

Category 1 Standard

S1972 Security Planning Criteria for the Powerlink System

(formerly Powerlink Technical
Specification SP81802 Rev 2)

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1 Purpose

- 1.1 The purpose of this LU Standard is to apply technical requirements for equipment and systems on the LU power system through the inclusion of a technical specification, previously owned and managed by the Power Service Contractor, UK Power Network Services (UKPNS) Powerlink, as an attachment to this standard.

2 Scope

- 2.1 This Standard applies to equipment and systems on the LU power system.

3 Requirements

- 3.1 The mandatory requirements of this standard are set out in Section 7 as an attachment to this document.
- 3.2 Where an attachment refers to the 'Contractor' it should be taken to mean LU and LU Suppliers following the termination of the Power Service Contract.
- 3.3 Where the attachment refers to the 'System' it should be taken to mean the LU power system including its associated SCADA system and the operational properties.

Note: It is the intention to fully re-work this LU standard into the standards format over a period of time. While the content of the ex-Powerlink specification should not conflict with the remainder of the LU standards suite, should any discrepancies occur, these should be brought to the attention of the LU technical authority.

4 Responsibilities

- 4.1 **The Head of Power Engineering** is responsible for the technical content of this standard. Concessions in relation to this standard shall be directed to the Head of Power Engineering who has overall accountability for compliance with this standard. The Head of Power Engineering may request support from the other technical authorities when reviewing concessions or queries arising from the application of this standard.
- 4.2 **LU and LU Suppliers** shall be responsible for compliance with the requirements of this standard.
- 4.3 **Heads of Profession** are the LU technical authorities for each asset group, and shall be responsible for auditing technical compliance with this standard in accordance with the engineering asset grouping of LU Standard S1041 and with respect to the assurance of assets to which they are accountable for. They shall provide support to the Head of Power Engineering, if requested, with regard to any technical issues arising from concession requests or other queries to this standard.



5 Supporting Information

5.1 Background

- 5.1.1 From the 16th August 1998 through to the 15th August 2013 the LU power system was operated, maintained, renewed and upgraded by UKPNS Powerlink under the Power Services Contract. The contract was a Private Finance Initiative contract where UKPNS Powerlink were responsible for setting the detailed technical requirements for the LU power system.
- 5.1.2 At the start of the Power Service Contract on 16th August 1998 LU transferred its detailed technical standards for the LU power system to UKPNS Powerlink. Powerlink has owned and managed these technical standards as Powerlink technical specifications for the duration of the Power Service Contract.
- 5.1.3 The Power Service Contract ceased on the 16th August 2013 and the UKPNS Powerlink technical specifications for the LU power system were transferred back into LU as Category 1 standards.

Note: At the time this standard was produced, it was deemed necessary to utilise a non-standard for standard format. This however, does not diminish the mandatory requirements contained within the attachments.

5.2 Safety, Environment and Customer Considerations

- 5.2.1 Safety, environment and customer considerations relevant to this engineering standard are covered within the text of the attachment.

6 References

6.1 References and Abbreviations

- 6.1.1 Where references and abbreviations are used in this engineering standard they are given within the text of the attachment.

6.2 Definitions

- 6.2.1 Where definitions are used in this engineering standard they are given within the text of the attachment.
- 6.2.2 The following topic specific definitions are created:
- a) Within London Underground's Glossary of Terms (1-622)
(a Category 1 Standard);

Term	Definition	Source
LU	London Underground is the operating company of the former London Underground Limited.	a
Supplier	Supplier to London Underground, the primary organisation or individual that is selected to deliver a product, service or facility to London Underground and contracting directly to London Underground. This includes Consultants, Contractors, Infracos and PFI Contractors and excludes organisations or individuals selected by and contracting directly to them.	a



6.3 Person Accountable for the Document

Person accountable for the document
Phil Carmichael - Head of Power Engineering

6.4 Document History

Issue no	Date	Changes	Author
A1	Aug 2013	Incorporation of UKPNS Powerlink technical specification SP81802 Rev 2 as Category 1 LU standard following the termination of the Power Services Contract as per DRACCT No. 01934. No technical requirements have been changed.	G Bloch



7 Attachment - Technical Specification SP81802 Rev 2 (Ex Powerlink)

1 Introduction

This specification is for use only within the scope of the London Underground Limited (LUL) Power Service Contract (PSC). It is one of a series of specifications which mandate UK POWER NETWORKS SERVICES Powerlink (PL) technical and associated requirements for equipment for use on The System.

These specifications are supported by Powerlink Work and Operating Instructions, and shall be read in conjunction with the Conceptual and Outline Design documentation, as appropriate.

2 Purpose

This specification states the criteria that shall be used to achieve appropriate levels of security of supplies on the Power System when undertaking modifications to the System.

It is supported by an Application Guide forming an Appendix to this Specification which provides further detailed guidance on the application of these security planning criteria and other aspects that influence the availability of supplies at various levels throughout the system.

3 Scope

This Specification for Security Planning Criteria shall be applied to all future variation works, and in addition, when undertaking future Renewal & Upgrades works possible improvements in line with this specification (over and above those which Powerlinks R&U budget can support) will be raised with LUL for their consideration.

It has been confirmed by ECMT to UK Power Networks Services Powerlink, in letter 20910/IBJ/Se003704 of the 25/10/04, that this Specification for Security Planning Criteria will not be retrospectively applied to the existing power system upon its adoption by UK Power Networks Services Powerlink, and in particular that Powerlink will not be required to carry out works under their Renewal & Upgrades budget to bring the power system into line with this Specification for Security Planning Criteria where it is not in line with this Specification prior to the Specification coming into force. This point has been further reinforced by ECMT letter 20910/AJMbr/SE003762 of the 04/02/05.

Having said the above, it also equally applies that this Specification for Security Planning Criteria should not be used as justification for reducing the system security, where the security of the System at contract start was higher than that stipulated within this specification. It should also be emphasised that the PSC requirement to ensure that Delivery Point theoretical reliability figures do not drop below contract start figures (as demonstrated by the 5 yearly theoretical reliability calculations) would also tend to preclude any such system design decisions being made



4 Definitions

Common Mode Failure	A failure which is the result of an event(s) which causes a coincidence of failure states of two or more components leading to a system failing to perform its required function.
Power Service Contract	The contract awarded by LUL to Powerlink to deliver low voltage three phase and single phase power; dc power; signalling equipment power; low voltage dc power; Docklands Light Railway high voltage a.c. power; emergency power; and compressed air to prescribed delivery points. Note: The performance requirements of the Power Service Contract are contained in the LUL Standard 1-105.
Power Quality	A measure of the characteristics of the Power Supply in relation to both Connection Agreement and Performance Specification requirements (Ref 3.1).
Security Planning Criteria	Criteria set to define the level of redundancy on the System as measured at specific points, to achieve the required level of system security.
System Security	A measure of the Systems capability to withstand failure without adverse effects on the operation of the railway.
The System	System means the electrical conductors and apparatus for the distribution and control of electricity from any Bulk Supply Points (and for the avoidance of doubt, excluding any assets belonging to any Distribution Network Operator) and from and including the Generating Stations to and including the Delivery Points and for the production of compressed air all as at the Starting Date and includes the Electrical Control Equipment, the interests in and rights in respect of the Properties granted under this Contract (PSC) but excludes LUL's Distribution System, the IT Systems (other than the SCADA System) and the Telephony Systems the Waterloo and City Line, the District Line from Putney Bridge to Wimbledon and Gunnersbury to Richmond, the Bakerloo Line from Queens Park northwards and the interface with the System for each such part as is set out in the Performance Specification and as altered by the Contractor, any Variation, any Known Third Party Works or adoption of Third Party Works.
Theoretical Reliability	Methodology for calculating reliability of the System in terms of Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) at defined points.
Type 1 Secondary Substation	A Secondary Substation, within the 11kV or 22kV Distribution Network, defined as a 'key node' by virtue of the number, importance or size of the connected loads, where any failure in supply is expected to cause significant disruption to the operation of the railway.
Type 2 Secondary Substation	A Secondary Substation (or Transformer Room), within the 11kV or 22kV Distribution Network, not defined as a 'key node'.



5 Abbreviations

A.C.	Alternating Current.
BSP	Bulk Supply Point.
CB	Circuit Breaker.
CENELEC	European Committee for Electrotechnical Standardisation.
CEPS	Central Emergency Power Supply.
CT	Current Transformer.
DC	Direct Current.
DNO	Distribution Network Operator.
ECMT	Energy Contracts Management Team
FEL	Frame Earth Leakage.
GSP	Grid Supply Point.
HF	Harmonic Filter.
HV	High Voltage.
LUL	London Underground Limited
LV	Low Voltage.
MTBF	Mean Time Between Failure.
MTTR	Mean Time to Repair.
NGT	National Grid Transco.
PCC	Point of Common Coupling.
PL	UK POWER NETWORKS SERVICES Powerlink Limited.
PQ	Power Quality.
PSC	Power Service Contract.
SCADA	Supervisory Control and Data Acquisition.
SER	Signal Equipment Room.
SVC	Static Var Compensator



6 References

Documents referred to by title and/or alphanumeric identity within this specification are listed in Appendix B. Some are mandatory, others provide information or guidance. Unless specified otherwise, reference shall be made to the latest editions.

7 General

The Power Service Contract (PSC) entered into between Seeboard Powerlink (now UK Power Networks Services Powerlink) and London Underground Limited (LUL) specifies a number of theoretical reliability requirements, however these are oriented around the Delivery Points specified within the Contract, and there is very little in the way of theoretical reliability requirements higher up in the system (at the 11kV busbars and above). As the system security embedded higher in the power system heavily influences the final theoretical reliability at the contract Delivery Points, and the absence of system security requirements within the PSC makes it difficult to establish appropriate security planning criteria for works within the System, there is a clear need for the production of a specification that defines security planning criteria for use throughout the power system.

This Specification stipulates security planning criteria for various parts of the System that make up the Power System supplying electrical power to London Underground. The Application Guide then discusses the various factors that must be considered within a system design to ensure that the security planning criteria are complied with, and that the operational reliability of the power system is enhanced as far as is practicably and economically justifiable. It should be emphasised that this specification is not primarily concerned with plant or equipment reliability.

In determining the appropriate security planning criteria for each part of the Power System it is necessary to consider the consequences of failure. While at the bottom end of the System the failure of a single substation may result in a single station closure, further up the System the consequences may be the loss of a number of stations, of parts of a number of lines or even the loss of a substantial part of the entire Underground network. It is clearly appropriate that higher levels of system security are required at the top of the power system (where the consequences of loss are so much higher) than at the bottom of the system, but at the same time the need for higher security must be balanced against the economic cost of achieving the defined level of security. The security planning criteria described below have been defined in accordance with these principles.

8 Security Planning Criteria

The minimum criteria to be met in all parts of the network (excluding the actual Delivery Point) is defined as **N-1**, with higher standards of security specified in some parts of the network as described in the table below.

These criteria are applicable for an initial state with the system intact and in normal operation.

In summary, the following security planning criteria shall be applied.

Table 8.1

	Description of Power System Node	Criteria
i	Bulk Supply Points (at BSP 22kV Busbars) (Note 1)	(N-1)-1
ii	22kV Primary System Cable Routes (Notes 1 & 2)	N-2
iii	22kV Primary Substation Busbars (Note 1)	(N-1)-1
iv	11kV Primary Substation Busbars (Note 1)	(N-1)-1
v	Type 1 Secondary Substations at HV Busbars (Note 1)	(N-1)-1
vi	Type 2 Secondary Substations at HV Busbars (Note 1)	N-1
vii	Power Quality Equipment (System wide) (Note 3)	N-1

Note 1 Failures at these nodes are deemed not to include failures of power quality equipment. Failure of Power Quality equipment is considered further in 8.4 and section A1.7 of the Application guide.

Note 2 This requirement is extracted from Clause A2.1.9 of the Performance Specification. It is expected that this criteria would normally be met by default through compliance with the criteria for Items (i) and (iii).

Note 3 It is acknowledged that this is a pseudo-(N-1) criteria as there will be a delay while the System is reconfigured before full power quality compensation can continue.

For a full description of the criteria for a Type 1 or Type 2 secondary substation refer to section A4.0 of the Application Guide to this Specification.

8.1 The N-1 Criteria

The single contingency event, commonly referred to as N-1, covers the security of the power supply against an unplanned outage of any single circuit, transformer or generator on the power system, including those same items on the higher voltage distribution and transmission systems that feed the Underground. It does not include equipment downstream of the Delivery Point and switching equipment at the Delivery Point interface. This category will cover, for example, a super-grid transformer, a BSP transformer or an auxiliary transformer, but not, for example, a DC track feeder cable or an LVAC lighting main.

For these events there should be no disruption to the operation of the railway and following the event the quality of supplies should still be within the requirements set by the PSC.

8.2 The (N-1)-1 Criteria

The planned-plus-trip outage (referred to as (N-1)-1) event includes disturbances where an unplanned outage occurs when another element of the power system is out of service for planned works (including maintenance or construction activities, or repairs following a previous unplanned outage). Prior to (or following) the first outage measures can be taken (including transfer of load) to improve the resilience of the system in anticipation of a further unplanned outage. Immediately following the first (planned) outage there should be capability to run a full train service with the quality of supplies within the requirements set by the PSC.



Immediately following the second (unplanned) outage there should be capability to run a full train service with the quality of supplies within the requirements set by the PSC, and there should be sufficient capability within the power system to rearrange it where necessary to remove any short term overloads without disrupting supplies. There may be a very short interruption associated with an auto-changeover scheme, but this must be arranged so it doesn't affect railway operation. It is recognised that after an (N-1)-1 event the railway may well be disrupted by any further tripping event.

If the first event is an unplanned outage, the power system is at risk until such time as it can be reconfigured to remove the risk associated with a second unplanned outage. This risk is managed by UK Power Networks Services Powerlink through the decision as to when and how to reconfigure the system, and is an operational matter. However the design of the system shall be such as to facilitate the operational reconfiguration of the system in a safe and efficient manner.

8.3 The N-2 Criteria

This criteria covers the security of the power supply against the unplanned coincident outage of any two circuits, transformers or generators (or combination of these) on the power system, including those same items on the higher voltage distribution and transmission systems that feed the Underground. This criteria is more onerous than the (N-1)-1 criteria as it assumes that there is insufficient time between the first and second unplanned outages for appropriate contingency actions to be taken. Compliance with an N-2 criteria would by default achieve compliance with the (N-1)-1 criteria.

For these events there should be no disruption to the operation of the railway and following these events the quality of supplies should still be within the requirements set by the PSC.

8.4 Power Quality Equipment

Power Quality (PQ) equipment is likely to be required for all major points of connection to the public network to maintain any voltage disturbances and harmonic distortion, arising from the demand load, within prescribed limits set by the Network Operator.

Where PQ equipment is found to be necessary as a condition of the connection, it is not required to operate in a fully redundant mode. However for sustained connection to a BSP, sufficient equipment must be available to meet the existing minimum criteria of N-1 after allowance for switching into service a standby unit to replace any failed item. The existing minimum (N-1) criteria shall be reviewed if the number of BSPs is changed.

System design principles to be adopted for the provision of PQ equipment are given in Section A1.7 of the accompanying Application Guide.

9 Requirement for System Analysis

To demonstrate compliance with this Specification for Security Planning Criteria it is a requirement that system analysis studies shall be carried out to demonstrate compliance with the specified security criteria for all normal and contingency running arrangements. This system analysis is particularly important in assessing whether load transfer capability exists to meet the (N-1)-1 criteria under all credible contingency scenarios. As such, accurate load information will be required for both present loads on the system (obtained via a programme of load measurements) and projected future loads (obtained from train system modelling and including an allowance for anticipated load growth).



Theoretical reliability analysis will also be required to ensure that Delivery Point theoretical reliability figures are not reduced below those at Contract Start as required by the PSC. The theoretical reliability figures may be affected not just by design modifications to the system, but also through load changes reducing redundancy in existing circuits or operational changes such as (permanent) relocation of open points.

Additional guidance regarding the type of system analysis that should be undertaken is given in Section A1.8 of the accompanying Application Guide.

10 Factors in Design

Reference should be made to the Application Guide to this Specification for a full description of the factors to be considered when undertaking a design to achieve compliance with the security criteria, but a fundamental principle is to ensure, so far as is reasonably practicable and economically justifiable, that no single event can lead to the loss of multiple system components.

In particular this means that detailed consideration should be given to the avoidance of common mode failures and the implementation of a protection design that ensures good discrimination of faults and appropriate back up protection is available.

At the same time, care must be taken to ensure that in the process of attempting to meet the requirement above, a design does not become so complex that system reliability could be compromised through the difficulties associated in operating, maintaining or extending the designed system.

The capability to implement an auto-switching scheme as a means of maintaining system availability in the event of the loss of a BSP, Primary Substation or Type 1 Substation shall be considered in the design, and should at least be facilitated in the design where practicable for possible future application.

Appendix A Guidance to the Application of the Specification for Security Planning Criteria for the Powerlink System

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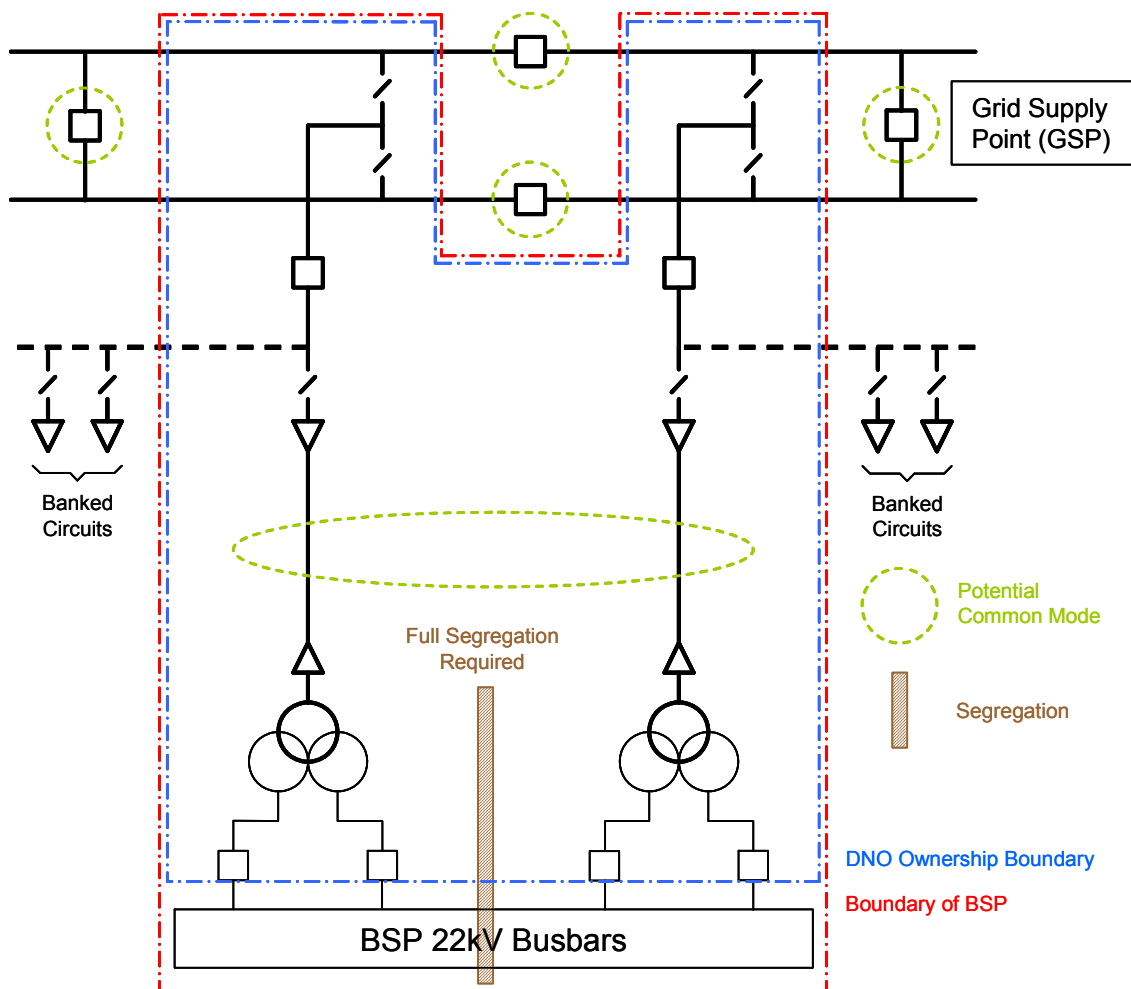
A1 Bulk Supply Points

Although Bulk Supply Points (BSPs) can be supplied from different network operators and at different voltages (e.g.: National Grid at 400kV or 275kV or a Distribution Network Operator (DNO) at 132kV or 66kV) the most common within the LUL system is at 132kV from EdF Networks, and as such the text below makes reference to this situation. However the principles stated would apply to any network operator or supply voltage.

The BSP consists of connections from a Grid Supply Point (GSP) to a Transforming Station for the provision of Bulk Supplies. It is ideally a Sole User asset comprising the following principal elements.

- **132kV Switchgear / Busbars** at GSPs.
- **132kV Feeder Cables** – Direct connection between the Grid Supply Point and the HV Terminations of the Grid Transformers at the BSP site.
- **132/22kV Grid Transformers** and associated Earthing Transformers.
- **22kV Cable Connections** (from Transformer LV terminals to associated 22kV Switchgear).
- **22kV Switchgear / Busbars** at BSPs.

Figure A1.1 – Boundaries Associated with Bulk Supply Points





A1.1 Security Criteria:

- Normal Running :
The BSP is required to meet an **(N-1)-1** criteria with normal running arrangements (system intact with normal loading) as measured at the BSP 22kV busbars.

Following first outage, the system continues to operate with all load supported, but system switched to transfer load in anticipation of a further forced or unplanned outage at the BSP. The transfer of load should be prearranged such the BSP is not left on a single circuit risk.

A1.2 Capacity:

- Normal Running :
While it is common to state that the maximum load should not exceed the firm capacity for the BSP as determined by the Nominal Rating of the transformers with assisted cooling (i.e. OFAF), such a statement is an over simplification of quite a complex issue.

For example, if all BSPs are loaded to 100% of the nominal rating of one transformer (assuming two identical BSP transformers at each site), in a load transfer contingency situation (following a planned outage), the load on adjacent (two) BSPs would rise to at least 150% of the nominal rating. A further unplanned outage at one of these adjacent BSPs may well result in a transformers emergency rating being exceeded and all supplies from this BSP being lost. This situation may be exacerbated if the BSPs adjacent to the original BSP had a lower installed capacity in the first place. This situation is discussed further in Attachment 1. This simple example demonstrates that the establishment of the maximum load of a BSP under normal operation can only be determined following a detailed study that assesses the loading of all BSPs on the system under contingency operating conditions, and that in some cases this may lead to a maximum load being assigned that is less than the firm capacity of the BSP.

- Contingency Operation – (Load Transferred to Site from Another BSP)
The maximum load shall not exceed the defined Emergency Rating of the lowest overall rated circuit at the site (i.e. transformer + associated HV & LV cabling + switchgear). This assumes that contingency action can be taken within the defined time constraint to offload the circuit. If this would not be possible, then the maximum load shall not exceed the circuit Sustained Overload (cyclic) rating.

In the event of the further failure of one transformer (second outage) this will allow the load to be supported in the short term until action can be taken to relieve the overloaded transformer. It is required that this action should result in a seamless transfer of load (possibly through a short term parallel) without any disruption or loss of service.

If such a seamless transfer of load were not possible for practical or economically justifiable reasons, then remedial switching to relieve the overloaded transformer through transfer or controlled shedding of load resulting in some disruption or loss of service may be necessary.

Subsequent restoration of normal service may be achieved through the transfer of load back to the BSP site with the original transformer outage. It is acknowledged that the system may then be required to operate at single circuit risk until the subsequent restoration to service of the transformer originally planned out of service. Refer to Attachment 1 for a further discussion of this issue.



A1.3 Network Topography:

It is acknowledged that it may not be possible achieve the preferred GSP configuration as this will be very dependent on the configuration of the existing DNO system, however the following requirements should at least be requested from the DNO.

The DNO should also be required to provide mean time between failure (MTBF) information for the BSP (to enable accurate theoretical reliability calculations to be carried out) along with details of proposed maintenance strategies to enable determination of the risk to the supply.

Preferred configuration:

- At GSP – minimum of a two section busbar with feeder circuits disposed across different busbar sections. Would prefer additional sections so that feeders are not disposed on adjacent sections to minimise the risk from common mode failures.
- (132kV) Double busbar for maximum selectivity.
- Direct parallel radial transformer feeder circuits.
- Avoid banked circuits at GSP where possible. Auto isolation / switching required where banked connections utilised.
- Diverse / segregated 132kV feeder routes.
- Interconnected arrangement with two radial transformer feeders fed from separate GSPs may provide resilience against loss of GSP but likely to limit available capacity and increase complexity due to parallel across NGT/EdF system.
- No perceived advantage with 132kV switchgear at BSP site.
- Standardised designs. Availability of strategic spares.

A1.4 22kV Switchgear / Busbars:

As this equipment is owned by Powerlink as opposed to the DNO, please refer to Section A2.4 for a description of the factors to be considered with regard to this equipment.

A1.5 Protection Arrangements:

EdF Networks largely responsible for design of protection schemes.

Expected that schemes would be based on current standards to provide

- Fully discriminating main protection schemes based upon a unit principle.
- Separate transformer and feeder protections with overlapping zones.
- 132kV busbar protection scheme at GSP. (N.B. may not be practice at some GSPs to provide circuit breaker failure scheme).
- Local back up protection schemes that provide complete discrimination in the event of main protection failure. This requires provision of directional phase and earth fault protection on the LV side of the transformer.
- Dedicated two way Intertripping scheme independent of the main protection. Fully supervised.
- Segregated supervised pilot communication channels for feeder protection on each circuit. Alternative (standby) route available from other circuit.
- Independence of main and back up protections as far as practicable to eliminate common mode failures e.g. with dedicated CT's, separate trip coils, etc.
- Duplicate battery / charger arrangement at BSP.
- LVAC Auxiliary supplies – 2 supplies, auto-changeover, essential / non-essential boards, LUL supply onto essential board (CEPS back-up).



A1.6 Automatic Switching

The application of automatic switching schemes to enable rapid restoration of supplies following a forced outage on the system should be considered in all future system design.

The prime objective of such schemes is to achieve the fast switching of the network to resupply loads before the operation of the undervoltage protections on the DC Traction and LVAC systems causes a more widespread disconnection of loads throughout the affected system.

The operating time of these undervoltage devices impose a limitation upon the time available to execute automatic switching routines. Current settings on the DC Traction systems, in particular those present in track feeder protection schemes, require that interruptions in supply are constrained to times that are less than 1.7 seconds. In practise this would require resupply to occur in a maximum of 1.5 seconds.

Whilst some increase in this time might be conceivable, if track feeder protections were inhibited from tripping for system wide loss of voltage, the existing rectifier undervoltage protection (set at a nominal 3 seconds) or LVAC undervoltage would allow a moderate increase only to the available switching time. Any consideration to increase existing undervoltage settings must be carefully studied.

For the total loss of a BSP (e.g. failure of upstream GSP) there is significant benefit from an automatic scheme to reinstate supplies since, if fast enough, it has the potential to prevent widespread disruption to the railway. The automatic resupply of a BSP load may be feasible utilising an Auto-Close scheme where the total load can be supplied from an adjacent BSP with sufficient interconnection capacity.

An Auto-Close facility designed to operate within the available time window may be implemented using a dedicated scheme based on locally derived data only (e.g. voltage, circuit status, protection operation, etc). The practicability of such a scheme would be determined by the busbar configuration.

Where this is not possible and loads have to be redistributed across two or more BSPs the logistics of such a scheme are likely to be extremely complex because of the possible variations in running arrangements that have to be considered. It may be further complicated by the constraints of PQ and possible implications for CEPS operation.

It is expected for the more complex schemes that the sequence of switching involving permissive and/or inhibit interlocks would require data obtained from remote sources (e.g. voltage, circuit status, protection operation, etc) and this is unlikely to be accomplished in the above short timescales. The integration of automatic switching schemes into the SCADA system is not acceptable.

Whilst the implementation of automatic switching schemes at the BSP level is expected to be more difficult to achieve, their application to Primary substations or Secondary systems must not be discounted since they may be more readily facilitated where the network is less complex.

In all cases a detailed study needs to be undertaken to determine the practicality of installing an automatic switching scheme, including the mechanism for implementation and the failure modes and switching actions that would be required under various operating conditions.