1. SCOPE

This Specification outlines SP Energy Networks (SPEN) technical requirements for the civil design and construction works associated with existing and new Primary Substations. Where changes are proposed to existing substations these should be undertaken in line with this document. The Constructor is entirely responsible for all aspects of the civil design and construction process.

This is a generic technical specification written in a manner that it may be used without alteration for all such works therefore certain parts may not be applicable to all substation construction types. It is not designed to cover every eventuality or site-specific situation; however, prior agreement must be obtained in writing from SPEN Engineering Design and Standards (ED&S) to any proposed variation to the guidelines provided in this Specification.

Development of proposals for site-specific variation that are acceptable to SPEN shall be the Constructor's responsibility and shall be submitted to ED&S for acceptance.

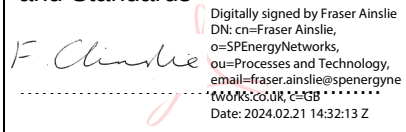
2. ISSUE RECORD

This is a Reference document. The current version is held on the EN Document Library.

It is your responsibility to ensure you work to the current version.

Issue Date	Issue No.	Author	Amendment Details
February 2020	Issue 4	C Ritchie	Use of sustainably sourced and recycled materials incorporated, Section 10.3.3 Security Requirements updated and security interfaces included throughout the document, Section 12.6 updated to cover the use of Esters and Emergency Drainage Plans, Section 12.16.17 general updates to door requirements.
December 2023	Issue 5	G Rees	Section 10.4.1 added to consider sustainable design. Updates to flood section inline with new policy. Changes to climate change allowance for drainage. Changes to concrete strength to allow for GGBS. Earthing changes to reflect policy. Changes to timber type for doors. Humidity levels in buildings reduced from 75% to 60%

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
Gareth Rees Principal Civil Engineer	Craig Young Engineering Design Manager	Fraser Ainslie Head of Engineering Design and Standards  Digitally signed by Fraser Ainslie DN: cn=Fraser Ainslie, o=SPEnergyNetworks, ou=Processes and Technology, email=fraser.ainslie@spenergynetworks.co.uk, c=GB Date: 2024.02.21 14:32:13 Z Date: .....

4. REVIEW

This is a Reference document which has a 3 year retention period after which a reminder will be issued to review and extend retention or archive.

5. DISTRIBUTION

This document is part of the SPD and SPM System Design Virtual Manuals and Construction Virtual Manual maintained by Document Control, but does not have a maintained distribution list. It is also published to the SP Energy Networks website.

6. CONTENTS

7. GLOSSARY

33kV Primary Substation:	An assembly of High Voltage Switchgear up to 33kV together with associated Control and Ancillary equipment where the lowest voltage is 400/230V and which may also include one or more 33/11kV Transformers and/or Reactors, all housed within secure enclosures.
Adopt:	Transfer of title, ownership, operation and maintenance responsibilities as defined in the adoption agreement.
AEP	Annual exceedance probability flood event.
Approved:	Equipment that is Approved in accordance with SPEN documents for use or installation on the Company network.
ARC:	Alarm Receiving Centre operated by Corporate Security or 3rd party.
CBA:	Cost Benefit Analysis.
CDM Regulations:	Construction (Design and Management) Regulations.
Civil:	Reference to civil or similar shall mean civil, structural and building engineering and shall apply to the design, manufacture, installation and demolition of all related permanent works.
Company:	Refers to SP Distribution plc, SP Transmission plc and SP Manweb plc.
Container:	Approved prefabricated containerised housing for 11kV and/or 33kV Switchboard(s) together with associated Control and Ancillary equipment within a secure Prefabricated Enclosure.
Constructor:	The party, including SPEN or other Third Party 'Turnkey' Design-Build Contractors and Third Party New Connection Developers and Contractors (ICPs), having ultimate responsibility for provision of the 33kV Primary substation, including design, construction and CDM. The 'Constructor' should also be read as the Designer or Contractor depending on the type of Contract.
Deemed to Satisfy:	Considered fit for the Company's purpose and compliant in principle with this Specification by and without further reference to SPEN.
Designed Flood Level	The flood level plus an allowance for climate change.
ED&S	SPEN Engineering Design and Standards.
Energisation:	The application of Voltage to an item(s) of Equipment from the system.
Equipment:	Switchgear, transformers, cables, overhead lines, surge arresters, voltage transformers, current transformers, protection & control, telecommunications, unit substations.
GIS:	Gas insulated switchgear.
GRP:	Glass Reinforced Plastic.
GPRS:	General Packet Radio Service is a packet oriented mobile data standard on the 2G and 3G cellular communication network's global system for mobile communications.
High Voltage (HV):	An alternating current (AC) voltage exceeding 1000 volts measured between the phase conductors.

HVAC:	Heating Ventilation and Air Conditioning.
Indoor Equipment:	Equipment designed solely for installation within a building or other housing where the Equipment is protected against wind, rain, snow, abnormal dirt deposits, abnormal condensation and frost.
IP:	Ingress Protection
LED:	Light Emitting Diode.
Low Voltage (LV):	An AC voltage not exceeding 1000 volts measured between the phase conductors.
National Environment Agency:	Environment Agency (EA) in England. Natural Resources Wales (NRW) in Wales. Scottish Environment Protection Agency (SEPA) in Scotland.
NGTS:	National Grid plc Technical Specification.
Outage:	De-energisation of an item(s) of Equipment on the Company's electricity network system.
Outdoor Equipment:	Equipment designed to be suitable for installation out with a building or other housing where the Equipment is not protected against wind, rain, snow, abnormal dirt deposits, abnormal condensation and frost.
SCADA:	System Control and Data Acquisition.
SP Distribution plc (SPD):	The Distribution Licence Holder for the distribution service area formerly known as ScottishPower.
SP Transmission plc (SPT):	The Transmission Licence Holder for the transmission service area formerly known as ScottishPower.
SP Manweb plc (SPM):	The Distribution Licence Holder for the distribution service area formerly known as Manweb.
SPEN:	SP Energy Networks, the brand name for the division of the ScottishPower group of companies that encompasses SP Distribution plc, SP Transmission plc, SP Manweb plc, SP Power Systems Ltd and ScottishPower Energy Networks Holdings Ltd.
SRA:	Security Risk Assessment conducted by ScottishPower Corporate Security.
SUDS:	Sustainable Urban Drainage Systems.
Third Party New Connection Contractor (ICP):	Connection Contractor: Suitably Lloyds/National Electrical Registration Scheme Accredited Contractor undertaking contestable work in the competitive connections market.
Transformers:	Reference to Transformers shall mean Transformers and Reactors.

8. RELATED DOCUMENTS

The design and construction of the works shall be in accordance with the relevant Eurocodes and British Standards specific to that design element. This is detailed further in Section 11 'Standards'.

8.1 Specific SPEN Documents

ASSET-01-021	Asset Inspection and Condition Assessment Policy
ASSET-01-023	Substation Security Policy
CAB-15-003	Handling and Installation of Cables up to and including 33kV
EART-03-004	Technical Specification for Earthing and Bonding at Primary Substations
SUB-01-012	Substation Fire Protection Policy
SUB-01-018	Substation Flood Resilience Policy
SUB-03-017	General Specification for the Civil Engineering and Building Design and Construction of Secondary Substations
SUB-03-018	Specification for Prefabricated Glass Reinforced Plastic Enclosures
SUB-03-026	General Specification for the Civil Engineering and Building Design and Construction of 132kV Grid Substations
SUB-03-029	Substation LVAC Installation Wiring Specification for New and Refurbished Substation Sites
SUB-03-034	General Specification for the Civil Engineering and Building Design and Construction of 275 and 400kV Substations
SUB-03-039	General Specification for the Re-Use of Concrete Structures

8.2 Iberdrola Networks Specifications

INS 50-40-11	Pre-fabricated enclosures for distribution substations

8.3 National Grid (NG) Documents

NGTS 2.10 Series	Generic Electricity Substation Design Manual Civil, Structural and Building Engineering.
NGTS 3.10 Series	Generic Technical Specification (Construction) for Civil, Structural and Building Engineering.
NGTS 3.01.02	Substation Earthing.

8.4 British Standards

BS EN 206-1	Concrete. Specification, performance, production and conformity.
BS 5266-1	Emergency lighting. Code of practice for the emergency escape lighting of premises
BS EN 60529	Degrees of protection provided by enclosures (IP code).
BS 8000	Workmanship on building sites, codes of practice.
BS 8500-1	Concrete. Complementary British Standard to BS EN 206-1
BS EN 14889	Fibres for Concrete
BS EN 12464-1	Light and lighting. Lighting of work places. Indoor work places
BS 1722-12	Fences. Steel palisade fences. Manufacturing and installation. Specification
BS 1722-14	Fences. Specification for open mesh steel panel

8.5 Other Documents

ENA TS 41/24	Guidelines for the Design, Installation, Testing and Maintenance of Main Earthing Systems in Substations
Standards for Highways DMRB Volume 2 - BD 43/03	The Impregnation of Reinforced and Prestressed Concrete Highway Structures using Hydrophobic Pore-Lining Impregnants.
Standards for Highways MCHW – Volume 1 – Series 0600	Earthworks
PAS 2080	Carbon Management in Infrastructure

9. INTRODUCTION

This document outlines SPEN's technical specification requirements for the civil design and construction works associated with existing and new Primary Substations. Where changes are proposed to existing substations these should be undertaken in line with this document. The Constructor is entirely responsible for all aspects of the civil design and construction process.

This technical specification shall be used for all Primary Substation types including:

- Substation containers housing Indoor Equipment, with or without Outdoor Equipment (e.g. transformers).
- Substation buildings housing Indoor Equipment installed within discrete purpose designed and traditionally built secure enclosures, with or without Outdoor Equipment (e.g. transformers).
- Indoor Equipment installed within a customer owned building, with or without Outdoor Equipment (e.g. transformers).

Certain sections within this specification may not be applicable to all aspects of a Primary substation project. Furthermore, the Specification is not designed to cover every eventuality or site-specific situation.

Where it can be demonstrated that a deviation from this Specification offers an equivalent or better technical and/or lower risk solution this will be considered on a site specific basis. All such deviations shall be fully discussed and agreed with ED&S within timescales that do not adversely affect project objectives and programme. The development of such proposals, that incorporate deviations from this Specification, shall be the Constructor's responsibility.

The technical specifications for the civil engineering and building design and construction of any Secondary or 132/275/400kV substations that form an integral part of Primary Substation schemes shall be as follows:

- Prefabricated substation enclosures — INS 50-40-11
- Secondary substations — SUB-03-017
- 132kV Grid substations — SUB-03-026
- 275kV & 400kV substations — SUB-03-034

9.1 Feasibility

Once the requirement for a Primary Substation has been established and the type of substation agreed, it is important that during the initial design stage the requirements detailed within this and other referenced documents are given due consideration.

In order to avoid possible abortive effort and subsequent delay; the Constructor shall confirm at the earliest opportunity how these requirements are to be met. This should be undertaken by forwarding preliminary layout drawings for comment to SPEN that demonstrate in particular the proposed means of achieving:

- Minimising Outages, Outage periods and impact on Company assets.
- Plant access/egress, including access routes and the method by which plant will be installed/removed.
- 24-Hour access/egress for SPEN personnel (NB access via third parties is not acceptable).
- Emergency egress.
- Fire segregation.
- ScottishPower Corporate Security's requirements.

- Cable entries / routes.
- Natural ventilation to Outdoor Equipment (in particular transformers).
- Avoidance of Noise nuisance.
- Avoidance of Flood risk.
- Consideration of site security.

Primary Substations shall be freestanding on a generally level site with access at ground level from the public highway. New buildings and containers should be designed and located such that they do not form part of the compound boundary.

Primary Substation enclosures (e.g., buildings or Containers), including where these are within Primary Substation compounds, shall have a minimum of 3m clear level access around.

Wherever practicable, Outdoor Equipment enclosures (e.g., to transformers), including where these are within Primary Substation compounds, shall have a minimum of 2m clear level access around.

Primary Substation compounds shall have a minimum of 2m clear level access around the perimeter externally and SPEN shall have bespoke rights of access, operation and maintenance over this (not applicable where this is in the public domain, e.g., at a frontage abutting public highway or footpath).

Actual clearances around substations and enclosures within substations shall be subject to the Constructor obtaining the express prior approval of ED&S with respect to requirements for operation and maintenance of the substation, plant access and cable/earth mat systems.

Enclosed type substations shall not be acceptable.

Enclosures to Outdoor Equipment that do not provide adequate natural ventilation shall not be acceptable.

9.1.1 Existing Substation Sites

Where works are proposed at existing substations and it is identified that existing civil assets have the potential to be utilised, a whole life cost analysis should be undertaken. Where a Primary substation compound contains concrete support structures then guidance shall be sought from SUB-03-039 - ‘General Specification for the Re-Use of Concrete Structures’. This analysis should conclude if the assets can be retained in their existing condition, repaired such that they can be reused or demolished and a new asset constructed. To identify the most appropriate solution the whole life cost assessment should incorporate the following:

- A Design and Condition Assessment of the relevant existing civil asset based on the requirement for it to support the functional requirements of the proposed electrical plant over the anticipated design life.
- Identification of any replacement/strengthening/repair/refurbishment works, and associated costs, required to extend the service life of the civil asset, in line with the life expectancy of the electrical plant.
- Identification of any departures from this Specification that are required to be agreed and any risks associated with utilising existing civil assets.
- An outline programme of the likely Inspection and Maintenance requirements associated with any extension to the service life of the asset.

10. GENERAL REQUIREMENTS

10.1 Consents

Consents matters are outside the scope of this document but the design and construction teams are responsible for ensuring that all necessary legislation is followed, that all statutory consents and permissions are in place and that any associated applicable conditions are discharged prior to commencement of construction.

Over and above the minimum legislation and statutory consent requirements the following should be considered:

- Land Acquisition or Lease arrangements.
- Approvals for discharge to surface water, groundwater and foul drainage systems from the relevant Regulatory Authority.
- Construction Site Licenses.
- Party Wall Etc Act, or where this is not applicable, prior formal notification of proposals to adjacent third-parties who potentially may be affected by the works.

10.2 Pre-Engineering Studies

The Constructor shall carry out adequate appropriate desktop and site-based Pre-Engineering Studies to provide the information necessary to ensure:

- The safe transfer of design loadings to ground.
- Compliance with respect to contamination and ground water risk.
- Drainage discharge options are identified.
- Environmental risks are identified and independently verified including, but not limited to, ecology, noise nuisance and flood related risks.

Other studies should be undertaken where considered necessary or appropriate on a site-specific basis.

Unless rock-head is confirmed as shallow by other means (e.g., trial pits) then boreholes shall be drilled as close as possible to the proposed locations of buildings, transformers and other items of plant within the proposed site.

Additional Pre-Engineering Studies should be undertaken as necessary where substations are located in complex situations. In particular where desktop studies indicate that particular risks may be present from:

- Brownfield or infilled sites.
- In the vicinity of principle aquifers, coastal zone areas or areas with a high water table.
- Potentially contaminated sites.
- Where piling or ground improvement may be required.
- Where there has been previous deep or shallow mine working activity (coal, salt, metals, etc).

Where ecology survey results indicate that they are present, all traces of invasive plant species such as Japanese Knotweed, Giant Hogweed and Himalayan Balsam shall be entirely removed as necessary for the purpose of the works and provision made to prevent them from re-establishing in those areas. Waste material from these plants is classed as 'controlled waste' and must be disposed of at a suitably licensed or permitted waste site.

Pre-Engineering Study records and reports shall be available for audit inspection by SPEN, including confirmation that:

- Worst case design load combinations would be safely transferred to suitable ground of adequate bearing capacity and that the extent of any potential future settlement would not adversely affect the operation of the substation, its infrastructure or its equipment (including cables/cable entries and other services).
- The substation operation would not be adversely affected by flooding.
- The substation operation would not be the source of a 3rd-party noise nuisance complaint in relation to transformers or other noise generating equipment (including in relation to adjacent 'future' new development).

10.2.1 Existing Substation Compounds

Where electrical plant is being replaced then theoretical assessments, visual inspections, non-destructive testing and intrusive testing/analysis as specified within SUB-03-039 shall be carried out to confirm the works that are required such that the existing foundation plinths, superstructure supports or other assets can be utilised as part of the new works.

10.2.2 Existing Substation Buildings

Where it is proposed to utilise an existing building to house new switchgear then a condition assessment of the building against the requirements detailed in this Specification, shall be undertaken.

The assessment shall consider the structural design integrity of the building and ability to withstand a disruptive failure event. Additionally, the main design and technical requirements of this specification, refer to Table 1, should be assessed, with cognisance taken of all design and technical requirements detailed in this document.

Upon completion of the assessment a whole life cost analysis should be undertaken to identify whether refurbishment or replacement of the existing building is the most appropriate solution. Consideration of deviations from this Specification, which offer an equivalent or better technical and/or lower risk solution will be reviewed on a project-specific basis and should be agreed with the SPEN Civil Asset Manager.

Design Requirements (Section 10.4)	Civil Technical Requirements (Section 12)	Building Services Technical Requirements (Section 14)
Flood Mitigation	Drainage	Heating Ventilation and Air Conditioning (HVAC)
Structural Design	Oil Containment	
Disruptive Failure	Acoustic Barriers	Building Electrical Systems
Fire Risk	Fire	
	Security	

Table 1 – Design and Technical Requirements

10.2.3 Substation Earthing

Substation Earthing Systems should be designed and installed in accordance with SPEN specification – EART-03-004. The Constructor shall carry out adequate and appropriate Earthing Studies, from which the earthing design shall be developed. The resulting Earthing Report shall be available for audit inspection by SPEN.

10.3 Scheme Development (Detailed Submission)

Subject to preliminary layout (feasibility) drawings being acceptable in principle to SPEN, it shall then be the Constructor's responsibility to develop the scheme in detail in accordance with this Specification. Proposed General Arrangement and Construction drawings shall be submitted to include plans, elevations and sections of the buildings, structures and external works and shall clearly indicate the main dimensions, material and forms of construction proposed by the Constructor as follows:

- Site location plan showing the whole of the site and access route, together with surrounding landscape and land use.
- Site layout plan(s) showing the configuration of equipment and equipment enclosures within the site, together with setting out data, electrical clearances, site finishes, drainage, external lighting and security fencing.
- General arrangement drawing(s) for buildings/containers/housings that include details of floor layout(s) and indicate dimensional access, operation and maintenance clearances between and around equipment.
    - Sections, a minimum of two (one in each plane) for each enclosure, to include all cable entries and outgoing services, clear headroom to plant and relevant finished ground and floor levels.
    - Elevations for the overall substation in total, including doors and any natural ventilation to equipment enclosures (buildings/containers/housings).
    - Building services etc., e.g., small power, lighting, heating, ventilation, water supply (if applicable), etc.
    - Earthing.
    - Signage.
- Other relevant information as applicable.

The constructor shall also complete the design submission checklist and submit this along with any construction drawings that form part of the design submission pack.

Where applicable and considered appropriate by SPEN, typical deemed to satisfy substation layout drawings may be issued for guidance, either generic associated with this Specification or on a project-specific basis. Such drawings would indicate minimum dimensional requirements and would be based on optimum layouts for equipment, ventilation, plant/personnel access/egress and cable entry.

The Constructor shall make proper provision in the programme for both the design and construction and shall allow a minimum of 28 days for SPEN to comment on each design and drawing submission, including any proposed site-specific variation to this specification or associated typical deemed to satisfy details. The Constructor shall ensure that cognisance is taken of all such comments, however, acceptance of the Constructor's design submissions by SPEN shall not relieve the Constructor of any design responsibility or any generic functional obligation of this Specification, nor shall it imply any liability on the part of SPEN.

10.3.1 Equipment Enclosures (Buildings, Housings/Containers & Compounds housing Indoor & Outdoor Equipment)

SPEN will only install equipment into or formally adopt Approved Equipment installed by others within enclosures that satisfy the requirements of this Specification and the specification for prefabricated enclosures 'INS 50-40-11 - Pre-fabricated enclosures for distribution substations'.

Selection of a particular type of enclosure may be subject to varying operational and supply requirements that take precedence over considerations of appearance, cost, local environment, etc.

General functional requirements include:

- Design to eliminate flood risk, including during a 1 in 1,000 year climate change flood event.
- Suitable access for and cover to high and low voltage (LV) cables, including sealed cable entries to prevent belowground ingress of moisture, gas and vermin into and beneath enclosures containing Indoor Equipment and escape of oil from enclosures containing oil filled Outdoor Equipment (e.g., transformers).
- Security, in preventing hazardous intrusions as well as unauthorised entry.

10.3.1.1 Indoor Equipment

SPEN utilise proprietary prefabricated and traditional conventionally built enclosures that are deemed to relieve and/or contain an internal pressure rise due to a disruptive failure of the plant by means of steel enclosures with pressure relief panels and/or structurally robust traditional construction.

Functional requirements for enclosures to Indoor Equipment include:

- Weather-tight enclosure construction to prevent moisture ingress.
- Preclusion of surface water run-off entry.
- Suitable internal enclosure environment, in particular with respect to natural ventilation and the elimination of moisture ingress or condensation.
- Minimum 1-hour fire segregation between substation compartments.

SPEN accept that in exceptional circumstances particular site-specific environmental situations may demand consideration of alternative enclosure types. In such situations, the same functionality requirements shall be factored into the enclosure design, together with any other relevant factors that are specific to the designed solution.

10.3.2 Security Requirements

To ensure the requirements outlined in SPEN's security policy 'ASSET-01-023 Substation Security Policy' are achieved ScottishPower Corporate Security should be engaged at the earliest opportunity to ensure that any required Integrated Security Systems (ISS) works or upgrades are incorporated into the substation project to mitigate the risks identified in the site Security Risk Assessment (SRA).

Any ISS works or upgrades that are required shall be agreed by the project team, ED&S and ScottishPower Corporate Security such that they prevent hazardous intrusions and unauthorised entry.

ISS solutions will be installed by the ScottishPower Corporate Security preferred framework contractor and any civil works (ducting, earth works, foundations) will be installed by a separate civil contractor however responsibility for the various elements of the works should be agreed on a project-specific basis.

10.4 Design

10.4.1 Design Methodology

Civil and building infrastructure in its entirety shall be designed to meet the functional requirements of the works for a minimum of 40 years. Where SPEN subsequently adopt the civil and building fabric, the design and construction detail shall be such that future inspection and maintenance is minimised with a first life maintenance of not less than 20 years.

Substation design shall take cognisance of Pre-Engineering Studies and shall be such that no sprinkler systems, gas, water, drainage or other third party service pipes, cables or heating and

ventilation ducts are detailed within substations, in particular through or beneath equipment housings or supports within substations.

The Constructor shall adopt a design methodology that shall identify all significant factors in the design and ensure that proper attention is given to each factor at every stage in the design process. The Constructor shall prepare for the whole works and each discrete section thereof a Design Basis Statement that shall be made available to SPEN 14 days prior to commencement of the full design process. The Design Basis Statements shall describe the high-level design philosophy and assumptions to be adopted and shall include but shall not be limited to:

- Geotechnical Assumptions.
- Foundation Design Concept.
- Load Cases giving the magnitude of all dead, imposed, plant, wind and short circuit forces (etc.) considered to be appropriate for each structural element.
- Load Case Combinations.
- Support Structure and Building parameters.

Design Basis Statements shall identify applicable BS/BS EN documents.

Dead, imposed and dynamic loadings/actions for approved equipment are available from the manufacturers.

The detailed design submission must be in the English language and shall be prepared in terms of SI units in accordance with the recommendations of applicable BS/BS EN documents. All dimensions shall be in millimetres.

10.4.1.1 Sustainability / Net Zero

SP Energy Networks are committed to achieving net zero by 2035 and have set ambitious Science Based Targets – focussed on decarbonising all operations. including indirect emissions associated with the development of our infrastructure.

Substation design and construction should follow the principles of PAS 2080 Carbon Management in Infrastructure. Where possible, whole life carbon emissions associated with the substation shall be quantified and opportunities to reduce carbon impact through more intelligent design, construction and energy efficiency should be considered at each stage in the project and taken forward where practical.

10.4.2 Flood Mitigation

Substations shall be designed such that there is no loss of supply or damage to strategic equipment during a 0.1% (1 in 1000) annual exceedance probability (AEP) flood event. Access routes to the substation shall also be considered to ensure access will be available during flood conditions and consideration of staff access to the key plant and buildings during the 0.1% (1 in 1000) annual flood event.

In those instances where there is a compelling reason to locate a substation inside this zone and this is accepted by SPEN Network Planning & Regulation the substation design shall eliminate or mitigate against the risk of such a flood impacting the operation of the substation (access requirements, loss of supply, or damage to equipment).

Primary substations shall be constructed at a minimum level of 600mm above the 0.1% or (1 in 1000) designed flood level, the 600mm freeboard allows for uncertainties in data and modelling. The designed flood level shall include an allowance for climate change for a 50-year design life, in accordance with the requirements of the relevant national environment agency. Where climate change guidance is not available then a minimum of 200mm shall be applied. The flood design should consider Pluvial, Fluvial, Coastal and Reservoir flooding, as well as combinations of these.

In addition, such schemes shall incorporate any requirement for compensatory storage as required by the Flood Risk Assessment (FRA) and be approved by the relevant national environment agency and/or applicable local authority.

Written acceptance for any proposed design measures to mitigate flood risk is required from ED&S prior to the construction of the works.

10.4.3 Structural Design

The structural design of the civil and building fabric is entirely the Constructor's responsibility and shall be prepared, checked and approved to professionally recognised design Quality Assurance procedures by appropriately qualified and experienced engineers, preferably Chartered Civil or Chartered Structural Engineers. Calculations shall be available for audit inspection by SPEN and, where applicable, calculation information shall be included within the CDM Health & Safety File handover to SPEN.

Dead, imposed and dynamic loadings/actions for approved plant and equipment are available from the manufacturers, in particular with respect to applied loading to floors from Indoor Equipment and to plinths/support structures for Outdoor Equipment.

10.4.4 Disruptive Failure

Although substation equipment is extremely reliable and the probability of a disruptive failure due to internal arcing is very low this does have implications for both the design and location of substations, and the Constructor shall ensure that substation designers are aware that considerable internal overpressure and fireball may be produced when this condition occurs.

Rooms within buildings (etc.) enclosing High Voltage (HV) switchgear shall be designed such that they maintain their integrity and relieve or withstand the overpressure that can be developed during a disruptive failure under the most onerous simultaneous operation condition. Whilst it is not possible to measure or reasonably quantify the magnitude of any potential overpressure, experience over many years has demonstrated that the approved prefabricated Container housings, robust construction steel clad-portal framed enclosures and the typical traditional (masonry/reinforced concrete) construction enclosure details indicated by this Specification are generally adequate to relieve and/or reasonably contain this overpressure and are therefore the preferred and most appropriate forms of construction.

Designers shall give due consideration to the potential for such disruptive failure in locating egress routes and in structural civil design. Designers shall note that masonry panels to traditional construction enclosures housing HV switchgear may require secondary steelwork support (e.g. wind posts) or other lateral structural reinforcement and that structural concrete slab roof construction may be necessary to provide lateral restraint to the tops of wall panels, even where this may be as a sub-roof beneath a superimposed pitched roof over.

Where it is proposed to utilise an existing building for housing new switchgear then an assessment of whether the existing building can withstand the consequences of a disruptive failure should be undertaken. This assessment should consider whether, for the new switchgear, the building can maintain its integrity and relieve or withstand the overpressure that can be developed during a disruptive failure under the most onerous simultaneous operation condition.

In line with the CDM design obligation to limit the risk associated with disruptive failure the preferred and optimum location for a substation is freestanding and detached from other development and every effort shall be made by the Constructor to comply with this requirement.

10.4.5 Fire Risk

The Constructor shall be responsible for ensuring that any necessary approvals are obtained from applicable fire authorities. Where applicable, any necessary fire certification shall be included within the CDM Health & Safety File handover to SPEN.

In addition, a site-specific risk assessment shall be carried out that shall consider:

1. The likelihood of members of the public being in the vicinity/close proximity.
2. The substation type and location with respect to property types and public areas.
3. The transformer, plant, and insulant type.
4. The access/egress arrangements for members of staff/contractors.

The fire risk should be assessed by the Constructor and shall provide no less than the minimum mitigation measures to enclosures housing Indoor Equipment and to oil containing Outdoor Equipment (e.g., transformers and reactors) in accordance with this Specification and SPEN Substation Fire Protection Policy SUB-01-012.

10.4.6 Discharges to Surface Water, Foul Water and Groundwater Drainage Systems

The Constructor shall be responsible for obtaining any necessary approval of proposals for discharge of storm, foul and oily-water drainage systems from the relevant national environment agency or applicable local authority before proceeding with the relevant construction work.

Any formal consent approvals shall be included within the CDM Health & Safety File when it is handed over, together with any applicable permits, consents, exemptions, licences and legal rights to discharge.

10.5 Substation Site Layout

Typical Drawings may be available from SPEN which indicate deemed to satisfy details for various Primary Substation layout types, however; Constructors shall note that where issued this guidance is generic only and that the Constructor's actual design proposals must reflect the supply-specific and site-specific situation.

The preferred and optimum location for a substation is freestanding on a generally level site with access at ground level from the public highway.

SPEN shall own or have rights over a 2.0m wide strip outside the perimeter substation security fence.

Reliance on recourse to third parties for compliance with the requirements of this Specification to provide suitable unrestricted 24-hour access/egress for SPEN Authorised personnel would not be acceptable, and standard Company suited lock(s) must control this.

Oil separators, septic tanks, SUDS features and associated equipment shall be sited adjacent or close to roads to facilitate access for maintenance vehicles.

Constructors shall note that pedestrian safety barriers may be required where the site layout is such that emergency egress from the substation is towards a vehicular traffic route, and that these barriers would be required to be demountable if this were also a plant access route for the substation.

Constructors shall note that vehicular crash barrier protection may be required external to the substation where the site layout is such that SPEN perceive there to be a risk of impact to the substation from vehicular traffic (e.g., substations adjacent to vehicle turning areas or where access roads are at a higher level).

10.6 Setting Out

It is essential that substations be set out in accordance with Land Acquisition drawings where the Company have or will subsequently take freehold or leasehold possession of the land on completion.

10.7 Services

At existing sites all utility apparatus, including cables, pipes, trenches, buried earthing conductors and services of any kind (including spare ducts) which may be encountered during the course of the works are to be maintained in position, protected and kept in working order. Where these are identified as not being in accordance with the existing records an accurate location and depth survey of these services should be undertaken during the construction works and this information should be incorporated into the CDM Health & Safety File.

Existing and new sites may be crossed by underground services, the location and depth of which may not be known. During the construction works all practicable measures should be undertaken to identify and prove the location of ALL underground services by detection and/or hand excavated trial pits prior to the start of the works. During the construction works a system to permanently mark the routes of such underground services for the duration of the site works should be implemented.

10.8 Construction

It is incumbent upon the Constructor to comply with all relevant legislation, including future updates and publications in keeping with industry best practice.

Typical Drawings may be available from SPEN which indicate typical deemed to satisfy construction details for various Primary Substation types. Constructors shall note that where issued these guide details are generic only with respect to such aspects as dimensions, handing, cable entries, etc.

The Constructor shall ensure that civil engineering and building contractors engaged to carry out works under this Specification are competent, qualified and experienced with respect to the nature of electricity substation construction. Civil and building contractors should hold appropriate membership of the National Federation of Builders, Federation of Master Builders, Civil Engineering Contractors Association or similar professional trade body. Operatives should hold appropriate Construction Skills Certification Scheme (CSCS) Cards or National Vocational Qualifications (NVQs); in particular welders shall be tested to meet and satisfy the requirements of the National Structural Steelwork Specification for Building Construction.

The Constructor shall be responsible for the design and construction of all temporary works deemed necessary to facilitate the construction works. All temporary works should be removed from site prior to project handover.

The standard of workmanship shall be in keeping with industry best practices and shall not be less than that specified by BS 8000.

The Constructor shall ensure that civil engineering and building contractors engaged to carry out works under this Specification take all reasonable precautions to ensure the safety of all parties concerned with or affected by operations associated with substation construction works.

The safety or operation of any existing Company utility plant must not be prejudiced; records of buried services must be obtained from all utilities and safe-digging practices must be adopted, including the use of a cable-locating tool.

The Constructor shall notify SPEN prior to commencement of substation construction works.

Substation construction shall be such that no sprinkler systems, gas, water, drainage or other third-party service pipes, cables or heating and ventilation ducts are built within, through or beneath substations, in particular through or beneath equipment housings or supports within substations.

SPEN will not install equipment into substation enclosures until and unless all building works (except post-commissioning finishing works) are complete and are in accordance with this Specification. Unless variation has been agreed in writing by SPEN prior to construction, a delay in plant installation and/or energisation could result if works are not in accordance with this Specification.

SPEN will not consider formal adoption of Approved Equipment or civil infrastructure installed and commissioned by others until and unless all associated building and civil engineering works are complete and in accordance with this Specification, including receipt of As-Built information where

applicable (i.e. in relation to adoption of the civil fabric of enclosures such as buildings, containers and compounds).

10.9 As-Built Information

As-Built drawings, Operating Manuals and CDM Health & Safety Files shall be submitted to SPEN in an agreed electronic format. To allow SPEN to manage their assets a Civil Asset Management Plan should be provided for each project. This document should be in an agreed format that will allow the development of an inspection and maintenance regime for the project.

10.10 Quality Assurance

All materials shall be of good quality, suitable for purpose, designed and manufactured such that they provide safe and continuous service and are capable of withstanding the various stresses and onerous conditions to which they may be subjected to on the site of installation without suffering any undue deterioration.

The Contractor shall adhere to the agreed project Environmental & Quality Management plan to ensure that the scope of the project is carried out in accordance with all specified standards, specifications, current legislation, drawings and documents and to ensure that a high standard of workmanship and quality is maintained throughout the project.

11. STANDARDS

Civil and building infrastructure in its entirety shall be designed and constructed to comply with the following documents, unless expressly varied by this Specification.

- SPEN Policy documents.
- SPEN Specification documents.
- NGTS 2.10 and 3.10 document suites.
- European Standards.
- British Standards.
- Codes of Practice.
- Relevant Industry Guidance.

Some basic civil engineering and building technical compliance information that is contained within such documents is repeated within this Specification, over and above functional design and construction requirements, in order to assist in the initial development and costing of the civil aspects of substation projects.

Where associated Standards do not explicitly relate to civil, structural or building engineering but nonetheless contain requirements that may impact upon these aspects it shall be the Constructor's responsibility to ensure a holistic and compliant overall design solution (e.g., in relation to earthing).

Building Regulations requirements shall apply unless stated or expressly implied otherwise within this Specification. Where literal compliance is not possible the work shall be to a standard agreed with ED&S that takes the Building Regulations as its basis.

12. CIVIL TECHNICAL REQUIREMENTS

Where applicable and considered appropriate by SPEN, typical deemed to satisfy substation construction detail drawings may be issued for guidance, either generic associated with this Specification or on a project-specific basis. Constructors shall note that such drawings would be typical only and that actual design proposals must reflect the supply-specific and site-specific requirements.

12.1 Security

Substation security is of prime importance and buildings generally shall be designed and detailed to minimise the potential for vandalism and unauthorised entry. Corporate Security shall be consulted on a project-specific basis and may undertake a site-specific SRA to identify any additional security measures. These additional measures shall only be incorporated with the express agreement of ED&S.

12.2 Site Clearance

Prior to the start of the construction works, the site should be cleared of all rubbish and debris, with nothing being burnt or buried on site. The removal of all natural or man-made features where they conflict with the proposed works including roads, fences, walls, and vegetation should be undertaken in accordance with any project environmental constraints.

Where materials cannot be reused within the works they should be taken off site and disposed of in strict accordance with current legislation and best practise.

12.3 Earthworks

All foundations shall be set on undisturbed inorganic strata that provide a minimum design safe ground bearing capacity of 100kN/m². Within existing sites testing of the ground bearing capacity should be undertaken at the proposed foundation formation level and the foundations designed to provide the most efficient solution.

A list of acceptable and unacceptable earthworks materials, including recycled materials, are detailed within Standards for Highways MCHW – Volume 1 – Series 0600. To align with SPEN's sustainability goals the preference is for proposed earthworks materials to be from reused or recycled sources however it is recognised that this may not be achievable in all situations.

The bottom of excavated areas shall be trimmed, levelled or graded and well rammed or otherwise compacted. The construction sequence shall be such that undue exposure of the formation level to excavations is avoided. Excavations shall be kept free from all sources of water, with any removal of water complying with environmental legislation and best practise.

Where the use of reclaimed infill material is proposed this shall be demonstrably fit for purpose subject to the express prior acceptance of SPEN, including submission of a true representative sample for inspection. These tests shall demonstrate that the fill material can be suitably compacted and that the settlement characteristics with regard to required design to tolerances can be reasonably achieved within the timescale of the proposed works. Where the use of reclaimed infill is accepted it shall satisfy the requirements of this Specification and shall not contain any deleterious or degradable material of any size or proportion.

The works should ensure that further settlement or ground heave effects after the construction of foundations, access roads, buildings, underground services, cable trenches, security fences and walls are restricted to a maximum long-term settlement of 25mm.

Any excess excavated material from the site which is unsuitable for use in the works and cannot be used elsewhere within the project, including in any designed landscaping, should be removed from site to a suitable landfill site.

Excavations to reinforced concrete foundations shall receive a minimum 50mm thick layer of blinding concrete cover on completion.

12.4 Compound Construction

12.4.1 Stoned Compound Areas

Compound surfacing shall not be less than 300mm overall depth of construction comprising an approved build-up of:

- A minimum 75mm layer of approved recycled angular 14-20mm graded aggregate.
- On a minimum 225mm layer of approved recycled Type 1/Type 3 granular layer compacted in a minimum of two layers.
- Where it is deemed that existing ground conditions are poor and to avoid surface rutting, and deformation of the sub-grade/sub-base layer an approved geotextile separation membrane can be provided between the sub-grade layer and the Type 1/Type 3 granular layer, unless the subgrade layer is a newly constructed platform with a minimum depth of 0.5m.

Structural geotextiles or *Geogrid* reinforcement type systems shall additionally be designed and incorporated into the substation platform design where ground conditions dictate and where reinforcement and or separation of the underlying strata is required to provide increased ground bearing capacity and limit ground settlement.

Stoned areas generally shall be finished at or below the bottom of chamfers to structure plinths and the detail shall be such that trip hazards are avoided.

12.4.2 External Perimeter to Substation Compounds

Primary Substation perimeters that do not otherwise abut adopted highway or highway footpath shall incorporate a minimum 1.0m wide perimeter maintenance access footpath external to the substation footprint/security boundary fence.

External perimeter footpaths shall not be less than 150mm overall depth of construction subject to removal of all organic soil matter; comprising an approved build-up of:

- A 50mm thick layer of approved recycled 6-10mm angular stone chipping topping.
- On a minimum 100mm thick compacted layer of approved recycled Type 1 sub-base.
- An approved weed suppressing geotextile membrane below the Type 1 sub-base.

12.4.3 Compound Earthing Systems

Compound Earthing Systems shall be installed and tested in accordance with EART-03-004.

12.4.3.1 Installation

Installation shall be designed and sequenced with the bulk earthwork and compound construction activities to minimise duplication of excavation.

Excavation and backfill complete shall be a minimum 300mm wide by 750mm deep (below finished compound level) with 150mm bed and backfilled with 300mm cover of fine textured firmly rammed recovered topsoil or similar approved material all enclosed within a structural geotextile surround and with specified compound construction over. The Constructor's detailed proposals shall be submitted to SPEN for comment prior to installation.

Installation of buried bare metal earth tape and earth rod systems to compounds shall be by SPEN approved specialist installers.

12.4.3.2 Testing

Testing to measure the total substation earth electrode impedance shall be a Hold Point within the agreed project Environmental & Quality Management plan.

12.5 Concrete

Concrete shall be designed to current standards, subject to the minimum strength classes and minimum standard of finish as indicated in Table 2. Exposure class and minimum cover to reinforcement shall be appropriate for the site and ground specific conditions in accordance with the civil design. Specified characteristic strength shall be verified by independent concrete cube tests.

A flat, level and smooth surface finish to floors and plinths is essential for the installation of plant to be acceptable to SPEN. The deviation from the underside of a 2m straight edge resting in contact with floors and plinths shall not be more than 3mm.

Exposed arrises to plinths shall be chamfered. Arrises to ramp transitions onto floors, vertical corners within cable trenches and the like over or around which cables could pass shall be rounded.

With the aim of working towards Net Zero the use of lower carbon concrete such as GGBS maybe considered, however this shall be suitable for the proposed application without reducing the required strength and/or durability requirements stated in Table 2.

Concrete containing additions such as fly ash and GGBS will exhibit lower relative early age strengths than those containing Portland Cement only. In these cases, it is possible to specify 56-day strength provided this has been considered in the structural design and the construction programme.

Where early strength is important, some compromise on the level of cement replacement may be needed.

The use of recycled materials within concrete is preferred, where appropriate, and where specified within the detailed design the use of fibre reinforced concrete should be in accordance with BS EN 14889 Part 1 or Part 2.

12.5.1 Reinforcement

In general, where the structural design concludes that reinforcement of a concrete element is required to resist the loading conditions and serviceability requirements, traditional steelwork reinforcement (bars or mesh) shall be provided in the designed solution. However, in appropriate circumstances, the use of fibre reinforcement is acceptable in principle on the basis of this solution being entirely suitable for the intended purpose.

12.5.2 Concrete Substructures

Concrete foundations shall incorporate a minimum 50mm thick blinding concrete.

Exposed edges of plinths, upstands and the like shall incorporate appropriate chamfers, which shall not be less than 25mm and shall be proud of surface finishes.

Where applicable, ducts and slots shall be incorporated within foundations and plinths to provide access for cables (multi-cores and power) and haulage or jacking points shall be provided where necessary for installation and removal of transformers and reactors.

12.5.3 Concrete Superstructures

Where SPEN will subsequently adopt the civil fabric of the substation the exposed surfaces of reinforced concrete superstructures (e.g., fire barrier walls, concrete support posts) shall be treated with a protective surface impregnation system. These works should be in accordance with DMRB BD 43/03, be undertaken not less than 7 days after the concrete has been poured and should comply with all H&S legislation including Control of Substances hazardous to Health (COSHH).

Concrete Use	Strength Class (Grade) to: BS EN 206-1/BS 8500-1	Max. Agg' Size (mm)	Type of Concrete Finish	
			Type	Description
Blinding Layer	C16/20	20	**BURIED UNFORMED SURFACE** Finish to buried worked surfaces produced without formwork	**BASIC FINISH**: Concrete shall be levelled & screeded initially for a uniform plain or ridged surface as required for subsequent work.
Mass Infill	C16/20	40		
Sub-structure (Below Ground Level) Buried Formed Finishes e.g., buried sections of buildings, bunds, equipment foundations	C32/40	20	**BURIED FORMED SURFACE** Finish to buried surfaces produced with formwork	**ORDINARY FINISH/ROUGH FINISH:** Forms designed to produce a dense smooth finish free from voids or honeycombing greater than 10mm and other large blemishes.
Sub-structure (Above Ground Level) Exposed Worked Finishes e.g., exposed top face of equipment plinths, floor slabs (finished with anti-slip paint)	C32/40	20	**UNFORMED SURFACE** Finish to exposed worked surfaces produced without formwork	**PLAIN FINISH/STEEL TROWEL/POWER FLOAT FINISH:** Wood float finish as below to be steel trowelled under firm pressure or preferably power floated to produce a dense uniform smooth polished surface free from trowel marks or other blemishes.
Sub-structure (Above Ground Level) Exposed Formed Finishes e.g., equipment plinth upstands, walls (bunds and others) (finished with anti-slip paint)	C32/40	20	**FORMED SURFACE** Finish to exposed surfaces produced with formwork	**PLAIN FINISH/FAIR WORKED FINISH:** Forms designed to produce a hard smooth surface with true, clean arrises. All surface blemishes and irregularities made good as specified (e.g., cement paste to green concrete). Concrete rubbed down after curing to produce a smooth and even surface.
Super-structure Exposed Worked Surfaces to tops of walls or roof slabs to receive waterproof systems	C32/40	20	**UNFORMED SURFACE** Exposed worked surfaces that will subsequently be covered produced without formwork	**PLAIN FINISH/WOOD FLOAT FINISH:** Basic finish as above to be wood floated under light pressure initially to eliminate surface irregularities then under firm pressure after moisture film has disappeared and the concrete cured sufficiently to prevent laitance being worked to the surface.
Super-structure Exposed Formed Finishes e.g., to tops of walls	C32/40	20	**UNFORMED SURFACE:** Exposed worked surfaces produced without formwork	**PLAIN FINISH/STEEL TROWEL/POWER FLOAT FINISH:** **AS ABOVE.**
Super-structure Exposed formed finishes e.g., to walls, columns etc	C32/40	20	**FORMED SURFACE:** Exposed surfaces produced with formwork	**PLAIN FINISH/FAIR WORKED FINISH** **AS ABOVE.**
Pavements at Ground Level Exposed Worked Finishes e.g., footways, roads	C25/30	20	**UNFORMED SURFACE** Finish to exposed surfaces produced without formwork	**SPECIAL FINISH/BRUSHED FINISH** Brushed textures applied with uniform pressure transversely across the slab while the concrete is still plastic. To produce even texture with no ridges being formed.
Others Not listed above or Precast e.g., equipment support posts, firewall, trenches			**UNFORMED AND FORMED SURFACES**	**BESPOKE FINISH** By prior agreement with SPEN on a project-specific basis.

Table 2 – Designed Mixes of Concrete

12.6 Masonry

12.6.1 Masonry Units

Masonry materials shall be selected to maximise durability consistent with the architectural or planning requirements for the substation.

The minimum acceptable standard for belowground masonry shall be High Density (HD) Category I clay brickwork of minimum 75N/mm² mean compressive strength, 7.0% maximum moisture absorption and durability designation F2 S2 (ex-'Engineering Class B' quality designation or equivalent).

External masonry shall be HD clay-facing brickwork of minimum 30N/mm² mean compressive strength, maximum 12% moisture absorption and durability designation F1 S1 or better. SPEN acknowledge that there may be certain site-specific situations where it is essential to propose the use of lower quality external masonry to meet Planning Authority or other aesthetic requirements. In such circumstances it may be necessary to apply an appropriate coating system protective hydrophobic impregnation system to ensure that undue moisture penetration is prevented.

Internal masonry enclosing rooms that house HV switchgear shall be light coloured solid smooth fair-faced clay or concrete facing brickwork of minimum 20N/mm² compressive strength and maximum 12% moisture absorption.

Internal masonry generally shall otherwise be the Constructor's design responsibility, however; modular, cellular, hollow and some forms of perforated masonry units would not be acceptable. It is essential that walls to support equipment present a smooth plumb even surface.

12.6.2 Ancillary Items

Mortar grade shall be appropriate for the masonry type, including the use of sulphate resisting cement where necessary (e.g., in certain belowground conditions). In particular, mortar to internal concrete brickwork shall be Class iii.

Brickwork ties to cavity walls shall be stainless steel Type 1 or Type 2 construction evenly spaced and staggered in alternate courses. Where enclosing rooms house HV Equipment they shall be spaced at maximum 450mm centres vertically and 450mm centres horizontally.

Where utilised, masonry bed-joint reinforcement shall be stainless steel construction.

Where utilised, built-in wind posts shall be galvanised or stainless steel construction.

Damp proof courses shall be incorporated and shall be either High Density (HD) Category I clay brickwork of minimum 125N/mm² mean compressive strength, 4.5% maximum moisture absorption and durability designation F2 S2 (ex-'Engineering Class A' quality designation or equivalent) or proprietary high performance (high load/strength, high bond) pitch-polymer systems.

12.7 Roads and Footways

12.7.1 Road Crossings from Highways

Where vehicular crossings are required to highway footways or verges the design and construction shall be to the Local Authority's approval and the Constructor shall be responsible for all notifications together with any associated fees.

12.7.2 Substation Access/Service Roads

Primary Substations shall have access roads that provide vehicular access adequate for the safe operation, maintenance and replacement of the entire substation (equipment and civil infrastructure), including access roads that facilitate transformer and switchgear installation and future removal together with access for all other vehicles necessary for general maintenance.

Wherever practicable, substation access roads shall incorporate parking and/or turning areas for vehicles that design out the risk associated with reversing out of the site.

Overall substation design shall facilitate the use of all substation access roads outside daylight hours.

The minimum width of substation access roads for new sites shall be as follows:

- 3.5m generally.
- 4.5m for primary transformer or reactor access, increased as necessary at bends.

Access roads shall be to the Constructor's own site-specific design to suit actual ground conditions but shall not be less than 400mm overall construction thickness, inclusive of a structural geotextile membrane beneath sub-base where applicable.

Access roads shall be a flexible pavement construction and the use of recycled plastics and other recycled materials is the preference. Where kerbs are required consideration to the use of recycled plastic kerbs should be given.

Where these minimum access road dimensions cannot be achieved on existing sites then approval is required from SPEN. Adequate access for the safe operation, maintenance and replacement of the entire substation will be required at all times and this shall be proved by the Constructor as part of any proposal that is submitted.

12.7.3 Personnel Access

Enclosures shall incorporate approach and perimeter edged-paving surfacing to and between doors (and to gates to transformer/reactor bays) to facilitate personnel access.

Prefabricated paved areas shall comprise a maximum 600x600x50mm precast concrete paving slabs constructed on a minimum 50mm layer of sand-cement bed, constructed on a minimum 100mm compacted recycled Type 1 granular sub-base. Perimeters to paved areas that are not otherwise contained by buildings, structures or road kerbs shall be edged with a 200x50mm precast concrete or recycled plastic edging kerb set in a concrete haunch and foundation.

Cast in-situ concrete, asphalt or other alternative paving systems shall be subject to prior acceptance by SPEN.

12.7.4 Surfaced Areas for Equipment Access

Enhanced surface construction for equipment installation/removal shall be subject to prior agreement with ED&S on a site-specific basis prior to construction.

12.7.5 Cable Duct Crossings

Cable crossings to roads within substations shall be shall robust rigid SPEN approved PVCu ducted systems installed in accordance with CAB-15-003. Where the required depths cannot be achieved then a minimum 150mm thick concrete surround shall be provided and shall include draw cords and proprietary expanding foam or other approved temporary stop-ends to spare ways.

Ducted systems to each cable road crossing shall accommodate all cable requirements, including trefoil formations where applicable and cable requirements for identified 'Future' circuits/installations, together with not less than 10% overall spare capacity or two additional ducts of the same type and diameter (i.e., whichever is the greater).

12.8 Drainage

Drainage systems shall meet the requirements of and where applicable be approved by relevant local authorities, utility companies and environment agencies.

The Constructor shall ensure that drainage schemes are adequately sized to accommodate flow rates that properly reflect the sources serviced by the system with pipes running un-surcharged at self-cleaning non-scouring velocities.

The project Civil Asset Management Plan shall incorporate a Drainage Management section which shall provide details of all drainage infrastructure and highlight any critical or exceptional infrastructure. It should include details of the inspection and maintenance regimes required for each element of the infrastructure.

"Emergency Drainage Plan(s)" should be created as part of the Civil Asset Management Plan and shall be provided and mounted within substation control buildings. Where appropriate as part of this plan, manhole covers and gullies shall be clearly marked on site by colour coding, red for foul/oily or combined water systems and blue for surface water only. Emergency Drainage Plan Drawings and "As-built" Site Drainage Drawings shall be similarly colour coded and noted accordingly.

12.8.1 Surface Water

Surface water drainage systems shall be designed to ensure:

- There is no flooding of the drainage system during the 1:25 return period event. The system shall be designed to include an allowance for Climate Change in accordance with the requirements of the relevant national environment agency.
- There is no standing water that could impact on the operation, inspection and maintenance of the substation during the 1:1000 return period event, including an allowance for climate change.
- It is in accordance with local planning guidance.

These requirements need to be considered in association with the requirements of the "Flood Risk" section of this Specification.

Storm water run-off from buildings shall be collected by an appropriate system of rainwater goods that shall positively discharge to storm water drainage in a controlled manner. Where a positive discharge cannot be achieved the installation of a rainwater harvesting system should be considered.

The system shall be designed to ensure the minimum self-cleansing velocity in any pipe is $0.75ms^{-1}$ and the maximum velocity in any pipe is $2.5\ ms^{-1}$.

SUDS features are likely to have a more onerous inspection and maintenance regime than traditional drainage systems. Therefore, where there is a proposal to incorporate SUDS into a design this should be agreed with ED&S on a project-specific basis such that it will allow SPEN to understand the implications of the proposed system.

12.8.2 Foul Water

Foul water drainage systems shall be connected to mains foul drainage wherever practicable. Where this is not practicable and SPEN will subsequently adopt the civil fabric then foul water drainage systems shall be the least cost, minimum maintenance system in accordance with the requirements of the relevant national environment agency (e.g., proprietary septic tank systems).

Cesspools shall be avoided as part of SPEN adopted systems, however, where these are accepted by ED&S as the only practicable option then they shall not be less than 4,000-litre capacity and shall incorporate alarms connected and commissioned to the substation local alarm and SCADA system. All cabling (power and alarms) and connection to power supply shall be designed and installed by the project team but final connection and commissioning of alarms to the substation SCADA system shall be by SPEN.

12.8.3 Oily Water

Oily-water drainage systems shall be capable of safely containing a major escape of oil from transformers, reactors or storage oil tanks. Rainwater build-up within oil containment bunds shall not be discharged directly into the system but shall be directed into an oily-water drainage system via a sump. It shall be the project team's responsibility to ensure that the relevant national environment agency and any appropriate local authority guidelines have been incorporated into the design of the oily-water drainage system.

Drains to oily-water drainage systems shall be designed to carry fluids at 80^0C.

12.8.3.1 Synthetic & Natural Ester Insulating Fluids

Although Ester Insulating Fluids are fully biodegradable there is still a potential for pollution to occur if discharged to ground or a controlled water during the biodegradation period.

Where Ester Insulating Fluids are used in place of traditional mineral oil these are to be treated in the same way as mineral oil. However, the chemical properties of ester fluids are very close to those of water therefore where ester insulating fluids are to be used the suppliers of bund dewatering units or separators shall provide written confirmation that the product has been type tested using that ester fluid and that the surface water discharge achieves a concentration of less than 5mg/l of oil under standard test conditions.

Where oil is referred to in this document it shall be read as meaning either mineral oil or ester fluids.

12.8.3.2 Oil-Petrol Separators

Oily-water drainage systems shall normally incorporate an Oil-Petrol Separator prior to discharge from the substation unless agreed with the relevant national environment agency. Oil-Petrol Separators shall be proprietary National Grid 'Type Registration Certificate' full retention Class 1 Separators with integral silt collection and quality of discharge sampling facilities, together with integral coalescing and automatic closure 'dead-stop' mechanisms to prevent the flow through the unit in case of excessive oil levels.

Coalescer units shall comprise oil resistant fire retardant material and be capable of removal for maintenance or replacement.

Oil-Petrol Separators shall be vented such that the build-up of potentially flammable or explosive vapour is prevented (as a minimum in accordance with the manufacturer's recommendations) and shall incorporate alarms connected and commissioned to the substation local alarm and SCADA system. Alarms for the system should include an excessive oil level alarm and a system cleaning alarm and be installed such that they alert the control room.

All cabling (power and alarms) and connection to power supply shall be designed and installed by the project team but final connection and commissioning of alarms to the substation SCADA system shall be by SPEN.

Separators shall have been type-tested to verify the stipulated design requirements for nominal flow rating, residual oil content of the discharge and water-tightness. A certificate stating details of its type-test, rating and class shall be provided with each unit.

By-pass type separators shall not be used.

Alternative systems will be acceptable including omission of a separator where:

- Expressly required on a project-specific basis and agreed with ED&S; or
- Justified through a site-specific risk assessment with written confirmation from the national environment agency or other applicable local authority to ED&S that formal consent to discharge direct has been granted.

In such cases alternative systems shall incorporate an oil separation/sampling chamber which shall be installed as specified local to the point of discharge.

12.8.3.3 Oil-Petrol Separator Design Note

Oil-petrol separators shall be designed to accommodate the applicable run-off area or the worst-case event of all bund pumps operating in unison, subject to national environment agency minimum size requirements as applicable – NGTS minimum size requirements shall not apply.

12.8.4 Oil Separation/Sampling Chambers

Where consent has been confirmed by the relevant national environment agency or other applicable local authority to omit the Oil-Petrol Separator, discharge water from bunds shall pass through a sampling chamber.

These sampling chambers shall as a minimum measure incorporate an integral oil separator plate and shall be of sufficient size to allow collection from flowing discharge, e.g., by means of raising inlets 100mm above outlets.

Where oil draw off comprising segregated sump, fire-trap and draw-off/sampling chambers are required on a project-specific basis or shown to be necessary by a site-specific risk assessment the design and method statements for operational use shall be subject to agreement with ED&S.

12.8.5 Oil-Petrol Spillage to Substation Access/Service Roads

Where substation access roads incorporate positive drainage systems and oil-petrol separators are provided in association with pumped discharge from bunds enclosing oil containing Outdoor Equipment, then such road drainage consideration shall be given to draining to the oily-water drainage system via the separator.

12.8.6 Road Channel Drain Systems

Where road channel drain systems are used to collect accidental oil-petrol spillage to roads these shall be proprietary heavy duty corrosion resistant grated top systems that incorporate precast polymer concrete or fibreglass channel sections.

12.8.7 Vented Battery Rooms

Requirements for drainage to bespoke Battery Rooms containing vented unsealed batteries shall be expressly agreed with SPEN on a project-specific basis but shall as a minimum incorporate:

- Natural ventilation such that these rooms are not designated as hazardous areas to BS EN standards.
- Where connecting services to adjacent rooms cannot reasonably be routed externally these shall be kept to an essential minimum with robust durable seals that are fire-stopped and gas-tight.
- Floors shall be of tanked acid resistant construction internally with sump facility for spillage collection.
- Belfast Sink with potable cold water supply and eye wash kit.

12.8.8 Soakaways

Soakaways shall be proprietary infiltration storm water management systems or as a minimum measure, in non-trafficked areas, infill pits or herring bone drainage systems filled with an approved recycled 32-40mm graded aggregate, all enclosed within a free-draining geotextile wrap.

Where necessary based on risk assessment, soakaways shall additionally be lined with oil absorbent matting contained between geotextile membranes.

12.9 Oil Containment

All oil containing Outdoor Equipment (e.g., transformers and reactors) shall be sited within oil-tight bund systems. Where practical, no part shall be sited within 50m of any borehole or well used for water extraction, 10m of any surface watercourse or 5m of any drain through which oil could enter and discharge directly into controlled waters.

No drainage or other ancillary service or pipe shall pass through bund systems. Equipment power and control cables may where necessary pass through bund systems provided these are within ducts and that cable entries in total are fully sealed to the satisfaction of SPEN (within and around ducts).

12.9.1 Bund Systems

Oil containment bunds generally shall be designed to safely contain a minimum of 115% of total oil content or where bunds contain more than one oil containing item of Outdoor Equipment (e.g., transformer or reactor) 125% of the capacity of the largest. In addition, oil containment bunds shall be designed to also safely contain a minimum 100% of total oil content plus 150mm freeboard.

Oil containment shall otherwise satisfy the relevant national environment agency guidelines as applicable. Bund enclosures should be of reinforced concrete construction or other proprietary systems subject to prior acceptance by ED&S.

Where bunds are of reinforced concrete, they shall be not less than 225mm thick designed and constructed to retain aqueous liquids such that crack width is controlled by the reinforcement to limit this to 0.2mm. The preference is for the reinforced concrete bunds to be a monolithic construction integral with support plinths however where movement joints are proposed then these shall incorporate proprietary cast-in hydrophilic seals or water-bars, non-absorbent joint filler and oil-resistant perimeter sealant. Where construction joints are necessary these shall have continuous reinforcement and incorporate proprietary hydrophilic seals cast-in centrally.

A sump shall be incorporated into the bund and sized to accommodate a bund pump. This should be sized based on the bund pump manufacturer's requirements to ensure efficient operation of a bund water control system. If manufacturer's guidance is unavailable the minimum sump dimensions should be 900mm x 900mm (or equivalent internal area on plan) with a sump down stand of not less than 450mm.

Bund layout shall be such that, as far as is reasonably practical, any 'spigot' or jetting' type flow is retained in the event of malicious damage or disruptive failure and that 'personnel' accessing completed bund structures do not compromise electrical safety clearance to exposed Live conductor and/or Insulator. The inner face of bund walls shall not be less than 1m clear on plan of oil containing parts, which may be reduced to 750mm for auxiliary transformers where this is necessary to accommodate the overall circuit layout.

Above ground bund walls shall not be less than 250mm above the adjacent internal and external finished surface level in order to avoid creation of potential trip hazards. Walls with an upstand of over 500mm to either side shall incorporate integral access and egress steps with anti-slip treads and demountable galvanised steel or GRP handrails on each side of the wall. Where appropriate to achieve electrical clearances and/or as an enhanced fire mitigation measure, walls that are relatively flush with ground level on each side (or buried) would be acceptable, for example bunds comprising 'moat' type below ground only containment.

Where moat type containment bunds incorporate below ground voids these shall be designed to be maintenance free for the design life period. All metal supports shall be of stainless construction and the layout shall be configured to prevent routine personnel access to the below ground areas, however; lockable flame-trapped man access and egress points (i.e. not less than two number in total) of not less than 600mm square clear access shall be incorporated to facilitate inspection, either directly by personnel access or remotely by camera.

All bund systems shall be water tested on completion, prior to post-commissioning finishing works.

Post-commissioning stone infill to bunds shall be a minimum depth of 300mm of approved recycled 14-20mm angular stone and shall incorporate appropriate protection to cables running within. The stone infill shall be at or below the bottom of chamfers to plinths.

12.9.2 Bund Water Control Systems

Oil containment bunds shall be designed such that build-up of rainwater does not compromise design capacity.

Where discharge is direct to a separator this shall be via an inverted pipe arrangement and shall incorporate a fire-trapped sump.

Where removal of rainwater build-up is via a proprietary intelligent pumped system there shall be no drainage outlets and this shall be via National Grid 'Type Registration Certificate' either:

- A bund water control (intelligent pump) systems to discharging to an oily-water drainage system (i.e. to separator); or
- A Certified Bund Dewatering system which achieves a surface water discharge with a concentration of less than 5mg/l of oil under standard test conditions.

These shall incorporate a point of isolation local to the control unit, anti-siphon device and alarms connected and commissioned to the substation local alarm and SCADA system, including power or pump failure and high oil level alarms. The pump shall automatically deactivate if the sensor system detects oil during a normal water removal cycle, thus ensuring that no oil will be pumped out of the bunded area.

All cabling (power and alarms) and connection to power supply shall be designed and installed by the Constructor's responsibility but final connection and commissioning of alarms to the substation SCADA system shall be by SPEN.

Alternative discharge systems may be acceptable subject to compliance with the requirements of this specification for oil water drainage

12.9.3 Water Test to Bund Systems

All bunds shall be water tested on completion as follows:

- Seal all cracks exceeding 0.2mm in width using a resin injection or other approved proprietary system.
- Temporarily remove the bund water control system.
- Plug the sump outlet and fill the bund with clean water to the maximum height permitted by SPEN but not less than equipment plinth level – record this level as datum.
- Monitor and record the level of water over successive periods of not less than 48 hours until the fall in level over a period of 24 hours is less than 3mm, making allowance for both rainfall and evaporation.
- Allow for rainfall and evaporation by monitoring water levels in a suitable watertight control container of not less than 200 litres capacity filled approximately 50%.
- At any point where the aggregate net fall exceeds 75mm the level of the water shall be topped back up to the datum level before resuming the test.
- Oil containing bunds shall be deemed to have failed the Water Test if the specified water retention has not been achieved within 7 days. In the event of failure remedial works shall be carried out as necessary to adequately seal the bund, which shall be re-tested.
- All test materials shall be removed from site on completion of successful water test, including environmentally controlled recovery or disposal of test water from within the bund.

Water Tests should be witnessed and signed off on site as part of the project Quality Management plan.

12.9.4 Fire Risk within Bund Systems

Subject to a fire risk assessment being undertaken during the detailed design, as detailed in SPEN Substation Fire Protection Policy SUB-01-012, alternative and/or additional fire containment measures may be necessary as follows:

- Fire-trapped discharge into sumps with fire-sealed covers.
- Fire-trapped discharge into moat systems (oil spill storage below plinth/ground level).
- Active Fire Detection/Extinguishing Systems.
- Synthetic Ester Insulant to transformers.

Fire-trapped construction shall have minimum 4-Hour fire resistance.

12.9.5 Fire-Traps

Fire traps shall as a minimum measure comprise a pit or chamber containing a 300mm depth of approved recycled 32-40mm graded aggregate. Metal grating supporting this loose stone infill shall be designed such that it requires no maintenance for the design life of the works and does not restrict the flow oil or loose a significant proportion of its strength in the event of a fire.

Design details and method statements for access/egress shall be agreed with SPEN on a project-specific basis where provision for planned access to below ground containment areas is required.

12.9.6 Protection to Cables within Bund Systems

All cable routes within bund systems shall be agreed with SPEN on a site-specific basis prior to construction. Wherever practicable multicore cables shall be run on wall or compound surface mounted cable tray that does not present a trip hazard.

Power cables and where necessary multicore cables routed within stone infill shall be protected from mechanical damage by ducting or by a minimum of 150mm sand cover with structural geotextile over (to prevent migration of stone through the sand).

12.9.7 Emergency Spill Kits

Where SPEN own or will subsequently adopt oil containing Outdoor Equipment a freestanding mobile (wheeled) proprietary oil spill kit capable of managing spills up to 750L of oil shall be provided. This shall be at new sites and at existing sites where such facilities are not already in place.

12.10 Fire Segregation to Outdoor Equipment

The requirements for fire enclosures and walls and the protection of key plant and buildings shall be in accordance with the current SPEN Fire Protection Policy. Enclosures and/or fire barrier walls shall be provided as a minimum measure where segregation distances are less than those given in Table 3.

Transformer or Reactor Type	Liquid Volume (litres)	Between Bund & Adjacent Oil Containing Parts or other Oil Containing Equipment (metres)	Between Bund & Combustible Building Surface[1]
Oil Insulated Transformers	< 1000 [2]	1.2	3
	> 1,000 < 2,000	3.0	7.5
	> 2,000 < 20,000	5.0	10.0
	> 20,000 < 45,000	10.0	20.0
	> 45,000	15.0	30.0
Less Flammable Liquid Insulated Transformers	All Volumes	0.9 Horizontal & 1.5 Vertical	

Table 3 – Fire Segregation Requirements for Outdoor Equipment

High risk locations may require the distances quoted above to be increased, for example adjacent to fuel installations, hospitals, high occupancy buildings or critical infrastructure.

It is not necessary to segregate or screen transformers (or reactors) up to 11kV or 33kV auxiliary transformers from higher voltage equipment, the required segregation or fire barrier screening parameters for the lower voltage equipment would apply therefore in these circumstances.

Fire barrier walls shall as a minimum extend:

- For a distance of at least 1m above oil containing parts or explosion vents, however, electrical clearances shall not be prejudiced.
- For a distance of at least 2m on either side of oil containing parts or explosion vents, or shall alternatively incorporate appropriately designed return walls that provide adequate equivalent screening.

Fire enclosures and fire barrier walls shall provide 4-hour fire segregation.

SPEN acknowledge that some generic deemed to satisfy Typical Primary Transformer Substation Layouts do not provide full 4-hour segregation where there is a connecting door between the transformer bay and the building. A 1 hour rated fire door is acceptable for SPEN operated substations in these circumstances as being adequate mitigation for the safety of operatives, however; third party end-users may require higher rated doors where they retain responsibility for the fabric of the substation or equipment and consider the risk to these to be significant.

[1] A combustible building is defined as one that is constructed of a predominantly combustible material such as timber. The distance to the building does not include the attached Switch Room but does include other SPEN substation buildings and 3rd party buildings.

[2] Subject to site–specific Fire Risk Assessment, oil insulated equipment containing less than 1,000 litres may require fire mitigation measures to be applied in high-risk locations or situations.

Where categorised as higher than normal risk by SPEN or as a result of the Constructor's own site-specific Fire Risk Assessment it may be appropriate or necessary to provide alternative or additional fire mitigation measures to Outdoor Equipment such as; fire-trapped sumps to bunds, below-ground fire-trapped oil catchment (moat system), Active Fire Extinguishing Systems or the use of Esters.

The preferred construction type for fire walls is solid in situ (or precast panelled) reinforced concrete or proprietary demountable steel structures.

Coolers to transformers shall not be enclosed to the extent that the detrimental effect on natural ventilation is unacceptable to SPEN. Forced electro-mechanical ventilation for cooling to transformers shall not be acceptable.

12.11 Acoustic Enclosures and Barriers

The substation layout shall incorporate acoustic enclosures or barriers where noise studies conclude that transformers or other equipment (e.g., compressors, filters, etc.) would give rise to a noise complaint. Calculations shall be provided, confirming that the acoustic design is such that a noise complaint would not arise subsequent to the installation of acoustic enclosures or barriers.

Coolers to transformers shall not be enclosed to the extent that the detrimental effect on natural ventilation is unacceptable to SPEN. Forced electro-mechanical ventilation for cooling to transformers shall not be acceptable.

Where required by SPEN on a project-specific basis the substation design layout shall be such that it can facilitate installation of future acoustic enclosures or barriers where there is the potential for transformers or other equipment to give rise to a noise complaint from possible future developments adjacent to the substation site.

Enclosures shall be designed on a project-specific basis to limit noise levels to meet the recommendations of associated pre-engineering Noise Studies and shall achieve an insertion loss of not less than 20dB at 100Hz.

Enclosures shall incorporate an acoustically absorptive inner surface that shall minimise internal reverberation and shall have adequate natural ventilation, which shall not promote corrosion of the equipment or of the enclosure elements nor compromise the overall acoustic performance.

12.12 Fencing to Substation Enclosures

All security systems, including fencing, shall be in accordance with ASSET-01-023 – Substation Security Policy. Fencing to Outdoor Equipment shall be a minimum of 2.4m overall height above anti-dig security kerb or bund wall level where applicable.

Substations classified by ScottishPower Corporate Security as critical or strategically important for supply or as high-risk sites with respect to the potential for unauthorised entry (e.g. theft or vandalism) may necessitate additional security requirements. These will be identified by ScottishPower Corporate Security on a site-specific basis and agreed between Corporate Security and the Civil Asset Manager.

All fencing shall be hot dip galvanised steel in accordance with this Specification. Hot dip galvanised materials shall not be post drilled; fixings to be made after galvanising shall be made with clamped fixings by prior agreement with ED&S.

Notwithstanding the stated minimum requirements of this Specification, structural performance shall be the Constructor's responsibility with respect to site-specific conditions including the nature of the ground, topography, applied lateral loading and overall fence height. When encountering changes in ground levels, the minimum height of 2.4m must be maintained from any point from finished ground level and not just vertically.

Earthing and all "property" and "danger notices" to fence panels shall be the Constructor's responsibility.

All signage including, but not limited to, “property” and “danger notices” should be clamped to the fence panels.

The layout of secure Primary Substation sites that do not otherwise have security fencing locally around Outdoor Equipment shall be such that there is a minimum 2.4m overall height clearance to perimeter security fencing within 2.0m external to the line of the fence.

Anti-climb measures shall be incorporated within Security Fencing systems where this presents ‘internal corners’ external to the fence, abuts substation buildings or, where agreed with ED&S as an alternative to raised fencing, external fences or potential climbing aids within 2.0 m external and internal.

Construction of fencing immediately adjacent to the position of a transformer or reactor shall be such that it is readily demountable to allow equipment to be removed for maintenance or replacement.

The design and fabrication of fencing systems shall make allowance for appropriate connection of earthing.

12.12.1 Gates

Gates shall provide the same (minimum) level of security as, and be compatible with, the associated fence to either side.

Locking arrangements to gates shall be expressly agreed with SPEN on a project-specific basis prior to procurement and installation. Locks, handles and cut-outs for these shall incorporate integral shrouds such that they do not present potential climbing aids.

Gates shall be designed such that failure of a single hinge does not allow the gate to fall. Hinge mechanisms shall be tamper-proof and hidden such that they do not present potential climbing aids. The spigot of the top hinge shall be reversed to point downwards to prevent the gate being lifted off.

Vehicular gates shall have clear openings not less than the width of the associated road or 4.0m whichever is the greater. Personnel gates shall have clear openings appropriate for their required operational use subject to a minimum of 900mm.

The maximum clear space beneath a gate in the closed position shall be 70mm.

12.12.2 Palisade Security Fencing Systems

Security palisade fencing systems shall have SP (security) standard of fixings and pale details to BS 1722 Part 12 that incorporate:

- Tamper resistant cup square headed bolt and ‘permacone’ shear nut fence panel fixings.
- Heavy duty 3.0mm thick ‘W’ section pales with tamper resistant swaged pin and collar grooved fasteners having special formed heads to suit pale profile.
- Maximum 85mm clear space between pales.
- Maximum 50mm clear space beneath pales.
- Minimum 65 x 50 x 6mm rail sections, or minimum 75 x 50 x 6mm to gradients exceeding 1 in 6 over more than two panels.
- Vertical posts to be minimum 102x44 x 7kg/m or equivalent post sections.

12.12.3 Alternative Mesh Security Fencing Systems

Security mesh security fencing systems shall be open mesh steel panel systems with Category 4 (extra-high security) standard of fixings and mesh panel details to BS 1722 Part 14 that incorporate:

- Tamper resistant cup headed bolts into full height flat metal plate fixing strips bolted full depth through posts to nuts on inner rear face.

- Welded mesh type panels with maximum 12.5 x 75mm mesh spacing, minimum 4mm thick wire and additional stiffening wires.

  Or

- Expanded metal type panels with maximum 10mm x 70mm mesh spacing with 3mm thick strand (5.5mm wide main strand).
- Minimum 80 x 80 x 3.5mm thick square hollow section posts or equivalent.

12.12.4 Post Pockets

Ground mounted posts shall be set within in situ concrete minimum 0.9 x 0.9 x 0.3m deep pads or minimum 0.45 x 0.45 x 0.9m pockets.

Where posts are set within or atop reinforced concrete walls (including to bunds) these walls shall not be less than 300mm thick.

Post foundation design shall allow for any height/load increase associated with attached or proposed future anti-climb barriers or electric pulse Power Fence.

12.12.5 Anti-Dig Security Kerb

Security fencing shall incorporate anti-dig measures below the fence and gate panels. This shall be a concrete beam not less than 200mm wide x 300mm deep, incorporating 25mm chamfers to top edges and set a maximum of 50mm beneath the fence panels. Anti-Vandal Scaling Barriers (Anti-Climb Mechanisms)

12.12.6 Anti-Climb Devices

Anti-climb mechanisms shall be approved rotating proprietary anti-vandal anti-scaling barriers, fixed such that support brackets are set one vane in from exposed ends to avoid presenting a climbing aid. Barbed wire or barbed tape anti-climb measures shall not be acceptable.

12.12.7 Coloured Fencing Systems

Appropriate painted systems may be applied after erection but pre-coated systems that impair electrical continuity for earthing purposes shall not be acceptable.

Where SPEN will subsequently adopt the civil fabric of the substation and paint systems to galvanised fencing are necessary then these shall comprise:

- Etch coat and wash preparation, including spot priming with one coat zinc phosphate primer to any areas where the galvanising has been damaged or bare ferrous metal is exposed.
- 65 microns: single-coat quick drying water-based metal primer designed to provide excellent adhesion to the surface of new bright or weathered galvanised metal surfaces.
- 80 microns: two-coat build-up of gloss finish specially formulated for metal with a quick drying solvent-based formulation that can be over-coated within 4 to 6 hours (depending upon conditions).

12.13 Metalwork

All steelwork, including members internal to substation buildings, shall be hot dip galvanised and shall facilitate fixings for earthing tape.

A minimum thickness of 85 microns is required. This should be increased where necessary to take account of any site-specific factors that may accelerate the corrosion rate.

As required by the National Structural Steelwork Specification for Building Construction, nuts to galvanised bolt systems shall be of a higher grade than the bolts.

As part of working towards Net Zero, steel suppliers should be able to meet any or a combination of the following:

- Steel produced by a steelmaking site where the steelmaker has a science-based emissions target, SBTi or equivalent
- ResponsibleSteel™ Certified Steel, or equivalent
- 'Lower Embodied Carbon Steel'

12.14 Woodwork

Timber should be sourced from a recognisable forest management certification body such as the PEFC or FSC. The use of timber from fast growing tree species is also preferable.

12.15 Prefabricated Enclosures

Prefabricated metal enclosures shall be in accordance with the principles defined within INS-requirements of INS 50-40-11. Lock mechanisms to doors shall be suited to SPEN site-specific requirements. Lock keepers/lock protectors must be fitted on any access doors. Fire exit doors should be fitted with multi point locking systems. Where prefabricated enclosures have cables exposed below floor level these shall incorporate galvanised steel mesh or other acceptable anti-vermin barrier between sub-frame and ground level.

Where stepped access into prefabricated enclosures is greater than 225mm this shall incorporate demountable galvanised steel or GRP personnel/plant access steps/platforms external to doorways inclusive of removable handrails. Alternative reinforced concrete access steps/platforms incorporating removable galvanised steel or GRP handrails would be acceptable where SPEN confirm that these are not required to be demountable to facilitate access for future installations or for excavation in the event of a fault.

Where utilised, independent steel beam support systems to proprietary Container units shall be galvanised steel construction of bespoke design to meet the Container manufacturer's requirements, including tolerances for flatness, level and twist.

Foundations to support Enclosures for Indoor Equipment that do not have floors (Housings) shall be in situ reinforced concrete construction, proposed details of which shall be submitted for consideration by SPEN prior to procurement of the unit. These foundations shall be of bespoke design to meet the Enclosure manufacturer's requirements and the requirements of this Specification (e.g., tolerances for flatness and level) such that a suitable environment for Indoor Equipment is maintained within the enclosure and all service entries are fully sealed against moisture ingress (e.g. ducts and cables/earth strip within ducts).

13. BUILDING ENCLOSURES (TRADITIONAL CONSTRUCTION)

Substation buildings shall be fully weatherproof, paying particular attention to design and construction details with respect to wind driven rain and storm water run-off.

Substation buildings shall be designed and detailed such that the potential for vandalism and theft is minimised.

Where exposed metalwork within is acceptable in principle to SPEN this shall be bonded to the substation earth system with adequately sized insulated conductor.

Basement construction will not be acceptable.

13.1 Plant Access

Building enclosures, where major plant access is through the doors, shall incorporate the following features, to facilitate the safe installation of equipment:

- Clear level area 3m^2 immediately outside plant access doors of adequate ground bearing capacity to receive vehicles carrying substation equipment.
- Temporary level platform 2m^2 at finished floor level immediately in front of plant access doors of adequate structural capacity to receive equipment.

13.2 Building & Equipment Layout

Sufficient space shall be provided within buildings to facilitate access for all necessary construction, testing and commissioning, inspection, maintenance and removal activities. The arrangement shall make allowance for future bays where required.

A clear passage of not less than 750mm wide shall be provided behind and around floor-mounted equipment where access for operation, maintenance or replacement of equipment is required and where access for maintenance or redecoration of the building fabric is required.

Where two rows of equipment face each other (control panels and/or switchgear) the clear distance between front faces shall not be less than 1.8m, increased as necessary to facilitate access for test gear and for removal for replacement of equipment.

The clear distance in front of equipment shall provide operators with a full view of instruments and indications to the unit under consideration and to the units immediately to either side and shall not be less than 1.2m.

Requirements for clear passage and operating distance shall be clear of obstructions such as wall-mounted equipment or tools, radiators, services, structural projections and the like as well as equipment door openings unless these are either removable or will open through approximately 180°.

13.3 Fire

Buildings shall be designed to prevent the propagation of fire generally and in particular in the event of an electrical failure from either external sources (e.g. outdoor power transformers) or from internal HV switchgear or power cable faults.

Although substation plant is extremely reliable and the probability of a disruptive failure is very low a fireball may be produced when this condition occurs and considerable heat and smoke can be generated as a result.

The maximum travel distance to a place of reasonable safety shall be in accordance with Table 4.

Room Type Containing	Building Regulations Purpose Group	Travel Distance – One Direction Only (m)	Travel Distance – One or More Direction (m)
Oil filled plant/ generator/battery room	Purpose Group 7 – Place of special fire hazard	9	18
Other rooms	Purpose Group 6 – Industrial, normal risk	25	45

Table 4 – Maximum travel distances to a reasonable place of safety

A reasonable place of safety shall be:

- A protected stairway enclosure (a storey exit).
- A separate fire compartment from which there is a final exit to a place of total safety.
- The nearest available final exit.

In addition, rooms enclosing switchboards in excess of 6m in length shall have a minimum of two exit doors, opening outwards, on or at opposite ends of the Switch Room, to allow egress in either direction from behind switchboards.

Escape route passages shall have a minimum clearance width of 900mm and the clear opening width and height of doors forming part of this escape route shall not be less than 750mm and 2000mm respectively. Emergency exit doors shall open outwards, external doors by means of panic bars without the use of a key, which shall be clearly marked with a suitable notice explaining the operation of the opening device.

Signage indicating escape routes and self-contained emergency lighting shall be installed.

The use of readily combustible materials shall not be acceptable; all internal lining and structural surfaces shall be non-flammable material of limited combustibility such that they adequately resist the spread of flame over their surfaces. In addition, but with the exception of external doors, civil fabric finishes internal to the substation enclosure shall meet the requirements of national building regulations for low surface spread of flame and low fire propagation index (e.g., Class O).

Where it is required, fire protection to steel frame construction shall be by means of a reinforced concrete surround or proprietary intumescent paint or spray system, not fireboard that could be displaced in the event of a disruptive failure.

Substation buildings shall be fully compartmented construction with minimum 1-hour fire segregation, including below floor trenches and ducts passing between rooms, such that spread of fire to other internal areas shall not occur for a minimum period of 60 minutes in the event of a fire initiating.

Risk assessment with respect to fire and smoke spread to property surrounding substations is entirely the Constructor's responsibility.

Portable fire extinguishers shall not be provided.

13.4 Earthing

13.4.1 Switch Room Floors

Reinforcement within substation Switch Room floors shall facilitate connection to substation earthing systems after construction. The Constructor shall be responsible for:

- Connecting reinforcement together to ensure electrical continuity throughout by welding or mechanical techniques at a minimum of two connection points per mesh sheet or re-bar, ideally on diagonally opposite corners of the building.
- Installation of fully rated appropriately sized flexible insulated copper cable connections projecting from cast in situ concrete such that these can be safely routed to a minimum height of 750mm on adjacent walls, including across the invert of multi-core trenches where applicable.
- The copper earth to steel rebar connection shall be by exothermic weld or mechanical crimp wrapped to prevent moisture ingress, e.g., bitumastic tape wrapping.

Where the Constructor has a bespoke site-specific Earthing Study Report that confirms that this connection of floor reinforcement to substation earth is not necessary then this may be omitted subject to the prior written acceptance of SPEN.

13.4.2 Metal Door Sets

The Constructor shall be responsible for the provision of earthing connections to metal door sets as follows:

- Appropriately sized (minimum 70mm²) flexible anti-fatigue braided copper connections top and bottom between frames and leaves.
- Appropriately sized (minimum M10) stud projections to each side of frames at a height of approximately 1.2m above finished floor level.
- In the area where the doors open the horizontal buried ring Earth Electrode shall be extended to 0.5m beyond their open position.

13.4.3 Raised Access (computer-type) Floor Systems

Raised access floor systems shall be connected to the substation earthing grid by appropriately sized flexible insulated copper connections at a minimum of one within each group of four adjacent support posts.

13.4.4 Lightning to Steel Framed Clad Buildings

The building frame shall be suitably connected to the substation earthing grid by appropriately sized copper connections at the bottom of every column stanchion and at the top of each column at the corners of the roof (or highest level roof where there is more than one height).

13.5 Substructure

Damp proof membrane systems shall be provided to fully enclose below ground masonry substructure construction to operational rooms with below floor cable access or multicore trenches, incorporating membrane protection where these are externally applied. This damp proof system may be omitted to reinforced concrete substructure construction in appropriate site-specific situations.

Sub-floor infill shall be weak-mix cast in situ concrete.

Cable trenches formed within solid floor construction shall have reinforced concrete bottoms and sides, alternative masonry sides would be acceptable where these are above structural reinforced concrete rafts.

13.6 Floors

Floors shall be capable of achieving sufficient thermal insulation as necessary to provide an appropriate internal environment as detailed in Table 6.

Floors to bespoke segregated telecommunications, SCS, sealed battery and relay control rooms shall be proprietary raised access systems. Floors to other areas shall be full bearing monolithic in situ concrete slabs. The quality and permitted tolerances for floor finish are important and shall comply with the requirements of this Specification together with the manufacturer's requirements for plant installation and operation for plant installation and operation.

Raised access systems shall incorporate tiles with cores that are fully enclosed by galvanised steel and have a durable non-slip vinyl tile anti-static surface finish. Supports to floor mounted equipment panels within raised access floors shall be independent galvanised steel pedestals, panels shall not be free-standing or supported on proprietary raised access systems.

Trench work within solid concrete construction shall incorporate galvanised steel or GRP kerb rebates cast within floors to receive trench covers.

Reinforcement within the top surface of floor slabs within GIS Substation Switch Rooms shall be bonded to the substation earth system in accordance with the requirements of this Specification.

Structural floor slabs shall be continuous at doorways, including suspended slab construction over trenches where applicable. Sand fill with screed topping or suspended trench cover systems shall not be acceptable to trenches at these locations.

Screed finishes to concrete floors shall not be acceptable in rooms with floor-mounted equipment.

Precast 'beam and hollow pot or block' type floor construction shall not be acceptable.

Once cured, concrete floors shall be prepared and painted with two coats of a proprietary anti-slip Epoxy Resin floor paint system strictly in accordance with manufacturer's recommendations. Slip-resistant floor paint systems to Battery Rooms with sealed batteries (valve-regulated) shall additionally be acid resistant.

Floor finishes to Battery Rooms containing vented batteries shall be agreed with SPEN on a project-specific basis but shall as a minimum incorporate quarry tiles with acid-resistant grout and spillage containment.

All floor mounted substation equipment shall be suitably fixed and supported in accordance with the manufacturer's recommendations. Where switchgear / plant is to be supported over open cable pits by additional steel beams then these shall be designed to withstand the operational loadings of equipment and be suitably spaced to align with all feet fixings.

13.7 33kV Switchgear Support Structures

Support systems to 33kV switchboards shall be galvanised steel construction of bespoke design to meet the switchboard manufacturer's requirements.

Top flanges of support steelwork shall be set flat and level to the following tolerances:

- Flatness 1mm in 1m.
- Level +/- 2mm over full length & front to back.
- No twist.

Support systems to 33kV switchboards shall incorporate uni-strut rails and, where necessary, intermediate support columns and upstand lips to retain permanent covers in position.

13.8 Cable Trenches & Pits

Cable trenches and pits beneath 11kV and 33kV switchboards within traditionally constructed buildings that can have all duct entries sealed using a SPEN approved mechanical duct sealing system, shall be cleaned out, unfilled and covered with a solid anti-slip GRP covers, which are preferred, or alternatively galvanised steel or aluminium chequer plate construction covers, including to spare and future bays.

Cable trenches and pits beneath 11kV and 33kV switchboards within traditionally constructed buildings that cannot have all duct entries sealed should be completely sand filled and screeded to finished floor level on completion, were practicable. Alternatively, where this is not practical, due to operational restrictions, then trenches should be backfilled with sand to the highest possible point not less than 400mm above the duct entries and covered with solid anti-slip GRP covers or alternatively galvanised steel or aluminium chequer plate construction covers.

Where a risk of water remains then a damp proof membrane shall be laid on top of the sand and then screeded.

Cable pits beneath containerised 11kV and 33kV switchboard solutions, at finished ground level, shall be filled with sand up to support beam level. The space within the cable entry area between the foundation and the support beam level shall be filled with sand. This will allow external compound finish to be completed uniformly around the installation.

Cable pits beneath containerised 11kV and 33kV switchboard solutions which are elevated on platforms shall be cleaned out and unfilled. A suitable security screen shall be installed to prevent 3rd party interference

Cable pits beneath new non-containerised 33kV switchboards shall be cleaned out and unfilled. All duct entries to the pit shall be sealed using an appropriate mechanical duct sealing system approved by SPEN.

Where cable pits and trenches are being left unfilled and require pit / trench covers, the covers shall be solid anti-slip GRP covers of suitable load bearing capacity, not less than 2 tonnes, to support personnel and switchgear loads incurred during movement of switchgear panels

Constructors shall fit and remove upon completion temporary timber covers as necessary to facilitate safe access prior to installation of equipment.

13.8.1 Cable Support Structures

Where grid tails are incoming and the cable trench is to be left void then the cables shall be supported by an appropriate cable restraining support system to support the cables and protect against damage during a cable fault.

Support systems shall be galvanised steel construction of bespoke design to meet the cable and termination manufacturer's requirements.

13.9 Cable Entries into/within Buildings

Where practicable all cable entries to cable trenches and pits shall be constructed to allow use of a SPEN approved mechanical cable duct sealing system,.

Where it is not practicable for existing cable ducting to utilise an appropriate duct sealing system that is acceptable to SPEN, the cable pit shall be sand filled and screeded (with visqueen membrane and minimum 50mm thick granolithic screed) flush with finished floor level wherever practicable but not less than a minimum depth to adequately cover all duct entries. Particular attention shall be paid to achieving full compaction of dry sand in layers and sealing of cable entry points in order to ensure that cavities cannot develop beneath the screed.

13.10 Cladding Systems to Steel-Framed Buildings (Walls & Roofs)

Steel-framed clad buildings shall have a life to first maintenance of not less than 20 years and:

- Provide a wind and watertight envelope to protect all sensitive plant and equipment installed within the building.
- Be capable of withstanding the effects of any corrosive substance present within or outside the building.

- Be sufficiently robust to withstand the effects of all loading combinations that may occur throughout the operational life of the substation.
- Incorporate if necessary provision of pressure-relief panels or vents to walls and/or roofs enclosing equipment;
- Be capable of achieving sufficient thermal insulation as necessary to provide an appropriate internal environment and avoid moisture ingress via condensation, in particular external walls and roofs shall provide as a minimum standard thermal transmittance U Values as detailed in Table 6.
- Be a minimum 150mm above finished floor level and facilitate minimum 900 opening to external doors.
- Steel-framed and clad buildings shall incorporate masonry or acceptable alternative internal wall structures for wall-fixing purposes generally.

13.10.1 Future Maintenance and Redevelopment

Where SPEN will subsequently adopt the civil fabric of steel-framed clad buildings these shall additionally:

- Offer a degree of flexibility to allow for future expansion of the building such that this causes minimal disruption to the operation of the plant and external facilities.
- Be readily available and replaceable should damage occur by whatever cause.
- Be readily maintainable, in most cases this will require a self-finished minimum maintenance surface with self-cleaning capability and minimal inspection requirements.
- Be of such a material as to provide a consistent finished surface colour throughout its working life and offer an acceptable appearance when viewed from a distance.

13.11 Masonry Walls

Masonry units and associated ancillary items shall be as detailed in this Specification "Masonry".

External walls to enclosures housing Indoor Equipment shall be cavity construction providing an appropriate internal environment that avoids moisture ingress via condensation, in particular external walls shall provide as a minimum standard thermal transmittance U Values as detailed in Table 6.

Irrespective of the building's purpose or generic construction type, where internal walls and the inner leaves of cavity walls are masonry construction these shall be of solid masonry units, fair-faced, plumb, smooth and even within rooms in order to be suitable for fixing wall-mounted equipment.

Walls shall incorporate any movement joints and additional reinforcing measures necessary to accommodate and/or resist post-construction movement, internal and external, such that they withstand all loading combinations without undue cracking, deflection or distortion.

13.11.1 Masonry Walls Enclosing Switchgear or Transformers – Disruptive Failure

Walls that enclose switchgear or transformers shall be designed such that progressive collapse does not ensue in the event of disruptive failure.

Irrespective of the Constructor's design requirements with respect to non-electrical forces (e.g. wind forces, including associated internal pressures), internal masonry walls and the inner leaves of cavity masonry walls to traditionally constructed masonry buildings that house HV switchgear or transformers shall be minimum 215mm overall thickness solid brickwork construction utilising clay or concrete bricks. This minimum requirement would not apply to the external walls of steel-framed clad buildings, similarly alternative segregating internal wall construction would be acceptable to these buildings where the design takes cognisance of and mitigates the potential overpressure forces and fire spread risk associated with disruptive failure.

Cavity masonry walls that enclose HV switchgear or transformers shall incorporate Type 1 or Type 2 stainless steel wall ties or other proprietary system specifically designed to ensure adequate transfer of lateral load between masonry skins. If necessary, ties shall be a greater density than the minimum centres given by the requirements for "Masonry" in this Specification.

Where applicable, walls enclosing transformers shall additionally comply with the requirements of this Specification for "Fire Barrier Walls".

Walls shall incorporate as necessary any combination of structural framing, enhanced cavity ties, bed-joint reinforcement, wind posts or enhanced lateral restraint (including that from roofs) to mitigate the impact of disruptive failure.

Alternative proposals for masonry walls enclosing switchgear or transformers that incorporate blockwork or other variation of specified construction detail will not be acceptable unless the Constructor has confirmed by structural design calculation to the satisfaction of ED&S that such alternative construction has equivalent lateral strength (or better) than that required by this Specification (e.g. by incorporation of structural steel frames, wind-posts or other masonry reinforcement systems).

13.11.2 Masonry Design Guide Notes (Disruptive Failure)

- Whilst it is not possible to measure or reasonably quantify the magnitude of any potential overpressure, experience over many years has demonstrated how typical substation construction types behave (or fail) in containing and/or relieving the associated overpressure. The guidance given here is based upon that experience, where the greater wall panel design requirements for increasing panel size appear to be more than offset by the increase in room volume available to dissipate overpressure.
- For guidance information only with respect to possible alternative masonry panel design options referenced above, Constructors may wish to note that the lateral design resistance offered by the construction details given in this Specification typically equate to an applied lateral UDL in the order of:
    - 3.5kN/m^2 for wall panels of 10/m^2 or less.
    - 3.0kN/m^2 for wall panels between 10/m^2 and 20/m^2.
    - A linear interpolation value between 3.0kN/m^2 and 1.5kN/m^2 for wall panels between 20/m^2 and 40m^2.
- The minimum 215mm solid brickwork internal wall/inner leaf cavity wall requirements given in this Specification shall be enhanced as necessary for long unrestrained wall panels (e.g., by incorporation of wind posts), such that the lateral design capacity is adequate for this applied design guide overpressure. This is the Constructor's design responsibility.
- While this design guidance may be adequate to prevent collapse, experience indicates that structural damage is likely still to occur.

13.12 Roofs

Roofs to enclosures housing Indoor Equipment shall provide as a minimum standard thermal transmittance U Values as detailed in Table 6.

Roofs shall be designed such that they eliminate or protect against the risk of failure due to vandalism or theft; in particular in relation to traditional construction pitched roofs where moisture ingress could lead to disruptive failure if associated with Indoor HV Equipment. For this reason or in relation to the potential for disruptive failure of plant and provision of adequate lateral restraint to the tops of wall panels, traditional construction pitched roofs may require incorporation of a waterproofed structural reinforced concrete slab or other equal approved robust sub-roof construction beneath (not applicable to steel-framed clad building construction).

The use of lead as part of waterproofing systems should be avoided unless essential for Planning purposes, in order to limit the potential for vandalism and theft and thereby mitigate against the risk of moisture related disruptive failure.

13.12.1 Roofs Enclosing HV Equipment – Disruptive Failure

Roofs that enclose HV Equipment shall be adequately robust and/or incorporate designed pressure relief such that progressive collapse does not ensue in the event of disruptive failure, including providing adequate lateral restraint to walls where necessary.

Roofs that enclose HV Equipment shall be adequately robust and/or incorporate pressure relief panels such that potentially hazardous roofing material is not discharged to adjacent public areas in the event of disruptive failure.

Wherever practicable; sub-roofs to traditional build superimposed pitched roofs that enclose switchgear or transformers shall be reinforced concrete construction (not applicable to steel-framed clad building construction).

Alternative proposals for roofs (or sub-roofs) to traditional construction buildings enclosing switchgear or transformers will not be acceptable unless the Constructor has confirmed by structural design calculation to the satisfaction of ED&S that such alternative construction provides equivalent lateral strength (or better) to walls than that required by this Specification (e.g. by incorporation of structural steel frames or other bracing systems).

13.12.2 Concrete Roofs

Concrete roof systems shall provide a fair-faced soffit finish and shall incorporate slip joints at wall bearings, where applicable polysulphide sealed externally.

Concrete roofs shall be cast in situ reinforced concrete construction or alternative preformed systems. Where alternative preformed systems are proposed these shall be composite construction either:

- Proprietary precast pre-stressed beam and in situ concrete screed topping systems with mastic sealed soffit joints and, where applicable, reinforcement to screed.
- Proprietary permanent metal soffit shutters and in situ reinforced concrete topping systems.

Precast ‘beam and block or pot’ type roof construction will not be acceptable.

Where permanent structural metal soffit shutters are used as part of a composite roof system these shall be corrosion resistant and the Constructor’s proposals for screening or tagging for earthing purposes shall be expressly agreed with SPEN prior to construction.

13.12.3 Flat Roofs – Structural Design Note

In certain site-specific situations flat roofs to Primary Substations may have the potential to be subject to unusually high ‘crowd’ or other imposed loading, for example from unauthorised personnel access such as malicious gatherings or groups seeking a visual vantage point in the event of an unusual adjacent public spectacle – it is the Constructor’s responsibility to assess and if necessary design for this risk.

13.12.4 Superimposed Pitched Roofs

Where a traditional construction pitched roof is required to be superimposed over a concrete sub-roof this shall incorporate cross-flow ventilation to the roof space.

Concrete sub-roofs beneath superimposed pitched roofs shall have a nominal waterproof covering applied and a means for rainwater to run-off external to the substation enclosure – to eliminate the risk of moisture ingress related disruptive failure of plant associated with possible failure of the superimposed pitched roof, in particular vandalism or theft.

Facias, bargeboards and the like shall be PVCu.

The use of natural slate or lead to pitched roofs should be avoided unless essential for Planning purposes, in order to limit the potential for vandalism and theft – and thereby also mitigate against the risk of disruptive failure.

13.12.5 Waterproof Coverings to Flat Roofs

Proprietary synthetic cover flashings shall be provided to upstands to higher level elevations of buildings and both upstands and cover flashings shall be chased into joints and appropriately pointed.

Single membrane systems that are vulnerable to accidental damage from impact and concentrated point loads or from deliberate vandalism (objects thrown onto roofs, malicious use of sharp objects) shall not be acceptable without protective coverings over, in particular where manufacturers typically describe these products as “suitable for limited foot traffic and light loads” or requiring that “care should be taken to avoid sharp objects or concentrated loads”.

Where SPEN will subsequently adopt the civil fabric of the substation, waterproof covering systems shall include an independent insurance backed guarantee to warranty both materials and workmanship for a period of at least 20 years.

The use of coping stone edge systems shall be avoided as these are particularly susceptible to vandalism.

13.12.5.1 Built-up felt waterproofing systems (insulated system)

Built-up felt waterproofing systems to exposed concrete roofs shall be insulated systems comprising preparation, vapour barrier, venting base layer over solid polyisocyanurate or similar insulation board and minimum two-layer polyester reinforced high-tensile high-performance elastomeric felts with mineral surface finish top sheet. Underlay and top sheet shall be taken full width over parapet upstands.

Roof-edge trims shall be GRP construction.

13.12.5.2 Mastic asphalt waterproofing systems

Mastic asphalt waterproofing systems to concrete roofs shall comprise preparation and two-coat roofing grade mastic asphalt not less than 20mm thick overall, laid to break joint and incorporating sheathing felt underlay beneath.

Upstands and apron down stands shall not be less than 12mm thick overall, incorporating fillets and galvanised or stainless steel metal backing mechanically fixed to the substrate.

Asphalt systems shall receive two coats of solar reflective paint finish.

13.12.5.3 Built-up GRP waterproofing systems

GRP waterproofing systems to concrete roofs shall be proprietary built-up systems, proposed details of which shall be submitted to SPEN for comment and acceptance prior to commencement.

As a minimum, built-up GRP systems shall comprise preparation, exterior quality treated timber decking mechanically fixed to the concrete sub-roof, pre-formed GRP edge trims, lamination with GRP 450gsm fibreglass matting to decking joints, GRP 450gsm fibreglass mat between two layers of polyester resin to form the main waterproof barrier and protective polyester topcoat.

13.13 Building Drainage

Where SPEN will subsequently adopt the civil fabric of the substation, rainwater goods shall be PVCu construction or other acceptable robust corrosion resistant systems by express agreement with ED&S.

Gutters and down pipes shall be external to buildings.

Gutters and down pipes to rainwater systems shall be a minimum 140mm and 100mm respectively.

Rainwater down pipe installations may require anti-climb and/or anti-vandal guards, subject to the site-specific location and environment.

13.14 Doors

It is essential that SPEN personnel can access and properly secure on egress all doors at all times. Any door material/construction type that may bind, shrink, warp, wind, corrode or distort will not be acceptable.

The preference is for external doors to be metal security doors of robust construction that provide security against unauthorised entry and shall incorporate protective surface finishes that are durable and maximise periods between maintenance.

All doors shall be emergency escape doors, including doors providing access internally.

The number of doors having external locking to access buildings shall be kept to a minimum consistent with adequate safe operational use (to limit opportunities for unauthorised entry). Only one leaf of double doors shall provide emergency egress, with the other being fixed by means of robust bolts top and bottom.

Emergency escape doors shall open outwards.

Doors shall not open over public highway (i.e., including public footways).

Subject to site layout, external doors may be required to open through 180^0 and/or incorporate removable panels over to facilitate the installation of plant.

Doors shall be fully weathered including appropriate seals to the external perimeter of frames, cover plate to un-rebated meeting styles and weathering to lintels over and to thresholds below. Weather bars shall be corrosion resistant construction, preferably built-into concrete thresholds to form 12mm weathered faces that are flush with finished floor level on the inside. Proprietary threshold weather bars shall not exceed 15mm upstand height to avoid presenting a trip hazard.

Where new build or replacement external doors are being installed at substations classified as ‘High’ and ‘Higher than Normal’, as defined in ASSET-01-021, these should be metal security doors.

Where the substation is classified as ‘Normal’ or ‘Lower than Normal’ then the doors should be metal security doors but in instances where the current doors are timber then a like for like replacement can be used.

All external access lock mechanisms to substation doors that utilise padlocks shall incorporate integral shrouds to prevent malicious access to locks. Subject to the SRA this may require the fitting of more than one padlock on the entry door.

Wherever practicable design layouts shall avoid locating emergency escape doors such that they open into high-risk areas such as HV Switch Rooms and AIS compounds with exposed live equipment or into areas where different types of Safety Rules Authorisation may apply.

Proposed door construction details shall be submitted to SPEN for comment and shall be subject to SPEN acceptance in principle prior to procurement – irrespective of location and risk, metal security doors are the preferred option type for external substation doors.

13.14.1 External Metal Security Doors

External metal security doors shall be sourced through an approved SPEN supplier. Should the Constructor wish to source doors through their own suppliers then these shall be certified by the LPCB with a minimum rating of LPS 1175 C5. Details of third-party doors shall be submitted to SPEN Engineering Design & Standards for approval prior to ordering.

External metal security doors shall be proprietary corrosion resistant and maintenance free steel or aluminium units.

Door leaves shall be finished with an anti-vandal GRP facing and be hung on full height continuous stainless steel piano hinges. Cill plates shall be solid stainless steel. Door cores to be formed from 2 interlocking trays of 2mm aluminium / steel filled with non-hygroscopic closed cell foam of minimum compressive strength 500kPa

Manufacture shall be such that these are sealed against water entry but allow discharge of condensation.

Metal security doors shall be bonded to the substation earth system in accordance with the requirements of this Specification.

13.14.2 External Timber Doors

Where external timber doors are necessary for aesthetic reasons (e.g., a planning requirement or to match adjacent existing) these shall be constructed in durable hardwood that is resistant to decay, dimensionally stable and well-seasoned to attain a moisture content within +/- 10% of average equilibrium moisture content.

Timber doors shall be double ledge and brace framed tongue and grooved board construction using the best commercial grade Eucalyptus Grandis or British Oak. Alternative timbers may be used on a project specific basis in agreement with ED&S. Alternative timbers shall have equivalent properties for strength and durability as the approved timber. Timber shall be sourced from a recognisable forest management certification body such as the PEFC or FSC.

Frames shall be built-in to new work using galvanised fishtail or ragged right-angled lugs. Frames shall be built-in to existing work using proprietary corrosion resistant frame fixings, pelleted or similarly sealed on completion.

External timber doors shall receive a protective decorative finish that is consistent with specified time to first maintenance, comprising as a minimum 2 coat preservative basecoat and 2 coat high performance wood stain or primer coat, undercoat and 2 coat high performance paint; all with an additional preservative basecoat or primer to all end grain.

Varnish to doors is not acceptable.

Protective decorative finishes shall be complete proprietary built-up external wood stain or paint systems that are water repellent and have appropriate designed levels of 'moisture vapour permeability'.

Typical deemed to satisfy external timber door construction guidance drawings are available from SPEN but Constructors shall note that these are generic only and are not indicative of any project-specific requirements such as dimensions, handing, locking etc.

13.14.3 External Composite Doors

The use of Wood Polymer Composite (WPC) doors may be used in agreement with SPEN on a project specific basis. WPC composition shall be 60% FSC certified reclaimed wood, 30% recycled High Density Polyethylene (HDPE) and 10% bonding agent.

13.14.4 Internal Doors

Internal doors shall be proprietary timber or steel doors. Internal doors to operational areas and to mess rooms shall be certified as having a fire resistance rating of at least 1-Hour and facilitate emergency egress.

13.14.5 Door Furniture

The Constructor is responsible for the supply and installation of all fixed door furniture, which shall be robust heavy-duty construction and corrosion resistant. The Constructor shall agree the type and designated category of user access for locking mechanisms with SPEN on a site-specific basis – SPEN will provide approved locksmith contact details for the supply of SPD and SPM suited locking mechanisms.

Doors designated as normal points of access shall be minimised (i.e., those having external locking), all other doors shall not have mechanisms for external access.

Lock bracket mechanisms shall be suitable to receive SPD or SPM suited padlocks or shall be hardened galvanised or stainless steel high-security lock-brackets that are tamper resistant such that these are non-removable without access into the substation. The use of other similarly suited lock mechanism types shall be subject to the prior approval of SPEN.

Lock bracket mechanisms to receive padlocks shall incorporate integral shrouds such that padlocks are protected against unauthorised removal. All external door furniture shall be anti-climb in profile.

Mechanisms for emergency egress shall be high-security multi-point locking mechanisms with emergency exit override operated by means of full width panic bars. If emergency escape mechanisms are fitted to access doors with external locking then the panic bars must operate when the doors are locked. Padlock access devices must not restrict panic function.

Bolts to fixed leafs shall be solid heavy-duty 16mm square section bow handle galvanised steel or other similar robust corrosion resistant construction.

Doors shall be fitted with appropriate proprietary garage type restraint stays to fix doors open at 90^0; in addition, where access for plant installation is restricted, doors shall be fitted with heavy duty galvanised or stainless steel cabin hooks systems to restrain doors open at approximately 180^0.

Hinges shall be stainless steel construction.

Where provided as essential external pull handles shall be appropriately designed heavy-duty galvanised or similar corrosion resistant construction. Pull handles shall be avoided where these have the potential to assist forced unauthorised entry.

Where transom rails are required, access to the full height of the aperture should be provided via hinged upper door leaves. Lift down panels will not be acceptable.

13.14.6 Door Louvres

Louvre ventilation within door leaves must comply to SPEN standards and must be specifically approved prior to use.

Full door height louvres shall not be acceptable as this increases the security risk of the substation due to unauthorised entry.

Louvres must protect from rigid body penetration and high pressure water ingress, must offer no line of sight through the louvre and be protected with vermin mesh.

13.14.7 Door Design Note

Site-specific requirements for door dimensions, door handing and door furniture may vary from that indicated in typical guidance drawings listed in this Specification or that indicated in any additional layout or construction detail drawing(s) that may be issued for guidance with respect to external doors.

13.15 Internal Finishes

Dust can be a significant contributory underlying cause of disruptive failure and minimum internal decoration shall be carried out to reduce this risk as follows:

- Preparation & minimum two-coat proprietary anti-slip Epoxy Resin paint to floors (typically colour grey).
- Preparation & minimum two-coat vinyl silk emulsion to masonry walls (typically colour magnolia).
- Preparation & minimum two-coat vinyl silk emulsion to concrete ceilings (typically colour white).

Other decoration shall be carried out as necessary to ensure the adequate ongoing safe operation of the substation and to minimise the requirement for maintenance access, inclusive of any necessary 'top-up' decoration to make good in the event of damage incurred during installation and commissioning of Equipment.

13.16 Internal Fixtures & Fittings

Internal fixtures and fittings shall be agreed with SPEN on a project-specific basis but shall typically include:

- Operational tool cabinet.
- Desk and chair.
- Lockable filing cabinet (or adequate drawer storage to desk).

14. BUILDING SERVICES TECHNICAL REQUIREMENTS

14.1 Heating Ventilation and Air Conditioning (HVAC)

The Building Services shall be designed and constructed such that they provide an environment suitable for the electrical plant to operate and function in accordance with the manufacturer's requirements.

Where it is proposed to utilise an existing building to house new switchgear then the existing building should be assessed against the requirements detailed below or the specific switchgear requirements, whichever are more onerous.

Buildings shall be designed to control ventilation, humidity and heating within the following limits for a daily average ambient external temperature range of -10˚C and +30˚C.

In order to maintain internal room temperatures heating, ventilating, and air conditioning (HVAC) systems shall only operate during periods when the internal room temperature is a direct function of the ambient external temperatures being outside the 'daily average ambient temperature range' as stated above and allowance shall be made for 'thermal lag'. This performance should be proved through modelling and calculation as part of the detailed design stage.

The internal design conditions for the various items of plant and their associated rooms are stated in Table 5. Where plant is co-located in a shared space then the more onerous of the conditions listed in Table 5 should be used.

Internal Design Conditions		
Location	**Max Temp**	**Min Temp**
Control Room/LVAC Room/Telecoms Room	30ºC (35ºC)	15ºC ± 2ºC
Battery Room	Uncontrolled	15ºC ± 2ºC
Switchgear	40ºC	5ºC ± 2ºC
Workshop/Store Room/WC/Mess Room/Corridors	Uncontrolled	15ºC ± 2ºC

Table 5 – Internal Design Temperature Limitations

SPEN recognise and accept that it is not economically viable to limit internal temperatures to 30˚C in all circumstances. In extreme weather situations where the external ambient temperature range is between -25˚C and +35˚C as a short-term and infrequent occurrence, the above limits on internal temperatures may be relaxed to those indicated in brackets in Table 5.

14.1.1 Heating

Rooms within the buildings shall be heated to achieve the minimum temperatures specified in Table 5. This shall be via electrical heaters installed and controlled by thermo-switches.

In each room the thermostat controlling the heaters shall be set to deliver minimum winter temperatures detailed in Table 5 and locked off against tampering. A manual override switch with a 2-hour maximum timer shall be fitted to allow an increase in ambient temperature to 21°C during occupation.

14.1.2 Ventilation

Ventilation shall be provided to achieve the maximum temperatures specified in Table 5 and to ensure a minimum of four complete air changes per day within rooms in the building. Natural ventilation should be used whenever possible. Mechanical extract ventilation should be provided in the Mess Room and WC, in accordance with Building Regulations.

14.1.3 Humidity

Humidity must be controlled to ensure the safe, efficient operation of the substation and to prevent any undue deterioration of the plant, equipment or fabric of the enclosure, in particular to prevent problems associated with condensation, typically by providing dehumidification or alternative natural air flow across the room from low to high-level through outside walls.

Relative humidity shall be maintained between 20% and 60%. Control of relative humidity is to be done by means of natural ventilation, wherever possible (a minimum of four complete air changes per day to unsealed rooms is required).

14.1.3.1 Humidity Control by Dehumidification

Where utilised, dehumidifiers shall be high-level wall-mounted units capable of efficient operation between the temperature range of +5˚C and +30˚C. Discharge pipes shall be taken directly through walls at high-level to drop externally within robust vandal and corrosion resistant protective downpipes to safely condensate and discharge at ground level. Low loss trace heating shall be provided on the dehumidifier drain.

Rooms utilising dehumidification shall be draught-sealed and shall not incorporate ventilation units.

The dehumidifier drying cycle shall be controlled by a humidistat, suitably located away from the dehumidifier airflow but forming an integral part of the unit. The switching point shall be capable of being set over the range of 40% to 80%, but factory set at 50%.

A second humidistat shall be provided in a similar position for use as a high relative humidity (RH) level alarm, which shall be pre-set at 60% and factory sealed. The auxiliary contacts of this humidistat shall be set to open at 60% RH and above, such that when the level is below 60% RH the auxiliary contacts are closed, giving a constant healthy signal to the SCADA system. The contact ratings shall be suitable to meet the rating of the dehumidifier.

Both humidistats shall be clearly labelled to indicate their function and RH level setting range.

The refrigerant shall be CFC free.

The defrosting cycle shall be controlled primarily by an auto-defrost device of the temperature sensing type.

14.1.3.2 Dehumidifier Design Note

Dehumidification shall be capable of extracting at least 75ml/hr of moisture from the sealed room environment at 10°C / 50% (RH) – more than one unit may be required per room. The following conditions shall be assumed:

- Ambient humidity 80%RH
- Ambient temperature +20°C
- Design humidity 50%RH

14.1.3.3 Humidity Control by Ventilation

Where it is proposed to control humidity by means of natural ventilation this shall achieve a minimum of four complete air changes per day to unsealed (non-dehumidified) rooms and there should be a minimum 1m clear external to walls incorporating ventilation units. These walls shall be located such that they are adequately clear of areas that may be a fire risk, be dusty or have potentially hazardous gas or chemicals in the air.

Ventilation units shall be of robust vandal and corrosion resistant construction such as masonry air bricks or galvanised steel louvres.

Ventilation units shall be secure and weathered to offer appropriate protection against moisture ingress and shall incorporate appropriate seals to the external perimeter. Furthermore, the construction of these ventilation units shall be such that long object probes of any type and cross-section do not have the potential to infringe safety clearance distances from hazardous parts.

Intumescent ventilation units shall be used where segregation in the event of fire is required.

Substation enclosures shall not have windows.

14.1.4 Battery Rooms

Ambient temperature to bespoke Battery Rooms shall be controlled such that it is maintained within the manufacturer's recommended upper and lower limits for optimum performance and lifespan, however, wherever practical the use of air conditioning schemes shall be avoided

Where a separate battery room is required, to house vented unsealed cell batteries, natural ventilation only shall be provided to Battery Rooms and designed such that these rooms are not designated as hazardous areas under applicable BS EN specifications. Overall substation design shall be such that services passing through internal substation walls to these Battery Rooms are kept to an essential minimum and, in addition to fire-stop requirements, seals shall be durable and gas-tight.

14.1.5 Insulation

New buildings shall be capable of achieving sufficient thermal insulation as necessary to provide an appropriate internal environment and avoid moisture ingress via condensation. This should also apply to existing buildings where major roof works are being undertaken.

In particular buildings shall provide, as a minimum standard, thermal transmittance U Values as detailed in Table 6. There is no requirement for insulation in cable basements.

Region	Roof U (W/m²K)	Walls U (W/m²K)	Floor U (W/m²K)
Scotland	0.2	0.27	0.22
England & Wales	0.25	0.35	0.25

Table 6 – Thermal Insulation Requirements

14.2 Building Electrical Systems

Electrical installation schemes shall be compliant with SUB-03-029 and entirely suitable to the intended purpose of each room within buildings, including LV AC supply distribution board and if applicable design to satisfy requirements for use in potentially explosive environments in Battery Rooms with unsealed batteries. These schemes shall conform in all respects to the requirements of the relevant British Standards and the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers (IEE) or its successor organisation. In addition, lighting design shall be in accordance with BS EN 12464-1.

The Constructor shall submit his proposals to SPEN for approval prior to commencing work, including loading calculations to verify the design for all aspects of the works.

The following should be provided as part of the building services works:

- Design proposals for review and acceptance prior to commencing work, including loading calculations to verify the design for all aspects of the works.
- A valid electrical test certificate for the works in accordance with the current IEE regulations. These should be included, where applicable, within the CDM H&S File that is handed over to SPEN.
- ‘As-Installed’ schematic and layout drawings showing the installed LV AC distribution system.

Internal cabling shall be run through surface-mounted conduit.

14.2.1 Small Power

Buildings shall incorporate complete electrical installations for lighting and small power schemes including 400V, 230V and 110V outlet sockets as required by SPEN.

LV systems will be designed to be compatible with the LV installation for the requirements of the plant operation.

14.2.2 Electro-Mechanical Heating, Ventilation & Air Conditioning Systems

Where provided electrical installations for heating, ventilation and air conditioning schemes to buildings shall incorporate control and instrumentation, interlocking and cabling systems necessary to maintain appropriate operational conditions. Wherever practical the use of air conditioning schemes shall be avoided.

14.2.3 Internal Lighting

Internal lighting shall allow safe movement of personnel and safe operation of equipment.

Internal lighting levels shall, where practicable, be LED type and as a minimum be in accordance with Table 7 and BS EN 12464-1.

Internal lighting shall be operated by wall switches positioned adjacent to doorways, including outside at the entrance to rooms and/or at more than one doorway if appropriate.

Internal lighting schemes generally shall be designed such that the positions of all light fittings and associated switches etc. take due cognisance of the locations of all equipment and access/egress routes within the building.

Emergency lighting shall also be provided in accordance with BS 5266: Part 1. A key test wall switch shall be installed adjacent to the entrance door.

14.2.4 Exterior Lighting

Exterior lighting shall allow safe access and emergency egress for personnel (including from buildings) and safe operation of equipment, subject to the following minimum requirements:

- Maintained average illuminance 6.0 lux
- Minimum maintained point illuminance 2.5 lux

Where SPEN expressly require frequent access to or increased security lighting within compounds containing Outdoor Equipment these levels shall be increased locally to an average of 100 lux and minimum of 50 lux respectively.

Lighting columns shall be bolted to their foundations and designed to be lowered for maintenance by one person. Lighting columns shall be sized and positioned such that they cannot fall onto HV Equipment. Luminaires shall, where practicable, be LED type with directable light output to minimise light pollution. Earthing of lighting columns shall be the Constructor's responsibility.

Exterior lighting to buildings shall incorporate IP65 wall mounted LED luminaires to illuminate all pathways surrounding the building and shall be controlled via integral PIR detectors (minimum detection range of 12m and minimum detection angle of 110 degrees).

An internal wall mounted override switch shall be fitted adjacent to the main entrance/exit door to enable constant operation of these luminaires. Note that a non-maintained IP 65 emergency bulkhead LED luminaire shall be mounted above each emergency exit doors.

Location	Lux (lx)	u_o	Workplane
Control Room and Offices	500	0.7	at 0.75 m above floor level
Relay and Telecoms Rooms	300/200[3]	0.6	at floor level
Battery Room	200	0.4	at floor level
LVAC Room	200	0.4	at floor level
Switchgear	300/ 200[4]	0.6	at floor level
Workshop/Store Room	150	0.4	at floor level
WC and Lockers	200	0.4	100 lx min at floor level
Mess Room/Corridors	200	0.4	at floor level
Cable Basement, Walkways	100	0.4	at floor level
Stairs	100	0.4	at floor level
Building Access Doors[5]	20 (6 min)	0.3	at floor level
Building Perimeter	6 (2.5 min)	0.25	at floor level

Table 7 – Substation Lighting Levels

[3] 200 lx where no accurate task is required, 300 lx @ 0.75 m AFFL at the front of the panels

[4] 200 lx where no accurate task is required, 300 lx @ 0.75 m AFFL at LCC area

[5] Final escape route exits to be provided with emergency features lighting fixtures

14.3 Security Alarm Systems

Where it has been identified through a site-specific SRA that an Intruder Detection System is required this shall be installed, connected and commissioned by Corporate Security. The project team shall provide a fused spur at an agreed location that will allow Corporate Security to test, commission and connect their Intruder Detection System back to the ARC.

The security system operating panel shall be located adjacent to the main access door.

14.4 Fire Alarm Systems

Where Section 10.4.5 – 'Fire Risk' and consultation with the ScottishPower Corporate Security Fire team highlights the requirement for fire systems it shall be installed to the ScottishPower Corporate Security 'Fire Specification' (available from SPEN), connected and commissioned to the substation local alarm and SCADA system for remote alarm indication.

All cabling (power and alarms) and connection to power supply shall be designed and installed by the project team but final connection and commissioning of alarms to the substation SCADA system shall be by SPEN.

15. POST-COMMISSIONING (RETURN) SITE VISIT

Programming is outside the scope of this document, but Constructors shall note for information that civil works return visits to sites are necessary anything between one and twelve months after substantial completion (i.e. after handover for equipment installation) to complete post-commissioning finishing civil and building works that may include but may not be exclusively limited to:

- Sand infill to cable pits/cable runs beneath and around Containers.
- Access platforms to Container doorways.
- Sand fill/screed to cable pits within buildings.
- Sealing cable entries against moisture and vermin entry where this has not otherwise been completed as part of equipment installation and commissioning works.
- Making-good original decoration within buildings where this has been damaged during installation of Equipment.
- Making-up ground levels as necessary and stone chipping topping or other agreed finishes to compounds.
- Sand/geotextile or other agreed protection to cables and stone chipping infill to Transformer Bunds.
- Kerbs, bituminous surfacing and drainage to internal roadways.

Where the substation has become operational under SPEN Safety Rules all Constructor operatives subsequently working at the substation shall have appropriate ScottishPower Authorisation(s).

16. DRAWINGS

Generic guidance drawings are available showing SPEN's typical layout and construction details.

These typical guidance plans are deemed to satisfy SPEN's functional civil and building requirements for Primary Substations. These drawings may be used to assist designers in designing substations, however it shall be noted that these drawings are for reference only and shall not supersede the requirements set out within this document.

Refer to SUB-03-025 (Appendix 1), published separately on the SP Energy Networks website.