3.2 Gateposts And Gates

To control hand-hand touch potential, gates in substation compound fences shall be effectively bonded together by:-

connecting each gate to its supporting gate-post using flexible copper conductor of 35mm^2 minimum cross sectional area conductor at both top and bottom hinges.

connecting gateposts together using bare copper tape or bare stranded copper conductor of 50mm^2 cross sectional area. This bond shall not be installed in a duct.
The inter-gatepost bond shall be used as a potential grading electrode to control hand-foot touch voltage by installation 1m from the gates, 0.15m deep. See Figure 4.

3.3 Posts And Panels

Metal fence panels which are not bolted to their supporting metal posts shall be bonded to the posts using copper conductor of 50mm^2 minimum cross sectional area. This applies to the loose fish-plate design of palisade fence which is no longer compliant with POL:SP5.

3.4 External Fences Abutting Substation Compound Fences

To control hand-hand touch potential, external fences which abut the compound fence and are or may be independently earthed shall be effectively separated from the compound fence.

Effective separation shall be achieved by one of the following:-

having a 2m separation (Figure 5a) if land under WPD control

installing a 'palisade wing panel' mounted on approved insulated bushings at each end, effectively achieving 2m separation (Figure 5b) between substation earth electrode and external abutting fence. Approved insulated bushings are given in Appendix A.

Alternatives, which are not preferred, but approved are:-

installing a wing panel constructed of non-conducting material, meeting Company fence security standards, effectively achieving 2m separation

having floating panels with 5cm effective air gap at each end, as shown in Figures 5c and 5d, mounted on posts insulated from the ground.

Note that WPD cattle fences are considered to be unearthed when mounted on concrete posts. Consequently, the above requirements do not apply.

4.0 BACKGROUND

There are several situations which could cause an electric shock hazard in the vicinity of a substation compound fence. These are briefly described below together with mitigative measures.

The most obvious hazard is a LIVE fence due to a fallen conductor. Effective earthing ensures rapid protection operation and fault clearance.

A substation compound fence may be subject to capacitive and magnetic coupling from LIVE lines/cables. This can present an electric shock hazard which is controlled by effective fence earthing.

Earth fault current flowing through a substation earth electrode causes a rise in voltage on the electrode relative to remote earth potential. All metalwork connected to the earth electrode achieves the same voltage (neglecting series resistance). Current flowing to/from the earth electrode causes a voltage on the ground surface. An independently earth fence is energised at the voltage corresponding to the ground voltage acquired by the associated earth rods. As a consequence, a person may be subject to a voltage difference between hands or hand-to-feet. The fence could present an electric shock hazard if sufficient current could flow in the body for sufficient time.

Hand-to-hand hazards can arise between an independently earthed fence and conducting parts connected to an earth electrode which can achieve a different potential. This may be overcome by 2m separation or effective insulation. Clearly, careful substation management is required to ensure the separation is not compromised by changes to plant/fence.

Hand-to-feet hazards can arise at a substation fence. Under earth faults an independently earthed fence is energised at a lower voltage than one connected to the substation earth electrode. The voltage gradient away from the fence is also less steep and so gives a lower 'touch voltage'.

It is possible to reduce the touch voltage by installing a 'potential grading electrode' in the ground below where a person could stand. By connecting this electrode to the fence the touch voltage between hand and feet is reduced. Since this electrode normally encompasses a larger area than the substation earth electrode, a reduction in earth electrode resistance is achieved by combining the grading electrode with the substation earth electrode.

PVC covered chain-link fencing is effectively a bare metal fence due to the low level of insulation provided and the fact that the PVC deteriorates over time.

WPD cattle fences typically used to define substation boundaries are considered to effectively 'float' with respect to earth. As a consequence, they cannot present a hand-to-hand touch hazard unless earthed.

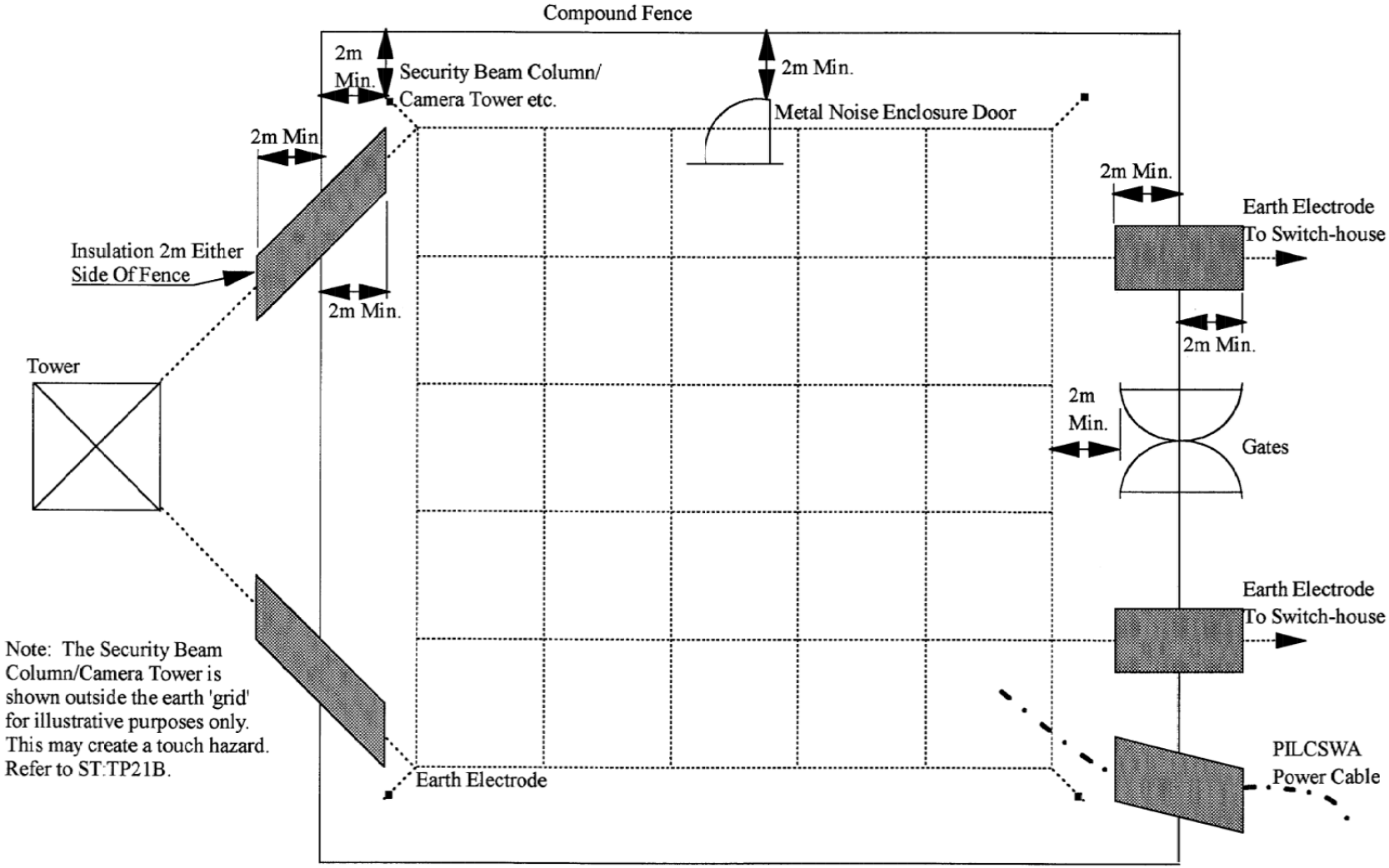

Figure 1 Independently Earthed Fence - Separation Requirements - Earth Rods Not Shown

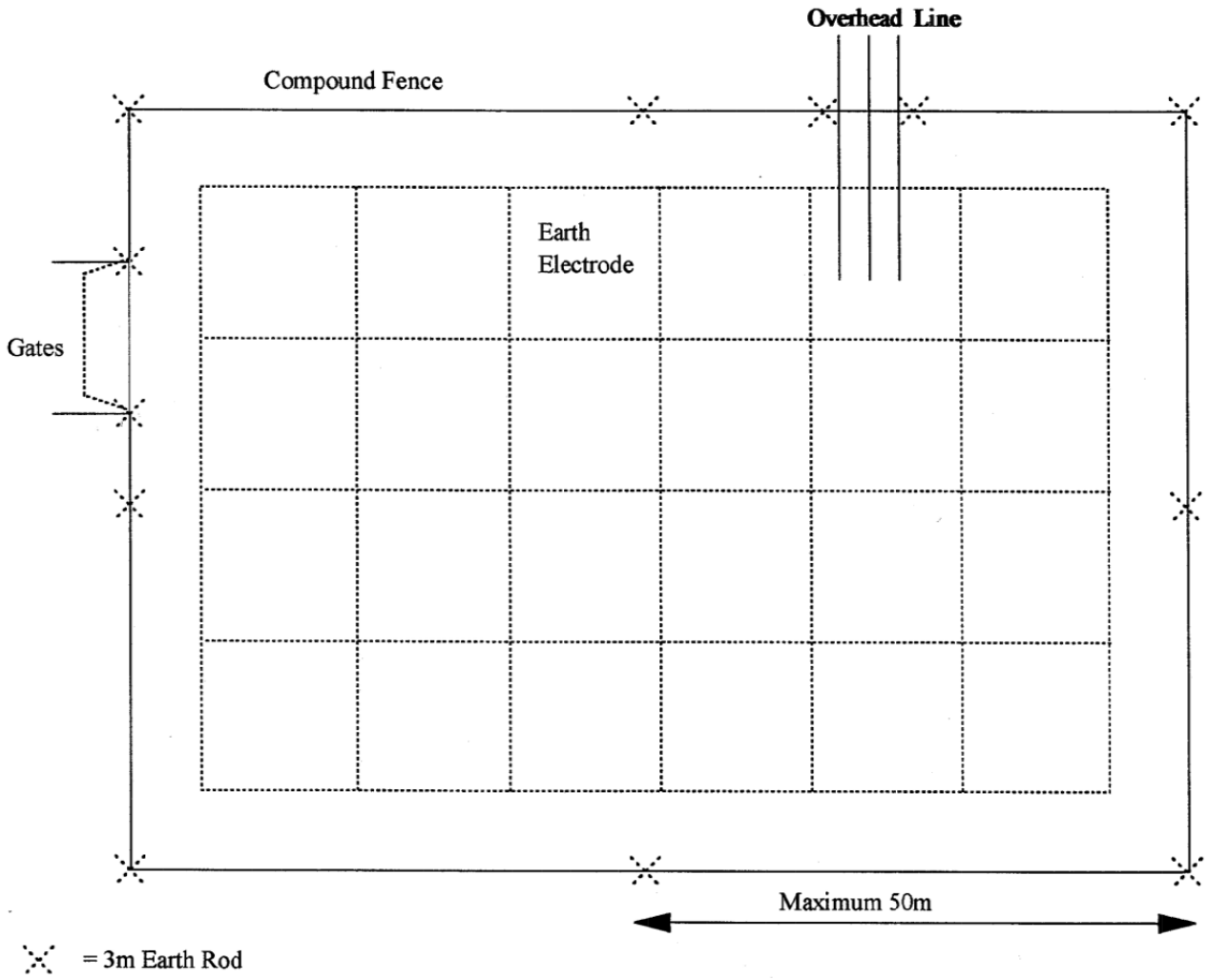

Figure 2 Effective earthing using earth rods

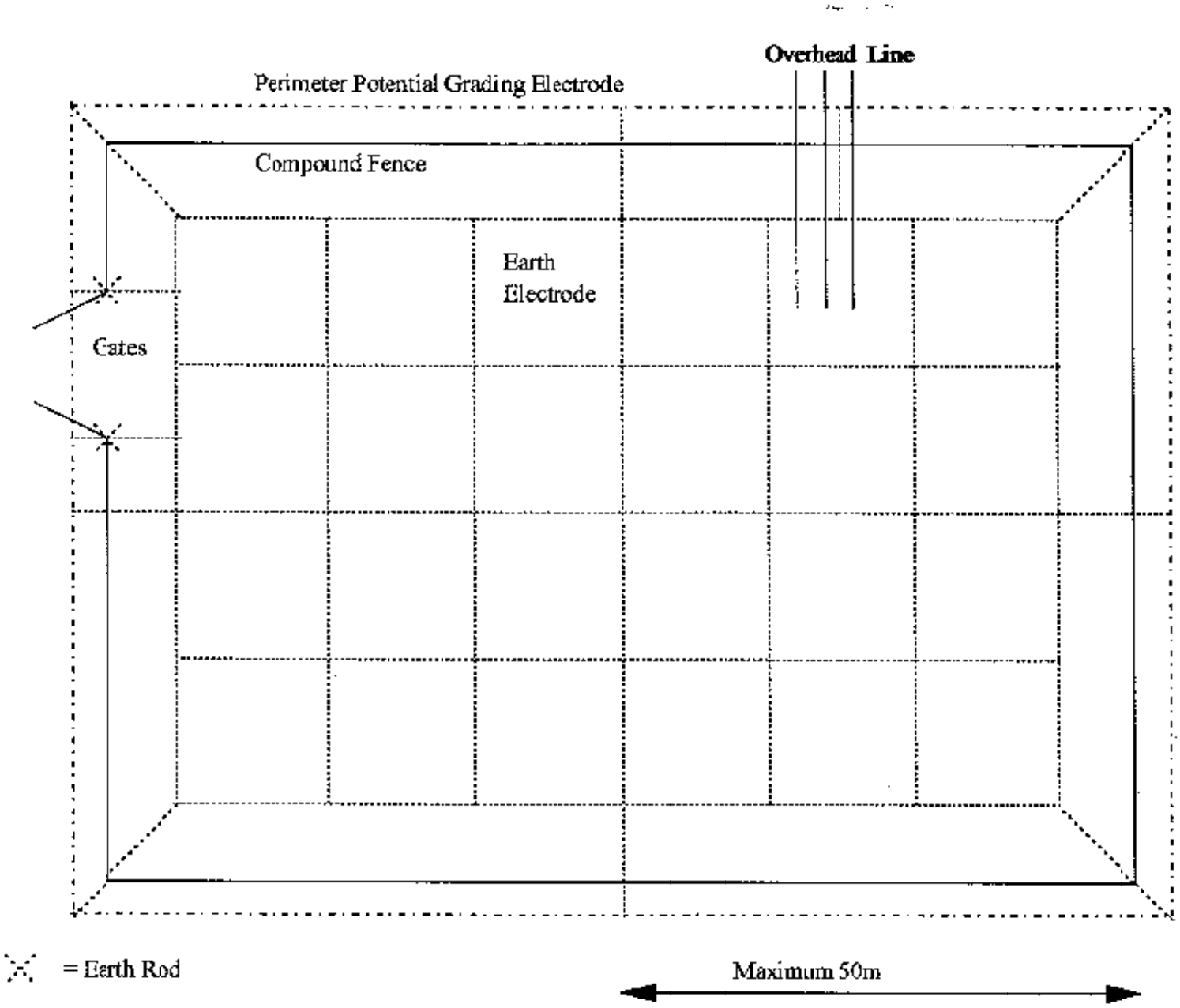

Figure 3 Effective earthing using substation earth electrode

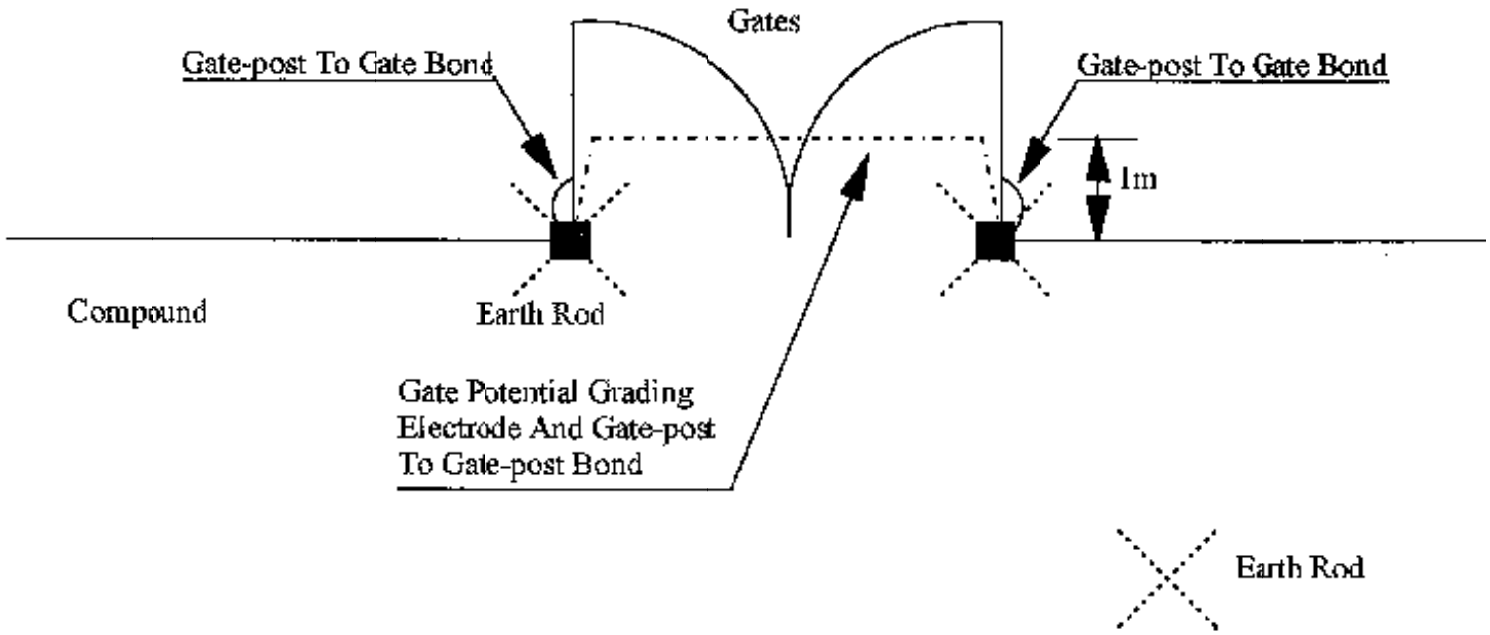

Figure 4 Inter-gate-post Bond And Gate Potential Grading Electrode

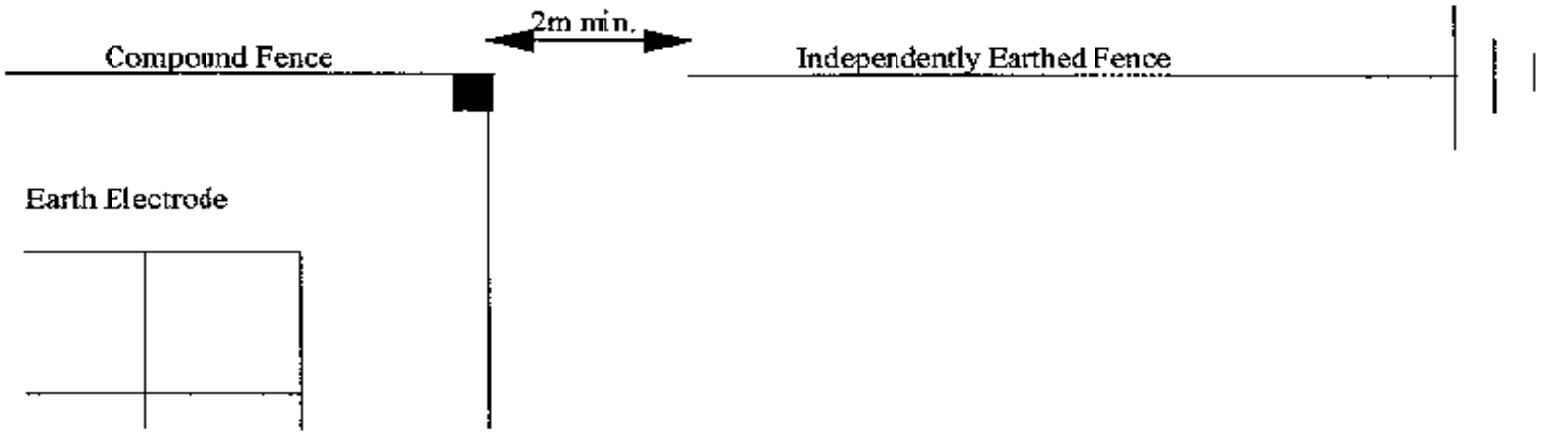

Figure 5a Effective Separation – 2m gap under WPD Control

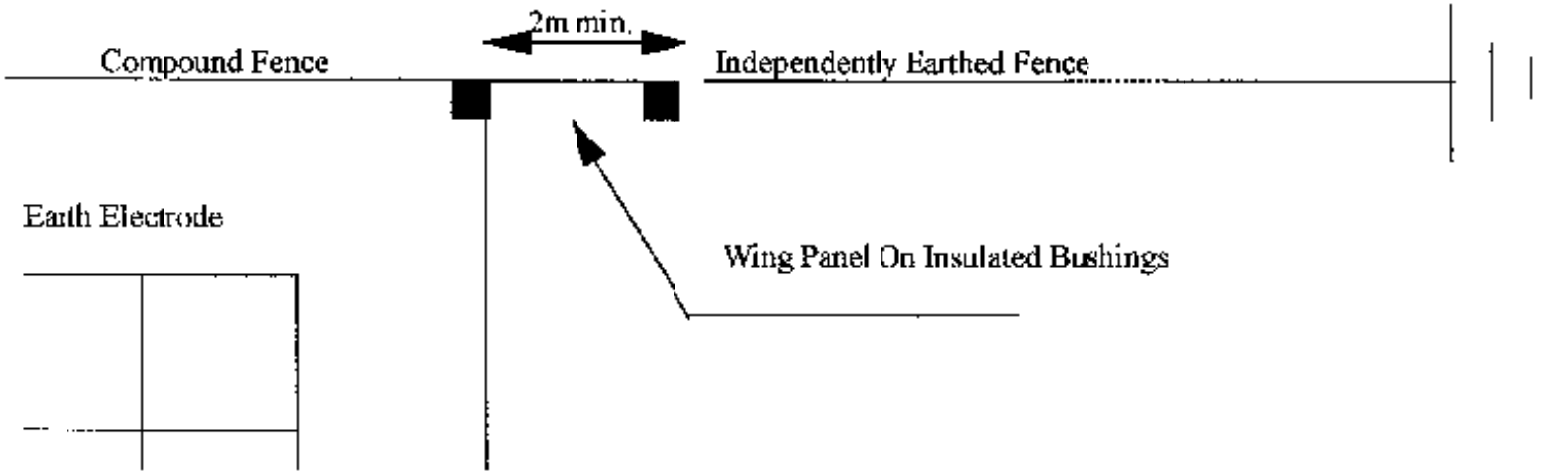

Figure 5b Effective Separation - Wing Panel On Insulated Bushings

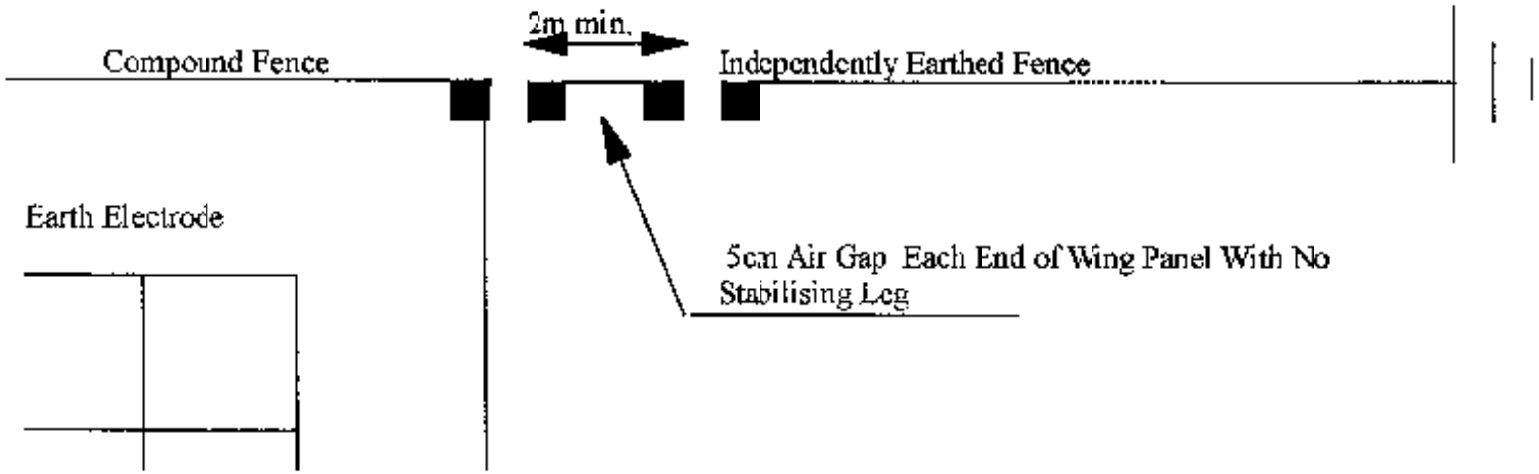

Figure 5c Effective Separation - Floating Wing Panel On Insulated Posts

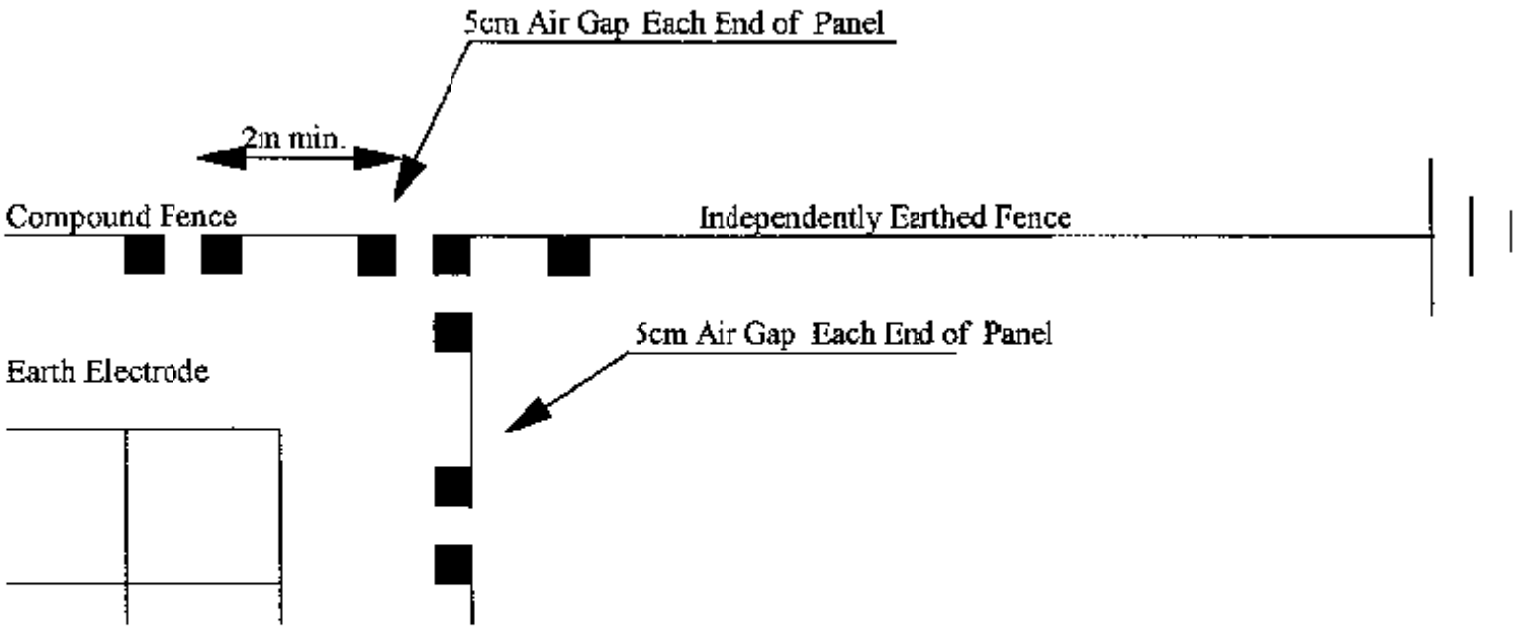

Figure 5d Effective Separation - Floating Panels On Insulated Posts

APPENDIX A

APPROVED INSULATED BUSHINGS

W J Furse Part Number IN005.

APPENDIX B

SUPERSEDED DOCUMENTATION

ST:TP21K dated May 1999.

APPENDIX C

ANCILLARY DOCUMENTATION

POL:SP5	Substation Security at 132kV and 33kV Substation Sites
ST:TP21L	Fixed Earthing Systems - Construction Techniques - Jointing
ST:TP21B	Design and Installation of Fixed Earthing Systems - Major Substations.

APPENDIX D

POLICY IMPLEMENTATION

This Standard Technique shall be implemented on issue for:-

new installations
major modifications to existing installations
minor modifications which may cause existing installations to become non-compliant, including:-

additional lampposts or security posts
fence changes
noise enclosure additions
bonds between independently earthed fence and substation earthing system
metalwork passing under an independently earthed fence (eg earth connections, PILCSWA cable)

if an existing installation is found to be unsafe

Where any difficulty is encountered in the application of this policy, the Technical Policy Manager shall be notified.

APPENDIX E

POLICY IMPACT

This policy is of particular relevance to staff responsible for substation assets and associated construction work.

APPENDIX F

KEYWORDS

Bonding, Earth Electrode, Earthing, Fences, Potential Grading, Touch Potential.