

TIMESCALES AND TECHNIQUES FOR THE RECTIFICATION OF OVERHEAD LINE DEFECTS

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PURPOSE AND SCOPE

This Technical Guidance Note details the maximum timescales until which a repair is carried out to various forms of defect and the severity thereof found on overhead transmission lines and also provides guidance on approved techniques for rectifying those defects.

The document is designed to be comprehensive and cover most everyday scenarios. However, for defects that are identified which do not fall into any category contained within, please contact Asset Integrity (OHL's & Cables team) in order for specific guidance to be given.

The document assumes that the methods used in order to access and ultimately enact the repair techniques are approved and signed off by the relevant National Grid business unit or external companies. It also assumes that the persons carrying out the work are suitably authorised and trained in those access methods and ultimately overhead line maintenance techniques.

If the defects detailed within this document cannot be rectified within the assigned timescale associated with those defects, an Asset Integrity OHL Engineer (OHL's & Cables team) shall be notified a minimum of 14 days prior to the 'overdue' date in order to carry out a risk assessment.

In the majority of cases, the assessment of the severity of the defect and ultimately the assignment of a suitable fix period (timescale) in accordance with this document will be carried out by ETO Operations Support (OHL's) in accordance with AMBP 238 'OHL Defect Management'.

PART 1 – PROCEDURAL

1 DEFECT IDENTIFICATION AND PRIORITISATION

1.1 General

Upon ETO Operations Support receiving the condition data, the defects shall initially be identified as outage dependant or non-outage dependant, and then prioritised within each category taking into account the type, severity and location of the individual defects. The process of this phase shall be documented to ensure the consistency of defect management within overhead lines across the electricity transmission system. The defects are prioritised utilising current knowledge on failure modes and the knock-on effects that these defects can have.

When identifying the location of the defect and the impact this could have on the electricity transmission system or even members of the public; categories of crossings shall be used as detailed below. This has been written by taking into account the exposure and vulnerability criteria's as detailed within TGN 227 'Safety and Environmental Criticality'.

CATEGORY 1 – A schedule of towers that span major crossings i.e. Motorways, other roads with high traffic loads*, Mainline or commuter railways, Housing, Schools, Commercial Car parks (e.g. supermarkets), Parkland/Play areas, Commercial/Industrial premises or other National Grid HV crossings.

CATEGORY 2 – A schedule of towers that span crossings of less busier roads as identified within Category 1 including all A and B roads, Picnic Areas, Other Utility Companies HV crossings and all other types of Car Park.

CATEGORY 3 – A schedule of towers that span unclassified roads, Country Parks, Farm Access Tracks, Navigable Waterways (canals/rivers), Mineral Railway Lines, Cycle Routes, Solar Farms, Golf Courses.

CATEGORY 4 – A schedule of towers that span Fields and Footpaths.

Note * - A road deemed to have a high traffic load would be one which typically sees traffic flows in excess of approximately 16602 vehicles per day.

Please refer to Appendix F for guidance on correctly identifying this type of crossing and the calculations used to identify the number of vehicles.

For the prioritisation of the defects, a simple categorisation of High, Medium or Low will suffice.

In order to increase our knowledge on failure modes / defect parameters and thus change the timescales we assign to the defects within this document, we will (on occasion) need to remove the defects from the system completely (rather than repair in-situ) and subject them to forensic testing. A working group with representatives from Asset Policy, Asset Integrity, ETO Operations, ETO Operations Support and Portfolio Planning shall meet on an annual basis to review any of these test results and evaluate the timescales accordingly.

2 FORMS AND RECORDS

Not applicable.

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

3 DEFINITIONS

Not applicable.

4 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
		See previous version for history		
5	August 2010	Added guidance for inspection of new joints on old conductor and further guidance on conductor repairs	Dave Bedford Asset Engineering	Gary Thornton Manager, Asset Engineering
6	April 2014	Complete rewrite. Updated repair timescales, escalation process for outages, applied trolley loads and various amendments throughout document	Richard Rowling Asset Integrity	Glenn Elworthy Manager, Asset Integrity
7	May 2018	Complete re-write and review of managing defects on OHL's. Updated timescales, repair techniques and added relevant suppliers in.	Wayne Steel Asset Integrity	Stewart Whyte Manager, Asset Integrity

5 IMPLEMENTATION

5.1 Audience Awareness

Audience	Purpose Compliance (C) / Awareness (A)	Notification Method Memo / letter / fax / email / team brief / other (specify)
ETO Operations Overhead Lines, Engineering and Asset Management Policy, System Operations and Capital Delivery	Awareness	E-mail

5.2 Training Requirements

Training Needs N/A / Informal / Workshop / Formal Course	Training Target Date	Implementation Manager
N/A	N/A	N/A

5.3 Compliance

To be used for the rectification of OHL defects thus ensuring operational compliance.

5.4 Procedure Review Date

3 years from publication date.

PART 3 – APPENDICES AND GUIDANCE NOTES

The timescales listed in the relevant sections below assume that ETO Operations Support OHL's have assessed the defects and assigned the repair to ETO Operations OHL's in order to carry out the fix.

If during the assessment the type/number of defect(s) is deemed to be assigned to National Contracts, then these timescales shall not be used, as the defects in their very nature are assessed to be able to withstand the timeframe on which National Contracts can respond (usually within 2-3 years).

There will be times at which the sheer number of defects identified on an overhead line route clearly shows that there is a problem with a certain asset type. In this instance, the correct approach towards these defects shall be to trigger an 'Asset Health Intervention', and create an investment in order to plan and deliver the required works across the affected assets (managed under TGN 004 and PS (T) EPS 12.04). This decision shall be reviewed by the 'Asset Lifecycle Working Group' and approved by the 'Risk Prioritisation Challenge and Review Group'. Works however, may be required prior to the main intervention in order to remove any intolerable risk. For example, this may involve clearing defects from category 1 & 2 crossing towers/spans.

Defect repairs can be capitalised if the total amount of assets requiring replacement is 50% or more of the particular defective asset family found on the tower or within the span i.e. If you find that you need to replace 2 phases of spacers within a single span, then you can capitalise this work. If you find that you need to replace insulator string sets on 2 phases, then you can capitalise the work.

A working group containing members of Asset Policy, Asset Integrity, ETO Operations Support (OHL's) and ETO Operations (OHL's) have produced the guidance found within all the appendices; it has been prepared utilising current knowledge of failure rates, the risk ratings given to safety of persons and finally system security.

The timescales take no account of mitigating actions being implemented, as the sheer variety of circumstances is far too great.

APPENDIX A - NON-OUTAGE CONDUCTOR DEFECTS

The timescales and techniques for the rectification of the following defects are contained within this Appendix.

A1 EARTH WIRE CONDUCTOR DAMAGE

Damage to the earthwire conductor can lead to possible system faults due to the nature of the defect and ultimately where the damage is located. The earthwire is required to protect the line from lightning and to provide a return path for fault currents.

Electrical clearance between conductors and earthed metal (including earthwire conductors) must be adequate to exclude the likelihood of flash-over under operational conditions including the steep fronted surges which occur during line switching.

Damaged strands within the span have in the past been known to ‘unwind’ from the tight lay of the intact conductor strands and hang in the vertical to lengths of 4 – 5 metres, thus lessening the electrical clearance to the top phase conductors, which in theory ‘can’ lead to system trips, though with the majority of National Grid towers being of the larger construction, hasn’t manifested itself as an issue, even so, it should be considered when assessing the defect. This however cannot happen on earthwire conductors which have a fibre optic cable wrapped along their length.

Failure of suspension fittings can lead to the earthwire laying at rest on tower steelwork, thus causing serious damage to the conductor if not identified quickly enough. The rate of deterioration of the conductor strands in this situation is impossible to know, due to not knowing the exact conductor affected (hardness of aluminium outer layers) and climatic conditions imposed onto it. The damage could in theory lead to the loss of the conductor itself within the spans adjacent and can cause damage to 3rd party assets.

Defect	Rectification Technique	Supplier
Failure of suspension fittings – conductor fallen into tower peak (steel core exposed)	<u>Option 1</u> – Installation of suspended tension arrangement (if design checks are approved). <u>Option 2</u> – Install length of conductor between 2 midspan joints. <u>Option 3</u> – Install new conductor in adjacent spans	Business Services – Logistics (National Stores, Didcot)
Damaged Strands (within span / away from tower)	Please refer to Appendix D. Tables D1, D2, D3, D3a or D4.	Business Services – Logistics (National Stores, Didcot)
Damaged Strands (at tope position)	Complete replacement of fittings and dampers and installation of helical repair	Business Services – Logistics (National Stores, Didcot)

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	3 Months	No further monitoring of defect required, other than annual foot / heli patrols.
Medium	9 Months	
Low	60 Months	Image shall be taken annually to ensure defect has not infringed safety clearance.

A2 EARTH WIRE HOT JOINT

The Earthwire is required to protect the line from lightning and to provide a return path for fault currents. Its presence adjacent to energised conductors causes induced currents to circulate through the earthwire between adjacent towers and earth. Currents of up to 450A can occur in some circumstances.

A small defect in the joints on an earthwire can lead to a higher resistance of compression joints which can cause these large currents to overheat the joints and ultimately wear them out leading to complete failure of the earthwire conductor.

Defect	Rectification Technique	Supplier
Bolted Connection	Split connections, clean surfaces, re-grease (<i>with grease rated for operating temperature of the conductor</i>) and tighten bolts to appropriate torque values. Check resistance of joint. All work to be in accordance with TGN (E) 247.	Business Services – Logistics (National Stores, Didcot)
Compressed Section (Jumper Palm)	<u>Option 1</u> : Replace full jumper leg with like-for-like conductor and jumper palms if possible. <u>Option 2</u> : If replacement of full jumper leg is not feasible, then a length of jumper may be removed and replaced with a single non tension joint, length of like-for-like conductor and jumper palm. All jointing and resistance figures to be in accordance with TGN (E) 247.	
Compressed Section (Anchor Clamp)	<u>Option 1</u> : Remove and replace anchor clamp with extended anchor clamp for appropriate conductor. <u>Option 2</u> : If extended anchor clamp is unavailable? Then remove a minimum of 100 x dia, length of conductor from span and install mid-span joint (full tension) between old and new conductor and new anchor clamp to other end of new conductor. Re-attach jumper palm. All jointing and resistance figures to be in accordance with TGN (E) 247.	
Mid Span Joint ACSR Conductor	<u>Option 1</u> : If steel is located centrally within sleeve, then install line-splice shunt over compression sleeve. <u>Option 2</u> : If steel is off-centre, then remove mid-span joint and replace with extended mid span joint (if available) a line splice shunt shall also be fitted. <u>Option 3</u> : If extended sleeve is unavailable, then replace with 2 mid-span joints and a length of new conductor with line splice shunts fitted also. <u>Option 4</u> : Re-conductor section. All jointing and resistance figures to be in accordance with TGN (E) 247.	

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	1 Month	Refer to Appendix E for further information on hot joints
Medium	6 Months	
Low	12 Months	

A3 EARTH WIRE JUMPER DAMAGE

Damage to an earthwire jumper can lead to possible system faults. The Earthwire is required to protect the line from lightning and to provide a return path for fault currents. Its presence adjacent to energised conductors causes induced currents to circulate through the earthwire between adjacent towers and earth. Continuous currents of up to 450A can occur in some circumstances.

With a break in the conductor's length, the return path isn't as designed and the fault / induced current would end up being transferred through the support fittings (which are not designed to carry current), leading to overheating and wear/failure of the support fittings and ultimately the loss of the conductor itself.

Defect	Rectification Technique	Supplier
Damaged Conductor – OPGW continuous jumper	Install Keziah OPGW jumper repair sleeve over damage. Check resistance of joint. All work to be in accordance with TGN (E) 247.	Business Services – Logistics (National Stores, Didcot)
Damaged Conductor – ACSR / AACSR jumper	Replace with new jumper and fittings. All jointing and resistance figures to be in accordance with TGN (E) 247.	

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	3 Months	No further monitoring of defect required, other than annual foot / heli patrols.
Medium	9 Months	
Low	18 Months	

A4 EARTH WIRE AEOLIAN VIBRATION DAMPERS

AEolian vibration (vibration of the conductor relating to or arising from the action of the wind) takes place as a result of wind-induced vortices which form downstream of the conductor, producing alternating lift and drag forces on the conductor. Aeolian vibration has been successfully controlled on National Grid transmission lines by the use of vibration dampers at tower attachment points.

If left unmanaged, damage is caused to the earthwire conductor by flexure of the conductor strands at clamp positions. The damage however, can occur to the inner strands prior to the

outer strands showing any wear, and therefore the damaged strands are not identifiable to the human eye, the result being the loss of strength of the conductor, and ultimately the failure of the conductor itself.

Defect	Rectification Technique	Supplier
Slipped or Defective Aeolian Vibration Damper	Replace defective damper with new. Fitment shall be in accordance with manufacturers' instructions.	Business Services – Logistics (National Stores, Didcot)

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	3 Months	No further monitoring of defect required, other than annual foot / heli patrols.
Medium	18 Months	
Condition State	No rectification required at this time	

A5 EARTH WIRE BONDS

ESQCR regulations require any metal support within an electrical transmission system to be effectively earthed to prevent danger to the public and livestock. Efficient earthing of towers will also reduce the risk of back flashovers across insulators and of severe travelling wave surges reaching the substations. The provision of an overhead earth wire electrically-bonded to each tower will provide parallel paths to earth, thus reducing the overall resistance and also the surge impedance to earth.

The electrical bonding of earth wires to towers should be efficient. If not, the fault / induced current would end up being transferred through the support fittings (which are not designed to carry current), leading to overheating and wear / failure of the support fittings and ultimately the loss of the conductor itself (the stray currents *can cause spark erosion of surfaces, particularly if they are dirty or corroded*).

Defect	Rectification Technique	Supplier
Defective Earthwire Bond	Replace defective bond with new. Manufacturers' installation instructions shall be followed.	Business Services – Logistics (National Stores, Didcot)

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	3 Months	No further monitoring of defect required, other than annual foot / heli patrols.
Medium	9 Months	
Low	36 Months	

A6 EARTH WIRE FITTINGS

During the asset life of the earthwire conductor and fittings, severe changes of tension can occur in adjacent spans, subjecting the intervening tower(s) to sudden longitudinal forces. These changes can be caused by environmental / climatic conditions such as galloping or ice falling from the conductor.

The effect on earthwire suspension fittings is to cause considerable longitudinal movement which in turn causes extensive wear on the fittings. The fittings are designed to tolerate appreciable wear but this is the primary cause of end of life of these fittings.

Earth wire fittings have been installed with a life span of 40+yrs, it is perfectly normal for wear to manifest itself over a period of time. If during inspection, it is found that the earth wire fittings have less than 40% wear then the defect shall be noted as a 'condition state'. If the earth wire fittings are identified as having between 40% - 60% wear, then the defect shall be assessed on an individual basis, and where there is no risk to the public or property then again, the defect shall be noted as a 'condition state'. If a risk is identified, then management of that defect shall be as the table below.

Galloping also has the effect of causing dowel pins in tension set linkages and suspension set clevises to migrate. The use of bolts in such fittings with nuts and split pins prevents excessive movement or failure of the fitting.

Defect	Rectification Technique	Supplier
Worn Suspension Fittings	Replace with new Helical Suspension or Cushion Grip Support Units. Manufacturers' installation instructions shall be followed.	Business Services – Logistics (National Stores, Didcot)
Migrating Dowel Pin (Old style – dowel, washer and split pin) (New style – nut, bolt and split pin)	<u>Option 1</u> – If old style on suspension towers, then replace earth wire fittings on tower <u>Option 2</u> – If new style on suspension tower, then replace individual dowel pin <u>Option 3</u> – If old or new style on tension tower, then replace washer and split pin accordingly	

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	3 Months	No further monitoring of defect required, other than annual foot / heli patrols.
Condition State	No rectification required at this time	

A7 FIBRE/CELLULAR DEFECT

The fibre optic cable wrapped around the earthwire or found within OPGW is used for high-speed transmission of data, for the purposes of protection and control of the transmission line itself. It is also used for National Grid voice and data communications.

A fault on the fibre wrap on an overhead line reduces the redundancy within the system and increases the risk that communications and protection control between sites will be lost.

Cellular equipment is owned and operated by 3rd party companies who enter into agreements with National Grid to use their towers to install their equipment on instead of building their own structures. The 3rd party companies are responsible for erecting and maintaining this equipment. However, should the equipment pose a threat to the security of the ACD or for some reason a threat to system security, then National Grid would have to intervene and ensure the security of the tower and the system is maintained.

Defect	Rectification Technique	Supplier
Failure of fibre wrap on earthwire resulting in system security issues.	Remove fibre optic wrap from earthwire. Replace if requested.	To be identified by Op's Support Minor Scheme Engineer
Defective fibre or cellular equipment not resulting in system security issues.	Consult with 3 rd Party Operator of Fibre / Cellular Equipment	To be identified by Op's Support OHL Unlicensed engineer

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	1 Month	No further monitoring of defect required, other than annual foot / heli patrols.
Condition State	No rectification required at this time	

APPENDIX B – NON OUTAGE TOWER DEFECTS

The timescales and techniques for the rectification of the following defects are contained within this Appendix.

B1 ANTI-CLIMBING DEVICES

Over the years there have been incidents involving members of the public climbing overhead line towers which have resulted in injuries, some of which tragically have been fatal. The causes of these deaths or injuries are either contact with the live conductors or more commonly by falling.

The reasons people climb towers are varied and range from; children climbing to recover kites or model aircraft, to erect swings, or to adults climbing with the intent of theft or suicide.

National Grid have obligations under two principle sets of legislation in order to keep the public safe from overhead lines; 'The Electricity at Work reg's 1989' and 'The Electricity, Safety, Quality and Continuity reg's 2002'.

Unauthorised access to our overhead lines is reportable and precautions to avoid access by unauthorised persons shall be implemented.

Defect	Rectification Technique	Supplier
Broken barbed wire strands	Replace with Stainless Steel barbed wire 1.95mm – 2mm, grade 304. As per TS3.04.27 (anti-climbing devices for overhead lines)	Business Services – Logistics (National Stores, Didcot) – Commodity codes identified within T-manual T238 – '400kV & 275kV Transmission towers & black steel schedules'
Individual items of steelwork (half-moons, gates etc)	Replace with like for like steelwork which shall conform to TS 3.04.16 (fabrication and erection of lattice tower steelwork).	
Full ACD	Install ACD as per TS 3.04.27 (anti climbing devise for overhead lines).	

Priority	Timescale	Interim Monitoring Requirements
High	24 Hours	No further monitoring of defect required, other than annual foot / heli patrols.
Medium	1 Month	
Condition State	No rectification required at this time, though defect shall go to national contracts for inclusion in work bank	

B2 TOWER FURNITURE

Tower furniture is the term we give to different forms of identification plates found on National Grid overhead line towers. These can be any of the following:

- Property Plate – Which show members of the public who owns and operates the circuits on the tower and also provides them with an emergency contact number for the Transmission Network Control Centre (ENCC).
- Number Plate – This is a unique identifier for the specific tower. It can be used by members of the public to identify the tower to the TNCC when contacting them by the emergency number, or by personnel authorised to access the tower ensuring the correct tower is being accessed.
- Safety Signage – These are known as ‘danger of death’ signs and are warning signs to inform members of the public, that there is a danger of death if the tower is climbed without authorisation.
- Circuit ID Plate – These are unique identifiers for the specific circuit(s) on the towers and can be used by members of the public when contacting the TNCC on the emergency number or by personnel authorised to access the tower ensuring the correct circuit is being accessed.
- Helicopter Plate – Difficulty has been experienced in identifying towers from the air, this is overcome by fitting these special number plates to the top of selected towers and at certain locations ‘helicopter hazard warning plates’ are also fitted.

There are requirements under the ‘Electricity, Safety, Quality and Continuity regs 2002’ to which National Grid are held accountable if the safety signage plates are illegible.

However, from a system management point of view, if any of the other plates on the tower are illegible, then identification of the tower and circuits in emergency conditions becomes harder and therefore more time is taken to provide safety from the system if required.

Defect	Rectification Technique	Supplier
Faded/Missing/Damaged, Circuit ID Plate / Heli Plate or Safety Signage	Replace like for like in accordance with requirements laid out in TS 3.04.09 (<i>safety signs and information plates for overhead lines</i>)	Freestyle Sign and Print Ltd

Priority	Timescale to Rectify	Interim Monitoring Requirements
High	1 Month	No further monitoring of defect is required, other than annual foot / heli patrols
Medium	12 Months	
Low	60 Months	
Condition State	No rectification required at this time, though defect shall go to national contracts for inclusion in work bank	