VOLUME 5 **CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITES**

SECTION 7 **MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES**

PART 2

SERIES 7000, 7100, 7200 AND 7300

STANDARD PERFORMANCE SPECIFICATIONS

SUMMARY

This Section of Volume 5 of the Manual of Contrat Documents for Highway Works covers the procedural, contratual and technical requirements for the mechanical and electrical installations for road tunnels, moveable bridges and bridge access gantries. Part 2 covers Standard Performace Specifications

INSTRUCTIONS FOR USE

1. Insert Part 2 into Volume 5 Section 7.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from the Stationery Office Ltd.

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MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Mechanical and electrical installations in road tunnels, movable bridges and bridge access gantries

Part 2: Standard Performance Specifications

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REGISTRATION OF AMENDMENTS

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VOLUME 5 CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITIES

SECTION 7 MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

PART 2

STANDARD PERFORMANCE SPECIFICATIONS

Contents

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VOLUME 5 CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITIES

SECTION 7 MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

PART 2

SERIES 7000

GENERAL REQUIREMENTS

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7000. INTRODUCTION

General

1 This Section of Volume 5 of the Manual of Contract Documents for Highway Works (MCHW) covers the procedural, contractual and technical requirements for the mechanical and electrical installations for road tunnels, movable bridges and bridge access gantries, and is sectionalised in the following Parts:

Part 1

2 A Model Contract Document and Notes for Guidance for the mechanical and electrical installations in road tunnels, movable bridges and bridge access gantries.

Part 2

3 Standard Performance Specifications:

i) Series 7000 - General Requirements

ii) Series 7100 - Mechanical, Electrical and Communications Work for Road Tunnels

iii) Series 7200 - Mechanical, Electrical and Communications Work for Movable Bridges and Bridge Access Gantries

iv) Series 7300 - Testing and Inspection for Road Tunnels, Movable Bridges and Bridge Access Gantries

Part 3

4 Notes for Guidance on the Standard Performance Specifications.

i) Series NG7000 - General Requirements

ii) Series NG7100 - Mechanical, Electrical and Communications Work for Road Tunnels

iii) Series NG7200 - Mechanical, Electrical and Communications Work for Movable Bridges and Bridge Access Gantries

iv) Series NG7300 - Testing and Inspection for Road Tunnels, Movable Bridges and Bridge Access Gantries

Part 4

5 Method of Measurement and Bills of Quantities, Notes for Guidance and Library of Standard Item Descriptions for the mechanical and electrical installations in road tunnels, movable bridges and access gantries.

Scope

6 The Specifications shall form the basis for mechanical, electrical and communication installations in tunnels and for movable bridges and access gantries and may be used in traditional and design and build type contracts.

7 The Specifications are intended to complement the Standard BD Planning, Equipping and Operating Road Tunnels and all other applicable design manuals for roads and bridges, and cover:

i) equipment performance

ii) material standards

iii) workmanship standards

iv) functional effectiveness

v) installation standards

vi) off-site and on-site testing

vii) inspection and maintenance

viii) operational safety

ix) training

8 When the specifications are used in preparation of contract documentation, each section as applicable shall be used in its entirety, with additional documentation in the form of appendices or other annexes provided to set out the particular requirements for the specific project.

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Implementation

9 This document shall be used for all schemes currently being prepared by the Overseeing Organisations - the Highways Agency, the Scottish Office Industry Department Roads Directorate, the Welsh Office Highways Directorate and the Department of the Environment for Northern Ireland, Roads Services, provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Maintenance Agents shall confirm its application to particular schemes with the relevant Overseeing Organisation.

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7001. ABBREVIATIONS AND DEFINITIONS

Abbreviations

TERM/ ABBREVIATION	MEANING
ACB	Air circuit breaker
ASTA	Association of Short Circuit Testing Authorities
AWA	Aluminium Wire Armoured
BBC	British Broadcasting Corporation
BS	British Standard
BSI	British Standards Institution
Cavitation	A physical combination of vapour (and liquid) forming on the blades of a moving impellor causing noise and poor pumping ability
CCTV	Closed circuit television
CFC	Chlorofluorocarbon
CIBSE	Chartered Institute of Building Services Engineers
Coaxial cable	Type of cable consisting of two concentric conductors separated by insulation, used to transmit high frequency (eg television) signals
Conductor	Set of wires, or conductors, which together form a power supply or data communication cable.
CP	British Standard Code of Practice
CPU	Central Processing Unit
dB	decibel
dB(A)	decibel related to sound level
DC	Direct Current
DIN	A German standard
DP	Double pole
Duct	Pipe or conduit for access to and mechanical protection of cables
Earth	Any zero-voltage point
Earth electrode	A conductor or group of conductors providing a sound electrical connection with the earth (soil or ground)

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TERM/ ABBREVIATION	MEANING
Earth leakage current	A stray current which flows to earth, in a circuit which is electrically sound
EMS	Electronic Message Sign
EN	European Standard (or Euronorm)
EPROM	Erasable programmable read only memory
Fuse	Protective device which operates and causes current flow to cease under overcurrent or fault current conditions
Glanded off	Cable fitted with a proprietary termination device or sleeve, employed to press packing tight on or around it, and the action of fitting such a device
GRP	Glass reinforced plastic
HRC	High rupturing capacity
HTHW	High temperature hot water
HVAC	Heating, ventilating and air conditioning
High voltage (**HV**)	Voltage exceeding 1,000 volts AC or 1,500 volts DC between conductors, or 600 volts AC or 900 volts DC between conductors and earth
HSE	Health and Safety Executive
IBA	Independent Broadcasting Authorities
IEC	International Electrotechnical Committee
IEE	The Institution of Electrical Engineers
Impedance	A measure of the response of an electric circuit to an alternating current (resistance, inductance and capacitance)
Inductance	The property of an electrical circuit by which a voltage is generated by a change in the current
IP	Ingress Protection
I/O	Input/Output. The term is used to refer to those operations, devices and data bearing media that are used to pass information into or out of a computer
ISMC	International Society for Measurement and Control (Formally Instrument Society of America)
ISO	International Organisation tor Standardization
kVAr	Kilovoltamperes Reactive
LCD	Liquid crystal display
LED	Light emitting diode
LSOH	Low smoke zero halogen
LTHW	Low temperature hot water
Low voltage (**LV**)	Voltage not exceeding 1,000 volts AC or 1,500 DC between conductors, or 600 volts AC or 900 volts DC between conductors and earth

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TERM/ ABBREVIATION	MEANING
LSF	Low smoke and fume
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
MCC	Motor Control Centre
MICC	Mineral Insulated Copper Covered
MICS	Mineral Insulated Copper Sheathed
MIS	Management Intormation System
MTBF	Mean Time Before Failure
MTHW	Medium temperature hot water
MTTR	Mean Time to Repair
NMCS	National Motorway Communications Systems
'On Snore'	The ability of a pump to run for a limited amount of time whilst cavitating
PID	Proportional integral derivative
PLC	Programmable Logic Controller/Programmable Controller
PSTN	Public switched telephone network
PVC	Polyvinyl Chloride
QWERTY	Standard UK keyboard arrangement
RCD	Residual current device (earth leakage circuit breaker)
RF	Radio frequency
RFI	Radio frequency interference
RH	Relative Humidity
RMS	Root mean square value of voltage
ROM	Read only memory
RTD	Resistance Temperature Device
SCADA	Supervisory Control and Data Acquisition
Screen	To surround or encase a circuit with metal in order to reduce the effect of electric or magnetic fields
SELV	Satety extra low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock
Short circuit	A deliberate or accidental low resistance connection, on an electrical circuit. (Its effect is to equalise voltages at two points and allow current to flow)
SP&N	Single pole and neutral
SWA	Steel wired armoured. A cable type

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TERM/ ABBREVIATION	MEANING
Switchfuse	Fuse incorporating a switch or isolator, thereby enabling the power supply or devices fed from it to be turned off
Telemetry	The measurement of events at a distance. Transducers are used to measure physical activities and to convert these to signals that reflect the measurement
TP	Triple pole
TP&N	Triple pole and neutral
Transit system	A system of intumescent compressible blocks within metal frames to seal cables and pipes where they pass through walls
Twisted pair	A cable consisting of a pair of conductors twisted around each other, in order to reduce interference
UPS	Uninterruptible power supply
VDU	Visual Display Unit
VMS	Variable message sign
XL	Cross linked
	XLPE Cross-linked Polyethylene

Definitions

1 In construing the specification, the following words and expressions, additional to those defined in the model contract document, shall have the following meanings assigned to them.

2 The term 'the Supplier' shall refer to any person or organisation who shall supply and/or install any equipment in compliance with the Project Specification. All references to 'the Contractor' shall apply equally to 'the Supplier'.

3 The term 'the Manufacturer' shall refer to any person or organisation who shall construct, build or manufacture any equipment in compliance with the Project Specification. All references to 'the Supplier' shall apply equally to 'the Manufacturer'.

4 The term 'the Employer' shall refer to any person or organisation who has called for tenders to provide and execute the works and who will employ the Contractor.

5 The term 'the Designer' shall refer to any person or organisation who shall design, supply or install any equipment in compliance with the Project Specification. The designer shall be that person or organisation which conducts the detailed design of the equipment, system or installation in accordance with the project specification.

6 The term 'Approved' shall mean checked and approved by the Engineer.

7 The term 'User/End User' shall mean the person(s) or organisation who will ultimately use the equipment referred to in the Project Specification.

8 The term 'Operator' shall mean the person(s) who are responsible for operating the plant or equipment referred to in this Specification.

9 The term 'shall' and 'will' means that the requirement referred to is mandatory.

10 The term 'project specific documentation' shall refer to the appendices or other annexes issued with this standard specification.

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7002. STANDARDS AND LEGAL REQUIREMENTS

1 Standards and legal requirements (to which reference is made in the Specification) are listed where relevant in Appendices at the end of each section. They are of the following type:

i) Statutory Requirements;

ii) European Standards;

iii) British Standard English language versions of European Standards (BS EN);

iv) British Standards;

v) Department of Transport and Highways Agency Standards and Advice Notes.

2 Standards and legal requirements incorporated in the contract by a reference which does not include a date shall be those respective editions current 3 months before date of tender, or as stated in the instructions for tendering, incorporating all amendments current on that date. Standards and legal requirements incorporated in the contract by a reference that includes a date shall be deemed to exclude amendments issued after that date unless otherwise agreed.

3 In respect of all other references, the date of the edition, applicable to the contract, shall be that stated. Where no date is stated, the date of the edition current on the Tender Return Date stated in the Instructions for Tendering and incorporating all published amendments current on that date.

4 Where a British Standard incorporated in the contract has been superseded by a Harmonised European Standard, or a European Standard, issued prior to the Tender Return Date stated in the Instructions for Tendering, then such Harmonised European Standard or European Standard shall be substituted for the British Standard and any amendments thereto contained in the Specification.

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7003. EQUIPMENT, WORKMANSHIP, MATERIALS AND DESIGN

1 Workmanship shall be of the highest standard (as defined by the appropriate standard, institute or trade body) and work shall be carried out by personnel properly trained and qualified in the appropriate trade. Untrained persons shall work only under the supervision of, or in conjunction with, appropriately trained persons.

2 All equipment, materials and accessories are to be supplied new, unused and complete (together with guarantees and maintenance following commissioning as stated in the contract specific documentation) to be of the best quality of their respective kind and manufactured and tested to recognised quality control standards, or as defined in the Specification. The equipment provided shall be of the model or type in current production at the time of installation, and there shall be no known obsolescence.

3 Permanent equipment shall not be used for temporary works during construction unless specifically agreed in the contract specific documentation.

4 All equipment, materials, accessories and their housings shall have the requisite degree of protection necessary to ensure safe and durable operation under the environmental conditions in which they are to be installed and operated, and shall have a reliability not less than the mean time between failure stated by the manufacturer or, in accordance with published standards, or, where this is not available, equivalent reliability standards of alternative manufacturers for the type of equipment concerned.

5 All materials, equipment and accessories are to be quality control tested off-site, by the manufacturer, prior to delivery and installed in accordance with the manufacturer's recommendations and in accordance with the standards of good practice to be expected from properly trained and qualified tradesmen.

6 All off-site manufactured plant and equipment shall be constructed or assembled in the appropriate department of the suppliers/manufacturer's works which shall be suitably equipped. Rotating equipment such as fans, pumps, etc shall not be left in storage for long periods without due care being undertaken to obviate physical damage due to environmental conditions.

7 Where more than one similar item is constructed, all items of equipment shall be interchangeable and, to ensure this, site built multiple assemblies shall not be permitted.

8 Factory built assemblies shall be constructed to properly prepared drawings, fully describing the method of construction so that items built by different persons shall be identical within the tolerances allowed. This shall include the installation of interconnecting wire and cables, as appropriate. All replacement components and all equipment made up of multiple parts shall be fully interchangeable.

9 Particular attention shall be paid to the neatness (alignment and close fitting) of plant, cables, conduit and/or pipes runs as appropriate.

10 All components shall be identified using engraved labels by a reference number to agree with that shown on the drawings. Where components are readily removable and interchangeable such markings shall be on the mounting plate or other suitable permanent item. Alternatively, a chart showing the location of removable and interchangeable components shall be permanently fixed to the cover or side of the enclosure, as long as it remains easily readable.

11 All wiring within units shall be neatly looped and secured with insulated cable clips or shall be run in plastic slotted trunking with capping. Where multicore or multi-pair cables are terminated into equipment on site the cables shall be properly glanded off, any armouring properly earthed and the cable sheath carefully stripped back to manufacturer's instructions, and/or the minimum necessary to effect satisfactory termination. Each core shall be identified by cable markers agreeing with the number on the terminal or drawings, and sufficient slack shall be provided in the form of a loop to leave enough spare cable to enable any broken end into the terminal to be remade at a later date.

12 Sheet metal work shall be carried out in such a manner as to prevent any distortion of the finished article, either by heat from welding or by cutting of the metal sheets. All holes in panels shall be accurately cut

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to size with clean edges free from all burrs and sharp edges. Bonded and other panel finishes shall be protected from damage during fabrication, transport and erection. Any damage to the protective finishes shall be reinstated immediately by an approved method. Soldering of components shall be carried out in such a manner as to prevent damage to either the component or the insulation of the wiring. Only resin-cored solder shall be used and the use of additional flux shall not be permitted.

13 All nuts and bolts used to secure components shall incorporate a locking device of the correct size and shall be tightened by a socket or ring spanner. Alternatively, other vibration proof fixings may be used where more convenient. Self tapping screws shall not be used where these would need to be removed for routine maintenance. Screw heads (except those for labels) shall not appear in the faces of instruments and/or control panels.

14 Where trunking, ducts, pipes and conduit, cables, etc pass through fire walls then fire penetration barriers or proprietary transit system shall be installed to maintain the fire integrity of the wall, and gas and water-tight seals shall be provided.

15 Ease of future maintenance of equipment, by others, shall be borne in mind during design, assembly and site erection. All components shall be installed in assemblies so that they are easily accessible for replacement purposes and so that terminal screws are also easily accessible. Where assemblies are then mounted in housings the assembly shall be easily replaceable and accessible.

16 Designs adopted should be as simple as practicable using proven methods and materials, unless it can be shown that significant operational advantages will be ensured. Due regard shall be given in designs to minimise any traffic delays during future maintenance.

17 Preference, in design, shall be given to the provision of automatic equipment where it can be shown that operational costs will be reduced.

18 Due regard shall be given to aesthetics where this is relevant, together with protection against harmful effects to the environment.

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7004. STANDARDISATION

1 For ease of maintenance and stocking of spares, it is essential that the minimum number of different components of a similar type be provided. All components or assemblies deemed to be identical shall be fully interchangeable, in accordance with Clause 7003.

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7005. SPECIAL TOOLS

1 As far as possible, the equipment shall be designed so that maintenance can be accomplished using conventional standard tools. However, where access by unauthorised personnel could give rise to danger, eg electrical shock hazard, then access shall be via a special tool or key.

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7006. RADIO INTERFERENCE SUPPRESSION

1 All electrical and electronic apparatus, including such items as thyristor controls, sensors, contactors, starters, etc, shall be fitted with means for suppressing the radio interference frequencies caused and shall be immune to interference fields.

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7007. FIRE SAFETY ENGINEERING

1 The design and arrangement of all plant, apparatus and connection wiring shall be such that the risk of fire, sustained combustion and any damage resulting from fire is minimised. This shall also take into consideration welding, cutting and other processes encountered as part of the installation process.

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7008. SAFETY PRECAUTIONS (GUARDS, GUARD RAILS AND FALLING OBJECTS)

1 Fixed or removable guarding shall be fitted to all moving parts of plant, whether specifically stated in the contract documentation or not. All guard rails, plant and equipment shall comply with the relevant regulations made under the Health and Safety at Work Act and Factories Act 1974.

2 Fixed or removable guard rails shall be fitted to all access routes where there is a potential for an operative to fall more than 2m, whether specifically stated in the contract documentation or not.

3 Due regard shall be taken as far as is reasonably practicable, to prevent loose objects falling from heights onto construction personnel or the travelling public at any time.

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7009. IDENTIFICATION OF SERVICES AND UNITS

1 Engraved labels, adequately describing the function of the unit to which it is attached shall be secured whenever practicable by screws to the outside of each item. Equipment shall be fitted with labels giving reference numbers in a similar manner. Labels secured by adhesive are not acceptable.

2 Manufacturer's nameplates and load plates shall be of an approved design and shall only be fixed in approved positions.

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7010. DESIGN LIFE

1 A minimum design life of 25 years, unless stated otherwise in the Specification, is required for all plant and associated fixings and non-consumable components. This design life shall assume continuous operation from handover. The exceptions to this requirement in non-rotating plant and communications/software dependent equipment.

2 To achieve this design life high quality plant, together with a recommended maintenance regime for the particular installation, shall be provided.

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7011. DURABILITY AND MATERIALS

1 Protective systems for steelwork and associated fixings and components appropriate to the location, to be installed and suitable for the expected life of components, shall be selected in accordance with the relevant Standards, and the Specification for Highway Works, Series 1900, to enable the required design life stated in Clause 7010 to be achieved.

2 Electro-potential differences between dissimilar metals, particularly with respect to luminaires in tunnels and their support components, can lead to corrosion. / Therefore, insulating spacers between dissimilar metals, likely to have high potential differences, shall be provided. Where conductivity is required to be retained then proprietary mixed metal joints shall be used.

3 The above shall be taken into account in the selection of appropriately durable materials, in particular whether materials such as stainless steel, or non-metallic products, need to be used.

4 Other factors to be taken into consideration in selection of materials are mechanical fatigue, surface abrasion and stress corrosion. Any coatings on non-metallic materials used within tunnels shall combine corrosion resistance with a performance under fire conditions, which will produce zero halogen and low smoke emissions.

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7012. MAINTENANCE AND SPARES

1 All plant shall be designed to facilitate ease of inspection in safe conditions, maintenance and replacement, including consumable components, with the minimum of disruption to other services.

2 Wherever feasible, items of plant shall be standardised types with sizes and ratings for the particular systems forming the mechanical and electrical services.

3 Manufacturer's recommended spares shall be provided, as detailed in the contract specific documentation. Wherever feasible, assurance shall be obtained that the spares will be available for a minimum of 10 years from handover.

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7013. PARTICULAR ENVIRONMENTAL CONDITIONS IN TUNNELS

1 Plant and equipment located within tunnels will need to withstand the aggressive environmental conditions prevalent. These may be moisture from high pressure cleansing jets and brushes, detergents, salts, salt spray, condensation, vehicle spillages, fires, sulphur pollutants, dust, grit, exhaust fumes (hydrocarbons, acids, particulates and organics), etc in the air. These conditions will be further aggravated by the air movement caused by ventilation fans and vehicles which will accelerate the corrosion of most metals.

2 All plant and materials within tunnels shall be designed and installed to satisfactorily operate under the following conditions of temperature and humidity:-

i) Ambient Temperature -15°C to +35°C

ii) Humidity 0% to 100% RH

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7014. DOCUMENTATION

General

1 Operating and Maintenance manuals are required and shall be written by specialist technical authors and be specific to the contract. Written material that does not contribute to the understanding of the design, operation and maintenance of the specified plant or equipment shall be excluded from the manuals. Any ambiguous statements shall also be excluded. The document shall be complete, comprehensive and coordinated with a uniform style and presentation.

2 All manuals shall be of a standard international page size and presented in a loose leaf form to allow for any amendment pages complete with dates of issue. All paper used shall be of good heavyweight quality. The main body of the manual shall be compiled in a logical order and correspond to the contents, any amendments and tables. Nomenclature or references to any item of plant or equipment, diagrams, figure numbers or units shall be consistent throughout the text. Diagrams, drawings, sketches and actual photographs shall be added, where necessary, in order to clarify the text. Precautions and warnings for the safety of life and plant shall be explicit. Wherever specified and if practicable manuals shall be provided in an approved software package.

3 Manufacturer's data and handbooks, for individual items of plant that are a sub-component of the overall system, may also be included, but only where relevant.

4 Manufacturer's data for sub-assemblies may also be used in its existing published form, providing it fully meets the intent of this Specification, is integrated in the description of the plant or equipment and is indexed accordingly within the general index of the manuals. The information provided by manufacturers shall be complete for all plant and equipment, both main and ancillary.

5 Manufacturer's plant or equipment handbooks for sub-assemblies shall contain all necessary operating and maintenance instructions as well as a breakdown of parts in diagrammatic form together with a priced, recommended spares list.

6 Where a sub-assembly item is of such a nature that local repair at the tunnel or bridge site could not be employed and the item is usually returned to the factory as a unit for overhaul, the specific information concerning its repair and transport shall also be provided.

Format of Operating and Maintenance Manuals

7 The operating and maintenance manuals shall be in a loose leaf format and divided into sections specific to the completed works. The first section shall contain:

i) Title page, a comprehensive reference to other volumes, table of contents, amendment sheets, general description of the works, flow charts, plant, equipment and controls, start-up, shut down and emergency procedures, description of plant operations, etc.

8 The remaining sections shall be for specific parts of the works and shall include, but not be limited to, the following:

i) Title page, table of contents, isometric drawings and photographs.

ii) A schedule of all items of plant and equipment supplied under the Contract (including 'free issue' equipment).

iii) A written description of each component, and its relationship to other components. This shall include performance sheets and graphs showing capacities, efficiencies, loadings, etc. Performance information shall be presented as concisely and clearly as possible and contain only data pertaining to equipment actually installed. Marked up catalogue or catalogue cuts alone will not satisfy this requirement.

iv) The location of all plant, equipment, fittings, components, controls, etc should be shown on general arrangement, location and schematic drawings giving exact location, function, description and identification number.

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v) Operation: comprising general description, specified performance, starting instructions, operating instructions, shut down instructions, operation under component failure, fault diagnosis, fault repair and operation under non-automatic and emergency situations. The sequence of operation shall be cross-referenced to the relevant record drawing manufacturer's data, etc.

vi) Comprehensive records of all mechanical and electrical tests, reports and certificates.

vii) Parts catalogue and/or catalogue cuts of equipment installed showing applications maintenance information. Routine maintenance instructions - frequency, special tools, etc. Replacement part drawings and lists, instructions for ordering replacement parts with names and address of local suppliers and manufacturer's representatives, together with copies of all associated publications.

viii) Planned maintenance data sheets shall be provided in an agreed format.

9 A draft of the maintenance and operating manual shall be submitted for comment. Any comments made will be incorporated in the final draft, and sufficient time will be allowed (not less than 14 days) for review of the first draft.

10 A separate operators' manual for use by the emergency services, ie Police, Fire, Ambulance written in non-technical language shall be provided which covers comprehensively agreed emergency operation/ procedures.

Change and Configuration Control

11 A formal method of change control and communications shall be employed during the works. All changes shall be subject to agreement before implementation of the change.

12 Configuration control of any software shall be maintained throughout the life time of the plant and equipment. This is to include the design, development and commissioning stages of the software life cycle. The arising documentation shall be handed over as part of the handover process in both paper and agreed computer readable formats.

Design Documentation Package

13 A complete documentation package shall be provided for the Works Contract. In respect of the detailed engineering design the following shall be prepared:

i) design manuals

ii) quality assurance and control manuals

iii) process and instrument drawings (P&IDs). Also on 35mm card reader system if specified.

iv) instrument location and cable/pipe routing layout

v) hook-up drawings (outline schematics)

vi) panel drawings

vii) material take-off (material schedules)

viii) cable schedules

ix) cable termination details

x) equipment lists, including:

a) general arrangements (GA) drawings

b) instrument loop diagrams

c) instrument lists

d) I/O schedules

xi) installation details (supports, transit frames, special items, etc)

xii) power supply and earthing diagrams

xiii) instrument data sheets and equipment specifications;

xiv) test specifications and records

xv) software documentation for PLC and SCADA

xvi) system log

xvii) system defects logs

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Panel Documentation

14 Full and detailed panel drawings shall be provided for the following:

i) front of panel arrangement

ii) back of panel arrangement

iii) instrument loop diagrams

iv) panel piping layout

v) power distribution diagram

vi) panel wiring diagram

PLC and SCADA Software Documentation

15 Full and detailed documentation supporting each phase of the software development shall be supplied. Documentation shall include as a minimum the following:

i) functional specification

ii) software system specification

iii) software system design description with logic diagrams

iv) systems acceptance test schedules and results

v) configuration control

vi) installation and operation manuals

vii) user manuals

16 Copies for future use by the user of all documentation shall be archived and information relating to the software development for a minimum period of 5 years after the expiration of the warranty.

PLC and SCADA Documentation

17 In addition to the standard documentation supplied with the PLC and SCADA packages the following documentation shall be supplied:

i) interface and I/O schedules

ii) termination schedules

iii) configuration and layout drawings

iv) internal resource allocation schedules where used (ie flags, registers, imaginary points, etc)

v) software documentation and listings

18 Installation, operating and maintenance and user manuals shall also be compiled which shall be based on the equipment Manufacturer's own documentation. These manuals shall also provide evidence that the equipment supplied is as specified and that it is fit for its purpose. These manuals shall include, but not be limited to, the following:

i) Health and safety measures to operate the equipment and associated processes safely

ii) COSHH notices

iii) Training

iv) Calibration method procedures and original calibration data

v) Instrument data sheets and Specifications

vi) Suppliers' acknowledgement of purchase order (prices may be deleted)

vii) Copies of certification, eg hazardous area use

viii) Pre-installation check sheets

ix) Loop test sheets

x) Acceptance certificate

xi) Calibration test certificates

xii) As-installed documentation

xiii) Recommended spare parts for 25 year operation

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7015. TRAINING

1 Training for nominated personnel, which covers all aspects of operation and maintenance of the specified plant and works, shall be provided as part of the mechanical and electrical works. The numbers of personnel shall be as detailed in the contract specific documentation.

2 Training shall include for procedures for testing and routine inspection of all items of equipment within the scope of the Works. Training shall also be given in fault diagnosis and assessing the extent of any remedial work required. Reference and training manuals shall be provided for staff who attend each training course.

3 Wherever possible, training shall be provided at the Employer's Works and shall include 'hands on' experience of equipment and software identical as far as is practicable to that of the installed system.

4 Training shall be programmed to be complete prior to commissioning of the system on site so that tunnel and bridge operation and maintenance staff are fully conversant with the system's operation.

5 The Employer shall provide operators during the commissioning period, who will be used to train the nominated personnel on the plant and its operation in readiness for handover of the system and plant.

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7016. VALUE ENGINEERING

1 Before final selection of types of plant and equipment, the potential benefits of alternative design solutions shall be fully evaluated. The evaluations shall include a full consideration of capital, life cycle operating costs and fitness for purpose for each element, mechanical and electrical plant and equipment as well as the whole.

2 In view of the importance of high quality requirements relating to mechanical and electrical plant and equipment, and future reliability, running and maintenance costs, these aspects shall be recognised in the evaluation to ensure optimum investment decisions, without compromise to safety, environmental, energy, operational and maintenance requirements.

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7017. ENQUIRIES

Approval of this document for publication is given by the undersigned:

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The Deputy Chief Engineer The Scottish Office Development Department National Roads Directorate Victoria Quay Edinburgh EH6 6QQ	N B MACKENZIE Deputy Chief Engineer

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All technical enquiries or comments on this document should be sent in writing as appropriate to the above.

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A7000. APPENDICES

The following table lists the Statutory Acts and Regulations applicable to the Specifications

STATUTORY ACTS AND REGULATIONS
Health and Safety at Work Act, 1974
The Factories Act, 1961
Public Health Acts, 1936, 1961
Offices, Shops and Railway Premises Acts, 1974
Control of Pollution Act, 1974
Fire Precautions Act, 1971
The Clean Air Act, 1993
Electrical Supply Regulations, 1988
Building Regulations
Electricity at Work Regulations, 1989
Gas Safety Regulations
The Traffic Signs Regulations and General Directions, 1994

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VOLUME 5 CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITIES

SECTION 7 MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

PART 2

SERIES 7100

MECHANICAL, ELECTRICAL AND COMMUNICATIONS WORK FOR ROAD TUNNELS

Contents

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7100. INTRODUCTION

1 This series of the Specification covers the mechanical and electrical performance requirements for the plant associated with road tunnels in the United Kingdom and is categorised under the following headings.

i) High Voltage Switchgear

ii) Distribution Transformers

iii) Low Voltage Switchgear

iv) HV and LV Cabling and Distribution

v) Standby Generators

vi) Uninterruptible Power Supply (UPS) systems

vii) Tunnel Lighting

viii) Tunnel Ventilation

ix) Fire Safety Engineering

x) Service Buildings

xi) Drainage and Pumping

xii) Communications

xiii) Closed Circuit Television

xiv) Traffic Control

xv) Traffic Monitoring

xvi) Plant Monitoring and Control

2 These Performance Specifications are intended to indicate the minimum standards for mechanical, electrical and communication services for all road tunnels, underpasses and their associated facilities. They shall be used in conjunction with a contract specific documentation which shall define the design and extent of plant and equipment for the proposed application.

3 A list of the Standards and Codes of Practice to which the equipment shall comply is included in the Appendices at the end of each section of the Specification.

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7101. HIGH VOLTAGE SWITCHGEAR

General

1 High Voltage (HV) switchgear shall be suitable for operation on 3 phase 3 wire 50Hz systems, Switchgear for use on 11kV networks shall be insulated for 12kV rated voltage operation and tested to an impulse voltage withstand level of 75/95kV and stated in the contract specific documentation.

2 HV switchgear may take the form of indoor continuous cubicle switchboards or indoor/outdoor ring main type switchgear. HV switchgear shall be metal clad, totally enclosed with separate compartments for the busbars, cable box, fixed isolating contacts, current transformers, voltage transformers and instrumentation panels.

3 Complete protection shall be provided against approach to live parts or contact with internal wiring parts under all circumstances of normal service and maintenance. A minimum degree of protection IP31 shall apply to indoor enclosures. All ventilation openings and vent outlets shall be screened to prevent ingress of vermin.

4 HV switchgear in the form of cubicle switchboards shall be capable of withstanding the designed symmetrical three phase short circuit ratings for the times specified.

5 Each current carrying component of the equipment supplied shall be capable of continuous operation at the specified ratings without exceeding the maximum temperatures stated in the appropriate standards specified without assistance from any forced cooled ventilation or air conditioning plant.

6 Switchboards shall be provided with cable boxes suitable for the cable types specified. Phasing of all primary terminals shall be positively marked by an approved method on the main structure and not on removable covers.

7 The complete switchboard shall have an earth bar along its full length to which shall be bonded circuit breaker frames and other extraneous metalwork.

8 The short circuit rating of complete switchboards shall be certified by ASTA or other approved European testing authority.

9 The list of the Standards and Codes or Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Busbars and Connections

10 Busbars and connections shall be continuously rated for the site conditions and currents stated in the contract specific documentation. Busbar minimum current ratings for switchboards on 11kV systems shall be 630A. Busbars and current carrying parts shall be manufactured from hard drawn high conductivity copper.

11 The peak asymmetric fault current rating of the busbars and connections shall be equal to, or greater than, the make rating of the circuit breakers with a minimum 12.5kA rating for 11kV systems. Insulated busbars shall be provided. Taping is not acceptable. Any insulating materials used shall be capable of withstanding the heating effects of the rated short time withstand current without permanent deformation or deterioration and for 11kV systems shall have a minimum impulse voltage withstand level of 75kV.

Circuit Breakers

12 Circuit breakers with a minimum fault level of 250MVA and for indoor switchgear applications shall be vacuum or sulphurhexafluoride SF6 units. The circuit breaker assembly shall be fully interlocked with vertical or horizontal isolation. The circuit breaker assembly shall be horizontal withdrawable or withdrawable truck type. Circuit breakers shall have the current rating as specified and the short-circuit rating for the switchboard as stated in the contract specific documentation.

13 SF6 circuit breakers shall be provided with a gas filling and sampling point together with an associated two stage alarm to give indication of low pressure and to trip the circuit breaker when gas pressure falls to pre-determined level.

14 The moving portion of each horizontally withdrawable circuit-breaker unit shall consist of a three-pole circuit-breaker with operating mechanism, primary and secondary disconnecting devices, auxiliary switches, position indicators, eg ‘isolated’‘on’ or ‘earthed’ and the

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necessary control wiring all mounted on a substantial steel framework. This framework and all metal parts of the moving portion apart from current carrying parts, shall be solidly earthed via the fixed portion. Means of registration shall be provided so that circuit-breakers may be readily placed and secured in the correct position in the fixed portion.

15 Circuit-breakers of the same current and voltage rating shall be fully interchangeable one with another. Means shall be provided to prevent circuit-breakers from being placed into fixed housings of different and other contacts.

Isolating Devices and Shutters

16 All horizontally withdrawable circuit-breakers shall be connected to their associated busbars and cables through isolating devices which shall be of the off-load type but suitable for operation whilst the busbars or feeder circuits are live.

17 The design shall be such that it is impossible for the isolating devices to be opened by forces due to current in the primary circuit and shall be interlocked with the circuit-breaker so that it is impossible to make or break current with the isolating device. Attempted isolation shall not trip the circuit-breaker.

18 When isolation is effected by withdrawal of the circuit-breaker provision shall be made for positively locating the circuit-breaker in the service, isolated positions. Stops shall be provided to prevent over-travel and each position shall be clearly indicated.

19 Isolating devices shall incorporate self-aligning contacts, the fixed contacts of which shall be such that access can readily be obtained for maintenance purposes.

20 Metal shutters shall be provided to completely shroud fixed isolating contacts of the circuit-breaker busbar and feeder circuits. These shutters shall be opened and closed automatically by the movement of the circuit-breaker carriage and shall prevent access to fixed isolating contacts when the circuit-breaker is withdrawn.

21 The shutters for fixed isolating contacts connected to busbars and cables shall have independent operating mechanisms. All shutters shall have painted labels indicating whether they are busbar or feeder shutters, those for the busbars shall be red, and those for the circuit shall be yellow and labelled.

22 Self-aligning plug and socket isolating devices of an approved design shall be provided for all auxiliary circuits. The position of these devices shall be such that individual circuits on different units in the same relative physical positions.

Operating Mechanisms

23 The circuit-breakers mechanism shall be either motor charged, stored energy spring, solenoid or independent manual. The circuit-breaker shall be capable of closing fully and latching against its rated making current.

24 Spring operated mechanism shall have the following additional measures:

i) If the circuit-breaker is opened and the springs charged the circuit-breaker can be closed and then tripped.

ii) If the circuit-breaker is closed and the springs charged there shall be sufficient energy to trip, close and then trip the circuit-breaker.

iii) Positive mechanical indication and an auxiliary switch for remote electrical indication shall be provided to indicate the state of the spring.

iv) Motor charged mechanism shall be provided with means for charging the springs by hand, and also a shrouded push button for releasing the springs. An electrical release coil shall also be provided.

v) Under normal operation, motor recharging of the operating spring shall commence immediately and automatically upon completion of each circuit-breaker closing operation. The time required for spring recharging shall not exceed 30 seconds.

vi) It shall not be possible to close a circuit-breaker, fitted with a motor charged closing mechanism, whilst the spring is being charged. It shall be necessary for the spring to be fully charged and the associated charging mechanism fully prepared for closing before it can be released to close the circuit-breaker.

25 All circuit breaker operating mechanisms shall be fitted with an electrical shunt trip release coil and in addition a mechanical hand tripping device.

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26 The electrical tripping and closing devices shall operate satisfactorily over the ambient temperature range when the voltage at their terminals is any value within the voltage range stipulated.

27 All operating coils for use on the DC supply shall be connected so that failure of insulation to earth does not cause the coil to become energised.

28 Tripping and closing circuits shall be provided with a fuse in each pole on each unit and shall be independent of each other and all other circuits.

29 Approved, positively driven mechanically operated indicating devices shall be provided to indicate whether a circuit-breaker is in the open or closed service, or isolated position.

30 Locking facilities with padlocks shall be provided so that the circuit-breaker can be prevented from being closed when it is open and from being manually tripped when it is closed. These facilities shall not require the fitting of any loose components prior to the insertion of the single padlock required. It shall not be possible, without the aid of tools, to gain access to the tripping toggle or any part of the mechanism which would permit defeat of the locking of the manual trip. It shall not be possible to mechanically lock the trip mechanism so as to render inoperative the electrical tripping.

Interlocking Gear

31 Interlocks shall be provided to safeguard personnel and prevent maloperation of the equipment.

32 Interlocks shall be of the mechanical or key operated type and shall be provided to prevent the following operations:

i) A moving portion from being withdrawn from or inserted into the isolating contacts when the circuit-breaker is closed.

ii) The closing of the circuit-breaker unless the movable portion is correctly plugged in or isolated from the equipment.

33 When key interlocking is employed, any attempt to remove the trapped key shall not cause closing or opening of the associated equipment.

34 Where a circuit-breaker or other switchgear is fitted with means for mechanical or electrical operation, interlocks shall be provided so that it is impossible for the electrical and mechanical devices to operate simultaneously.

Locking Facilities

35 In addition to any requirements already specified the following padlocking facilities shall also be included:

i) Selector mechanism on circuit-breaker - isolated and service positions.

ii) Safety shutters on primary contact isolating orifices in closed position.

36 All cubicle access doors, other than those which are interlocked with a switching device shall be provided with an integral type locking facility.

Testing Facilities

37 All circuit-breaker units shall be provided with facilities to enable applied high voltage tests to be carried out.

38 Provision shall also be made for temporarily completing the auxiliary circuits when the circuit-breaker is isolated and withdrawn to enable the functioning of the circuit-breaker to be tested.

39 When current transformers and protective relays are fitted, facilities shall be provided for primary and secondary injection tests to be carried out. These facilities shall be such that wires and connections need not be disconnected for the tests to be carried out.

Control and Indication

40 Approved, positively driven mechanical indicating devices shall be provided on all equipment to indicate whether the primary equipment is in the open or closed position. Care shall be exercised in the design and fitting of these indicators to ensure that the indicating device and associated apparatus does not interfere with the correct operation of the circuit-breaker or isolator.

41 Each circuit-breaker shall be provided with the necessary auxiliary contacts and internal wiring to facilitate remote indication to control rooms or remote indication system if filled.

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42 Automatic/manual control shall be provided for complete switchboards together with status indication of automatic manual and supply failure.

43 Indicating lamps and lampholders shall where specified be arranged so that replacement of lamps and cleaning of reflectors and glasses employed can be readily effected. Lamp test facilities shall be provided to reduce heating and fouling of the panels, lamps which are continuously energised shall have the minimum consumption consistent with good visibility in a brightly lit room.

Auxiliary Switches

44 Approved, positively driven auxiliary switches shall be provided on all circuit-breakers for indication, control and interlocking.

45 Auxiliary switches shall have a positive wiping action when closing and shall be mounted in an accessible position clear of operating mechanisms.

46 They shall be designed to make, break and carry, without undue heating, the current of their associated circuit or a current of three amperes DC, whichever is the higher.

47 Not less than four spare auxiliary switches shall be provided with each circuit-breaker. All auxiliary switches shall be wired up via secondary disconnecting devices to a terminal board on the front of the fixed portion, arranged in the same sequence for each individual unit of the same type.

Anti-Condensation Heaters

48 Anti-condensation heaters of an approved type controlled by fixed preset thermostats shall be provided inside each cubicle. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. Unless otherwise specified the heaters shall be controlled from a common double-pole miniature circuit-breaker, with a lamp to indicate ‘cubicle heaters on’. The circuit-breaker and indicating lamp shall be mounted externally at one end of the switchboard. The heaters shall operate from a single phase AC supply.

Current Transformers

49 Current transformers of the class and accuracy suitable for the application shall be provided for the operation of protective gear instruments and/or metering equipment.

50 Current transformers shall have an output rating adequate to cater for all the burden connected to them. They shall have sufficient rating, terminal voltage and accuracy class for the satisfactory operation of their associated equipment.

51 The primary windings shall not, without special approval, have a short time current rating less than that specified for the associated circuit-breaker. Windings shall be capable of carrying the rated primary current for a period of one minute with the secondary winding open circuited.

52 Multi-ratio current transformers should be tapped on the secondary side and not on the primary side unless otherwise approved.

53 The current transformer particulars shall be given on an accessible plate mounted external to the current transformer.

54 All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi-ratio secondary windings are required a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio. The connections and ratios in use shall be shown on all diagrams of connections.

55 Current transformer secondary circuits shall be complete in themselves, and shall be earthed at one point only, through links situated in an accessible position. Each separate circuit shall be earthed through a separate link, suitably labelled. The links shall be of the bolted type and have provision for attaching test leads.

56 The earth links for protective and instrument current transformer secondary circuits shall be mounted inside the relay panels. Earth links for metering current transformer secondary circuits shall be mounted at the switchgear.

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57 Current transformers shall be air-insulated and be installed on the side of the switching device electrically remote from the busbar. They shall be mounted in the fixed portion of the switchgear with a method of securing in position such that undue mechanical pressure cannot be exerted on the transformer windings.

58 Current transformers shall be mounted on removable links when connected to busbar systems for ease of future replacement.

59 Shorting terminals shall be provided for the secondary windings for all current transformers.

60 Magnetisation curves of each type of current transformer shall be submitted for approval.

Voltage Transformers

61 Voltage transformers shall be cast resin insulated and housed within a metal clad housing. When in service, a circuit connected voltage transformer shall plug into the disconnectable cable adaptors described. It shall be possible to fully isolate the voltage transformer within the metal clad housing. In the isolated position it shall be possible to remove the HV fuses for inspection or replacement. Voltage transformers shall have the appropriate class and burden to suit the specified application.

Protection, Relays and Instruments

62 HV unit protection shall be provided for system interconnectors and HV circuit protection for bus section units, electricity utility supply units and transformer feeder units. The minimum protection requirements shall be overcurrent and earth fault and restricted earth fault for transformers above 1000 KVA.

63 Protection relays shall provide discrimination between fault and healthy circuits with time graded tripping of circuit breakers as applicable.

64 Relays may be static or electro-mechanical, flush or surface mounted and shall be fitted in draw out cases to facilitate inspection and testing without disturbing wiring and connections. Current transformer short circuiting devices to ensure that current transformers are not left open circuit when the relay is withdrawn shall be provided.

65 Where under voltage relays are specified they shall be voltage transformer operated with settings adjustable to close contacts at between 60% and 100% of nominal voltage on a rising voltage. The relays shall be time delayed with adjustable setting between 0.2 and 1.0 second.

66 Over voltage relays shall be voltage transformer operated with close contacts at between 100% and 150% of nominal voltage on a rising voltage and resetting at 10% of nominal voltage below the set value on falling voltage. The relay shall be capable of being time delayed with adjustable settings between 0.2 and 1.0 second.

67 Over current and earth fault protection shall be provided by current transformer operated trip coils.

68 The protection shall operate for phase faults and earth faults within the protected zone, and remain stable for through faults equal to the maximum rupturing capacities of the associated switchgear.

69 Phase and earth fault sensitivities should be not more than 120% and 40% respectively of the nominal rated load of the circuit.

70 Trip circuit supervision relays shall be provided, fitted with alarm contacts and arranged to supervise continuously the trip circuit with the circuit breaker either open or closed. Series resistor(s) shall be incorporated in each circuit such that short circuit of the relay coil shall not result in trip coil operation.

71 Instruments for displaying the voltage, current, frequency or power factor may be digital or dial type.

72 Non-digital instruments shall be moving iron pivotless type having 100 mm minimum scale. Where only one voltmeter is provided for a 3 phase circuit or voltmeter a switch to allow readings of all phases shall be provided.

73 The current passed through an ammeter shall not exceed 10 amps inductive or resistive. Above this rating current transformers must be used. Blade terminals are preferred to accept insulated plug on connectors or recessed screwed connections to prevent inadvertent contact. Ammeters for inductive loads such as motors shall have an extended compressed scale greater than the value of the starting current.

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74 Protection relays shall be fitted in dust proof draw out type cases and shall have current transformer short circuiting devices.

Closing and Tripping Supplies

75 Self contained closing and tripping units comprising sealed lead acid or alkaline type batteries, trickle/boost chargers and distribution panels shall be provided suitable to maintain the specified HV switchboard duties.

76 The batteries shall be of a capacity to maintain the standing loads for a period of 24 hours at the end of which time two tripping and two closing functions as appropriate on each switching device fed by the unit shall be possible.

77 The necessary circuit protection equipment comprising fully protected type fuses or miniature circuit-breakers of suitable rating shall be included.

78 The earthed pole of earthed batteries shall be linked, instead of fused, by means of copper link.

79 All fuses and links, circuit-breakers, switches and lamps shall be front-of-panel mounted.

80 Outgoing distribution cables shall be connected directly to the relevant fuse and/or link, or circuit-breaker.

81 Cabling and wiring terminations shall be shrouded to avoid accidental short-circuit or earthing of the battery.

82 Each battery charger unit shall be provided with local indication of mains healthy, low battery volts and charge fail conditions. Volt free contacts hall be fitted to permit remote signalling.

Ring Main Switchgear

83 Ring main switchgear comprising fault making load breaking ring switches and automatic fuse switches or circuit breaker tee-off switches may comprise:

i) extensible or non-extensible oil switches and oil fuse switches having fuses in air or oil.

ii) extensible or non-extensible SF_6 switches and SF_6 circuit breakers.

84 The units shall be of totally enclosed weatherproof metal clad floor mounting design. A minimum IP44 degree of protection shall be provided.

85 Cable boxes shall be suitable for the cable types specified. Phasing of all primary terminals shall be positively marked by an approved method on the main structure and not on removable covers.

86 Mechanical interlocks shall be provided to safeguard personnel and to prevent maloperation of the equipment. In addition means shall be provided to prevent a switch from being operated to the 'Off' position within 3 seconds after being operated to the 'On' or 'Earth' position.

87 Each fuse link shall be clearly marked with its service voltage, breaking capacity and rated current. Fuse links of all current ratings shall be inter-changeable.

88 Where indicated, a weatherproof earth fault indicator, comprising a split core current transformer connected to an indicating relay, shall be fitted to ring switches.

89 Ring main switchgear shall include maintenance earthing facilities and test plugs.

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A7101. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:-

	HV SWITCHGEAR
BS EN 60269	Cartridge fuses tor voltages up to and including 1000V a.c. and 1500V d.c.
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS 142	Electrical protection relays
BS 159	Specification for high voltage busbars and busbar connections
BS 2692	Fuses for voltages exceeding 1000V a.c.
BS 5227	Specification tor A.C. metal-enclosed switchgear and control gear for rated voltages above I kV and up to and including 52 kV
BS 5311	Specification for high voltage alternating current circuit breakers
BS 5463: Part I	High-voltage switches for rated voltages above 1kV and less than 52kV
BS 5685	Electricity meters
BS 5992	Electrical relays
BS 6581	Specification for common requirements tor high-voltage switchgear and control gear standards
BS 7625	Specification for voltage transformers
BS 7626	Specification tor current transformers

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Sample Appendix : 7101/1 : H.V. Switchgear

The Contractor shall insert below details of the equipment proposed.

Item No.	Description	Unit	Detail
I	Manutacturer of switchboard		
2	Manut;acturer of circuit breaker		
3	Makes designation of circuit breaker		
4	Nominal service voltage		
5	Type of circuit breaker		
6	Busbars r ated current	A	
7	Frequency	Hz	
8	Rated symmetrical short circuit kA breaking capacity	kA rms	
9	Asymmetrical breaking capacity	kA peak	
10	Making capacity	kA rms	
11	Short time current (3 seconds)		
12	Method of system neutral earthing		
13	Method of closing		
14	Method of tripping		
15	Power required at normal voltage for shunt trip coil	W	
16	Type of operating mechanism		
17	Motor charged spring operated mechanisms Normal voltage of spring release coil Power required at normal voltage to release springs Rating of charging motor Time required to charge spring at normal voltage	 V W W Secs	
18	Solenoid operated mechanisms Normal voltage of closing coil Power required at normal voltage for closing coil	 V W	

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Item No.	Description	Unit	Detail
19	Current transformers for unit, circuit and instrumentation Type and class Voltampere		
20	Current transformers tor metering Type and class Voltampere		
21	Voltage transformers Type Rated output per phase Rated secondary voltage	 VA V	
22	Unit protection Type Maker Type of relay Range of fault setting Range of time delay	 % Secs	
23	Earth fault protection Maker Type of relay Range of fault settings Range of time delay	 % Secs	
24	Overcurrent protection Maker Type of 3 pole relay Range of current setting % of full load current a) Overcurrent b) Earth fault		

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Sample Appendix : 7101/2 : Ring Main Switchgear

The Contractor shall insert below details of the equipment proposed.

Item No.	Description	Detail
I	Ring main unit Manufacturer Type CT Ratio (metering) Meter type Dimensions Base dimensions Weight of basic unit	
2	Ring switch Main switch normal current Main switch breaking current Main and earth switches making capacity Main and earth switches short time current (3 see)	
3	Fuse switch combination Fuse switch normal current Fuse switch prospective breaking capacity Fuse switch prospective making capacity Earth switch making capacity Earth switch short time current (3 see)	

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7102. DISTRIBUTION TRANSFORMERS

General

1 Distribution transformers shall have the ratings and no-load voltage ratios as specified and manufactured to the appropriate standards specified.

2 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Transformers

3 Distribution transformers shall be ground mounted oil or low flammability synthetic fluid immersed or flame resistant dry type resin cast, naturally air cooled (ONAN) and suitable for indoor or outdoor use. Liquid filled transformers may be free breathing with or without conservators or hermetically sealed.

4 The distribution transformer windings shall normally be connected in Delta-Star to vector group DYnII with the neutral point of the LV winding brought out. Where loads are unbalanced or in other unconventional situations other vector groups, eg DZ may be appropriate.

5 On the HV side full capacity tappings shall be provided for ± 2.5% and ± 5% adjustment. The tappings shall be made at the centre of the transformer HV windings and brought out to a suitable padlocked tapping switch and capable of being operated without the removal of the main cover.

6 The transformers shall be designed with particular attention to the suppression of harmonic voltages so as to eliminate wave form distortion and any possibility of high frequency disturbances, inductive effects, or circulating currents.

7 After 12 hours running at continuous rated output and 0.8pf the oil temperature shall not exceed 85°C measured by a thermometer in the oil at the top of the tank, and the winding temperature shall not exceed 95°C as measured by the increased resistance of the windings.

8 The transformer shall be capable of working at 125% of continuous rated output for 4 hours without causing danger or other adverse effects to the windings and core, and without exceeding the permissible limit of temperature rise.

9 The transformer cores and coils for oil or synthetic fluid transformers shall be contained in an all welded sheet steel tank which shall be provided with the following as applicable:

i) Rating plate

ii) Connection diagram plate

iii) Earthing terminal

iv) Oil level gauge

v) Lockable drain valve and plug

vi) Thermometer pocket

vii) Filling hole and plug

viii) Pressure relief valve

ix) Lifting and jacking lugs

x) Four plain rollers / holding down bolts

xi) Conservator

xii) Cooling radiators

xiii) Epoxy or paint finish or galvanised

xiv) Warning notices and labels

Protection

10 Transformers may be provided with the following as specified:

i) Winding temperature indicator with volt free contacts for remote alarms

ii) Liquid temperature indicator

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iii) Pressure relief device

iv) Pressure/vacuum gauge

v) Breathing device with wire gauze insert

vi) Explosion vent

vii) Double float gas operated mercury switch relay

Cable Boxes

11 Cable end boxes shall be provided for both the primary and secondary terminations and shall be capable of terminating cables or trunking in accordance with the specification. On the primary side, the box shall be suitable for the reception of three core cables and on the secondary side, the box shall be suitable for the reception of single core cables or busbar type trunking.

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A7102. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

DISTRIBUTION TRANSFORMERS	
BS 171	Power transformers
IEC 726	Dry type power transformers

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Sample Appendix : 7102/2 : Transformers

The Contractor shall insert below details of the proposals.

Item No:	Description	Detail
1	Type of transformer Oil/Dry/Synthetic	
2	Manufacturer of transformers	
3	Continuous maximum rating (C.M.R.) kVA	
4	Normal ratio of transformation kV	
5	Impedance voltage at 75°C and at normal ratio and C.M.R. %	
6	Phase connections: a) HV windings b) LV windings c) BS vector group reference number and symbol d) Whether links are required tor alternative BS vector group	
7	Total range of variation of transformation ratio: Increasing ratio plus % Decreasing ratio minus %	
8	Cable boxes or busbar trunking for line terminals a) HV b) LV	
9	Oil Conservator	
10	Location	
11	Winding temperature indicator	
12	Liquid temperature indicator	
13	Pressure relief device	
14	Pressure/vacuum gauge	
15	Breathing device	
16	Explosion vent	
17	Buckholz double float gas operated relay	
18	Efficiency of the transformer: no load % 50% load % full load %	

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7103 LOW VOLTAGE SWITCHGEAR

1 Low voltage switchgear shall be suitable for indoor operation on single or 3 phase, 2, 3 or 4 wire systems, as specified normally, at a frequency of 50 Hz.

2 LV switchgear shall take the form of indoor continuous cubicle switchboards or industrial floor/wall mounted units as specified. Industrial type switchboards shall be fixed to steel frames suitable for bolting to the wall/floor.

3 LV switchboards shall comply with all appropriate standards specified and be capable of withstanding the designed symmetrical three phase short circuit ratings for the times specified.

4 Each current carrying component of the equipment supplied shall be capable of continuous operation at the specified ratings without exceeding the maximum temperatures and humidities stated without assistance from any forced cooled ventilation or air conditioning plant.

5 The list of the Standards and Codes or Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

LV Cubicle Switchboards

6 Cubicle switchboards shall be freestanding modular units, bottom or top cable entry with the Association of Short Circuit Testing Authorities (ASTA) certified symmetrical fault withstand levels to a minimum 50KA for one second for main switchboards. The minimum form of internal separation for main switchboards shall be Form A Type 6 together with a minimum protection classification of IP31. Switchboards shall be manufactured, factory tested, and assembled by a specialist switchboard manufacturer.

7 Framework shall be constructed of folded steel angle of minimum 6mm thickness, doors and covers to sheet steel of 2.0mm minimum thickness, and all hinges shall be the concealed type and allow opening greater than 90°.

8 All steel shall be chemically cleaned and treated to prevent moisture and rust under the paint film. The steel work shall undergo a process of chemical spray degreasing, iron phosphating coating, automatic electro-static epoxy polyester film application and shall be cured in a high temperature control oven. Finish shall be as manufacturers standard or as otherwise specified. All front and rear panels shall be removable.

9 The installation of cables passing through busbar chambers to interconnect items of switchgear or distribution equipment will not be permitted.

10 Each connection for the secondary wiring shall terminate at an approved type of terminal block. The terminals and wiring shall both be identified by coded numbers. Test points to facilitate secondary injection testing of protective devices shall be provided.

11 All instruments and panel wiring shall be of a minimum size of 1.0mm² with standard conductors and 500/1000 volt black insulation. Where wiring is not enclosed in trunking or conduit it shall run in square and symmetrical lines and be fixed by means of purpose made insulated cable clips and shall be harnessed together using cable ties. Where subject to movement such as on hinged doors adequate slack shall be allowed to prevent fatigue. Cable clips shall be secured by screws or rivets. All instrument wiring shall have identification ferrules fitted to both ends marked with circuit numbers. Trip circuits shall have an additional ferrule coloured red and marked ‘Trip’. Each circuit number shall be suffixed with the panel identification letter.

12 All control, identification and instrumentation cables shall be terminated using crimp-on spade or flat-pin connectors as appropriate. No more than one conductor may be terminated at any terminal. Where more than one conductor is required at the same terminal then more than one terminal shall be used. The terminals shall be linked together.

13 All terminals carrying a voltage in excess of 25 volts RMS shall be shrouded to prevent accidental contact.

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14 Indicating lamps and lampholders shall where specified be arranged so that replacement of lamps and cleaning or reflectors and glasses employed can be readily effected. Lamp test facilities shall be provided. To reduce heating and fouling of the panels, lamps which are continuously energised shall have the minimum consumption consistent with good visibility of indications in a brightly lit room. Indicating lamps should have a minimum life of 8000 hours.

15 Incoming circuit switches and switches and fuse switches for outgoing circuits shall be flush mounted within the cubicle switchboards. Outgoing circuits shall be equipped with 25% spare ways of each outgoing device of the various ratings.

16 Current rating of the neutral bar shall be equivalent to phase bar rating and all busbars shall be manufactured from single section un-tinned copper bolted together with zinc plated high tensile steel bolts with captive nuts. Phase colour indications shall be fitted at either side of the joints and throughout the length of the busbars.

17 Busbars shall be capable of extension at each end of the switchboard.

18 A continuous copper earth bar of minimum dimensions 25mm x 3mm shall be provided throughout the entire length of the switchboard and shall be connected to the main earth terminal. The main earth bar, or a tee-off connection shall be located convenient to the cable gland plates to permit the earth bonding of all cable glands. For switchboards protected by a circuit breaker, the main earth bar and tee-off connection shall be not smaller than 300sq.mm and 160sq.mm copper respectively. All non-current carrying metallic components shall be permanently connected to earth. Metallic heat sinks forming part of semi-conduction devices may be required to be isolated from earth.

Busbars and Busbar Connections

19 Busbars may be round or rectangular section hard drawn high conductivity copper, supported by porcelain or moulded insulators the complete assembly rated to be capable of withstanding the maximum mechanical stresses to which it may be subjected under fault conditions.

20 Busbars shall be enclosed in separate compartments of cubicle switchboards and shall be so arranged that all conductors can be brought on to the bars without undue bending.

21 Connections to circular section busbars shall be made with single bolt split type cable clams for sizes up to 300 amp; for 300 amps and upward connection will be made with high conductivity cast brass clamps. For rectangular section busbars connections shall be made with double split cast brass clamps. Drilling of the bars will not be permitted.

22 Conductors between the busbars and the circuit breakers and switches shall be high conductivity copper rod, having a current rating of not less than that of the fuse switches or isolators to which they are connected. The conductors shall be insulated with P.V.C. (Polyvinylchloride) sheathing, colour codes for phase identification.

23 Bolted neutral to earth links shall be provided on each incoming circuit fully fault rated for the system neutral earthing.

24 Busbars compartments are not to be used as switchboard wiring ways. Only the bars themselves, together with the connection to fuse switches, isolators, instrument and current transformers shall be permitted within the compartments.

Air Circuit Breakers (ACB)

25 Low voltage circuit breakers shall be metal clad, and of the air break fixed horizontal draw out pattern with rupturing capacities at system voltages specified; they shall be complete with all ancillary protection circuits including overload, shunt trip, no-volt coil, intertripping etc; closing mechanisms shall be of the trip-free type, and incorporate a mechanical ‘ON/OFF’ indicator and mechanical interlock in order to prevent withdrawal, plugging, or access to the breaker in the closed position. When withdrawn, automatic shutters shall close over the fixed contacts to prevent inadvertent access.

26 Contacts shall be provided with arc quenching devices, be capable of carrying full load for an indefinite period and be readily renewable.

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27 All breakers may be equipped with independent manual, solenoid, manual or motor charged spring operating mechanisms suitable for operating from batteries or mains as stated in the contract specific documentation. In the event of a failure to latch in the closed position, it shall not be possible for the breaker to open except at normal speed. Closing and tripping supplies should comply with the requirements of Series 7101.

28 Electrical releases and trip circuits shall be suitable for operations at nominal battery voltages specified.

29 All types of operating mechanism shall be designed to allow the breaker to open immediately the trip coil is energised.

30 Circuit breakers shall be provided with padlocking facilities to prevent breaker closure and maintain isolation. Circuit breakers must be provided with means for connecting the circuit to the main earth bar of the equipment.

Moulded Case Circuit Breakers (MCCB)

31 MCCB's designed to be suitable for use as electrical isolation devices shall trip automatically under fault conditions. The trip mechanism shall be of the thermal-magnetic type, and shall be trip-free in operation. 'On', 'Off' and 'Tripped' position of the operating lever shall be clearly marked, as shall be the current rating and breaking capacity.

32 Breaking capacity for MCCB's of nominal rating 100 amps and less shall be 16kA minimum, and for nominal ratings in excess of 100 amps shall be 22kA minimum.

33 Where the circuit fault levels exceed these values for the particular circuit breaker then additional HRC fuses shall be fitted as back-up protection. All MCCB's shall have an accredited ASTA test certificate.

34 MCCB's shall have a factory calibrated and sealed trip unit which is interchangeable with similar units for varying the rating of the circuit breaker.

35 Contacts shall be silver tungsten tipped with a wiping quick make and break action. The case shall be non-hygroscopic, arc resisting material and incorporate arc chutes based on the de-ionising principle.

36 The overload trips shall be calibrated to take account of the method of mounting, the enclosure, the location in which the equipment is to be used and the ambient temperature.

37 Auxiliary devices, eg power closing devices under-voltage releases shall be provided if required.

38 Provision shall be made to enable the operating mechanism to be padlocked when it is in the OFF position.

Miniature Circuit Breakers (MCB)

39 MCB's designed to be suitable for use as electrical isolation devices within tunnels shall operate within the specified temperature and humidity conditions stated in Series 7013 without any alteration in the opening time or current characteristics.

40 MCB's may be either of the screw clamp connection or the plug-in type.

41 MCB's shall incorporate hermetically sealed thermal magnetic tripping mechanisms giving an inverse time/current characteristics for overload operation with instantaneous tripping on heavy overloads or short circuits.

42 Provision shall be made to enable the operating mechanism to be padlocked when it is in the OFF position.

43 MCBs shall be capable of withstanding the anticipated short circuit capacity at the point where they are installed. Where the circuit fault levels exceed these values for the particular circuit breaker then additional HRC fuses shall be fitted as back-up protection.

Fuses

44 Cartridge fuses shall be of the HRC type with an ASTA certified interrupting rating of 80kA.

45 Where cartridge fuses are used to provide back-up protection for miniature circuit breakers, their normal current rating and fusing factor shall be as specified.

i) Fuses shall be of the same manufacture

ii) No paralleling of fuses will be permitted.

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Fuse Switches and Switch Disconnectors

46 Fuse-switch and switch disconnector units shall be provided with interlocks to ensure that the unit access door can only be opened when the associated switch is open and the switch cannot be closed until the access door is closed.

47 All switches shall have visible ON/OFF position indicators and shall be lockable in both these positions.

48 The units shall be of the double break contact type with a quick make, quick break action independent of the operator's speed of movement.

49 The fuse switches shall be provided complete with HRC fuses and switch disconnectors fitted with copper links. The switches shall be suitable for switching high inductive loads 6 times the normal rated current at 0.35 power factor and 100% rated voltage and making and carrying the system prospective symmetrical fault current, but limited by the cut-off characteristic of the largest HRC fuse link that may be fitted to the fuse switch or backing up the switch disconnecter.

50 The cable terminal shall be suitable for accepting the size of conductors indicated in the cable schedules and shall be housed within the associated fuse switch unit enclosure. Wiring to common terminal blocks shall not be permitted.

51 Full sized neutral links shall be provided in each unit.

Contactors

52 Contactors shall be mounted in robust dust proof sheet metal cases with hinged and/or bolted covers and be suitable for surface or switchboard mounting as required. All contactors shall be provided with an earthing terminal.

53 The contactor selected shall be adequate for the duty required, especially when inductive loads are controlled.

54 The duty and rating of contactors shall also be suitable for intermittent or continuous use and where necessary shall be suitable for a service which may require the contactors to remain open for long periods. The operating coils, shall be suitable for the voltage specified. Provision shall be made for remote control where necessary.

55 AC operating coils shall be wound for the nominal voltage and shall operate within a -14% +10% voltage range. Operating coils and control circuits shall be protected by cartridge fuses contained within the enclosure.

56 Where the operating coil or any auxiliary contacts are fed from an external source, the isolator controlling the contactor shall have fitted the additional switch poles to completely isolate the contact.

Residual Current Devices (RCDs)

57 RCDs shall be of rating indicated and unless otherwise specified shall have a sensitivity of 30mA with a tripping time not exceeding 40mS; they must incorporate protection feature to ensure that the DC component of fault currents, or harmonics, do not affect the satisfactory operation of the unit.

Busbar Chambers

58 Busbars, connections and the arrangements shall be of high conductivity copper and be housed in a metal clad enclosure suitable for wall or pedestal mounting, and of the same manufacturer as the associated switches. Access to busbars shall be by removable covers requiring a special tool to remove a securing device.

59 Connections to busbars shall comprise split type cast brass clamps, drilling will not be permitted.

60 Busbar chambers shall be ASTA certified to withstand the symmetrical fault levels stipulated.

61 Only busbars and cables connected thereto shall be enclosed in the busbar chamber.

62 The busbar chamber shall be assembled to permit extension of the chamber in the future.

Busbar Trunking

63 Busbar trunking shall be for use on LV three phase 4 wire 50Hz systems and shall have a minimum degree of protection IP42.

64 The busbars shall be of a hard drawn high conductivity copper and shall be of the appropriate cross sectional area for the current rating required; busbars shall be rigidly mounted on non-hygroscopic insulators and connection of the bars shall be made by means of

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copper fish plates or specially designed clamps. Each system shall be complete with all accessories including cable feed unit, sealed end, self adjusting expansion units as appropriate, spreader and suspension units, and insulated support racks.

65 All busbars shall be constructed and ASTA certified to withstand a fault level equal to a maximum breaking capacity of the controlling incoming switch and neutral bars shall be of the same cross section as the phase bars.

66 Busbars shall be fully enclosed in sheet metal with adequate means for mounting as appropriate. Earth continuity shall be provided by the housing. The housing shall be adequately jointed between lengths and fitted with copper links for earth continuity.

67 In addition to the above, busbars rated at over 90A shall be fitted with an unbroken earthing tape fixed to the outside of the casing for the entire length of its run and terminating at the cable box of switchgear to which the busbar is connected at each end. The earthing tape shall have a cross section area not less than half that of any phase conductor.

68 The busbar trunking shall be designed to take account of varying conditions of ambient temperature, normal building movement and loading, and the conductors shall be capable of an end-wise movement. Expansion fittings to be fitted in accordance with the busbar manufacturer's recommendations.

69 The trunking shall be securely fixed to the wall at regular intervals in accordance with the manufacturer's recommendations. Interconnections between the busbar trunking and local switchgear shall be made using purpose made tap-off units.

70 Plug-in unit enclosures shall make positive contact to the busbar housing before the phase conductors make contact with live busbars. Barriers shall be provided to prevent exposing live parts and arcing across phases. Means of padlocking the switch in the off position shall be provided for all tap-off units.

71 Fire resisting barriers shall be provided within the trunking where the enclosure passes through floor or wall positions. The fire barriers shall be manufactured to form a barrier not less than 100mm thick and be fitted by the busbar manufacturer to maintain the fire integrity specified.

72 Tapping boxes shall be of the 'clamp on' type fitted with isolation switches, HRC fuse fittings, MCCB's or fuse switches.

73 Tapping boxes shall be provided complete with integral flexible cables terminating in purpose made shrouded brass connection clamps to attachment to the busbars without drilling.

74 The design shall ensure correct polarity of tapping box connection and that earthing contact is made before the contact system engages with the busbar.

Distribution Boards

75 All LV distribution boards shall be of the totally enclosed metal clad type housing HRC fuses, MCCB's or MCB's and RCD's as required. Distribution boards may be single pole and neutral, double pole, triple pole or triple pole and neutral.

76 The distribution board enclosure shall be surface pattern or recessed as specified enclosure complete with hinged cover. This cover shall be fitted with an efficient dust gasket and to provide a minimum rating of IP 32 and a means of locking.

77 Removable gland plates shall be provided at the top and bottom of the boards.

78 Provision shall be included in the design of the enclosure for supporting the completed board via the rear of the enclosure.

79 All distribution boards shall be of the solid neutral pattern and the neutral bar which shall be rated as the phase bars shall have a separate terminal for each circuit neutral conductor is connected to the bar in the same order as the circuit phase conductors are connected to the fuse banks. Insulating shields shall be fitted to prevent accidental contact and barriers shall be provided between phases.

80 All access holes or slots shall be fitted with bushes or protective neoprene strip to obviate cable damage.

81 Distribution boards shall be of the same manufacture throughout.

82 Phases/Poles shall be indelibly identified by colour coding.

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83 Distribution boards shall be equipped with 25% spare ways of each outgoing device of the various rating and all blank ways shall be fitted with a suitable blanking piece.

84 Distribution boards shall be firmly secured to the building fabric by a method of fixing suitably insulated to prevent electrolytic corrosion resulting from connection of dissimilar metals. Alternatively, they may be fixed to a metal framework by means of nuts and bolts.

85 Engraved type labels shall be fitted to switches and boards.

86 Labels fixed to switches shall indicate:

i) The reference number of the switch

ii) The specified current rating

iii) The size and number of cores of the cable controlled

iv) The distribution board controlled

v) Phase and voltage

87 Labels fixed to distribution boards shall indicate:

i) The reference number

ii) The type of board, ie lighting, small power

iii) Location of sub-main cable supplying the board

iv) Position of the switch controlling the sub-main cable

v) Phase and voltage

88 Additionally, each distribution board shall have fitted internally a circuit chart. The chart shall describe the various circuits fed by the board, the correct device rating and type number for replacement.

Tunnel Panels

89 The following panel types may need to be located within the actual tunnel bores.

i) Electrical distribution

ii) Ventilation

iii) Emergency Communications

iv) Fire

v) Smoke control panels

90 Panels may comprise combined panel types and shall be manufactured from corrosion resistant materials such as stainless steel and all external doors provided with gaskets to ensure the panels, with the exception of emergency telephone and fire extinguisher compartments, are a minimum of IP 65 rated.

91 Panels within tunnels shall be vandal resistant and the panel insides and doors provided with insulated linings to provide the fire ratings for insulation and integrity as agreed with the Fire Authority.

92 All compartments with opening doors containing emergency equipment shall be provided with contacts to indicate on the plant monitoring and control system where the door's opened.

93 Door handles and locks, where provided, shall be of the recessed type and provide a smooth, flush finish with no projections.

94 All hinges, fitting, fixing nuts, bolts and washers shall be corrosion resistant of a material that will not induce corrosion when in contact with the adjacent panel components. Any attachments to the enclosure shall be welded in position; penetration of the enclosure by drilling shall not be permitted.

95 The panels shall be provided complete with access areas at the top and bottom as required for incoming and outgoing cables and pipework.

96 The top of the panels shall slops towards the rear to prevent any accumulation of water. Suitable measures shall also be taken to divert any seepage water away from electrical equipment.

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97 All compartment doors shall be fitted with labels appropriate to the contents.

98 Electrical distribution panels shall comprise distribution fuse boards and HRC fuses for tunnel lighting and ancillary circuits.

99 The enclosure shall contain an appropriate air cooled transformer and low voltage socket outlets for maintenance purposes.

100 Ventilation panels shall contain starter units and associated equipment relating to tunnel ventilation fans.

101 Emergency communications panel shall comprise a telephone, CCTV and traffic monitoring equipment, distribution fuse boards for communications and associated circuits.

102 Fire panels shall comprise portable dry powder type fire extinguishers, hydrant, telephone, indications and control units for manual operation of tunnel fans in emergencies.

Motor Control Centres and Control Panels

Motor Starters

103 Motor circuits shall be controlled by a contactor and an individual set of HRC fuses and shall be contained in segregated compartments.

104 The supply to each starter shall be controlled by an isolating switch of the on-load type, operated by an external handle which can be locked in the 'off' position. A mechanical interlock shall prevent the compartment door being opened while the main circuit is alive.

105 Contactors shall be of the air break type fitted with arc shields. Silver-faced butt contacts of the rolling self-cleaning type shall be used and all parts likely to suffer from arcing shall be easily renewable.

106 Contactors shall be electrically held-in during normal operating. Each unit shall be fitted with a mechanically operated flag indicator to show the contactor position.

107 The minimum current rating of contactors shall be capable of breaking inductive loads as required and shall operate correctly with a supply voltage of 80% of normal and shall hold-in at 66% of the normal voltage.

108 The units shall be completed with operating coils and neutral links. Control coils shall be so connected that failure of their insulation to earth shall not cause them to be energised. The coil shall be protected by an HRC cartridge fuse.

109 The control circuit shall be designed to incorporate an adjustable time delay which will automatically re-energise the contactor within a period not exceeding 10 seconds following the occurrence of a transient voltage reduction. An adjustable time delay not exceeding 90 seconds shall also be incorporated to provide a delayed sequence start facility.

110 All starters shall have integral Manual/Auto/Off override switches linked to remote emergency stop buttons as appropriate with manual 'start' and 'stop'/ 'reset' push buttons of the diaphragm type. The 'stop'/ 'reset' buttons shall have mushroom heads and shall be coloured red; the 'start' buttons shall be coloured green and shall be shrouded to prevent inadvertent operation. Indicating lamps shall be provided to show motor status running, stopped or tripped. A lamp test facility shall be provided.

111 Starters for motors of up to and including 4kW shall be direct on line, above 4kW and up to and including 22kW then shall be open transition automatic star delta, above 22kW they shall be closed transition star-delta, or electronic soft start/speed control as specified.

112 Overloads shall be hand reset, and shall have at least single pole changeover contacts.

113 Starter coils shall be for mains voltage 50 Hz or rectified DC operation.

114 All starters above 4kW shall be provided with ammeters to the requirements of Series 7101 of this Specification.

115 Automatic star-delta starters shall be rated for intermittent duty to the appropriate standards. They shall have changeover timers adjustable from one to 30 seconds. If the overload relays are connected for phase current, their scales shall be marked to show whether they are indicating phase current or line current. Electrical and mechanical interlocks shall prevent both star and delta contacts being closed at the same time.

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116 Closed transition star-delta starters shall be rated for intermittent duty class 0.3 and shall have appropriately rated resistors which shall be connected with heat resistant cables. The changeover timers shall be adjustable from one to 30 seconds. If the overload relays are connected for phase current, their scales shall be marked to show whether they are indicating phase current or line current. Where possible the resistors shall be mounted in a section separate from the starter.

Controls and Wiring

117 All equipment terminals and wires shall be numbered and identified as the schematic wiring diagrams and shall be of the cadmium plated type.

118 All control wiring which connects to the motor starter sections shall be multi-stranded and have a minimum cross section of 1.0 mm² and be coloured pink.

119 Where the use of screened cable is essential the screen shall only be earthed at one end which shall normally be at the control panel. A separate terminal shall be provided for each incoming cable screen. Where panels are supplied in sections, multi-pin plug and sockets should be used, with suitably numbered terminals and corresponding wire from numbers.

120 The electrical supply controller sections shall be SELV 50 Hz single phase sourced from a point exterior from the section. The SELV supply shall be derived from a safety isolation transformer.

121 Each 24 volt supply shall have a rail designated as ‘common’.

122 An isolator shall be provided inside the controller section to isolate the incoming 24 volt supply. This isolator shall not be interlocked with the panel door. The incoming terminals on the isolator shall be fully shrouded.

123 Where circuits of different voltages are terminated in a common enclosure the terminals shall be grouped by voltage with not less than 25mm space between groups, or separated by a suitable approved barrier. Terminal groups shall be clearly labelled by ‘Voltage’. Warning covers or shrouds shall be fitted over all terminals of 50V or above with respect to earth.

124 Low voltage wiring shall not be run in the same trunking as extra low voltage control wiring.

125 Neutral link carriers and bases where required shall be coloured white to clearly distinguish them from fuse carriers. White fuse carriers shall not be used.

Segregation

126 Incoming terminals operating at above 24 Volts shall be grouped by voltage, with not less than 25mm between grouping or separated by a suitable approved barrier. Terminal groups shall be clearly labelled by ‘Voltage’. Covers or shrouds with warning labels shall be fitted over all terminals of 50 volts or above with respect to earth. Mains wiring shall not be run in the same trunking as extra low voltage control wiring.

127 Interposing relays which have contacts operating at mains voltage for motor contactor control shall be located inside the appropriate motor starter compartment if multi-compartmented and not inside the controller compartment.

128 All mains terminals shall be shrouded against accidental contact and provided with warning labels.

Panel Construction

129 Control panels shall be of welded construction, made from folded and welded mild steel sheet not less than 2.0mm thick in conjunction with an integral angle or channel section framework, minimum thickness 6mm. A means for lifting, (eg removable lifting eyes) shall be provided for all floor standing panels and the panels shall be split where necessary, to facilitate on-site handling. The sheet steel shall be suitably radiused. All exposed screws, bolts and similar fastenings shall be smooth surfaced and protectively plated.

130 All access doors shall be constructed in sheet steel as described above and suitably reinforced and braced to prevent flexing. Each door shall be so arranged to permit easy access to the inside of the panel for general access and maintenance purposes and shall incorporate sealing gaskets.

131 Internal equipment mounting plates 2.0mm thick shall be provided with all edges returned to stiffen the plate. All fixing holes shall be drilled and tapped.

132 All door catches shall have a lockable handle of the ‘T’ type complete with lock and two keys which shall be common to all locks on all panels. An adequate number of door catches shall be provided to ensure compliance with the requirements of sealing.

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Earthing

133 Where a panel consists of several separate sections a copper earth strap or suitably sized green/yellow earth conductor shall be provided to securely bond each enclosure together and to the main earth point.

Internal Labelling

134 Each control item inside the panel shall be labelled with an identity reference which is shown on the electrical control diagrams. Labels shall be engraved plastic type or equivalent and shall where practicable be secured to a fixed part of the panel adjacent to the control item.

Protection Relays

135 Protection for LV circuits shall discriminate with and be co-ordinated with HV protection and necessary inter-tripping provided.

136 Protective relays may be static or electro-mechanical type. They must have characteristics, settings and ratings entirely suitable for the system and purpose for which they are utilised, and be compatible with all associated components and equipment.

137 All relays shall be housed in flush mounted casings installed on the front of the switchboards and be readily withdrawable for testing or inspection without disturbance to any connection.

Current Transformers

138 Current transformers shall be to the requirements of Series 7101.

Instruments Relays and Meters

139 Instruments and relays shall be to the requirements of Series 7101.

140 All switchboards shall incorporate ammeters and volt meters. Electricity check meters, including kWh, kVA and maximum demand meters may be direct reading up to and including 80A and shall be current transformer operated for all higher values of current.

141 Metering compartments or panel boards shall be provided as necessary to house the supply company's metering equipment. The provision shall include an insulated panel, for mounting the meters and fuses to protect the meter coils circuits; they shall incorporate a hinged glazed door for viewing, and facility for fitting the supply authority seals.

142 Allowance shall be made for mounting the associated current transformers on the relevant conductors.

Power Factor Correction

143 Centralised power factor correction equipment shall be provided where the design calculations indicate that the power factor will be below 0.92 for the estimated average running loads. Power factor correction equipment shall comprise all necessary capacitors, step controllers, contactors and sensing apparatus. The equipment shall be suitable to keep the power factor lagging to a minimum overall of 0.92 under all conditions.

144 Power factor correction equipment may be free standing units in separate cubicles connected to the LV switchboard busbars via a suitably rated switch or incorporated with the main LV switchboard. Equipment may be static or automatically switched in stages to suit the load.

145 Capacitors shall consist of an assembly of individual low loss, metallised film power capacitor elements incorporating discharge circuits housed in a sheet steel enclosure complete with main terminals.

146 Individual capacitor elements shall comprise a winding of metallised polypropylene film, the metallisation having a graduated profile across the element width.

147 The outer layer of each element shall incorporate a solid aluminium foil electrode connected in parallel with the active winding and each element shall have its own individual fuse housed within the element core tube.

148 Each assembled winding shall be housed in its own container and encapsulated in a thermo setting resin to ensure a perfectly sealed element.

149 Prior to encapsulation the element windings shall receive a specialised liquid heat treatment under vacuum to ensure perfect electrical characteristics.

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150 The mechanical assembly of the elements within the container shall incorporate thermal equalisers to ensure low operating temperatures for the elements.

151 The sheet steel enclosure incorporating the required number of capacitor elements shall be filled with inorganic, inert and non-flammable granules to absorb the energy of any non-permissible overload.

152 Discharge resistors shall be fitted to ensure safe discharge of the capacitor to less than 50 V in one minute after a switch off.

153 All internal and external connections shall be adequately rated and fully insulated.

154 The design shall not contain any free flammable liquid and all materials must be environmentally acceptable.

155 Where capacitor banks are automatically controlled, the total capacitor rating of each bank shall be in a number of separate equal parts. Each part shall be brought into line automatically.

156 Switching of capacitor banks may be cascade/soft switching or block contactor switching.

157 The automatic control shall be accomplished by the use of an automatic multi-stage kVar sensitive, solid state relay having a number of stage switches, which shall operate the capacitor contactors.

158 The control relay shall be incorporated within the cubicle.

159 The control relay shall be fitted with a loss of voltage no volt release re-setting feature such that the switching sequence resets itself to an all contacts open position following a failure of supply.

160 Visual indication by means of LED's for capacitor stages and capacitor/inductive load and Hand/Off/Auto selection shall be provided.

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A7103. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

LV SWITCHGEAR	
BS 89	Direct acting indicating analogue electrical measuring instruments and their accessories
BS 142	Electrical protection relays
BS 381C	Colours for identification, coding and special purposes
BS 921	Rubber mats for electrical purposes
BS 1650	Capacitors for connection to power-frequency systems
BS 4293	Residual Current-operated circuit-breakers
BS 5486	Low-voltage switchgear and control gear assemblies
BS 5685	Electricity meters
BS 5992	Electrical Relays
BS 7626	Current transformers
BS EN 60269	Cartridge fuses for voltages up to and including 1000V a.c. and 1500V d.c.
BS EN 60439-1	Requirements for type tested and partially type tested assemblies
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 60898	Circuit breaker for overcurrent protection for household and similar installations
BS EN 60947	Low Voltage switchgear and control gear
BS EN 60947-2	Circuit breakers
BS EN 60947-3	Switches, disconnectors, switch disconnectors and fuse combination units
BS EN 60947-4	Contactors and motor starters
BS EN 60947-5	Control circuit devices and switching elements
BS EN 60947-ó-2	Control and protective switching devices (or equipment) (CPS)

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Sample Appendix A7103/2: LV Switchgear

The Contractor shall insert below details of the equipment proposed.

Detail No:	Description	Unit	Detail
1	Manufacturer of switchboard	-	
2	Manufacturer of air circuit breakers	-	
3	Manufacturer of moulded case circuit breakers	-	
4	Manufacturer of miniature circuit breakers	-	
5	Manufacturer of protection relays	-	
6	Manufacturer of switches and disconnectors	-	
7	Manufacturer of cartridge fuses	-	
8	Manufacturer of motor starters	-	
9	Manufacturer of contactors	-	
10	Manufacturer of power factor correction capacitors	-	
11	Manufacturer of power factor correction step controller	-	
12	Manufacturer of distribution boards	-	
13	Manufacturer of indicating instruments	-	
14	Manufacturer of integrating meters	-	
15	Normal service voltage	V	
16	Busbars rated current	A	
17	Frequency	Hz	
18	Rated symmetrical short circuit breaking capacity	kA	
19	Short time current duration	secs	
20	Floor/Wall mounting	-	
21	Rear/Front access	-	
22	Degree of protection	IP	
23	Colour of switchboard	-	
24	Form of separation	-	
25	Closing mechanisms for circuit breakers	-	

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Detail No:	Description	Unit	Detail
26	Closing mechanisms for MCCBs	-	
27	Electrical tripping required	-	
28	Lamp indication of open/closed position	-	
29	Auxiliary switches	-	
30	Type of protection relays	-	
31	MCB electrical details	-	
32	Switches ancl disconnectors - electrical details	-	
33	Fuses - current ratings	-	
34	Motor starters - types	-	
35	Contactors used tor distribution purposes - duty rating, utilisation, category and endurance	-	
36	Contactors used tor motor control purposes - category and endurance or motor starting duty	-	
37	Power factor correction equipment number of steps	-	
38	Remote control from alternative positions	-	
39	Details of distribution boards	-	
40	Instrument dials	-	
41	Tripping unit dc output (state voltage if not 30v)	-	
42	Cubicle space heaters	-	
43	Fire rating of tunnel panels	Hours	

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7104 HV AND LV CABLING AND DISTRIBUTION

General

1 HV and LV cabling shall be suitable for operation on the frequency and system voltages as stated in the contract specific documentation.

2 All cables shall be sized for continuous operation at full load, taking into consideration derating, grouping, fault level and installation conditions.

3 Installation of cables shall only be carried out when the ambient temperature is above 0°C unless a written statement from the manufacturer confirms no cable damage will result from installation at 0° or below.

4 The temperature of the cable shall have been above 0°C or the minimum temperature stated by the manufacture for 24 hours immediately prior to installation.

5 Where any part of a cable is installed within the tunnel confines the cable insulation outer sheath shall be LSOH throughout the entire length.

6 Power cables associated with communications single phase applications shall be 3 core.

7 No joints will be permitted in cables run between any two points unless the lengths involved are longer than standard manufactured lengths. Any necessary joints shall be agreed and installed by qualified approved jointers.

8 Wherever feasible cables terminating at distribution boards, electrical outlets etc. shall be provided with a sufficient amount of slack cable for future trimming, stripping back and reconnection to the terminals without causing stressing to the cable in any way.

9 Where single core cables enter any item of metal-clad switchgear the cables shall all pass through the same aperture in the enclosure or case of the unit concerned. Where separate holes are provided by the manufacturer for cable entries, a smooth continuous slot shall be provided between the holes or the holes shall be drilled in a plate of non-magnetic material to obviate induced currents.

10 Where cable lugs, terminal or sweating sockets are employed, they shall be of the correct bore to suit the cable which they are intended to connect. The cables shall be of good fit in the sockets which shall be of adequate bore to contain all strands. The filling in of surplus space with solder will not be permitted. All cable sockets, clamps, etc. shall be proprietary manufactured fittings.

11 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

High Voltage Cables

12 HV cables may be of the following types:

i) Cross linked polyethylene insulated (XLPE), single wire armoured (SWA) and LSOH bedded and sheathed. 6350/11000 volt grade.

ii) Cross linked polyethylene insulated (XLPE) aluminium wire armouring (AWA) and LSOH for bedded and sheeted x 6350/11000 volt grade for single core cables.

13 The outer sheath shall be red in colour.

Low Voltage Cables

14 LV cables may be of the following types:

i) Cross linked polyethylene insulated (XLPE), single wire armoured (SWA) and LSOH bedded and sheathed. 600/1000 volt grade.

ii) Mineral insulated copper sheathed (MICS) with LSOH oversheath, 600 or 1000 volt grade.

iii) LSOH insulated single core in trunking/conduit. 450/750 volt grade.

iv) Flexible fire resistant cable with orange LSOH sheath for power requirements and red for fire alarm requirements.

15 Outer sheaths shall be black in colour and no reduction in cross sectional area of neutrals will be accepted.

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Installation of Cables

16 Cables shall be run neatly on the surface of the structure, laid in floor trenches, drawn into ducts or buried in the ground as specified. Cables shall be fixed at centres recommended by the manufacturer.

17 Single core cables used for three phase supplies shall be aluminium type armour (AWA) and laid in trefoil formation to enter equipment via non-ferrous gland plates to prevent induced circulating currents.

18 Cables shall be identified at each end, at each access point and at 25m maximum intervals and changes of direction when on trays or in preformed ducts by means of a permanent label indicating cable size and circuit reference to correspond with the controlling supply protection device.

19 Underground cables shall be laid direct in trenches or be drawn through ducts or laid in purpose designed trenches or troughs in structures.

20 After cable trenches are opened, all cables shall be laid and the trenches backfilled within 24 hours. Safety precautions shall be taken and arrangements made to prevent damage to cables at all times.

21 Trenches shall be excavated to provide the minimum cover from finished ground levels specified as follows:

i) In open ground and pavements
- under 500mm all cables except HV
  800mm HV

ii) Under roadways subject to vehicular traffic
- 800mm all cables except HV
  1000mm HV

22 Excavations shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means and protected. Root disturbance of existing trees and shrubbery shall be kept to the minimum.

23 Before laying cables, the bottom of the trench shall be evenly graded, cleared of loose stones and covered with 75mm layer of earth which has passed through a sieve with a maximum mesh of 13mm or, where local ground is unsuitable, with sand.

24 Power cables shall be pulled in over adequately spaced cable rollers and the resulting surplus cable shall be snaked across the width of the trench. In straight run trenches cable crossing is not permitted except where cables branch from the main run. Cable slack sufficient to allow future hauling of cables shall be left at each drawn-in point, joint or junction box.

25 Cable stockings shall be used for cable hauling. In order to ensure that the strain is taken on the cores as well as the sheath when cables are laid with a cable stocking, a solid plumbed hauling end shall be made. The only permissible exceptions to this requirement are for lengths of up to 30m not pulled into a thrust bore ring.

26 Where more than one cable is laid in a trench the cables shall be spaced apart in accordance with their current rating but subject to the minimum spacings specified as follows. (Cables of the same service laid in the same trench may be bunched).

	LV	Communications Control & Data	Coaxial	Ductwork, Water, Gas, etc.
LV	25mm	150mm	150mm	300mm
Communications Control & Data	150mm	50mm	50mm	250mm
Coaxial	150mm	50mm	50mm	250mm

Table 7104.1

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27 The installation of HV cables within the same trench as the above services will not be permitted.

28 Minimum distances between cables and segregation from other services should be in accordance with the above table. When this is not possible, 50mm thick clay/concrete tiles shall be used as separators.

29 After laying, cables shall be covered with enough fine sieved earth, or sand where the local ground is unsuitable, to ensure 50mm cover after tamping. Warning covers and/or warning tapes shall be laid over cables and the trench filled and compacted.

30 Reinstatement shall be effected by backfilling in 100mm layers and hand ramming the first two layers. Power rammers may be used for the remaining layers. The level of the finished reinstatement shall not protrude more than 25mm above the finished ground level. A higher standard of consolidation is required for excavations within shoulders and overruns and adjacent to paved areas. At these positions the final 100mm of reinstatement to be compacted by a power rammer until the maximum possible compaction is achieved.

31 All cables drawn into ducts shall be effectively sealed where the cables enter sub-stations or buildings to prevent the entry of water and vermin. Where required by the engineer, duct entries into manholes shall be suitably sealed, after the installation of all cabling.

32 The invert levels of all ducts entering a building shall be such that the ducts slope away from the building. Should the duct entry into the building be below the water table then puddle flanges shall be incorporated into the building structure.

Cable Warning Cover

33 Interlocking cable warning covers shall be provided for cables laid direct in the ground.

34 Cable warning tape shall be laid 300 mm below finished ground level or on the top of concrete surrounded ducts where provided. The tape shall be minimum 150 mm wide, 0.1 mm thick and labelled to clearly indicate the service.

Cable Markers

35 The location of all directly buried cables shall be marked by slab markers 600mm square and 100mm thick.

36 HV and LV cable runs shall be marked at the point where they leave the sub-station, feeder pillar or other current controlling device, and shall be marked at approximately every 60m along the cable run with an additional marker at each change of direction of the cable run.

37 Cable markers shall be installed flat in the ground immediately above the cable with the top of the cable marker flush with finished ground level to prevent a tripping hazard to pedestrians.

38 The location of any underground cable joint shall be marked by concrete slabs placed over the joint with the top of the cable marker flush with ground level to prevent a tripping hazard. The word JOINT shall be impressed on each slab in letters of the size specified for cable markers above.

Cable Trunking and Fittings

39 The nominal thickness of material for fittings shall accord with that specified for the associated trunking.

40 Trunking systems mounted within a building, in plant rooms, outside a building or run in floor trenches or locations subject to continual dampness or accidental flooding shall have protection against corrosion suitable to the environ and to the contract specific documentation.

41 Trunking systems and associated supports mounted within the tunnel shall be corrosion resistant, typically stainless steel, having special regard for the tunnel environment. The trunking system were exposed to tunnel washing shall have an ingress protection as stated in the contract specific documentation.

42 Metal partitions in trunking and fittings shall be of the same material and finish as the trunking material, and of thickness 0.5mm less than that of the trunking, with the minimum of 1mm.

43 Trunking shall be run neatly on the surface of buildings, and truly vertical, horizontal or parallel with the features of the structure and agreed before any work is started. Trunking shall be run at least 150mm clear of plumbing and mechanical services.

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44 Manufacturer's standard fittings shall be used throughout. Only where these are inadequate to meet special local conditions will fabricated fittings be accepted.

45 Where special fittings or sections of trunking are fabricated they shall be prepared and finished to the same standard as manufacturer's standard items.

46 Standard flanged couplings to terminate trunking at apparatus shall be used at adaptable boxes and at points where it is desired to connect one section of trunking to another. The material of trunking shall not be cut or bent to form flanged attachments.

47 A screwed cup and bush shall be used for connections between trunking and apparatus or a standard flanged coupling or an adaptor neck, fabricated or cast. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the lid of the trunking is left intact.

48 Where connection is made between trunking and distribution board, the cable entry or entries shall be sized to accept all cables from all used and spare ways.

49 Holes in trunking shall be drilled, punched or cut by ring saw.

50 Individual pieces of trunking shall be independently supported. On straight runs they shall be fixed at regular intervals in accordance with manufacturer's recommendations.

51 Copper earth bonding links shall be provided between each trunking joint.

52 Trunking shall be de-burred and all debris removed before installing cables.

53 All damaged paintwork and exposed metalwork shall be made good and returned to its original condition.

Conduit and Fittings

54 Corrosion resistant conduit typically stainless steel having an outside diameter of less than 20mm shall not be used unless otherwise specified.

55 Where final connections to moving or rotating machinery are to be made, the use of a proprietary manufactured flexible conduit shall be used. The maximum permissible length of flexible conduit shall be limited to 1000mm.

56 Conduit or adaptable boxes mounted outside buildings or in damp locations shall have:

i) external fixing lugs

ii) covers with machined surface around perimeter, mating with similar machined surface on box and seal gasket.

iii) brass cover fixing screws or stainless steel as appropriate

57 Conduit shall be run neatly on the surface or buried within the carcass of building(s) or in the ground, as specified and agreed before any work is started. Conduit shall be run at least 150mm clear of plumbing and mechanical services.

58 Surface conduit shall be run truly vertical, horizontal or parallel with features of the structure.

59 Conduit buried in concrete shall have at least 35mm depth of cover over the entire length. Conduit buried in plaster shall have at least 5mm depth of cover over the entire length.

60 Temporary plugs shall be provided for all open ends of conduits where buried in the carcass of the building or in the ground, to prevent ingress of foreign matter or water.

61 Where conduit buried in concrete crosses an expansion joint in the concrete, the method of protecting the conduit against expansion strains is to be approved.

62 Conduit shall be bent or set on site to suit local conditions.

63 Solid (non-inspection) conduit elbows or tees shall not be used anywhere on the installation.

64 A draw-in box shall be provided in all conduit runs exceeding 10 metres in length or containing more than two right-angled bends

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65 Conduit boxes, both standard and adaptable shall be fixed to the structure independently of the conduit fixings.

66 The length of thread on the ends of conduit shall suit the length of internal thread in the end of the fitting or accessory. Excess lengths of thread will not be permitted.

67 Spanners or purpose-made tools shall be used to tighten hexagon bushes, pliers and tooth wrenches shall not be used.

68 Conduit terminating at boxes, trunking or accessories not provided with spout or tapped entry,shall be made mechanically and electrically continuous by means of a coupler and bush to male thread.

69 Conduit run on the surface of buildings shall be fixed by means of spacer bar saddles and steel saddle fixing screws.

70 Conduit systems erected outside of buildings shall be weatherproofed.

71 Conduit run on the surface of structures shall be fixed by means of distance saddles. Fixing screws for saddles shall be corrosion resistant.

72 Running couplers with back nuts shall not be used. Three piece conduit unions only will be accepted.

73 Conduit buried in the ground and subject to corrosion shall be wrapped with waterproof self-adhesive tape half lapped. Tape shall be extended for a distance of 150mm beyond the point where the conduit emerges from the ground.

74 The interior of all conduits shall be cleaned prior to wiring.

Cable Tray

75 Bends shall be of the same material, thickness and finish as the cable trays, and have an inner radius corresponding to the minimum bending radius of the largest cable installed subject to a minimum internal radius of 50mm.

76 Tees shall be of the same material and finish as the cable trays. The distance measured between a point of intersection and the end of the fitting shall be 100mm.

77 Cable trays shall be of the widths and thickness with the finish as applicable to the particular environmental conditions as detailed in Table 7104.2.

78 Site fabrication of accessories shall be kept to a minimum and manufacturers' standard items shall be used. Where special sections are required, the material thickness and finish shall be as for specified standard items.

79 Where welding has been employed in the fabrication of cable tray and/or accessories, the area around the joint shall be mechanically prepared and thereafter treated with zinc chromate primer or zinc rich paint, according to the original finish of the metal.

80 Holes cut in cable tray for the passage of cables and all cut edges of metal cable tray shall be painted with zinc rich paint and holes shall be provided with grommets.

81 A minimum clear space of 25mm shall be provided behind all cable trays.

82 Cable tray shall be fixed at regular intervals in accordance with manufacturers recommendations. Cable tray fixings and supports shall be of the same material and finish as the cable tray.

83 Copper earth bond link shall be provided at all metal cable tray joints.

Cable Ducts

84 Cable ducts shall be a minimum of 100mm diameter bore and be of the material, manufacture and method of jointing specified.

85 Trenches for earthenware ducts shall be scooped out at all points where the sockets rest, so that the body of the ducts lie upon solid ground.

86 In rocky soils a layer of loose earth shall be spread over the bottom of the trench and rammed to afford a bedding for the ducts.

87 In water logged or soil which could be subjected to subsidence a foundation for the ducts shall be provided by laying 70mm of concrete (using 10mm course aggregate) followed by 75mm of soil on the top of the hardened concrete.

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DIMENSIONS AND FINISH OF CABLE TRAY				
Nominal width	**Min.height of upstand**	**Nominal thickness of sheet**	**Finish**	**Application**
100mm	12mm	1.0mm	Zinc Chromate Paint	Internal installation
150mm	12mm	1.0mm	Zinc Chromate Paint	Internal installation
225mm	18mm	1.5mm	Zinc Chromate Paint	Internal installation
300mm	25mm	1.5mm	Zinc Chromate Paint	Internal installation
450mm	25mm	2.0mm	Zinc Chromate Paint	Internal installation
600mm	25mm	2.0mm	Zinc Chromate Paint	Internal installation
100mm	25mm	1.5mm	Hot dip galvanised	External installation
150mm	25mm	1.5mm	Hot dip galvanised	External installation
225mm	18mm	1.5mm	Hot dip galvanised	External installation
300mm	25mm	1.5mm	Hot dip galvanised	External installation
450mm	25mm	2.0mm	Hot dip galvanised	External installation
600mm	25mm	2.0mm	Hot dip galvanised	External installation
100mm	12mm	1.2mm	Stainless steel grade 316	Tunnel installation
150mm	12mm	1.2mm	Stainless steel grade 316	Tunnel installation
225mm	12mm	1.2mm	Stainless steel grade 316	Tunnel installation
300mm	25mm	1.5mm	Stainless steel grade 316	Tunnel installation
450mm	25mm	1.5mm	Stainless steel grade 316	Tunnel installation
600mm	25mm	1.5mm	Stainless steel grade 316	Tunnel installation
100mm	50mm	3.0mm	GRP/LSOH	Internal installation
150mm	50mm	3.0mm	GRP/LSOH	Internal installation
200mm	50mm	3.0mm	GRP/LSOH	Internal installation
300mm	50mm	3.0mm	GRP/LSOH	Internal installation
400mm	60mm	3.0mm	GRP/LSOH	Internal installation

Table 7104.2

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88 Fibre ducts shall be laid on, and surrounded with, a concrete mix to provide a minimum cover of 150mm above and below and 100mm on each side of the side of the collar.

89 All cable entries to ducts and cables enclosed in preformed ducts, walkway/verge ducts shall have a 2 hour fire resistance when the duct covers are on. Smoke/ fire barriers shall be provided at 50m maximum spacing in tunnel ducts and between junctions.

90 Ducts shall be kept clear of gas and water pipes, drains, sewers and electrical plant. In order to allow the use of taping machines on gas and water mains that may be adjacent, at least 150mm clearance should be provided wherever possible. This clearance shall also be given, if practicable to other services. No clearance less than 25mm will be permitted. Where services cross, the minimum clearance shall be 50mm.

91 Where ducts pass below roadways, the bottom of the trenches shall be rammed and the ducts laid on and surrounded by concrete providing a minimum cover of 150mm all round. At each joint the ducts flexibility shall be maintained by forming a joint in the concrete by 25mm thick compressible filler.

92 Cable ducts shall extend not less than 1000mm beyond the limit of roadways and paved areas.

93 Where required, separate ducting systems shall be provided for communications, lighting, fire alarms and LV power. Colours shall be:

Orange	- for lighting
Purple	- for communications and data
Black	- for LV power
Red	- for fire alarms

94 To prove duct alignment a wooden mandrel of 250mm in length shall be drawn through the duct. The mandrel shall be 7mm less than the duct bore diameter.

95 If it is necessary to deflect from a straight line or vary the depth, as in passing from footway to carriageway or in entering an underground chamber, a lateral set not exceeding 25mm in a length of 750mm or a vertical set not exceeding 25mm in a length of 1500 shall be given to the joints but the deflection shall be small enough to pass the alignment tests.

96 Ducts shall be plugged with wooden plugs before and after each test. Wooden plugs shall be inserted at the ends of each section of duct to prevent entry of soil or stones.

97 Ducts shall be cleared with a mandrel not smaller than the internal diameter of the duct minus 13mm followed by a circular wire brush 13mm greater in diameter than the duct just before any cables are drawn in.

Sealing of Duct Entries

98 After cables have been installed both the cable and the exposed duct end shall be lapped with fire resistant tape and rendered with intumescent fire stopping material to form a gas, water and fire barrier.

99 Spare ducts shall be sealed with fire resistant covered and taped hardwood plugs rendered with intumescent fire stopping material to form a gas, water and fire barrier.

Installation of MICC Cable

100 Generally 600 volt class (light duty) cable shall be used except where the nominal cross sectional area of conductor or the number of cores required is outside the range of 600 volt class when 1000 volt class (heavy duty) cables shall be used.

101 All mineral insulated cables shall be of totally inorganic construction (free of any organic additives).

102 Cables shall have a LSOH outer covering when:-

i) They are laid upon or fixed direct to a concrete or stone surface subject to dampness.

ii) They are laid upon or fixed direct to a zinc coated surface, eg a galvanised cable tray or corrugated sheeting, subject to dampness.

iii) They are buried direct in the ground or in the fabric of the building.

iv) Other locations which may cause corrosion.

103 The colours grey or black may be used for the LSF outer covering in place of the standard colour orange subject to approval.

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104 The colour red shall be used for the LSOH outer sheath of all fire alarm wiring applications.

105 The colour white shall be used for the LSOH outer sheath of all emergency lighting wiring applications.

106 The method of termination shall be by means of the cold screw-on pot type seal and universal brass gland to the manufacturer's recommendations. LSF sleeves shall be used on the conductor tails, for identification purposes and LSOH shrouds over glands shall be provided when LSF covered cables are used.

107 Where cables are installed in a flameproof area the glands shall be of flameproof type.

108 Cable ends shall not be left unsealed at any time during installation.

109 Saddles and clips may be metal or non-metallic. Where cables have a LSOH outer covering, plastic or metal saddles with a LSOH covering shall be used. Saddles and clips shall be spaced at not more than 300mm apart.

110 Cables shall be run at least 150 mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose conductors shall be kept to the minimum.

111 A loop shall be introduced in a cable immediately before its entry into equipment subject to vibration or occasional movement. A clear space of at least 10mm shall be maintained at the point in the loop where the cable passes over itself.

112 Tools of a design approved by the cable maker shall be used for manipulation and termination of cables.

113 Where a cable buried in concrete crosses an expansion joint in a building the joint shall be wrapped with waterproof building paper for a distance of 300mm on each side of the joint.

114 Where cables pass through walls or floors, they shall be protected by a length of conduit fitted at both ends with female brass bushes and fire sealed for 2 hours resistance.

115 A cable buried direct in the ground shall be laid on and covered by 25mm of sand or earth passed through a 6mm sieve and protected by interlocking cable covers.

116 Cables emerging from the ground or floor shall be protected adequately from mechanical damage up to a height of 1200mm. The protective enclosures, which may be heavy gauge galvanised conduit for single or multicore cables, or a galvanised channel for groups of cables, shall be bonded to the cable sheath and securely fixed to the building fabric.

Cable Joints and Terminations

117 No cable shall be cut or prepared until such time that jointing or terminating commences. The work shall then continue until the joint or termination is complete. The materials to be used shall be proprietary for the type of cable to be jointed or terminated and the system adopted shall be consistent throughout all cable runs.

118 Where circumstances prevent completion cable ends shall be hermetically sealed.

119 All necessary precautions shall be taken to prevent damage, the ingress of water and impurities.

120 Cable ends shall be free from moisture before jointing commences.

121 Core identification shall be matched at the joint without twisting or crossing of cores occurring.

122 For joints in armoured cables, bonding conductor straps shall be connected across the armouring.

123 A proprietary protective ferrule shall be placed under the armouring to prevent deformation of the cable by the clamp.

124 At terminations, armouring and metal sheaths shall be connected directly to the external earthing terminal of the equipment, where applicable, by a bonding conductor.

125 Metal sheaths of single core cables, when used, shall be bonded and earthed at one point only.

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126 At terminations cable tails shall be formed by separating the cores. Each tail shall be long enough to connect to the terminal without strains being placed on gland plates or similar where provided.

127 Continuity of spare cores shall be maintained at joints and at terminations the spare core/cores shall be connected to spare terminals.

128 The location of any underground joint shall be marked as defined in Series 7104.

129 Where joints are enclosed in brass sleeves and are buried in the ground, the ends of the sleeve shall be plugged with filling compound before the glands are screwed onto the sleeves.

130 All cables shall be delivered to site with makers' seals and test certificates intact.

131 The insulation resistance of all seals shall be checked as they are completed. The resistance shall be not less than 100 m W in all instances. Any cables failing this test shall be resealed.

Installation of Wiring Cables in Conduits and Trunking

132 Cables shall be drawn into conduits/trunking only after the conduits have been finally fixed, de-burred and cleaned out.

133 Where cables emanate from separate distribution boards or serve different parts of an installation, for each system shall be in separate conduit or trunking unless otherwise indicated.

134 When trunking or adaptable boxes are separated by compartments, cables for differing services can be installed in the same trunking or box providing the different services are run in separate compartments.

135 Through joints in cables will not be permitted. Cables shall be looped from connection point to connection point.

136 At conductor terminations, cable insulation shall be neatly removed without damaging conductor strands and the conductors shall be tightly twisted and where space is available in the termination, doubled back.

137 Bare conductors shall not be terminated such that they project beyond any insulated shrouding or mounting of a terminal.

138 Single phase conductor insulation shall be coloured red for phase conductor and black for neutral conductor.

139 Conversion from single core cables to flexible cords shall be made by means of a fixed base connector in a conduit or similar box except where the flexible cord emanates direct from a switch, or similar fixed connector accessory.

140 Flexible cords shall not be installed in a manner such that they are dependent upon the electrical connections for mechanical retainment.

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A7104. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

HV/LV CABLES AND DISTRIBUTION	
BS 3573	Polyolefin copper conductor telecommunication cables
BS 4808	LF cables and wires with PVC insulation and PVC sheath for telecommunication
BS 5425	Coaxial cable for wideband distribution systems
BS 5467	Cables with thermosetting insulation for electricity supply for rated voltages of up to and including 600/1000V and up to and including 1900/3300V
BS 6004	PVC insulated cables (non-armoured) tor electric power and lighting
BS 6007	Rubber insulated cables tor electric power and lighting
BS 6081	Terminations for mineral insulated cables
BS 6121	Mechanical cable glands
BS 6207	Mineral insulated copper sheathed cables with copper conductors
BS 6346	PVC insulated cables for electricity supply
BS 6469	Insulating and sheathing materials of electric cables
BS 6480	Impregnated paper insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33000V
BS 6500	Insulated flexible cords and cables
BS 6622	Cables with extruded cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3800/6600V up to 19000/33000V
BS 6724	Armoured cables for electricity supply having thermosetting insulation with low emission of smoke and corrosive gases when affected by fire
BS 6746	PVC Insulation and sheath of electrical cables
BS 6910	Cold pour resin compound and heat-shrink cable joints in the voltage range up to 1000V ac and 1500V dc
BS 7211	Thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire
BS 7671	Requirements for electrical installations (The IEE Wiring Regulations 16th edition)
BS 2G 210	PTFE insulated equipment wires and cables, single and multicore with silver plated copper conductors (190°C) or nickel plated copper conductors (260C)
MCG 1022	Testing tor Newly Installed Communications Cable
MCG 1055	Testing tor Newly Installed Optical Fibre Cable
EIA/TIA-568(A)	Standard ‘Commercial Building Telecommunications Wiring Standard’
TR 2029	Inductive Loop Cable tor Vehicle Detection Systems

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HV/LV CABLES AND DISTRIBUTION	
TR 2031	Armoured Feeder Cable for Inductive Loop Systems
TR 2157	NMCS Armoured Cables Standard Materials and Procedures
TR 2158	NMCS Armoured Copper Communications Cable
TR 2159	NMCS Armoured Optical Fibre Communications Cable
TR 2160	NMCS Armoured Coaxial Communications Cable
	CABLE SUPPORT COMPONENTS
BS EN 10142	Continuously hot dip zinc coated low carbon steel sheet and strip for cold forming: technical delivery conditions
BS EN 10143	Continuously hot dip metal coated steel sheet and strip: tolerances on dimensions and shape
BS EN 10147	Continuously hot dip zinc coated structural steel sheet and strip. Technical delivery conditions
	CONDUIT AND CABLE TRUNKING
BS 31	Steel conduit and fittings tor electrical wiring
BS 381C	Colours for identification coding and special purposes
BS 731	Flexible steel conduit for cable protection and flexible steel tubing to enclose flexible drives
BS 2994	Cold rolled steel sections
BS 3382 Parts 1 & 2	Electroplated coatings on threaded components Cadmium on steel components. Zinc on steel components
BS 4345	Slotted angles
BS 4568	Steel conduit and fittings with metric threads of ISO form for electrical installations
BS 4607	Non-metallic conduit and fittings tor electrical installations
BS 4678	Cable bunking
BS 6099	Conduits for electrical installations l
BS EN 10142	Continuously hot dip zinc coated low carbon steel sheet and strip tor cold forming: Technical delivery conditions
BS EN 10143	Continuously hot dip metal coated steel sheet and strip: tolerances on dimensions and shape
BS EN 10147	Continuously hop dip zinc coated structural steel sheet and strip. Technical delivery conditions
BS EN 60529	Degrees of protection provided by enclosures (IP code)

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Sample Appendix A7104/2: HV and LV Cabling distribution

The Contractor shall insert below details of the equipment proposed.

Item No:	Description	Detail
1	Type of cable	
2	Manufacturer of cable	
3	Type of cable terminations	
4	Manufacturer of cable terminations	
5	Manufacturer of cable supports	
6	Manufacturer of trunking and fittings	
7	Protection against corrosion	
8	Manufacturer of conduit and fittings	
9	Protection against corrosion	
10	Manufacturer of cable tray and fittings	
11	Type and manufacturer of cable ducts	
12	Type and manufacturer of cable joints and terminations	
13	Manufacturer of cable warning covers	

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7105. STANDBY GENERATORS

General

1 Standby generators shall be suitable for use on HV or LV 3 phase 50Hz systems and for the site operating conditions relating to altitude and maximum and minimum ambient temperatures. The prime mover for standby generators shall be normally a reciprocating internal combustion engine, although for high standby power loads or other special circumstances other prime movers such as gas turbines may be considered. The type of fuel for the standby generating system shall be diesel fuel.

2 The engine and generator shall be mounted on a welded steel common skid/bedplate. Where flange mounted generators are not employed, the bedplate shall be stress relieved before machining.

3 All exposed moving parts of the engine, alternator and ancillaries shall be fully guarded so as to prevent accidental contact by personnel. The guards shall be securely fixed and so constructed as to be readily removable to facilitate inspection and maintenance.

4 The rotating system of the engine, alternator and ancillaries shall, as a unit be statically and dynamically balanced during manufacture to reduce out of balance forces to a minimum.

5 Flexible connections shall be provided to all exhaust, air, fuel and water piping to avoid fracture due to vibration and to minimise conduction of noise.

6 All flexible pipework shall be capable of withstand a temperature of 1000°C for a 5 minute period without failure.

7 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Engine

8 The engine selected shall be capable of providing continuously at site not less than the specified output and an overload of 10% in excess of this output for one hour in any twelve hour period at the rated voltage and frequency.

9 Diesel engines as the prime mover may be naturally aspirated or turbocharged. Engines may be water or air cooled.

10 Safeguards appropriate to the engine type shall be provided and arranged to stop the engine automatically by de-energising a solenoid coupled to the stop lever on the fuel line. The operation of this safeguard shall at the same time give individual warning of the failure by illuminating an appropriate visual indicator. The safeguards shall operate when any of the following conditions occur, irrespective of whether the set is on automatic or manual control:

i) Engine overspeed

ii) High cooling water temperature

iii) Low lubricating oil pressure

iv) Overload

v) Underspeed

vi) Fail to start

vii) Low coolant level

viii) Operation of an emergency stop button

11 The normal speed of the engine shall be 1500 revolutions per minute, governing shall be:

i) Steady state speed band
- nominal 1%

ii) Transient frequency change on application of rejection
- nominal ± 10% of 60% load

iii) Recovery time to steady state speed band on application of b)
- 10 seconds

iv) Maximum speed drop
- 5%

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Generator

12 Generators shall be brushless, salient pole, revolving field self regulating type with a screen protected and drip proof enclosure.

13 LV generators shall be wound for a 3 phase, 4 wire, star connected output at 50Hz with an earthed neutral and shall have a continuous maximum rating as stated with phase rotation and waveform as stated in the contract specific documentation. The generator shall be continuously rated and shall be capable of providing 110% of full load for one hour in any twelve hour period. The generator shall be capable of supplying its rated output at a power factor of 0.8 lagging.

14 The operation of an automatic or manual start shall initiate the starting of the set which shall run up and attain 75% full power in 3 seconds and 100% full power in 10-15 seconds from initiation of the starting sequence when starting from cold at a minimum air temperature of -15°C.

15 The generator shall be capable of carrying 2.5 times its full load current for 3 seconds without damage to any part.

16 The neutral point of the star connected winding shall be brought out and terminated in a mains terminal box mounted on the stator frame. The box shall be suitable for the termination of the specified outgoing cables.

17 Generators shall be capable of accepting up to 70% of their full load output in one step.

18 The generator shall be complete with all necessary cooling fans, excitation and voltage regulating equipment.

Anti-Vibration Mountings

19 Robust anti-vibration and shock absorbing devices of an approved pattern shall be fitted between the main frame and floor/base unit. They shall have adjusting screws for optimum setting and levelling and be so designed and installed that no appreciable engine vibration shall be transmitted to the floor or to any surroundings.

20 The anti-vibration mountings shall be designed to prevent movement across the surface of the floor when the engine is running.

Cooling System

21 Water cooled engines shall be by water jacket, with water circulating pump and heavy duty local or remote radiator with mechanically or electrically driven fan. The radiator shall be fitted with flanges or other suitable arrangement to enable ventilating ductwork to be attached with airtight joints. The fan rating shall be adequate to overcome the resistance of the attenuators, ductwork and louvres.

22 The cooling equipment shall be composite with the engine, and be complete with all pipework, valves, sensing devices and expansion tanks.

23 A thermostatically controlled valve shall be provided in the cooling system to assist rapid heating up the water in the engine jacket when starting from cold and to control its temperature when the engine is running. Where necessary to limit the oil temperature rise a water-cooled lubricating oil temperature stabilizer shall be incorporated in the engine cooling system. Sufficient inhibitor shall be added to the cooling water to protect the cooling system from internal corrosion.

24 Thermostatically controlled immersion heater(s) of an approved type and suitable for operating on the mains supply shall be installed and connected in the cooling water circuit, with suitable ‘ON/OFF’ control switches mounted on the main panel. The heater(s) shall be capable of maintaining the whole of the cooling water system at a minimum temperature of 10°C with an ambient temperature of -15°C.

25 Anti-freeze to the manufacturer’s recommendations shall be mixed with the cooling water to a percentage of 40% anti-freeze.

26 Visual indicators shall be provided on the main control panel and be illuminated when the immersion heater control switches are in the ‘ON’ position. Heaters shall be easily removable for replacement.

Fuel System

27 The storage of the various fuels shall comply with the local authority requirements.

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28 Bulk storage fuel tanks for oil to provide 7 days running of the set(s) at full load shall feed a daily service tank above or adjacent to each generator set sized to provide an 8 hour continuous running capacity. Transfer of the fuel from the bulk storage tank shall be automatic with manual back-up facilities. Automatic transfer shall be by gravity or electric pump controlled by means of float switches in the daily service tank and electrically actuated solenoid valves in the supply pipeline. Fuel filters (dual in line) with disposable filters shall be provided within the pipeline. Manual transfer shall be by hand operated gate valve and level indicator in the daily service tank. Float switches in the daily service tanks shall have the facility to initiate low and high level alarms and to close a second solenoid valve should the primary valve fail in the open position. For automatic electric oil pumps semi-rotary hand pumps shall be provided in parallel to allow manual transfer in the event of pump failure.

29 Bulk storage and daily fuel tanks shall be of welded steel construction. Tanks (and support frames if used) shall be treated with a rust inhibiter and finished with coats to match the other equipment. Tanks shall have the following fittings:

i) bolted manhole

ii) fill socket

iii) vent complete with flame/anti-flash gauze

iv) socket for drain valve

v) socket for outlet connection

vi) lifting lugs

vii) spill return connection if required

viii) tank contents gauge mounting and sender unit for remote location of gauge in fill panel.

xiv) label to state manufacturer's name and address, tank contents, year of manufacture

30 Bulk tanks shall be capable of withstanding 0.6 bar gauge air pressure for 1 hour.

31 Test certificates shall be submitted before the tank is delivered to site.

32 Lockable fuel fill point cabinets shall be provided for fuel transfer from road tankers and should contain the following items:

i) fill point valve with cap and chain and drip tray

ii) contents dial gauge, marked in litres with the 'full' and 'empty' content positions marked

iii) overfill alarm to consist of audible and visual alarm to warn of overfilling of bulk tank.

Dump Tank

33 Dump tanks to take the full capacity of the daily service tanks when jettisoned in the event of a fire shall be located externally to the engine room or underground and be complete with the following fittings:

i) suction drain

ii) jettison connection

iii) vent connection

iv) access manhole with bolted cover

v) lifting lugs

34 The tank finish shall be as specified for the bulk and daily service oil tanks.

Sump Unit

35 Where specified a sump unit shall be installed within the stand-by generator room. In the event of a fuel spill the float switch will trigger a solenoid quick release mechanism and free fall fire valve.

Fire Valve

36 A free fall fire valve shall be installed in the gravity fuel supply line between the bulk fuel tank and daily service tank.

37 The fire valve set shall comprise the valve plus stainless steel cables, fusible link, pulleys, warning notices, solenoid quick release mechanism and manual quick release mechanism. On activation of the fusible link the valve should stop the flow of fuel from the bulk tank shut down the generator set and dump the fuel to an exterior dump tank.

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38 An interface terminal box for collecting the solenoid quick release mechanism initiation signals shall be provided (ie for interface with fire alarm system).

39 All wiring between the terminal box (if remote to the generator) and generator/solenoid quick release valve shall be the responsibility of the generator supplier.

Lubrication System

40 Lubrication shall be by means of an engine-driven integral pump. The pump shall have on the suction side a coarse strainer and on the delivery side a dual 'full flow' filter complete with changeover cock incorporating pressure bypasses to facilitate oil flow to the engine should the filter become blocked. The lubricating oil system capacity shall be sufficient to enable the engine to run continuously for twelve hours at any load without replenishment.

41 A lubricating oil lever dipstick suitably graduated and oil drain valve shall be provided and located in an accessible position. Suitable means shall be provided for turning by hand the engine main shaft bearing gear and the associated alternator to facilitate inspection and overhaul.

Starting System

42 Engine starting shall normally be automatic in the event of mains failure and shall be effected by batteries or compressed air electric motors.

43 Battery starting shall be by electric starter motor complete with starting and sequencing control equipment and starter cut-out switch. The engine starting control cubicle equipment shall be arranged to disconnect the mains operated battery charger to prevent its being overloaded during starting. The starter motor shall be of adequate power for its duty and of 'non-hold-on' type in which the pinion is moved axially to engage within a gear-ring on the engine flywheel before the starter motor is fully energised. The pinion shall positively disengage when the engine starts or when the motor is de-energised.

44 The starting equipment shall incorporate a suitable automatic cut out relay so arranged that, if the engine fails to start within a reasonable time (eg 10 seconds) the starter motor shall be disconnected. The starting attempt shall be repeated after an interval of 10 seconds and, if necessary, repeated. If the engine fails to start after a minimum of five attempts, the starter motor shall be automatically isolated from the battery. An ambient temperature of -15°C shall be assumed for starting purposes.

45 Disconnection of the starter by the fail-to-start device shall operate visual warning indicators and remote alarms.

46 Batteries for starting purposes may be of the alkaline or sealed lead acid type and shall be heavy duty, high performance suitable for trickle or rapid charging where appropriate and supplied complete with electrolyte. Battery cells shall be contained in a robust housing fitted with an insulated cover to protect the terminals and connectors. The battery shall be supplied in a fully charged state ready for use and shall be complete with hydrometer for testing the electrolyte.

47 The battery shall be of sufficient ampere-hours capacity to provide five consecutive starts of the engine.

48 The battery charger shall be of the static type employing semi-conductor rectifiers, the whole being enclosed in an adequately ventilated enamelled corrosion resistant sheet steel case of an approved type, having a front control panel. The unit shall be arranged for either wall of floor mounting, or may be included in the above metal case, within the main control panel.

49 The charger shall be connected to the mains supplies via a protective device shall have an indicator to show when the charger is switched on.

50 The charger shall be of the constant voltage type, complete with all necessary relays, cut-outs, controls, switches and instruments, including an ammeter, suitably scaled to indicate clearly the charging rate over the whole range of charge of the battery, and shall be connected to the battery in an approved manner. The equipment shall be of adequate charging capacity in relation to battery size and shall at all times monitor the battery condition and automatically control the charging rate to suit the state of the battery, maintaining it in a properly charged condition when not in use.

51 Following a period of use the charger shall automatically recharge the battery in the shortest practicable time consistent with battery welfare, and the size and output of the charger shall be sufficient for this purpose.

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52 Compressed air starting shall be by an air receiver having a capacity sufficient to enable the engine to be started for a minimum of five times without re-charging.

53 The receivers shall be designed for free standing at floor level and to permit drainage, operation of all valves, inspection and cleaning.

54 The receivers shall be supplied complete with pressure gauge, isolating valves, water drainage facilities and high pressure relief.

55 Two adequately rated air compressors of heavy duty design shall be provided. Compressors shall be of identical design to provide interchangeability of spares.

56 One compressors shall be driven by an electric motor the second driven by a diesel or petrol engine and rated to charge the air receivers to full working pressure capacity in not more than a period of 15 minutes.

57 The compressors shall be air cooled and shall be supplied complete with all accessories to form complete working units.

58 The electric motor driven compressor shall be arranged for automatic operation and shall be equipped with a pressure sensing device with adequately rated contacts for operation of the associated contactor starter.

59 All air piping, valves, drains, gauges, fittings and all other material to connect the air receivers to the engine and also the air receivers to the air compressors shall be provided.

Exhaust System

60 The exhaust system shall comply with the noise criteria stated in the contract specific documentation when the generator is run at full load or part load.

61 The first section of the exhaust system, after leaving the engine manifold, shall include a flexible section to absorb thermal expansion and stresses due to engine movement.

62 The main section of exhaust which contains the silencer shall be supported using spring hangers, roller brackets or similar to allow for expansion of the pipe.

63 Where the exhaust pipe passes through external wall the builder's work hole shall be sleeved. Thermal and acoustic insulation and wall plates shall be fitted as necessary to maintain the specified noise criteria and prevent thermal or movement damage to the structure.

64 Suitable thermal insulation shall be applied to the exhaust system to minimise heat gains into the generator room and for personnel safety.

65 All exhaust ductwork shall be constructed of corrosion resistant materials.

Voltage Regulation

66 Automatic voltage regulation equipment responsive to the generator line to line voltage and loading conditions shall be provided to maintain the generator voltage within ± 2.5% under all conditions of load, power factor and temperature including cold to hot variation.

Noise Emission

67 The standby generator installation shall comply with the specified noise emission criteria but not to exceed 80dBA at 1 metre from the generator when running on full or part load.

68 Where required air intake and discharge attenuators in the form of silencer ducts with louvres, splitters, acoustic lagging and linings shall be provided.

69 Intake and extract louvres shall be compete with interlocked motorised dampers to automatically open on generator start up.

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Control Equipment

70 The engine control panel may be set mounted or free standing or the engine and generator controls may be combined in a separate panel to provide the following minimum facilities:

i) Switched ammeter

ii) Switched voltmeter

iii) Wattmeter

iv) Frequency meter

v) Battery charger ammeter

vi) Selector switch (manual/off/auto)

vii) Engine start push button

viii) Raise/lower speed switches

ix) Engine emergency stop push button

x) Fault reset push button

xi) Water temperature gauge

xii) Oil temperature gauge

xiii) Oil pressure gauge

xiv) Tachometer

xv) Hours run meter

xvi) kW hour meter

xvii) Turbo charge air pressure

xviii) Lamp test facility

71 Indication lamps for:

i) Failed to start

ii) High water temperature

iii) Low coolant level

iv) Low oil pressure

v) Overspeed

vi) Engine running

vi) Fault shut down

vii) Battery low/high voltage

72 Volt free contacts wired to a terminal rail shall be provided for:

i) Engine fail to start

ii) Low oil pressure

iii) High engine temperature

iv) Overload

v) Engine running

vi) Low fuel level in daily service tank

vii) High fuel level in daily service tank

viii) Low fuel level in main tank

ix) Overflow from main tank

73 The panels shall incorporate all electrical protection, circuit breakers, switches, fuses, relays and distribution equipment to form a complete control unit as specified.

74 Control panels shall generally conform to the requirements of Series 7103 of this Specification.

Parallel Running

75 Where stated in the contract specific documentation an automatic scheme of synchronising shall be provided.

76 The voltage and frequency for all sets must be the same.

77 Automatic synchronisers shall be designed to bring an incoming generator into acceptable conditions, both of voltage and speed and then to initiate a pulse of sufficient duration to close the generator circuit-breaker.

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78 The limits within which the incoming and running voltages are considered matched shall be adjustable up to a maximum of 10% difference.

79 Synchronising shall be inhibited when the phase angle exceeds 30°, but alternative settings of 15° and 45° shall be available.

80 Closure of the circuit-breaker shall also be prevented if the slip exceeds a setting which shall be adjustable over the range 0.1% - 1.5%. The frequency control relays shall be arranged to control the incoming frequency when this reaches 40 - 45Hz.

81 The unit shall provide a 'close' pulse of at least 350ms duration to close the circuit-breaker, followed by a lock-out to prevent further operation.

82 The automatic synchronising equipment shall be designed so that it will not initiate closure of the circuit-breaker if either synchronising voltage or any auxiliary supply is absent. The burden imposed on either the running or incoming supply shall not exceed 5VA.

83 In addition to the auto-synchronising equipment, one set of manual synchronising instruments shall be supplied comprising incoming and running voltmeters, synchroscope, frequency meter, set of lamps for synchronising, and all necessary plug selectors etc.

On-Load Testing

84 Where stated in the contract specific documentation an externally located load bank shall be provided to facilitate on-load testing to enable the generator set to be tested up to 110% of its full load rating at power factors between 0.8 and unity in accordance with Series 7300.

85 The load bank shall be manually switched between no-load and maximum load with the generator connected to the bank.

86 All parts of the load bank operating at temperatures in excess of ambient shall be shielded. Fans required to assist with ventilation of the load bank shall automatically be engaged when the load bank is connected.

Spares and Tools

87 A complete set of good quality tools complete with case hardened spanners, to fit and provide access to every nut and bolt head of the equipment, contained in a wall-mounted lockable sheet steel cabinet, shall be provided and located in the plant room. The manufacturer shall list the tools that he proposes to supply.

88 The manufacturer shall supply one spare set of fuel, oil and air filters, one alternator voltage regulator, one set of rotating diodes, and one set of spare lamps. The manufacturer shall provide a wall mounted lockable steel cabinet to accommodate these spares which shall be located in the plant room.

89 All spare parts of the same type must be interchangeable and suitable for use in place of the corresponding parts supplied as part for the works. They shall comply with the specification and must be suitably marked for identification and prepared for storage by greasing or painting to prevent deterioration.

Warning Labels and Information

90 A non-ferrous metal plate shall be securely fixed to the engine alternator unit giving the attenuator specification.

Finish

91 Diesel generator sets shall be finished to an industrial quality and unless otherwise stated to the specialist manufacturer's standard colour.

92 The control panel shall be finished to the specialist manufacturers standard colour internally and externally.

93 Any damage to the print finish which may be occasioned during transportation, off-loading or erection, shall be made good without.

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A7105. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

STANDBY GENERATORS	
BS 89	Direct acting indicating analogue electrical measuring instruments and their accessories
BS 142	Electrical protection relays
BS 587	Motor starters and controllers
BS 775	Contactors
BS 800	Limits and methods of measurement of radio interference characteristics
BS 4999	General requirements for rotating electrical machines
BS 5000	Rotating electrical machines of particular types or for particular applications
BS 6290	Lead-acid, stationary cells and batteries
BS 6413	Lubricants, industrial oils and related products
BS EN 60269	Cartridge fuses tor voltages up to and including 1000V ac and 1500V dc
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 60622	Sealed nickel cadmium prismatic rechargeable single cells
BS EN 60623	Vental nickel cadmium prismatic rechargeable single cells
BS EN 60947	Low voltage switchgear and control gear
BS EN 60947-2	Circuit breakers
BS EN 60947-3	Switches, disconnectors, switch disconnectors and fuse combination units

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Sample Appendix : A7105/2 : Standby Generators

The Contractor shall insert below details of the equipment proposed.

Item	Description	Detail
1	**ENGINE**	
	Manufacturer	
	Rated kW	
	Method of starting	
	Recommended fuel	
	Injector manufacturer and type reference	
	Fuel consumption lts/hrs of generator at full load at ¾ full load at ½ full load	
	Type and grade of recommended lubricating oil	
	Lubricating oil consumption at full load of generator	
	Overload capacity on continuous rating	
	Cooling system control - type and reference, total coolant capacity	
	Time in seconds from start before the following percentage of load can be carried: 25% 75% 50% 100%	
	Aspirated air	
	Heat radiated from engine carcass	
	Water circulation rate required by engine heat exchanger and intercooler	
	Water circulation rate required by engine heat exchanger	
	Maximum temperature of water required by engine heat exchanger	
	Maximum water pressure acceptable by heat exchanger	
	Maximum ambient temperature at which rated output will be achieved	
	Schedule of recommended maintenance and overhaul periods	

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Item No:	Description	Detail
	Cooling air requirements	
	Combustion air	
2	**GENERATOR**	
	Manufacturer	
	Type reference	
	Excitation	
	Class of insulation	
	Response times	
	Heat radiated from AC generator	
	Efficiency at full load at ¾ full load at ½ full load	
3	**VOLTAGE REGULATOR**	
	Manufacturer	
	Type	
	Reference	
4	**STARTER BATTERY**	
	Manufacturer	
	Type and reference	
	Voltage	
	Ampere-hour capacity at ½ hour rate of discharge	
5	**CHARGER**	
	Manutacturer and type reference	
	Type of rectifying element employed and manufacture	
6	**CONTROL PANEL CUBICLE**	
	Manufacturer	
	Air circuit breaker & MCCB manufacturer(s) and type(s)	
	Fuse switch and isolator manufacturer(s)	
	Contactor manufacturer(s) and type(s)	
	Relay manufacturer(s) and type(s)	

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Item No	Description	Detail
	Timer manufacturer(s) and type(s)	
	Instrument manufacturer(s)	
	Overall dimensions	
	Weight	
	Assigned through-fault capacity in MVA to the main side of the panels	

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7106. UNINTERRUPTIBLE POWER SUPPLY EQUIPMENT

General

1 This Specification covers the requirements for uninterruptible power supply (UPS) units which may be used to supply the emergency lighting within the tunnel, essential communications and fire brigade, traffic signal and control equipment to provide continuous, transient-free power not susceptible to voltage or frequency variations or loss of the normal mains supply. The UPS shall be permanently connected to such essential loads at the main LV switchboards.

2 The UPS shall be rated for continuous duty and shall have the phase and voltage inputs and outputs as specified. Unless otherwise stated in the contract specific documentation the UPS shall be capable of supplying the continuous local for a minimum period of 2 hours or until the standby generators system has run-up and taken up the essential loads.

3 Static UPS systems shall include a fully rated rectifier/battery charger and inverter, maintenance free sealed lead-acid or nickel cadmium batteries, static 'no-break' bypass switch, maintenance bypass switch, system metering, controls and alarms.

4 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Enclosures

5 Enclosures for UPS units shall be of rigid steel construction, free standing and floor mounting type and, unless otherwise indicated, and shall have a minimum degree of protection IP31. They shall be rodent proof and permit adequate ventilation. Enclosures and the installation arrangement shall permit reasonable access to all components for inspection, maintenance and replacement. Full size lockable doors shall be provided to parts requiring regular access.

6 Adequate shielding shall be provided to prevent inadvertent contact with internal live parts and all live parts warning labels shall be clearly visible when any of the enclosure doors are opened.

7 All steel shall be chemically cleaned and treated to prevent moisture and rust under the paint film. The steel work shall undergo a process of chemical spray degreasing, iron phosphating coating, automatic electro-static epoxy polyester film application and shall be cured in a high temperature control oven. Unless otherwise indicated, the colour of the final coat shall be the manufacturer's standard.

8 Enclosures shall be provided with adequate ventilation to ensure components are operated within the specified environmental ratings. Where forced ventilation is necessary, at least two fans per enclosure shall be provided on a separate circuits and the equipment shall be capable of operating at the specified load with one fan out of operation. The failure of any fan shall initiate an audible and visual alarm.

Isolation and Fault Protection

9 Each UPS unit shall be provided with a lockable (in 'off' position) mains input circuit breaker or switch disconnecter which shall be accessible from the front of the unit without the need to open the enclosure doors.

10 Switch disconnectors and circuit breakers shall comply with the clauses in 7103 of this specification.

11 UPS equipment shall incorporate protection against damage resulting from:

i) Input over voltage and under voltage surges.

ii) Output over voltage and under voltage surges.

iii) Sudden changes in output load.

iv) Internal electrical faults and failures.

12 The units shall be continuously rated to supply 100% of their rated load at the output terminals as specified. The units shall be capable of supplying 125% of its rated load for not less than 10 minutes whilst maintaining rated voltage at the output terminals. The units shall be capable of accepting current surges when lighting is switched on without going into the by-pass mode.

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13 The units shall maintain full output voltage up to 150% of their rated power. Above 150% of full system output power the UPS output voltage shall be reduced to prevent the total current exceeding 150% of the rated figure.

14 Operation of an internal circuit protective device shall initiate an audible and visual alarm.

Components

15 All components and conductors within the equipment enclosure, which remains at a potential above 50v AC or 120v DC when the equipment is switched OFF, shall be screened to prevent inadvertent contact and be adequately labelled.

16 Contactors shall comply with the appropriate utilisation category for uninterrupted duty.

17 Logic and control circuits shall be on readily replaceable printed circuit cards. Mechanical interlocks shall prevent incorrect insertion of plug-in printed circuit cards, and electrical interlocks shall prevent system operation if any of the cards are not fitted.

18 Capacitors shall consist of an assembly of Individual low Los, metallised film power capacitor elements incorporating discharge circuits housed in a steel enclosure complete with Main terminals.

Cable Entries

19 Cable entry enclosures shall be as indicated in the contract specific documentation. Removable undrilled gland plates shall be provided at cable entry points.

Acoustic and Electromagnetic Emission

20 Unless otherwise indicated, noise emission from the UPS equipment shall not exceed a sound pressure level of 50dB(A), measured at a distance of one metre from any surface of any enclosure.

21 The high frequency electromagnetic interference generated by the UPS equipment shall not exceed the levels required by the appropriate standards specified.

Fault Indication

22 A comprehensive system of indicators shall be incorporated in the UPS equipment for diagnosing faults and for assisting in the commissioning procedure, as stated.

Detail Plates and Labelling

23 Detail plates shall be fixed on the UPS equipment enclosures giving the following information:

Max continuous output	- kW - kVA
Voltage	- phase - wire
Frequency	- Hz
Maker's name	Maker's serial no.
Total weight	Year of supply

24 Each major component within the UPS unit shall be labelled with its duty and rating. Items operated or viewed externally shall be labelled on the outside face of the unit. Components fitted within the unit shall be labelled internally.

25 A clear external warning notice shall be provided indicating that several electrical sources and incoming supplies are present within the panel and what appropriate action shall be taken to completely isolate the switchboard. An additional warning notice shall be provided over terminals of incoming supplies indicating procedure for isolation and safety.

Rectifier and Battery Charger

26 The rectifier of a UPS unit shall be continuously rated to supply the rated load of the unit plus the maximum current necessary for battery charging.

27 The rectifier shall be of the constant potential type and fitted with current limiting devices to prevent excessive charging of a fully discharged battery. It shall have the necessary full wave bridge rectifiers, surge suppression, control and indication equipment to provide float and boost charge. The boost charge shall be voltage monitored and controlled, ie., auto switched 'ON' and 'OFF'. It shall also be possible to initiate the boost charge manually but with a variable timed switch off. A facility shall be provided inside the cubicle so that boost charge can be disabled if required.

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28 The levels of individual harmonic currents taken from the supply by the UPS equipment shall not exceed those given in the specified standards, the point of common coupling being regarded as the input terminals of the UPS equipment.

29 Where an input filter is used to limit the harmonic currents taken from the supply, the design shall minimise the possibility of resonance with any power factor correction capacitors incorporated in the UPS equipment. The filter design shall also ensure that the filter does not draw excessive harmonic currents from the supply due to harmonic voltages having values up to the limits given in the specified standards.

30 The battery charging regime shall be current limited constant voltage, provided either from the rectifier or from a separate battery charger. The current limit and flat voltage values shall not exceed the battery manufacturer's recommendations.

31 Over voltage protection, over current protection and charger failure detection shall be provided on the battery charging system. Operation of any protection or detection circuit shall initiate an audible and visual alarm. Volt free contacts shall be provided for remote monitoring.

32 Where the batteries of the DC supply are not connected to earth or to an earthed system, a DC earth fault indicator and alarm shall be provided.

33 The battery charger shall be capable of performing the duty as stated in the contract specific documentation. The battery rms ripple current, in amperes, shall not exceed 7% of the battery 3 hour ampere-hour capacity during recharge or float operation.

34 Where the battery charger is separate from the rectifier, it shall be provided with a lockable mains input circuit breaker with adjustable overload and over current protection.

Batteries

35 Unless otherwise indicated, the batteries shall be maintenance free lead acid sealed recombination or low maintenance valve regulated gas recombination nickel cadmium type with cell containers designed to withstand shock and vibration and shall have a design life of at least 10 years and 20 years respectively during which time the capacity should not drop below 80% of the rated capacity.

36 Lead acid cells shall have a nominal voltage of 2 volts and nickel cadmium a nominal voltage of 1.2 volts.

37 The battery shall be supplied housed within a ventilated acid resistant enclosure or installed on multi-tier free standing modular steel or hard wood stands with adjustable bases for uneven floors. Both the enclosure and racks shall be finished as Series 7106 of this specification. The battery shelf or shelves shall be of robust construction and rigidity to withstand the weight of the cells without bowing. The height between shelves shall be such that free access is given to all cells and connections for the purpose of maintenance and testing.

38 Batteries shall be placed on the racks and within the enclosures to allow easy replacement and maintenance of individual cells.

39 The batteries shall be designed to provide the full load for the standby duration as specified.

40 Batteries shall have resealing, safety release valve set at 0.35 bar to release pressure in the event of severe overcharge. The valve shall incorporate a flame retardant barrier.

41 Containers and lids shall be hermetically sealed and of robust construction capable of withstanding 2 bar of internal pressure without container deflection of over 0.5mm.

42 Batteries shall have high conductivity brass core terminal pillars and be connected in parallel strings. Intercell connections and output terminals shall be shrouded with impact resistant plastic to prevent inadvertent contact.

43 The positive and negative connections points of all cells/blocks shall be clearly labelled as follows:

Positive	-	Red marker and '+'
Negative	-	Black marker and '-'

44 The manufacturer's name and the date of manufacture of all cells/blocks shall be clearly and permanently displayed.

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45 The battery and charger system shall be capable of performing the following duty cycle:

i) Discharge at specified UPS output power for the period of autonomy indicated.

ii) Recharge for a period of three hours.

iii) Discharge at a specified UPS power for a period equal to 80% of the period of autonomy indicated.

46 A DC circuit breaker with overload, over current and earth fault protection shall be provided for the supply from the battery. The circuit breaker shall be mounted in an accessible position either on the battery rack or within the battery enclosure accessible without opening the enclosure door.

Static Inverter

47 The inverter shall comprise power transistors connected in bridge formation, together with the associated commutation, firing, smoothing circuits and electronic voltage and frequency regulation, such that the output characteristics specified are complied with.

48 The inverter shall be capable of supplying an overload current of 150% of its full-load rating for 60 seconds and 125% for 10 minutes whilst maintaining rated voltage at the output terminals. For greater currents on longer time duration, the inverter shall have current-limiting protection to prevent damage to components. The connected load will normally be supplied via the inverter. If there is an inverter failure, the load shall be transferred automatically to the by-pass supply by means of a static switch. This transfer shall be a no-break transfer type.

49 The inverter shall supply sufficient short circuit current, without recourse to mains changeover, to operate the largest downstream protective device excluding any distribution board main incoming protection. The time taken for fuse rupture shall not be greater than 10m sec. Such inverter performance shall not depend upon the availability of AC mains power.

50 The static switch shall be capable of withstanding the short circuit current of both the inverter and the UPS by-pass supply.

51 The inverter shall be capable of providing the specified quality of AC output power while operating from any DC source voltage within the battery operating range. The inverter output voltage and capacity shall be as specified and shall operate in accordance with the requirements described hereinafter.

52 The inverter steady-state output voltage shall not deviate by more than ± 1% balanced load. The regulation with a 100% load application or load removal shall be ± 3% with a recovery time of within 50 ms.

53 The inverter steady-state output frequency shall not deviate by more than ± 0.1%.

54 The inverter shall have sufficient filtering to reduce the output harmonic voltages to within the limits indicated.

55 Solid state inverters shall be a step type forced-commutated thyristor type or transistor pulse width modulated type.

56 Inverters for single or multi-unit UPS systems shall each have their own voltage regulator and internal oscillator.

57 For multi-unit UPS systems each inverter shall have its own load sharing control and shall operate independently of the other inverters as practicable. The load sharing and synchronising common circuitry shall be such that the failure of one inverter will not cause failure of others.

58 In the event of an inverter failure, this failure shall be rapidly detected and the failing inverter isolated from the bus before it can cause the output bus to deviate from specified limits.

By-Pass Facilities

59 An automatic by-pass shall be provided as an integral part of the UPS. The switches and connections of an internal manual by-pass shall be incorporated within the equipment enclosures.

60 The automatic by-pass device shall be either a static switch or an electro-mechanical device. It shall be capable of withstanding without damage any over current that the equipment is capable of delivering.

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61 The automatic by-pass device shall transfer the load to the by-pass supply without interruption in the event of an equipment malfunction or of the output voltage deviating outside the limits indicated, i.e. less than 4 milliseconds.

62 Following operation of the automatic by-pass device due to overload or external fault, the load shall be automatically restored to the UPS equipment when normal conditions return. Following operation due to any other cause, restoration to normal conditions shall require a manual operation.

63 Transfer of the load to or from the automatic by-pass shall be inhibited when the equipment output is not in synchronisation with the by-pass supply.

64 It shall be possible by manual operation to transfer the load to and from the automatic by-pass supply whenever the two supplies are in synchronisation.

65 The system shall be provided with a manual by-pass switch for maintenance and service purposes. The manual by-pass switching shall be arranged such that the transfer of the load is carried out without any interruption to the supply.

Control Equipment

66 Indicating lamps and push buttons shall be coloured in accordance with the appropriate standards specified. A lamp test facility shall be provided.

67 Alarms shall include both audible and visual signals. It shall be possible to cancel or accept the audible signal, leaving the visual signal maintained until the cause of the alarms has been corrected.

68 Volt free contacts shall be provided to signal an alarm to a remote station as required.

69 Indicating instruments shall be flush mounted in dust and moisture resistant cases. Instruments indicating alternating current and voltages shall indicate true RMS values.

70 Single, or where applicable multiple units shall display a mimic single line diagram and incorporate clearly identified displays by means of LCDs or instruments, indicating lights and alarms as necessary to indicate the status of the unit, including:

Instruments:

i) Input supply AC voltameter with phase to phase and phase to neutral selector switch.

ii) Internal by-pass supply AC voltameter with phase to phase and phase to neutral selector switch (if the by-pass supply may differ from the input supply).

iii) Input supply AC ammeter and phase selection switch

iv) Battery voltmeter

v) Battery ammeter indicating charge and discharge current

vi) Output supply AC ammeter and phase selector switch

vii) Output frequency meter

viii) Output supply AC voltmeter with phase to phase and phase to neutral selector switch

LED or neon indicating lights showing:-

i) The open or closed state of all circuit breakers

ii) Incoming supply available

iii) Battery on booster charge

iv) Transfer to by-pass inhibited

v) The status of the by-pass circuit

Alarms:

i) Incoming supply failure

ii) Battery charger failure (including under and over voltage)

iii) Overload

iv) Fan failure

v) Fuse operation

vi) Battery approaching discharged condition

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vii) Equipment over temperature

viii) Battery circuit breaker open

ix) Output supply not within specified limits

x) Load on by-pass supply

xi) Control power failure

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A7106. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

Uninterruptible Power Supply	
G5/3	Electricity Association's Engineering Recommendation. Limits for harmonies in the United Kingdom electricity supply system.
BS 142	Electrical protection relays
BS 5424: Part 2	Specification for semi-conductor contactors (solid state contactors)
BS 6290	Lead-acid, stationary cells and batteries
BS EN 60073	Coding of indicating devices and actuators by colours and supplementary means
BS EN 60127	Miniature fuses
BS EN 60269	Cartridge fuses for voltages up to and including 1000V a.c. and 1200V d.c.
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 60622	Scaled nickel-cadmium prismatic rechargeable single cells
BS EN 60623	Vental nickel-cadmium prismatic rechargeable single cells
BS EN 60947	Low voltage switchgear and controlgear
BS EN 60947-1	Electromechanical contactors and motor starters
BS EN 60947-3	Switches, disconnectors, switch disconnectors and fuse combination units
BS EN 60947-4	Contactors and motor starters
BS EN 60947-5	Control circuit devices and switching elements
BS EN 60947-5-1	Electromechanical control circuit elements
IEC 146-2	Semi-conductor self commuted converters
IEC 146-4	Method of specifying the performance and test requirements of uninterruptible power system
IEC 146-5	Switches for uninterruptible power systems (UPS switches)
IEC 257	Fuse holders for miniature cartridge fuse links
IEC 269-2	Supplementary requirements for fuses for use by authorised persons for industrial applications
IEC 947-3	Switches disconnectors, switch-disconnectors and fuse-combination units
DIN VDE 0871	Radio interference suppression of radio frequency for equipment, for industrial, scientific and medical (ISM) and similar purposes

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Sample Appendix A7106/2: UPS Equipment

The Contractor shall insert below details of the equipment proposed.

Item No.	DESCRIPTION	UNIT	DETAIL
1	Manufacturer of rectifier/charger		
2	Manufacturer of batteries		
3	Manufacturer of inverters		
4	Manufacturer of contactors/transfer switches		
5	Inverter Rating Inverter DC input range and power factor variation with constant maximum outputs Inverter output overload capacity and total harmonic content Inverter efficiency	 kW V % %	
6	Battery Battery type Number of cells and cell capacity Total battery internal resistance Battery capacity prior to duty specified Battery terminal voltage following duty specified	 • • ohms kw/s V	
7	Rectifier/Charger Rated output Rated direct current and voltage Rating class Output float and charge voltages Voltage stability Limitation of charger current	 kw v v	
8	Degree of cubicle protection		
9	Acoustic noise	dB	
10	UPS total heat output	kW	
11	UPS efficiency at 100%, 75% and 50% rating	%	
12	Maximum fuse clearing capability without transfer to by-pass	A	
13	Weight and overall dimensions of UPS cabinet	kg	
14	Weight and overall dimensions of battery cabinet	kg	

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7107. TUNNEL LIGHTING

General

1 A complete lighting installation shall be designed and provided.

2 The detailed luminaire layout shall be designed by a specialist lighting manufacturer to comply with the performance parameters specified.

3 Due consideration shall be given to the disposition of the luminaires in the tunnel to avoid conflicts with the ventilation system and any other plant and to provide good visual guidance to drivers. Wherever practicable a symmetrical layout shall be provided.

4 The design shall be carried out in two stages. The first stage, which shall be submitted with the tender return, shall be for Approval In Principle. This shall consist of completion of all the tables in the Appendices for Series 7107 together with a drawing showing the proposed luminaire layout. The second stage shall be the detailed design, which shall be submitted for approval within the time stated in the contract specific documentation.

5 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Performance Parameters

6 Tunnel luminaires shall comply with the specific photometric, electrical and mechanical design requirements. The luminaire optical system shall have high performance characteristics suited to the particular tunnel geometry and to minimise the number of luminaires required.

7 The tunnel lighting design shall take into consideration the following parameters:

i) Height of tunnel:

ii) Width of tunnel:

iii) Length of tunnel:

iv) Orientation & number of bores:

v) Speed limit:

vi) Design speed:

vii) Direction of traffic flows:

viii) Location of Access Zone Luminance at the stopping point L_{20} (SP):

ix) Maximum value of L_{20} (SP):

x) Diffuse reflectance of road surface:

xi) Diffuse reflectance of wall surface below 4m above carriageway:

xii) Diffuse reflectance of wall surface above 4m above carriageway and roof:

xiii) Luminaire maintenance factor: [0.85]

xiv) Wall maintenance factor: [0.70]

xv) Ratio of L_{20} (SP) to Threshold Zone Luminance Lth: [0.07] = k factor

xvi) Longitudinal uniformity ratio along each lane: >0.7

xvii) Overall uniformity ratio: >0.4

8 The luminaire and wall maintenance figures may vary, but should not be less than the figures quoted.

9 The first and last 5 metres of the tunnel shall not be lit to allow for daylight penetration.

Tunnel Luminaires

10 The construction of the tunnel luminaires shall be designed to withstand the tunnel environment and the corrosive effects of electrolytic action between different materials which can accelerate failure of the luminaire and luminaire suspensions.

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11 The luminaire housings shall be constructed to provide a dust proof and water jet proof enclosure with a minimum ingress protection to IP65 and shall have smooth external surfaces on all sides to prevent the accumulation of dirt and permit easy cleaning. Detailed drawings of the luminaire and of the luminaire photometric distribution shall be provided.

12 Wherever practicable, the housings for all tunnel luminaires shall be visually alike and shall have the same access and suspension arrangement.

13 The luminaire glazing shall be of laminated glass or equivalent materials which will not shatter and allow broken glazing to fall to the carriageway in the event of damage. The glazing shall from an integral part of the luminaire housing which, under normal routine maintenance procedures, shall not be detachable from the luminaire housing.

14 Control gear for the luminaires shall be mounted on an easily removable tray placed behind the optical system, or directly at the end of it, with vibration proof plug and socket connections to the supply and lamp wiring. Wiring which may be subject to movement in service shall be flexible multi-strand cable. Terminal blocks and terminals shall be pressure plate type.

15 The optical system shall comprise easily removable mirror reflectors and lamp assembly, the type of reflector being purpose designed to suit the type of lamp employed. Due consideration shall be given to minimise glare for example by means of appropriate detachable cross louvres if necessary

16 All removable metal components shall be separately bonded to earth and shall be positively located within the luminaire housing to prevent them inadvertently dislodging when the luminaire is opened.

17 Internal wiring shall be heat resistant and shall be suitably fixed to the luminaire housing and trays to prevent contact with heat emitting components.

18 Speed and ease of maintenance shall be a prime consideration. Lamp changing may be effected by front access hinged glazing frame or detachable end caps. Luminaires shall be installed in the same direction with respect to the tunnel.

19 The sealing gaskets for the end caps and glazed front covers shall be fixed to prevent them inadvertently dislodging and to ensure the mating surfaces correctly align to maintain the integrity of the luminaire.

20 Each luminaire shall be provided with a label/ labels in viewing from below which will identify the following:

i) A unique luminaire reference number (50mm high)

ii) Circuit reference number (6mm high)

iii) Warning if the luminaire is supplied from more than one circuit (6mm high)

iv) Lamp wattage of each control gear (6mm high)

v) Fuse rating (6mm high)

vi) Phase (appropriately coloured label)

vii) Stage (6 mm high)

21 The labels where mounted within the luminaire housing shall be manufactured from a heat resistant material with indelible water-proof lettering and black characters on a phase coloured background. Where mounted on the external housing the labels shall be water-proof and shall be screw fixed or fixed by adhesive without detriment to the luminaire. The luminaire reference number shall be positioned such that it is visible from ground level.

22 The maximum internal temperature of the luminaire shall not exceed the component manufacturer's recommendations to prevent premature ageing of control gear and wiring and the reduction in the lamp life and efficiency.

23 An overall maintenance factor of 0.85 and an IP rating of 65 is required and the luminaires shall be capable of achieving this value throughout the design life period. The manufacturer shall specify the maintenance regime required to achieve this performance.

Luminaire Control Gear

24 Fluorescent lamp control gear shall be high frequency electronic type with a power factor of not less than 0.95.

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25 Igniters for discharge lamps shall not be incorporated in the lamps.

26 A thermal cut out or other device shall effectively prevent repeated attempts to strike failed lamps.

27 A separate fuse and associated fuse carrier shall be provided for each lamp way with the exception of electronic ballasts controlling the lamps and a double pole isolation switch shall be provided for each incoming luminaire circuit which shall isolate the power supply to that luminaire when the glazing frame is opened.

Lamps

28 Fluorescent lamps shall be of the same length, wattage and colour for the complete tunnel road lighting installation.

29 Discharge lamps shall be of the same standard and type for the complete installation.

30 Lamps with a 12,000 hour or greater bulk change period shall be utilised and no lamp, with the exception of those on electronic dimming systems and of the maintained emergency lighting, if fitted, shall be on for more than 4500 hours per annum.

Support, Fixings and Cable Trays

31 The tunnel luminaire suspension system shall be of corrosion resistant materials suitable to achieve the required design life and shall support all luminaires and associated cable trays, trunking and conduits for the system wiring.

32 The luminaires shall be mounted to the suspension system in accordance with the manufacturer's recommendations. Measures shall be taken to ensure that the method used to attach the luminaire to the suspension system does not compromise the integrity of the finish which could result in contact of dissimilar metals and consequential electrolytic corrosion.

33 The luminaire suspension system shall comprise all necessary components for a complete supporting framework for the luminaires. Steelwork and fixings shall be formed of metal channel sections, brackets and other metal components or of purpose made brackets fixed direct to the tunnel fabric. Self locking nuts or equivalent devices shall be used throughout.

34 The suspension system shall support the proposed luminaire installation comprising but not limited to the lamps, control gear and housings and associated system wiring.

35 The suspension system shall maintain stability against sway in any direction.

36 In respect of the loading to be applied to the suspension system the following shall be considered:

i) Dead loading. Unfactored dead load shall comprise only the structural elements of the suspension framework, including all bracing members, nuts, bolts and connection devices.

ii) Imposed loading. Unfactored imposed load shall comprise all components attached to the suspension framework, including but not limited to the luminaires, trunking, cable tray, conduit, labels, cables, etc.

iii) Wind loading. Unfactored wind load applied as either a positive pressure or as a suction acting in any one direction on all exposed components comprising or attached to the luminaires suspension system.

37 The applied load shall be calculated based on the area of all components projected onto a plane perpendicular to the direction of the applied pressure. This wind pressure allows for the effect of air pressures arising from vehicles travelling through the tunnel bores. No accidental loading shall be considered.

38 The system shall also take due account of effects of the heat generated by the luminaires and the temperature variations with the tunnel.

39 No part of any structural element of the suspension framework, including sway bracing, shall deflect by more than the structural element length (measured between notional pin jointed connections) divided by 200, under the action of unfactored 'imposed and wind' loading as defined above.

40 The entire suspension framework and the connections with the luminaires shall be sufficiently rigid and damped against vibration and oscillation, induced by the cyclic buffeting effect of air pressures from passing vehicles, so that fatigue failure is not caused in the suspension frame or the connections with the luminaires which could lead to premature failure of any part of the

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luminaire including lamps and tubes. The luminaire manufacturer shall provide limiting design criteria with respect to vibration and oscillation that can be tolerated without compromising the design life of any components of the luminaire.

41 The suspension system shall be free draining and not retain or cause ponding of any moisture or washing fluids used during tunnel wall and luminaires cleansing within/upon any component of the lighting system.

42 Copies of all calculations, detailed drawings, manufacturer's data and information of whatsoever kind as required for the purpose of approving the design shall be provided.

43 Cable trays, conduits and trunking systems shall be metal corrosion resistant or LSOH non metallic correctly sized for the cables to be carried in accordance with Series 7104. Cover plates shall not be fitted and cables shall be neatly clipped to the cable trays.

44 The dimensions of the support system shall ensure that sufficient clearance is maintained between the vehicle gauge clearances stated in the contract specific documentation and the luminaires, even if the luminaire glazing frame is inadvertently left hanging open.

System Wiring

45 Final lighting circuits may be served from the tunnel lighting distribution boards by means of cables on tray or wiring in trunking/conduits. Final connections to luminaires may be by wiring cables in flexible conduits or flexible cables on a plug and socket system.

46 Where cables clipped to trays are adopted as the system wiring the cables shall be connected to the luminaires on a loop-in/loop-out basis and all glands shall be hose proof to IP 65 rating.

47 All cables shall be identified by indelible labels at each end and shall indicate:

i) Lighting stage

ii) Circuit number

iii) Source of supply

iv) Phase (indicated by the colour of the label)

48 All cable support system, cables and wiring shall be LSOH type in accordance with Series 7104.

49 The luminaires shall be provided with suitable cable entry and terminations suitable for 2.5mm² minimum wiring for the method of final connection adopted. Cable containment for the final connections and terminal blocks shall be capable of accepting the looping of the proposed sizes of cable. Only one phase shall be permitted within each luminaire.

Lighting Control and Monitoring

General

50 The number of lighting stages required shall be as defined by the tunnel design.

51 The level of daylight in the access zone, for tunnels in excess of 150m, shall be determined by external luminance meters. For underpasses less than 150m long a simple photo-cell control system may be appropriate.

52 Under automatic control, luminance meters shall signal to a lighting control panel which shall select the appropriate stage of lighting corresponding to the access zone daylight level.

53 The access zone daylight level at which each stage is switched shall be adjustable at the lighting control panel, between the minimum and maximum measured values to facilitate calibration of the external luminance meters.

54 The control of various stages shall incorporate adjustable time delays of 1 to 20 minutes to avoid unnecessary switching due to transient variation in the external access zone daylight level.

55 Switching and control of the lighting stages may take the following forms:

i) contactors

ii) intelligent switching units located in the luminaires

iii) other prior approved techniques

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56 Facilities shall be provided for a security key operated manual override at the lighting control panel and any remote stations for the lighting stages in individual tunnel bores.

57 Each lighting control system for the tunnel bores shall be independently controlled. Where the tunnel consists of only a single bore with 2 way traffic the lighting for both traffic flows shall be independently controlled.

58 A system of measurement by means of luminance meters located in the tunnel or current monitoring to check that the stage lighting has switched on shall be provided.

Luminance Meters

59 External sensors shall be directional luminance meter type, housed in an enclosure to IP65 located to look at the entrance portals at the stopping sight distance in the access zone and mounted at approximately 5 m high on adjustable brackets to allow adjustment of the meter's axis in azimuth and elevation.

60 The luminance meter shall give a signal related to the luminance of the field of view. The maximum measurement range shall be at least equal to the maximum access zone luminance anticipated at the portals.

61 Luminance meters shall be of solid state design and shall comprise a silicon photodiode with an optical system for luminance measurement, a rain and sun hood, a thermostatically controlled heated glass screen, optional wash wipe facility, an amplifier with a 4-20 milliamp current output characteristic and a thermostatically controlled internal anti-condensation heater. Accuracy shall be better than ± 3% with facilities for calibration at lower and upper luminance values. Luminance meters shall be suitable for operation within a temperature range of -30° to +40°C. The optical system shall enable the photodiode to measure the luminance of a field of view equivalent to a 20° angle from the sight stopping distance as defined in the relevant design Standards.

Photo-Electric Cells

62 Where specified for short tunnels or underpasses photo-electric cells shall be mounted on a suitable socket adaptor box with minimum ingress protection to IP65 positioned at high level above the portal clear of any reflective surfaces and clear of any obstruction to full ambient light which may lead to false readings but having due regard to natural sources of shadow which should be considered when calibrating the switch-on levels of lighting.

63 They shall be indelibly marked with the manufacturers identification mark, model number and switch on level. They shall be designed where possible so that in the event of a fault occurring in the unit they cause the control system to switch on the lighting.

64 The number of photo-electric cells may range from either two, (main and standby) with the sensitivity controlled by the lighting control panel, to one per lighting stage.

Intelligent Electronic Switching Units

65 Intelligent electronic switching units may be located within the main LV switchboards to control the lighting contactor coils or within the tunnel luminaires to control individual or groups of luminaires.

66 The units shall incorporate the power switching relays which shall be separately addressed, either via the mains wiring or a bus wire, from the lighting control panel.

67 The address of each unit shall be capable of being set to any of the lighting stages required.

68 The units shall be provided with an output which shall monitor the status of the switching unit and be provided with the facility for manual remote override.

69 Consideration shall be given to the load applied to the units such that any surge current when the luminaires are switched on does not exceed the unit total load capability.

Lighting Control Panels

70 A lighting control panel shall be provided incorporating the control requirements for each tunnel and shall be located in the Services Building or Control Room.

71 The type of control panel shall depend on the control system adopted. For a microprocessor based system the control panel may take the form of a desk top computer or a purpose built panel as for a hard wired system. For a PLC or hard wired system the construction

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and finish of the panels shall generally be as that detailed for switchboards and other control panels, but the operational panel and indications shall be behind a lockable glass fronted door to avoid inadvertent operation.

72 The following control and indication facilities shall be provided on each operational panel fascia:

i) An indicator for each lighting stage in use.

ii) An indicator for a fault on each lighting stage if appropriate.

iii) A digital display of the number of hours run on each stage of lighting (minimum of 5 digits).

iv) Local stage lighting override facility.

v) A control panel indicator test switch and activate/ deactivate switch.

vi) 24 hour Stage 1 and Stage 2 changeover timer of the lamps in these stages.

vii) A selector switch with indicator to disconnect the external luminance meters from the automatic control system and to revert to time switch control.

viii) Luminance meter wash/wipe control facility as appropriate

ix) A display showing the current and maximum photometer luminance readings in Cd/m² (the maximum shall be resetable).

x) A display to show the programmed luminance levels at which the control system switches between stages, and the facility to adjust those levels.

xi) A display to show the programmed time delay between switching stages and the facility to adjust that delay.

xii) A digital ammeter on each phase of the luminaire power supply located at the lighting control panel with an appropriate range for the total load with an accuracy of ± 0.5A.

73 The lighting control panels shall house all components necessary for controlling and switching the contactors or intelligent switching devices for the various lighting stages. Detailed drawings of the control panel layout and details of the equipment within the control panels shall be provided.

74 Any timing devices in the control system shall be provided with an auxiliary battery supply to ensure the integrity of the system during a supply failure or maintenance.

75 If the output from a luminance meter falls outside the 4-20 milliamp range then that luminance meter shall be considered faulty and the lighting control system shall automatically revert to a solar time switch control that shall activate Stage 1 during the night and Stage 4 during the day. This status shall be indicated by a lamp on the control panel and an alarm on the remote indication system if fitted.

76 If the PLC or photometer interface device has a zero output, ie none of the stages are selected, then it shall be considered faulty and the lighting control system shall automatically revert to a solar time switch control that shall activate Stage 1 during the night and Stage 4 during the day. This status shall be indicated by a lamp on the control panel and an alarm on the remote indication system if fitted.

77 The lighting control panels shall house all the necessary terminals for the interface with a remote station as appropriate.

78 The local and remote control shall be such that they ensure that there is no break in supply and that the luminaires do not have to restrike.

79 When switching between stages discharge lamps shall be allowed to warm up to full brightness before switching out any lamps associated with the previous stages.

80 The method of isolation of the control panel shall be such that it will be possible to replace fuses/ contactors etc on any stage without extinguishing luminaires on any other stages.

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Emergency Lighting

81 Tunnels shall be provided with a system of emergency escape lighting incorporating illuminated directional signs, for use during emergency incidents, capable of automatic operation in the event of failure of the normal lighting. This shall consist of sufficient Stage 1 luminaires to provide a minimum illuminance level of 10 lux with a minimum overall uniformity ratio of 0.3

82 Tunnel luminaires which form part of the emergency lighting system shall be clearly identified with a label located in the luminaire housing visible through the front glass.

83 The luminaires for emergency lighting shall be uniformly distributed along the length of the tunnel.

84 The emergency lighting supply source, which may be a generator or UPS system in accordance with Series 7105 and 7106, shall have sufficient capacity to maintain the luminaires for the required emergency duration following routine testing. A minimum running duration of one hour is required.

85 The emergency luminaires shall be supplied from an uninterruptible power supply in MICS cable and shall not contain integral battery packs. These lamps shall burn continuously and shall not be controlled. The light output from these luminaires shall be considered in lighting calculations.

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A7107. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:-

	LIGHTING
BS 4533: Sec 102:51	Luminaires with type protection 'N'
BS 5042	Bayonet lampholders
BS 5225: Part 1	Photometric measurements
BS 5266: Part 1	Code of Practice - Emergency lighting
BS 5489: Part 7	Code of Practice for the lighting of tunnels and underpasses
EN 55015	Radio interference - lighting
EN 60081	Double capped fluorescent lamps
EN 60662	High pressure sodium lamps
EN 60188	Low pressure sodium lamps
EN 60283	Edison screw lampholders
EN 60400	Fluorescent lampholders and startholders
EN 60742	Safety isolating transformers
EN 60920	Ballasts for fluorescent lamps - Safety
EN 60921	Ballasts for fluorescent lamps - Performance
EN 60922	Ballasts tor discharge lamps - Safety
EN 60923	Ballasts for discharge lamps - Performance
EN 60924	DC supplied electronic ballasts - Safety
EN 60925	DC supplied electronic ballasts - Performance
EN 60926	Electronic lamp starting devices - Safety
EN 60927	Electronic lamp starting devices - Performance
EN 60928	AC supplied electronic ballasts - Safety
EN 60929	AC supplied electronic ballasts - Performance
EN 61046	Electronic transformers for lamps - Safety
EN 61047	Electronic transformers for lamps - Performance
EN 61048	Capacitors used in lamp circuits - Safety
EN 61049	Capacitors used in lamp circuits - Performance
EN 29000	Quality systems
BS EN 50018	Flameproof enclosure 'd'
BS EN 60529	Degrees of protection provided by enclosures (IP code)

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Sample Appendix A7107/2 : Tunnel Lighting

The Contractor shall insert below details of proposals

Lighting Levels in Cd/msq (separate table for each bore)

Stage Number						
Access Zone Luminance L_{20} (SP)						
Threshold Zone						
Transition Zone 1						
Transition Zone 2						
Interior Zone						
Exit Zone						
Contraflow						

Luminaire Details Per Bore

Manufacturer	Reference Number	Quantity per bore	No: and Type of Lamps

Lighting Power Consumption Per Bore

Lighting Stage Number	Number and Type of Lamps	Total Circuit Watts

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Luminance Meter Details	
Manufacturer	Reference Number

Control System Details	
Manufacturer	Reference Number

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7108. TUNNEL VENTILATION

General

1 Tunnel ventilation shall be provided to ensure that the emissions created by traffic passing through the tunnel do not lead to unacceptable pollutant concentration levels within the tunnel or reduce visibility to an unsafe level.

2 The ventilation system shall be designed to provide smoke control in a fire situation. This includes transporting the smoke safely out of the tunnel so as to minimise the passage of smoke into escape routes and to assist in the evacuation of people safely out of the tunnel. Due consideration shall be given to the presence of emergency services and stationary vehicles in the tunnel in a fire situation. The design quantity of smoke shall be based on the specified megawatt rating of a possible fire. Refer to Series 7109, Fire Safety Engineering.

3 The tunnel ventilation system may also be used to create a safe working environment during maintenance and repair works in the tunnel.

4 The ventilation system shall automatically and efficiently maintain a safe environment within the tunnel under all likely prevailing weather and traffic conditions.

5 This Specification covers the ventilation equipment associated with the following systems:

i) Longitudinal

ii) Transverse

iii) Semi-transverse

iv) A combination of the above

6 Reference should be made to Series 7110 for details on:

i) Ductwork

ii) Louvres

iii) Dampers

iv) Grilles and diffusers

v) Noise and vibration control

7 Where ductwork, louvres, dampers, grilles, diffuser and other such air distribution system equipment air mounted in a tunnel environment or are handling air from a tunnel environment, the materials of construction shall be suitably treated to withstand corrosion.

8 The fire resistance of the ductwork and components in terms of stability, integrity and insulation shall be appropriate for the particular installation and shall be in accordance with the requirements of the Fire Officer. Ventilation shafts and ductwork shall be suitably rated and stopped with fire dampers and fire resistant material as applicable to withstand conditions in a fire situation for up to 2 hours. Fans and electrical wiring shall also be suitably fire resistant.

9 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

10 The ventilation system shall take account of:

i) Maximum permissible pollutant concentrations including Carbon Monoxide and Nitrogen Dioxide.

ii) Minimum permissible visibility level.

iii) Maximum megawatt rating of possible fire.

iv) Maximum temperature of air to be handled by fans in a fire situation and duration at this temperature.

v) Maximum allowable air velocity in tunnel.

vi) Maximum noise level inside and outside of tunnel.

vii) Maximum noise level at 10m from the ventilation building.

viii) Peak traffic flow criteria.

ix) Road gradients

x) Traffic pollutant emissions during peak traffic flow.

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xi) Predicted worst ambient wind conditions at the portals.

xii) Ambient air pollution levels

xiii) Redundancy for breakdown and fire loss

xiv) Reversibility of air flow direction

11 Account shall be taken of the fact that the full capacity of the ventilation system may not be available at all times. A percentage of the full capacity may be lost due to fire damage, plant failure, maintenance and repair. The capacity of the remaining fans shall compensate for such a loss.

Ventilation of Service/Escape Tunnels

12 Where service, escape tunnels and/or cross passages between tunnel bores are provided, these shall also be mechanically ventilated. The ventilation systems serving such tunnels shall be designed such that under all ventilation conditions in the traffic tunnels, the pressure resisting the opening of emergency doors does not exceed 50Pa.

13 Air shall be supplied to service/escape tunnels and cross passages in such a way as to preclude pockets of unsafe air accumulating within the service/escape tunnel and cross passages.

14 In the event of a road spillage or fire in the traffic tunnel(s), the escape tunnel ventilation system shall permit the public to gain access to the escape tunnel, via the emergency doors, without the ingress of smoke or fumes arising from a fire or hazardous spillage in the traffic tunnel(s).

Fans - General

15 Jet fans for longitudinal ventilation systems and axial fans for transverse and semi-transverse systems shall be of a design that has been successfully proven in a similar application, shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty and shall comply with the specified noise requirements.

16 All fans shall be selected so that the operating point on the pressure/flow characteristic is well clear of the stall point and provides stable, efficient and low vibration operation.

17 A durable, easily legible plate shall be securely fixed to each fan casing in a position where it can easily be read when the fan is installed. The plate shall give the following information:

i) Manufacturer's name, fan code and manufacturing reference number

ii) Year of supply

iii) Motor voltage, phase, frequency, kW rating and running current

iv) Fan normal rotation direction, normal airflow direction

v) Total fan assembly weight

vi) Contract fan reference number which should relate to the operating and maintenance manuals

18 Fan bearings shall be of a type suitable for the installed attitude of the fan. They shall be of the ball or roller type and suitable for grease lubrication. All bearing seatings or housings shall be precision located in position. Bearing enclosures shall be protected against the ingress of dust and water.

19 The bearings shall be provided with grease in amount and quality recommended by the bearing manufacturer.

20 All drives shall be provided with a warning notice in accordance with the requirements of the Health and Safety at Work Act to indicate the danger of rotating equipment.

Jet Fans

General

21 Jet fans shall be of the horizontal spindle, axial flow type and shall be supplied complete with silencers fitted to both ends of fan where required to meet specified sound levels.

22 The design of the jet fan unit shall provide ease of access for maintenance of moving parts.

23 The fan units shall be so designed that there are no external moving parts and shall be of a type that has been successfully proven in a similar application.

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24 Where specified, jet fans shall be arranged to be reversible, ie to run in either direction. Where jet fans are specified to be truly reversible, they shall:

i) be designed to give the same thrust in either direction.

ii) be capable of achieving full speed in the reverse direction within 30 seconds of the fan being switched off while at full speed in the forward direction, and vice versa,

iii) be capable of operating in either rotational direction at full speed for up to 2 hours at the specified fire/smoke temperature conditions with at least one fan reversal after 10 minutes.

25 Where jet fans are not required to be truly reversible they shall be designed to give their maximum thrust in the forward single direction and, when run in reverse, they shall achieve the specified thrust for this direction.

26 Where jet fans are not required to be reversible, guide vanes may be fitted to increase fan efficiency.

27 Jet fans shall be spaced sufficiently far apart so as to avoid aerodynamic interference between fans which would reduce their installation efficiency.

28 An appropriate number of standby jet fans shall be held in stores ready for replacement installation.

Motors

29 Motors shall be continuously airstream rated and shall be 3-phase, 50Hz, with IP65 enclosure, normally wired for direct on line starting. Both ends of each winding shall be uniquely identified and shall be brought out via a solid conduit to a terminal box on the outside of the fan casing. The terminal box shall be to IP65.

30 Motors shall be capable of emergency operation for two hours at 250°C and shall have class H insulation. The manufacturer shall provide test certificates which shall demonstrate that the fan and motor are suitable for the specified temperature/time criteria.

31 Motor bearings shall either be sealed for life with an L10 life of not less than 20,000 hours when calculated in accordance with BS 5512 or shall be fitted with extended lubricators mounted on the fan casing, whichever is specified.

Hub and Blades

32 The hub and blades shall be of cast aluminium-silicon alloy with epoxy paint finish. They shall be X-ray inspected to ensure flaw free castings. The hub shall contain a cast iron or steel insert bored and keyed to the motor shaft.

33 An aerodynamic spinner shall be fitted to the fan hub or a pod located in the silencer. Blade configuration shall be provided suitable for either unidirectional or truly reversible running arrangements, as required.

34 The impeller shall have aerofoil section blades fitted to the hub in a manner which allows for pitch angle adjustment.

Casing

35 Fan casings and silencers shall be rigidly constructed of welded mild steel or other similar material which provides equal or better performance. Fan casings and silencers shall be stiffened and braced where necessary to prevent drumming and vibration. Motor support arms of mild steel plate or other material which provides equal or better performance shall be bolted or welded to the fan casing.

36 The casing shall be reinforced as necessary for ease of use with the demounting equipment. Where specified, 25mm inside diameter lifting eyes shall be fitted to the fan assembly.

Silencers

37 Where specified, silencers fitted to inlet and discharge of a fan shall have aerodynamic bellmouth entry and exit, with flanged connections to fan casing. Water resistant and corrosion resistant perforated liners shall be fitted. Silencer pods, where required shall have aerodynamic cones on inlet and outlet, stainless steel perforated liner and mineral/glassfibre infill. Pod location arms shall be of stainless steel.

38 Mineral/glassfibre infill shall be resistant to water spray. Two 10mm diameter holes shall be drilled in the outer casing of each silencer at each end along the underside. These holes are to drain any water from tunnel washing activities which may enter the fan and silencer assembly.

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Mounting

39 Each fan shall be installed by means of purpose made mounting brackets which shall be bolted to the fan casing and designed so that each fan is readily de-mountable. Mounting brackets shall be fabricated of steel angle or channel and shall be designed to allow adequate adjustment of the fan axis in both the vertical and horizontal planes, so that each group of fans achieves its design function and provides a consistent appearance.

40 Anti-vibration mounts shall be provided at all fan assembly supports where specified to avoid resonance in the supporting structure. The anti-vibration mounts shall provide the specified isolation efficiency and shall be suitable for use in the tunnel environment. They shall also be capable of withstanding the specified temperature in a fire situation for the specified duration.

41 Anti-vibration mounts shall be installed in a fail-safe manner such that if a mount fails, it shall still support the fan.

42 Safety chains shall be provided to prevent each fan unit from entering the traffic space in the event of a mounting bracket, anti-vibration mounting or fixing bolt failure.

Guards

43 Where specified, guards shall be fitted to the inlet and discharge of the fan and silencer assembly.

44 Guards shall comply with the requirements of the Health and Safety at Work Act.

45 Construction and installation of guards shall ensure strength and rigidity and it shall not be possible to remove any guard or access panel without the aid of a tool.

46 Unless otherwise indicated guards shall be provided by the equipment manufacturer.

Materials and Finishes

47 Fan and silencer casings, supports, motor support arms, and all other ancillary steel items shall be hot dip galvanised and finished in accordance with Series 1900 of the Specification for High Works to give a total minimum dry film thickness of 75 microns. Metal surfaces shall be pre-treated before painting to ensure good adhesion, in accordance with series 1900 of the Specification for High Works.

48 All fixings and fasteners used in construction shall be suitably protected against corrosion to a level equal to the level of protection to the fan casing.

49 The complete fan assembly, including silencers and supports, shall be capable of withstanding pressurised water/detergent jet washing without deterioration.

Mobile Jet Fan Cradles

50 Where specified, mobile rigid lightweight construction cradles shall be provided for the purpose of supporting and manoeuvring the jet fan units during maintenance activities. The design of the cradle shall be such that it does not impinge on adjacent fans when in use.

51 The cradles shall be complete with jacking facilities, lockable castor wheels, restraining straps and all other equipment necessary to safely support a complete jet fan unit. The load bearing points in contact with the fan shall be so designed as to prevent structural or paint damage to the fan units.

52 Cradles shall be designed to provide the best working height for maintenance personnel to mount and demount each fan unit when operating from a lifting platform. Jacking facilities shall be provided for adjusting the height of each cradle as necessary to perform the required maintenance functions. The system shall incorporate all necessary safety interlocks and allow for the lifting platform being raised parallel to the road camber.

53 Castor wheels shall be fitted to the cradles to provide manoeuvrability. All wheels shall incorporate quick action safe locking facilities and shall provide good general grip.

54 Lifting points shall be incorporated in the cradles to facilitate the safe lifting of the cradle complete with a fan unit by means of a crane.

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Axial Fans

55 The fan units shall be designed so that there are no external moving parts and shall be of a design that has been successfully proven in a similar application.

56 Where axial flow fan units are used, the rotors shall consist of adjustable blades manufactured from cast aluminium, steel or other material of equal performance. The blade pitch shall be preset and the blades shall be securely fixed to hubs of cast aluminium, steel or other material of equal performance. The hubs shall be bored and keyed to fit the motor shafts.

57 Silencers shall be provided if required to meet the specified noise levels.

58 Fan casing shall be reinforced as necessary to support the motor and rotor assembly in operation.

59 Each fan unit shall be secured in position and be demountable for maintenance purposes. Fans shall be installed using bolts, nuts and washers with all 'as cast' bearing surfaces for bolt heads and washers counterfaced. Holding-down bolts for fans and motor shall be provided with means to prevent the bolts turning when the nuts are tightened. Fans heavier than 20kg shall be provided with eyebolts or other suitable means of lifting. The securing arrangements shall incorporate anti-vibration mountings where specified.

60 Fan motors shall be of the totally enclosed squirrel cage, induction type. Fan motors shall have a full load power factor of not less than that specified and shall be suitable for use with a 3-phase, 50Hz power supply.

61 The fan manufacturer shall provide all necessary specialised tools and equipment to facilitate the demounting of the fan units and the complete removal and refitting of the fan impellers and motors from the fan casing.

62 The shaft and impeller assembly of all axial flow fans shall where specified be statically and dynamically balanced.

63 Guards shall comply with the requirements of the Health and Safety at Work Act.

64 Construction and installation of guards shall ensure strength and rigidity and it shall not be possible to remove any guard or access panel without the aid of a tool.

65 Unless otherwise specified guards shall be provided by the equipment manufacturer.

66 Unless otherwise indicated guards shall be of galvanised steel wire not less than 2.5mm diameter attached to a rigid galvanised steel rod or angle framework. The mesh size and/or the location of the guard shall prevent finger contact with any enclosed danger point.

Noise Control

67 Fan silencers and where specified mounting arrangements shall be designed to minimise noise emissions. The specified noise level shall not be exceeded with all tunnel fans running at full speed when measured at any point 1.5m above the tunnel road surface when the tunnel is empty of traffic.

68 The specified noise level outside of the tunnel shall not be exceeded when measured at the specified distance away from the tunnel portals with all tunnel fans running at full speed and the tunnel empty of traffic.

Tunnel Ventilation Control and Monitoring

69 Pollutant (including Carbon Monoxide) and visibility monitors shall be installed within the tunnel bores to continuously monitor the air quality.

70 Automatic controls shall use the signals from the pollutant and visibility monitors to determine the minimum number of fans and the minimum fan speed required to maintain specified conditions in the tunnel.

71 Provisions shall be made for the automatic control of the ventilation fans to be overridden by the emergency services in the event of a fire or other incident.

72 The strategy for controlling the ventilation in both normal and emergency situations shall be as specified.

73 The automatic controls shall sequence the operation of the fans to limit electrical power demand during fan start-up. Fan run-on timers shall also be provided to prevent frequent switching of fans.

74 The status of the ventilation system shall be logged and monitored by the Plan Monitoring and Control System which is detailed in Series 7116.

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A7108. APPENDICES

Standards and Codes of Practice

The following list covers the Standards and Codes or Practice applicable to tunnel ventilation systems.

DESIGN GUIDELINES
PIARC (Permanent International Association of Road Congresses) Technical Committee on Road Tunnel Reports
Current WHO (World Health Organisation) legislation on human occupational exposure limits to air and noise pollution
Proceedings of BHRA (British Hydromechanics Research Association) symposia on Aerodynamics and Ventilation of Vehicle Tunnels

FANS	
BS 729	Hot dip galvanised coatings on iron and steel articles
BS 848	Fans for general purposes
BS 1449	Steel plate, sheet and strip
BS 1490	Aluminium alloy ingots and castings for general engineering purposes
BS 4999	General requirements for rotating electrical machines
BS 5000	Rotating electrical machines of particular types or for particular applications
BS 5512	Method of calculating dynamic load ratings and rating life of rolling bearings
ISO 13350	Industrial fans - performance of jet fans
SOUND ATTENUATORS	
BS 4718	Methods of test for silencers for air distribution systems

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Sample Appendix : A7108 Tunnel Ventilation

The Contractor shall insert below details of the equipment proposed.

Schedule of Jet Fans

Item No.	DESCRIPTION	DESIGN
1	Area Served	
2	Location	
3	Number Required	
4	Fan Type	
5	Fan Size	
6	Forward Thrust	
7	Reverse Thrust	
8	Outlet Velocity	
9	Impeller Speed	
10	Impeller Pitch Angle	
11	Motor Frame	
12	Motor Rating	
13	Full Load Current	
14	Starting Current	
15	Power Factor	
16	Mounting Details	

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Schedule of Axial Flow Fans

Item No.	DESCRIPTION	DESIGN
1	Area Served	
2	Location	
3	Number required	
4	Fan Details Volume m^3/sec	
5	Static Press. kN/M^2	
6	Type/Model	
7	Diameter	
8	Type of Casing	
9	Speed (RPM)	
10	Form of Running	
11	No. of Stages	
12	Pitch Angles per Stage	
13	Fan Efficiency %	
14	Overall Sound Power Level	
15	Overall Weight	
16	Motor Details Absorbed kW per Stage	
17	Actual kW per Stage	
18	Full Load Current per Stage	
19	Power Factor	
20	Class of Insulation	
21	Electricity Supply	
22	Silencers Down Stream Silencer	
23	Size	
24	Resultant NR Level	
25	Weight Kg	
26	Upstream Silencer	
27	Size	
28	Resultant NR Level	
29	Weight Kg	
30	Accessories Pairs Fan Feet	

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Item No.	DESCRIPTION	DESIGN
31	No. AV Mountings	
32	Matching Flanges	
33	Flexible Connections	
34	Coned Inlet	
35	Wire Guard	
36	Non Return Dampers	
37	Down Stream Guide Vanes	
38	Weight of Accessories	

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Schedule of Motors

Item No.	DESCRIPTION	DESIGN
1	Driven Machine	
2	Location	
3	Number required	
4	Type	
5	Frame Size	
6	Electrical Supply	
7	Type of Terminal Box	
8	Type of Enclosure	
9	Method of Starting	
10	Class of Insulation	
11	W. (B.S. Rating)	
12	Speed at Rated Output (RPM)	
13	Starting Current (AMP)	
14	Full Load Current	
15	Power Factor at Rated Output	
16	Type of Bearings	
17	Efficiency (%)	
18	Run up time (seconds)	
19	Weight of Motor (kg)	
20	Temperatures after 1hr on Full Load (°C)	

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7109. FIRE SAFETY ENGINEERING

General

1 The requirements for all fire fighting systems shall be as agreed with the local fire authorities.

2 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

3 Reference should also be made to Series 7108 for Tunnel Ventilation and Series 7111 for Drainage and Pumping.

Fire Mains

4 Fire mains, where specified, shall be provided to serve hose reels and hydrants within the tunnel bores.

5 The fire main shall be connected to a water boosting installation if required and shall be capable of meeting the minimum design flow rate and pressure requirements.

6 Fire mains shall be connected to two independent sources of mains water supply.

7 Isolating valves shall be provided at connections to water mains at all the branch connections, and at suitable intervals along long sections of mains within a tunnel

8 Air vents shall be provided at all high points and drain cocks at all low points.

9 All pipework, valves and fittings shall be of a material that is suitable for use in a tunnel environment and shall have a corrosion resistant finish, or be provided with a protective coating or wrapping externally.

10 Pipework, valves and fittings shall be of a material that is suitable for the maximum pressures that are likely to occur within the fire main system. Pipework, joints, valves, fittings, supports, anchors, guides and expansion devices shall be capable of withstanding the maximum water pressure and the maximum thrusts imposed on them resulting from water flow and thermal expansion.

11 To avoid corrosion, the use of dissimilar materials shall be avoided, or otherwise such materials shall be isolated from one another.

Water Boosting Installations

12 Water boosting installations shall comply with the requirements of the water authority and shall be sized to meet the specified flow rate and pressure requirements.

13 As a minimum, water boosting installations shall comprise:

i) An electrically driven pair of pumps, one duty and one standby, each capable of meeting the design duty requirements of the fire main (the pumps shall be constructed of suitably compatible metallic components. All pumps shall be fitted with self-adjusting mechanical seals or other alternative to prevent any leakage.

ii) A separate break tank fed from the mains supply, as required by the water authority, with adequate capacity to sustain the full demands of the fire main for the specified period. The water levels in the storage tanks shall be automatically controlled by level switches giving alarm at falling level and if the maximum level is exceeded. Water metering facilities shall be provided.

iii) All interfacing equipment and facilities with power supplies and Plant Monitoring and Environmental Control System.

14 The booster pumps shall be of centrifugal type driven by electrical motors.

15 Electrical supply to the pumps shall be dual fed and form part of the essential services supply.

16 Both the electrical supply and pipework systems shall be configured to automatically enable the changeover from the duty to standby pump in the event of a duty pump malfunction. No manual intervention to complete this process shall be required.

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17 The booster pump arrangement shall facilitate maintenance of the fire main in a primed state. Should there be a loss of water resulting from the use of a fire hose then the booster pump set shall be brought into operation automatically.

18 The booster pump set(s) shall be supplied as a packaged unit complete with run and standby pumps mounted on a bedplate, pressure vessel, suction and delivery manifolds, control panel and all necessary isolating valves and drain down facilities for maintenance. A bypass with manual isolating valve shall be fitted around booster pumps to be used in the event of pump failure in a fire condition.

19 Generally, materials used for construction shall be:

i) Pump casings, close grained cast iron or cast steel

ii) Impellers, bronze or gunmental

iii) Shafts, stainless steel

20 The permissible service pressure of cast iron pump casings shall be generally in accordance with the manufacturer's recommendations, however no pump part of component part shall be subjected to a gauge pressure in excess of 15.6 bar.

21 Flexible drive shaft couplings shall be used to minimise the effect of mis-alignment.

22 Generally, pump base plates shall be constructed from cast iron, however unit constructed close coupled pumps may be mounted on mild steel rails or a fabricated mild steel flat bed plate.

23 The booster pump set(s) shall be provided with manual override facilities both local to the pump set(s) and via the Plant Monitoring and Environmental Control System.

24 The location of the booster pump set(s) shall be external to the tunnel.

Gas Extinguishing Systems

25 For building areas covered by gas extinguishing systems, there shall be 2 types of smoke detector in each of the areas covered, both ionisation and optical. Each area shall have two types of audible alarm, a bell and an electronic sounder plus all necessary visual alarms. The operation of either one of the detectors shall result in a warning alarm to the fire alarm panel indicated on the zone affected and sounding the local fire alarm bells (stage 1 alarm). The operation of the second detector shall result in an evacuation alarm to the fire alarm panel (stage 2 alarm), the electronic sounder shall activate and after a 30 second delay the gas for the affected area only shall be released.

26 The gas extinguishing medium shall be an inert type with zero ozone depleting potential and minimum decomposition products in event of a fire.

27 The gas bottles shall be located in an area external to the protected space, in cylinder racking secured to the structure. Each gas cylinder shall be fitted with a quick action valve assembly and charged with the required quantity of extinguishant gas. Provision shall be made with respect to space allocation such that access is not impeded by gas bottles.

28 A 24V DC solenoid type actuator shall be fitted to each master cylinder valve assembly for system actuation. All slave cylinders shall be actuated pneumatically. A manual lock off facility shall be provided for maintenance purposes.

29 The installations shall incorporate a cylinder distribution manifold arrangement. The manifold shall be supplied with non-return valves and be pressure tested to the specified pressure. A pressure reducing orifice unit shall be fitted to the end of the manifold assembly to reduce the system working pressure within the distribution pipework to the manufacturer's recommended discharge pressure.

30 Total flood type discharge nozzles shall be provided for each system to disperse the gas. The final discharge nozzle size and orifice code shall be determined by computer hydraulic analysis and testing prior to mechanical installation.

31 The pipework installation shall be galvanised steel or stainless steel and painted red and bonded to the main earth bar.

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32 Gas warning signs and status indication shall be displayed at the entrance of each protected space.

33 A provision shall be made for release/override panels at all entrance/exits to protected spaces. Each protected area shall be equipped with a control panel mounted outside the access door to provide the following facilities:

i) A key switch to select automatic or manual operation of gas discharge.

ii) Indicator lamps to show the status of the system for that area:

a) System discharged

b) Automatic operation

c) Manual operation

d) System healthy

e) System fault

f) Mains failure

iii) Remote indication of the above six signals to the Plant Monitoring and Environmental Control System.

iv) Lamp test push button.

v) On detection of a fire condition, generating an audible warning, closure of fire dampers and, after a timed period adjustable from 10 to 30 seconds, discharge of the extinguishing gas.

vi) Mute button for the audible warning device.

34 The automatic gas discharge system in each area shall be controlled by a microswitch operated by turning the key in the lock of the entrance door to the area, so that when the door is unlocked the system is automatically switched from 'automatic' to 'manual', and reverts to 'automatic' when the door is locked again. A further microswitch on the door lock shall be provided to interface with the Intruder Alarm / Staff on Duty System to warn staff leaving the building if the door has not been locked and the system is still set for manual operation.

35 Inside each protected area a clearly labelled control shall be provided adjacent to each exit door for manual operation of the system. The units shall be of the lift up flap type with a push button. Electronic sounders shall be provided to give advance warning of gas discharge, which shall be clearly distinguishable form other audible alarm devices in the building.

36 A repeat indicator to show the status of the discharge system shall be provided over every entrance door to the room.

37 Operation of the manual release shall only be possible when the key selector switch is in the manual position. Operation of the manual release shall produce an immediate gas release.

38 All gas discharge system circuits shall be wired in mineral insulated cable with red LSOH oversheath, minimum conductor size 1.5mm².

39 On detection of a fire condition, the appropriate control panel shall immediately transmit a signal to the fire alarm panel to sound the fire alarm bells.

40 Manual release warning signs shall be displayed next to the extinguishant release 'Break Glass' unit on the front of each fire alarm and gas panel and each secondary Manual Release Unit.

41 The gas system shall be designed by a specialist manufacturer.

42 When the fire system is at rest then the mechanical ventilation plant and dampers shall return to their normal operational mode.

43 Fireman's override shall be provided external to the protected space for the control of the mechanical systems with a purge facility provided for gas removal following discharge.

44 All services penetrations through the envelope of the protected space shall be sealed to prevent gas leakage into surrounding areas.

45 Simulation test gas canisters shall be provided as part of the spares, holding sufficient for 5 years maintenance.

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Fire Hydrants

46 Fire hydrants shall be located such that they receive adequate mechanical protection and protection from the tunnel environment whilst affording ease of operation and maintenance. Fire hydrants shall be located within the tunnel at each fire point cabinet and outside the tunnel adjacent to each portal. Hydrants outside of the tunnel shall be of the underground type and shall be located such that they do not cause an obstruction to entry/exit from the tunnel when the hydrants are in use.

47 Fire hydrants within the tunnel shall have double couplings, each having a shut-off valve. Valves shall be supplied complete with a lockable cap and chain.

48 Each hydrant coupling shall be capable of delivering the specified water flow rate.

49 All hydrants shall be protected against damage by frost by the use of self regulating heater tape or a heater/thermostat combination.

50 All materials, components and plant shall fulfil the requirements of the local water and fire authorities.

Fire Hose Reels

51 Hose reels and their connection to the fire main shall be designed, installed and commissioned to meet the requirements of the local water and fire authorities.

52 The jet from the hose reel nozzle shall be fully controllable at the nozzle and shall allow a plain jet or a spray and shall generally be of the swinging arm pattern. Where physical restrictions require that fixed pattern hose reels are used, means shall be provided for guiding the hose so that it can easily be pulled for use in either direction.

53 A minimum of 45m of hose shall be provided with each hose reel (based on emergency points being every 50m and allowing an overlap for standby should one hose reel prove to be inoperable). The hose diameter shall be a minimum of 19mm in internal diameter. The reels shall be of appropriate size to accommodate the hose and shall automatically charge with water when the hose is pulled for use.

54 Notices and operating instructions shall be displayed on or adjacent to the hose reels. Lettering shall be white on a red background.

55 A hose reel isolating valve shall be provided. This valve shall normally be left open and shall not be accessible by the public.

56 Hose reel compartments shall be provided with a low wattage tubular heater for protection against freezing.

Foam Injection System

57 Foam inlet and delivery pipe systems shall be designed and installed in accordance with local Fire Authority requirements.

58 Foam inlets comprising of foam inlet box, associated pipework and discharge system, shall be provided for remote appliance of foam.

59 The foam inlet box shall be positioned in a readily accessible position to the remote foam generating appliance as agreed with the local Fire Authority.

60 The box shall be labelled ‘FOAM INLET’. The box shall contain the foam inlet which shall be 65mm diameter and terminate within the box in an instantaneous coupling to local Fire Authority requirements.

61 The delivery pipe shall be installed with an upward gradient towards the delivery point. The radius of pipe bends near the inlet shall be not less than four times the pipe diameter. The delivery pipe shall terminate with a foam spreader.

62 Where more than one foam inlet is housed within the inlet box, each inlet shall be clearly identified with its discharge location.

63 Enclosed sumps shall be provided with foam injection points for use by the Fire Authority to permit them to discharge foam directly into the sump from a fire appliance in the tunnel. All fittings are to be agreed with the local Fire Authority prior to installation. These points shall be labelled ‘FOAM INLET’.

64 The foam injection system shall be designed to be capable of providing adequate protection to each sump in the event of a fixed nitrogen foam system failure. The system shall suit the foam type to be used by the local Fire Authority and by the fixed system.

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Fire Point Cabinets

65 Fire point cabinets may be surface mounted in service access areas or recessed flush with profile of secondary lining in tunnel, and shall be capable of housing cartridge or stored pressure fire extinguishers or hose reels as specified capable of dealing with Class A, B and C fires, as classified in the appropriate standards specified. They shall be complete with all necessary hose reels, communication devices, lighted emergency signs, telephone connection to the police control, door alarms for remote indication in the designated area, as specified, and electrical socket outlets on UPS feed for use by the emergency services if required by the local Fire Authority.

66 Cabinets shall be of a durable, proprietary, proven design which prevents the ingress of dust and water into the cabinet.

67 Cabinets shall be fitted with a numbered door mounted on 180° opening hinges and retained by catches released by push button.

68 The cabinet door shall be finished in a durable coloured finish and labelled 'FIRE POINT'.

Portable Fire Extinguishers

69 Portable fire extinguishers shall be installed in pairs at each emergency point along the length of the tunnel. When installed in an emergency panel, a pressure sensor or micro switch shall be installed to indicate to the Plant Monitoring and Environmental Control System in the designated area that a door has been opened or a fire extinguisher has been removed.

70 Portable fire extinguishers shall also be provided in all switchrooms, outside transformer chambers and at any other locations recommended by the fire authority.

71 Portable fire extinguishers shall be of the specified size and shall be marked with an approved identity label.

72 The following is a minimum guide to the number of portable fire extinguishers to be provided:

i) 2 No. CO^2 extinguishers shall be provided and installed in each switchroom.

ii) 1 No. 9 litre foam extinguisher and 1 No. CO_2 extinguisher shall be provided and installed outside each transformer chamber.

iii) 2 No. CO_2 extinguishers shall be provided and installed in each corridor.

iv) 2 No. 3kg dry powder extinguishers or 9 litre AFFF shall be provided and installed at each tunnel fire point cabinet.

73 Portable breathing apparatus as approved by the local fire authority for each permanent staff member down to a minimum of two shall be provided and fitted within the service building or other designated areas.

Fire Protection Systems in Enclosed Sumps

74 A separate extinguishing system shall be provided in each enclosed sump. Each system shall detect a potentially explosive atmosphere and/or the presence of a fire within the sump, provide remote alarms to warn of the hazard and discharge sufficient inert foam into the sump to prevent a fire or explosion. The foam shall also be capable of extinguishing a fire.

75 The foam generation provisions shall suit the potential drainage water levels, road spillage volumes and physical characteristics of the respective sumps. It shall ensure that adequate ullage space will exist, under all reasonable circumstances, to permit the successful discharge of the nitrogen foam into the sump.

76 The foam shall be compatible with that which the local Fire Authority would use via the separate Foam Injection System through a dry fire main. See Clause 7109.57 to 7109.64.

77 The nitrogen foam inlets shall be bonded to earth such that the impedance to earth shall not be greater than 10 ohms.

78 A gas sampling system shall be provided for the constant monitoring of each sump for the presence of flammable gases or vapours such as methane, hydrogen sulphide and petroleum/hydrocarbons. The system shall also monitor oxygen depleting gases. The system shall meet but not be limited to the following requirements:

i) A sampling system such as to obviate the need for personnel to access the sumps for routine maintenance and re-calibration purposes. All sampling equipment shall be located external to the sumps in the nitrogen foam panels.

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ii) Tubes shall be used for the continuous gas sampling from sufficient sampling points as necessary to provide adequate explosion protection of the sumps. The sample gases shall be passed over the flammable gas/vapour and oxygen depletion detectors dedicated to each sample point. Sequential sampling via common detectors shall be permitted provided they serve no more than two sample points. Micron filters shall be provided to prevent the ingress of detrimental solids during sampling and an automatic back flush system shall be provided to periodically flush the filter clean. Automatic back flushing of more than one sample point at a time shall be prevented. Flow detection shall be used to raise a warning alarm should flow from a sample point be sufficiently impaired.

iii) The flammable gas/vapour detector shall be of the type based on the principle that flammable gases or vapours will react with oxygen in the presence of a catalyst. The detector shall be calibrated for maximum sensitivity to hydrocarbons. As a minimum these should include:

a) Hydrocarbons/Methane/Hydrogen Sulphide and low Oxygen

iv) The oxygen deficiency detectors shall be of the electrochemical cell type within a range of 0 - 25% oxygen.

79 On the detection of a 20% depletion of the normal oxygen level the system shall raise a warning alarm to the Plant Monitoring and Environmental Control System only.

80 Detection of a concentration of flammable gases or vapours exceeding 5% of the lower explosion limit anywhere in the sump shall raise an alarm to the Plant Monitoring and Environmental Control System.

81 Detection of either a concentration of flammable gases or vapours exceeding 10% of the lower explosion limit or detection of a fire within the sump shall cause the following to happen:

i) the Plant Monitoring and Environmental Control System to be given an 'URGENT' alarm.

ii) isolation of all pumps from their electrical supply

iii) isolation of sump ventilation fans from their electrical supply

iv) initiation of a nitrogen foam discharge into the sump and the isolation of any remaining electrical supplies to the sump.

82 Gas/heat detection shall inhibit (power off) pump and ventilation fans operation thus allowing spillages, ie petrol to be environmentally removed via a skimmer pump.

83 Links shall be provided to the plant monitoring system for run/trip/fault and LV switchboard to achieve the aforementioned power off requirement.

84 'Rate of Rise' heat detectors with a fixed temperature element of 60°C shall be provided in sufficient locations within the sumps to afford adequate protection. They shall be of the same type wired in such a way that the set will raise an urgent alarm and initiate the generation of nitrogen foam should more than one detector sense a fire. The accidental submergence of any unit shall not affect the system's integrity.

85 All gas detection equipment within sumps shall be suitable for use in hazardous area Zone 2.

86 All detectors shall as a minimum meet the requirements of (Ex)'e' Increased Safety, Gas Group IIB, temperature group T5, as defined in IS 236 and shall be certified by the British Approvals Service for Electrical Equipment for Flammable Areas (BASEEFA) or equivalent.

Protection against Freezing

87 Pipes and valves for fire-fighting water shall be thermally insulated and trace heated with a heat producing tape if needed, to prevent freezing. The trace heating tape shall be of the 'self limiting' type and be applied 'spirally wound' along pipework with all connection boxes/junction boxes, feeds/cables rated to IP 55, and hence be resistant to complete immersion in water.

88 Insulation and trace heating is not required for pipes buried deeper than 1 metre below ground level.

89 The trace heating installation shall be inspected, tested and commissioned prior to thermal insulation being applied.

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90 Thermal insulation shall be provided with a protective finish which shall be vermin proof and capable of withstanding pressure jet washing without deterioration. Insulation materials which give off toxic fumes in a fire shall not be used.

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A7109. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice appropriate to the following equipment:

BS 336	Fire hose couplings and ancillary equipment
BS 750	Underground fire hydrants and surface box frames and covers
BS 1710	Identification of pipelines and services
BS 3169	Fire hose reels fixed installations
BS 3251	Indicator plates for fire hydrants and emergency water supplies
BS 5274	Fire hose reels, fixed installations
BS 5306	Fire extinguishing installations and equipment on premises
BS 5345	Selection, installation and maintenance of electrical apparatus for use in potentially explosive atmosphere
BS 5970	Thermal Insulation of pipework and equipment
NES 713	Naval Engineering Standard for testing of combustion products.

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Sample Appendix : A7109 Fire Safety Engineering

The Contractor shall insert below details of the equipment proposed.

Fire Hydrants within Tunnel	
Type	
No. off	
Flow rate per coupling	
Pressure at coupling	
Fire Hydrants outside Tunnel	
Type	
No. off	
Flow rate	
Pressure	
Fire Hose Reels	
Type	
Flow rate	
Pressure	
Fire Main	
Design flow rate	
Working pressure	
Pressure at most remote outlet	
Material of construction	
Method of jointing	
Fire Water Break Tank	
Capacity	
Material of construction	
Fire Water Booster Pumps	
Design flow rate	
Design pressure	
Manufacturer	
Power consumption	
Thermal Insulation	
Trace Heating	

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7110. SERVICES BUILDING

General

1 The extent to which engineering services are provided in a Tunnel Service Building will be dependent on whether the building is manned or unmanned.

2 Depending on the design requirements, tunnel services buildings may be provided with the following systems:

i) Lighting installations including all cable, conduit, trunking, switches, normal and emergency luminaires and lamps.

ii) Socket outlet and small power installations including all cable, trunking, socket outlets, fused connections units etc.

iii) Fire alarm and gas extinguishing systems installations including all items of equipment necessary to meet the Fire Officer's requirements.

iv) Intruder detection installations including all items of equipment necessary to meet the performance requirements specified.

v) Heating systems including heat source, heat emitters and temperature controls.

vi) Ventilation and air conditioning systems where specified, eg for electronic equipment rooms, including air handling plant, ductwork, air terminal devices, cooling plant, etc.

vii) Metered mains water supply, domestic water services, including hot and cold water storage and distribution and water heaters.

viii) Drainage system including waste, foul and vent pipework and sanitary fittings.

3 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification. The layout and provision of services shall be such to give optimum performance.

Design Criteria

4 The following design data shall be used for the calculation of equipment, distribution and plant sizes for mechanical and electrical systems in services buildings.

Typical Area	Temperature Range	Humidity Range %RH	min lighting Levels (LUX)	Min Glare Index	Ventilation (min)	Noise Rating (NR)
Battery Rooms	10°C -0/+10°C	30% - 80%	150	16	Separate Zone 2 acid resistant	45
Switchrooms	10°C -0/+20°C	30% - 80%	150	16	-	45
Plant Rooms	10°C min	30% - 80%	200	16	-	45
Workshops	18°C min	30% - 80%	300	16	-	40
Corridors	16°C min	30% - 80%	100	19	-	40
Electronic Equipment Rooms	16°C -0/+8°C	30% - 80%	300	16	-	40
Mess Rooms	20°C min	30% - 80%	200	16	12 Litres/sec Person	40

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Typical Area	Temperature Range	Humidity Range %RH	min lighting Levels (LUX)	Min Glare Index	Ventilation (min)	Noise Rating (NR)
Offices	20°C min	30% - 80%	300	19	12 Litres/sec Person	35
Control Rooms	20°C +/-2°C	50% +/-10	300	19	12 Litres/sec Person	35
Toilets	18°C min	30 - 80%	100	16	See Building Regulations	40

Power Distribution

5 The requirements relating to LV Distribution for the Mechanical and Electrical Engineering Services shall be in accordance with Series 7103, as applicable.

Systems of Wiring

6 The requirements relating to systems of wiring for the Mechanical and Electrical Engineering Services shall be in accordance with Series 7103, as applicable.

Lighting

7 Interior lighting installations appropriate to the area or environment should be provided in services buildings and shall comply with the recommendations given in the appropriate guides listed in the appendices.

8 Unless otherwise specified the lighting for principal areas shall consist of fluorescent luminaries with lamps complying with the appropriate British/ European standards.

9 The service illuminance and limiting glare indices shall comply with the requirements for the particular area as listed in the design criteria.

10 Lighting shall be on the loop in system using XL/ LSF wiring with radial circuits served by 10A maximum protective devices. Lighting switches shall generally be 20A single pole and capable of operating at their full rated capacity.

11 External lighting installations shall comply with the requirements for the particular areas as recommended in the appropriate guides listed in the Appendices.

Emergency Luminaries

12 Emergency lighting fittings and escape signs shall be provided throughout Services Buildings to provide illumination complying with the appropriate British and/ or European standards to allow personnel to evacuate safely.

13 Emergency luminaries shall be either of the self-contained maintained type, fitted with compact fluorescent tubes, or shall be standard fluorescent luminaries fitted with converter packs for one tube. Both types shall be capable of 3 hours continuous emergency operation.

14 Unswitched supplies to emergency luminaries shall be taken from the local lighting circuit via key operated test switches located adjacent to the normal lighting switches, or incorporated within the switch as part of a grid switch arrangement. The key switch shall be clearly labelled ‘EMERGENCY LIGHTING TEST SWITCH’.

15 Emergency power sources for self-contained fittings and remote converter packs shall be rechargeable, maintenance free, high temperature nickel cadmium battery. Electronics shall be solid state electronic design and include low voltage battery isolator, short circuit thermal protection and red LED charging monitor.

16 Self-contained maintained emergency light fitting units shall be constructed and installed to conform to appropriate British and/or European Standards.

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17 Standard fluorescent luminaries fitted with converter packs shall be incorporated within the luminaire housing where adequate space permits. Where the luminaire manufacturer does not recommend the inclusion of the converter pack within the luminaire housing or where there is insufficient space remote packs shall be used. Where remote packs are used the red charge indicator LED shall be incorporated in the protected luminaire.

General Power

18 Switched socket outlets shall be provided in services buildings to serve portable equipment requiring a single phase supply.

19 All socket outlets shall be 13A and shall be of the same manufacture and finish as the light switches.

20 Socket outlets shall be connected on ring circuits using XL/LSF wiring. Circuits shall be protected by protective devices rated not greater than 32A.

21 Fused connection units shall be provided for control of single phase fixed items of equipment. All fused connection units shall be of the same manufacture and finish as the socket outlets.

22 110 volt and 25 volt 16 amp switched socket outlets shall be provided for maintenance. Low voltage transformers with 110V and 25V secondaries shall be double wound air cooled pattern contained in dust-right cases. Separate windings shall be provided for the primary and secondary and the mid-point of the low voltage windings shall be earthed with an earthed screen provided between the windings.

Fire Alarm and Detection

General

23 Complete fire alarm and gas extinguishing systems where required for specific areas shall be installed in services buildings and shall comply with the Fire Officer's requirements. The system shall comprise audible and visual alarms, detectors and manual call points. zoned indicator panels to activate local and remote alarms and to initiate automatic operation of the gas extinguishing systems if applicable.

24 The system shall be monitored open circuit type with both manual and automatic fire alarm facilities.

25 The fire alarm and gas extinguishing systems shall be wired throughout using XL/LSF cabling in conduit or MICC cable with LSOH red oversheath either clipped direct to the structure or for MICC cable if three or more cables are run together then on galvanised cable tray. The fire alarm cable shall be a minimum of 1.5mm^2 and no joints shall be allowed.

Fire Alarm Panels

26 The fire alarm and gas extinguishing indicator panels shall be multi-way signal fire/fault indicator type with the following facilities as applicable:

27 Each panel shall be provided with voltage free contacts for the annunciation of alarms to a remote user.

28 24V batteries and chargers shall operate the fire alarm system and shall consist of sealed lead acid cells of sufficient amp hour capacity to operate the system. The cells shall be supplied charged complete with electrolyte. The operating voltage of the system shall be 24 volts DC.

29 The capacity of each battery shall be such that it is capable of maintaining the system in full operation under non-alarm conditions for 72 hours minimum and thereafter operate the system, under alarm conditions, continuously for 30 minutes.

30 The charger shall be capable, whilst continuing to supply the operating loads, of automatically recharging the battery sufficiently within 8 hours for it to supply the maximum alarm load for at least 30 minutes.

Manual Call Points

31 Manual call points shall have a fragile element that is easily broken by thumb pressure.

Detectors

32 Automatic detectors shall comply with the appropriate British/European standard and be of an appropriate type to suit the fire risk of the areas they serve. Detectors of the same type shall have interchangeable bases and generally mounted on conduit boxes on the ceiling of each room. They must be sighted as recommended by the manufacturer.

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Function	Indication
Fire	Twin red LED per zone
Alarm silenced	Twin amber LED - internal buzzer
Remote signal isolated	Twin amber LED - internal buzzer
Power on	Twin green LED
System fault	Twin amber LED - internal buzzer
Extinguishant release auto	Twin amber LED
Extinguishant release isolated/faulty	Twin amber LED - internal buzzer
Extinguishant gone	Red LED
Extinguishant release imminent	Twin red LED
Silence alarm Test alarm/evacuate Isolate remote signal Silence buzzer Reset and lamp test Extinguishant auto Extinguishant manual Isolate release circuit	Individual push switch inoperable until master control is operated
Extinguishant release	Push switch
Extinguishant release protection	Break glass/push switch with flap guard
Master control - on - off	Key operated switch

Table 7110.2

Audible and Visual Alarms

33 Fire alarms audible devices shall have a sound output of at least 90dBA at 1m.

Fire Fighting Systems

34 Where required in services buildings, inert gas automatic total flooding systems shall be provided in accordance with Series 7109.

35 The extent of any other forms of fire fighting, eg portable fire extinguishers, hose reels, sprinklers etc., shall be ascertained through discussions with the local Fire Authorities.

36 The requirements for fire hydrants external to the service building shall also be agreed with the local Fire Authority.

Security Systems

37 A security system to guard against unauthorised access shall be installed in services buildings. These may comprise zoned security panels to activate local alarms with volt free contacts for initiating of remote alarms, sounders, external strobe light, panic buttons, magnetic reed switch contact assemblies for doors and passive infra red detectors for building interiors.

38 The security alarm panels shall be mounted internally adjacent to the building's main entrance door. The panel may provide the following features:

i) Real language alpha numeric display;

ii) Programmable zones;

iii) An event memory;

iv) Entry/exit delay variable up to two minutes;

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v) Personal attack button;

vi) 'Staff on duty' indication;

vii) Gas discharge system manual;

viii) Exit procedure;

ix) A minimum of 12 user codes;

x) An engineers code;

xi) A duress code;

xii) Tamper protection;

xiii) Rechargeable battery back up.

39 Security alarms shall activate internal and external electronic sounders with a sound output of at least 100dB(A) at 1m and external strobe lights.

40 The security alarm detection system shall principally consist of passive infra red detectors installed throughout the interior of the Services Building. Magnetic reed switch contact assembles shall be provided for all external doors. Personnel panic buttons shall be located at each entrance/exit to the building and within the building such that no person need travel more than 30 metres to a button.

41 The control panel shall be provided with a back-up battery charger and sealed lead acid cells with sufficient amp hour capacity to maintain the system in full operation under non-alarm conditions for 72 hours and thereafter operate the system, under alarm conditions, continuously for 30 minutes.

42 The control panel shall be provided with voltage free contacts for the annunciation of alarms to a remote user.

43 The wiring between each item of equipment shall be run in dedicated metal conduit. The cabling shall be a minimum of four core cable with two cores acting as anti-tamper.

Earthing and Bonding

44 Earthing and bonding of mechanical and electrical services within service buildings and the tunnel shall be provided.

45 The earthing shall comprise copper cables and tapes connected to a main earthing system. All separate protective conductors shall be XL/LSF insulated standard conductors.

46 A main earthing system shall be provided and shall comprise:

i) Copper main earth bar

ii) Insulator supports

iii) Neutral earthing

iv) Bonding links

v) Frame earthing all equipment

47 The main earth bars shall consist of a high conductivity, heavy drawn copper bar mounted on porcelain insulators.

48 The main earth bar shall be fitted with test links for the main bonding and equipotential bonding conductors and be complete with barrel insulators, brass studs and hexagon nuts as appropriate.

49 To facilitate testing of the installations duplicate earth electrode systems each connects to the main earth bar via test links shall be provided.

50 All exposed conductive parts of the installation, extraneous conductive parts and other services shall be connected to the main earth bar.

Lightning Protection

51 Lightning protection for the services building shall be provided if specified.

52 The system shall normally comprise an air termination network using tape clipped direct to the building structure with down conductors to earth electrodes.

53 Although building elements may be used to form part of or the whole lightning protection system.

54 Earth electrodes shall have an inspection pit with heavy duty cover and at a convenient point on the down conductor connected to the electrode a test clamp shall be fitted.

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Heating

55 Heating installations appropriate to the area or environment shall be provided in services buildings.

56 The minimum internal design conditions shall be as listed in the design criteria. Thermostatic controls shall be provided to maintain room temperatures at the set conditions.

Ventilation and Air Conditioning

General

57 Fresh air ventilation and air-conditioning shall be provided in certain rooms within services buildings such as control rooms UPS or electronic equipment rooms.

58 Such areas shall be provided with air quality, temperature and humidity control. In other areas, the degree of ventilation or air conditioning provided shall be appropriate to the environmental control required.

59 The quantity of fresh air supplied shall be suitable for the comfort and health of personnel and for the correct and safe functioning of space.

60 Mechanical ventilation shall be provided to exhaust gases from rooms served by gas extinguishing systems. Refer to Series 7109.

Air Terminal Devices

61 Sizes of air terminal devices shall be based on the nominal dimensions specified and suitable for the airflow rate, diffusion and noise rating specified in the design criteria. Air terminal devices shall be protected against corrosion. Blades and dampers shall be adjustable from the front of the device. The perimeters of all air terminal devices shall be provided with a sealing gasket.

62 Supply air grilles shall have the facility to direct air flow.

63 Return or exhaust air grilles may have either a single set of blades or bars, either horizontal or vertical, or a lattice front and be provided with an opposed blade damper.

64 External louvres shall be of the fixed blade type designed to withstand the design wind loads and to minimise rain penetration. For locations which experience severe weather conditions, louvres shall be double or treble banked to keep water ingress to a minimum. Suitable and adequate drainage channels shall be provided for all external louvres.

65 Unless otherwise specified louvres shall be provided with a bird screen as standard.

66 Where specified, louvres shall be provided with an insect screen.

Ductwork

67 All ductwork shall be suitable for, and unaffected by, the range of substances conveyed and/or conditions specified.

68 All connections between individual components of an air handling assembly and between an assembly and a ductwork system shall be made with angle flange joints. Access openings for inspection or cleaning shall be provided as specified.

69 All ductwork entering or leaving a plant room shall be provided with an angle closer frame fixed to the building structure and the connection sealed airtight.

70 All ductwork passing through a roof or external wall shall be provided with a weathering skirt, fixed to the building structure and the connection sealed weatherproof.

71 Any galvanised ductwork that is slightly damaged during manufacture or erection shall be painted with at least two coats of suitable corrosion resisting paint.

72 Ductwork shall be thermally insulated where specified.

73 Ductwork shall have a fire resistance relating to stability, integrity and for insulation where specified.

74 All supports shall be capable of supporting the ductwork and its associated acoustic or thermal insulation as specified.

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75 Flexible joints shall be provided on all connections to fans, duct mounted terminal units and elsewhere as specified. All flexible joints shall be of the same cross sectional areas as the mating equipment or duct sections. The centre lines of flexible joint connections shall be coaxial. All flexible joints shall consist of, or be externally protected by, material having a fire penetration time of at least 15 minutes.

Dampers

76 Sufficient duct mounted dampers shall be provided to regulate and balance the system to enable those on grilles and diffusers to be used only for secondary control.

77 Fire dampers shall be installed where ductwork passes through fire compartment boundaries. They shall have integral thermal actuators and fusible links. Access panels shall be provided adjacent to each damper. Fire dampers shall be independently supported.

78 Fire dampers used singly or in combination shall have an overall fire rating not less than two hours.

79 In all cases evidence, of fire rating shall be provided by a body accredited by the European Union.

80 Fire dampers shall be constructed of either a corrosion resistant material such as stainless steel or be galvanised or otherwise treated to minimise corrosion.

81 The dampers shall be housed in a corrosion resistant casing constructed to avoid distortion due to stress in fire conditions.

82 Provision shall be made to accommodate expansion of the damper blade(s) within the casing in fire conditions.

83 The fire damper installation frame shall incorporate provision for expansion within the surrounding structure together with lugs for building in.

84 Each fire damper casing shall be clearly marked with a permanent indication of the correct fixing attitude of the damper, the direction of airflow and the side in which the access/maintenance opening is located.

85 Fire dampers shall be located in a position and of the type which facilitate periodic manual release and re-setting for test purposes. Access openings shall be provided in the ductwork for this purpose.

86 Where ductwork serves rooms containing gas fire suppression systems, fast acting low leakage shut off dampers shall be fitted in the ductwork to ensure that when closed the ductwork system does not form an escape route for the fire suppression gas out of the room. The ductwork joints and seams shall be sealed to reduce leakage. The shut-off dampers shall be a resetting type to enable the ventilation systems to be used for purging after a gas release.

Air Handling Units

87 Air handling units shall be manufactured from hot-dip galvanised sheet steel and shall incorporate the specified components such as:

i) motorised fresh air damper

ii) frost coil or mixing chamber

iii) air filter

iv) air heater

v) air cooler

vi) fan

vii) sound attenuators

88 Air handling units shall incorporate a steel frame and easy to open/close inspection hatches and doors.

89 Heat recovery between the supply and extract air shall be provided whenever feasible.

Pipework and Fittings

90 Pipework and all associated components, valves, draincocks etc. shall comply with the appropriate guides and standards. Where applicable, isolating valves shall be fitted at connections to equipment, and at all branch flow and return mains. Drain cocks shall be provided on the equipment side of the isolating valves.

91 To facilitate commissioning, regulating valves and flow measuring devices shall be installed in the return water pipes of all main circuits and in the main returns in the plant room.

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92 Dial type thermometers shall be installed in the plant room on boilers and on the heating flow and return pipes including any branch within the plant room. Pressure gauges shall be fitted either side of each pump. Outside plant rooms test points shall be provided to allow temperature to be measured on main return pipes and on the flow and return pipes to heater batteries.

93 The pipework system shall be provided with a means of sampling the water in the system and a convenient means of dosing the water with corrosion inhibitors.

94 All heating distribution pipework shall be thermally insulated unless contributing useful heating to the occupied space.

Domestic Water Services

95 Domestic hot and cold water services shall comply with Water Byelaws and appropriate British and/or European Standards.

Drainage

96 Foul water drainage from service buildings shall drain to a sanitary drainage system to the appropriate British/European standards.

Noise and Vibration Control

97 Care shall be taken in the selection and installation of all equipment to ensure that noise levels in the spaces serviced, adjoining areas, plant-rooms and any adjacent buildings do not exceed the maximum acceptable noise rating (NR) indicated in the design criteria.

98 Where no ratings are indicated noise levels shall comply with the recommended levels given in the appropriate guides listed in the Appendices.

99 Noise data for fans, pumps, air control and air terminal devices, terminal unit compressors, condensers, etc. shall be provided.

100 Such data shall include details of the testing technique and generated noise levels for the octave band and reference level used.

101 All dynamic machinery shall be isolated from the building structure and pipework distribution systems by purpose designed vibration isolating materials.

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A7110. APPENDICES

Standards and Codes of Practice

The following list covers the Standards and Codes of Practice applicable to the following equipment:

	SERVICES BUILDINGS
	Chartered Institution of Building Services Engineers (CIBSE)
	CIBSE Code for Interior Lighting
	CIBSE Lighting Guide - Areas for Visual Display
	CIBSE Lighting Guide - The Outdoor Environment
	CIBSE Guide Volumes A, B and C
	CIBSE Commissioning Code, Series B, Boiler Plant
	CIBSE Commissioning Code, Series C, Automatic Controls
	CIBSE Commissioning Code, Series W, Water Distribution Systems

	Heating and Ventilation Contractors Association (HVCA)
	HVCA DW/142 - Specification for sheet metal ductwork
	HVCA Heating, Hot and Cold Water Supply-Standard for Installation Work TR10

	Local Authorities Bye-Laws and Regulations
	Water Supply Authority's Regulations
	Water Byelaws
BS 1363	13a fused plugs and switched and unswitched socket outlets
BS 1853	Double capped fluorescent lamps
BS 3535	Safety Isolating Transformers for Industrial and Domestic Purposes
BS 4533	Luminaries
BS 5266: Part 1	Emergency and Escape Lighting
BS 5306	Fire Extinguishing Installations and Equipment in premises
BS 5445	Specification for Components of Automatic Fire Detection Systems
BS 5720	Mechanical Ventilation and Air-conditioning in buildings
BS 5839	Automatic Fire Alarm systems in Buildings
BS 5925	Ventilation Principles and Designing for Natural Ventilation
BS 6467	Code of Practice for the Protection of Structures against Lightning
BS 6700	Services supplying Water for Domestic Use within Buildings
BS 7671	Requirements for Electrical Instructions (IEE Wiring Regulations 16th Edition with all latest amendments)

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Sample Appendix : A7110/2 : Services Building

The Contractor shall insert below details of the equipment proposed

SCHEDULE OF M & E EQUIPMENT

Item No.	DESCRIPTION	MANUFACTURER
1	LV Switchgear	
2	Distribution Boards	
3	LV Multicore Cables	
4	Mics Cables	
5	Cable Tray	
6	Cable Trunking	
7	Conduit	
8	Lighting Switches	
9	Socket outlets	
10	Connection Units	
11	Telephone Outlets	
12	Fire Alarm Equipment	
13	Gas Extinguishing System	
14	Security System	
15	Earthing Equipment	
16	Lighting Protection Equipment	

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SCHEDULE OF LUMINARIES

Item No.	REF.	DESCRIPTION	MANUFACTURER	CAT NO.
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SCHEDULE OF CENTRIFUGAL FANS AND MOTOR SETS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Fan Location	
3	Number Required	
4	Fan Details Volume m^3/sec	
5	Static Press. kN/m^2	
6	Type	
7	Size	
8	Outlet Vel. m/sec	
9	Speed RPM	
10	Motor Details Power kW	
11	Speed	
12	Type	
13	Electricity Supply	
14	Overall Weight of Fan, Motor, Base, Drive & Guard	
15	Additional Information Fan Absorbed Power	
16	Efficiency %	
17	Sound Power Level	
18	Handing & Discharge	
19	Type Bearings	
20	Driving Arrangement	
21	Motor Full Load Current	
22	Starting Current	
23	Power Factor	
24	Position on Base	
25	Insulation Class	
26	Number/Type AV Mtgs.	

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SCHEDULE OF PROPELLER FANS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	Number Required	
4	Fan & Motor Details Type	
5	Size Diameter	
6	Volume m^3/sec	
7	Static Press. kN/m^2	
8	Speed (RPM)	
9	Electricity Supply	
10	Motor Watts	
11	Full Load Current (AMP)	
12	Starting Current (AMP)	
13	Power Factor at Rated Output	
14	Class of Insulation	
15	Overall Sound Power Level	
16	Form of Running	
17	Mounting Ring/Diaphragm	
18	Type of Bearing	
19	Weight of Complete Fan Set	
20	Accessories Windshield/Shutters	
21	Fan Chamber	
22	Wire Guard Motor Side	
23	Wire Guard Fan Side	
24	Diaphragm Plate	
25	Weight of Accessories Kg	

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SCHEDULE OF AXIAL FLOW FANS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	Number Required	
4	Fan Details Volume m^3/sec	
5	Static Press kN/m^2	
6	Type/Model	
7	Diameter	
8	Type of Casing	
9	Speed (RPM)	
10	Form of Running	
11	No. of Stages	
12	Pitch Angles per Stage	
13	Fan Efficiency %	
14	Overall Sound Power Level	
15	Overall Weight	
16	Motor Details Absorbed kW per Stage	
17	Actual kW per Stage	
18	Full Load Current per Stage	
19	Starting Current per Stage	
20	Power Factor	
21	Class of Insulation	
22	Electricity Supply	
23	Silencers Down Stream Silencer	
24	Size	
25	Resultant NR Level	
26	Weight Kg	
27	Upstream Silencer	
28	Size	
29	Resultant NR Level	
30	Weight Kg	

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Item No.	DESCRIPTION	DETAIL
31	Pairs Fan Feet	
32	No. AV Mountings	
33	Matching Flanges	
34	Flexible Connections	
35	Coned Inlet	
36	Wire Guard	
37	Non Return Dampers	
38	Down Stream Guide Vanes	
39	Weight of Accessories	

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SCHEDULE OF FAN COILS UNITS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location (Room No.)	
3	Type	
4	Room Design Sensible kW	
5	Room DB/WB°C	
6	Fresh Air m^3/sec	
7	Cooling Coil Entering Air DB/WB °C	
8	Leaving Air DB/WB °C	
9	Max Sensible Duty of Unit kW	
10	Max Latent Duty of Unit kW	
11	Total Duty kW	
12	Chilled Water F & R °C	
13	Chilled Water Press Drop kPa	
14	Chilled Water Flow Rate Litres/sec	
15	Air Filter Type	
16	Pressure Drop Clean Pa	
17	Pressure Drop Dirty Pa	
18	Efficiency	
19	Eurovent 4/5 Arrestance	
20	Fan & Motor Type	
21	Resistance of Duct Work Etc. Pa	
22	Total Resistance Incl. Air Handling Unit Pa	
23	Fan kW	
24	NR Level Slow Speed	
25	NR Level High Speed	
26	Electrical Supply	
27	Total Weight of Unit Kg	

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SCHEDULE OF AIR HANDLING UNITS AND LARGER TYPE FAN COIL UNITS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	No. Required	
4	Type/Model	
5	Total Air Volume m^3/sec	
6	External Resistance Pa	
7	Room Sensible kW	
8	Room Latent kW	
9	Mixing Box Fresh Outside Air Volume m^3/sec	
10	Air Filter Type	
11	Pressure Drop Clean/Dirty/Working Pa	
12	Efficiency % BS 2831 Dust No	
13	Pre Heat Coil Air On/Off Condition °C	
14	Water Pressure KPa	
15	Heating Water Temp. F & R °C	
16	Cooling Coil Air ON Condition DB/WB °C	
17	Air OFF Condition	
18	Chilled Water F & R °C	
19	Chilled Water Flow Rate Litres/sec	
20	Max Coil Face velocity	
21	Water Pressure Drop kPa	
22	Re Heat Coil Air ON/OFF Conditions °C	
23	Water Pressure Drop kPa	
24	Heating F & R Temp. F & R °C	
25	Fans Type	
26	Speed	
27	Static Pressure kPa	

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Item No.	DESCRIPTION	DETAIL
28	Outlet Velocity	
29	Absorbed Power	
30	Efficiency	
31	Sound Power Level	
32	Type Bearings	
33	Motor Details Power kW	
34	Speed	
35	Type	
36	Electricity Supply	
37	Full Load Current	
38	Power Factor	
39	Insulation Class	
40	Type Bearings	
41	No. /AV Mountings	
42	Total Working Weight of Unit	

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SCHEDULE OF ROOM AIR CONDITIONERS

Item No.	DESCRIPTION	DETAIL
1	Room Served	
2	Room No.	
3	Type/Model	
4	Room Design Sensible kW	
5	Room Design Latent kW	
6	Maximum Duty of Unit kW	
7	Room Temperature DB & WB °C	
8	External Temperature DB & WB Summer °C	
9	External Temperature DB & WB Winter °C	
10	Air Flow Low Speed m^3/sec	
11	Air Flow High Speed m^3/sec	
12	Type of Filters	
13	Type of Fan N.R. Level Slow Speed	
14	N.R. Level High Speed	
15	Heating Elec/LPHW/NIL	
16	Water F/R Temp. °C	
17	Electrical Supply Total Electrical Load	
18	Evaporator Fan	
19	Condenser Fan	
20	Compressor Motor	
21	Heating Element	
22	High Level Unit	
23	Low Level Unit	
24	Total Weight of Unit Kg	
25	Split System Condenser Unit Elec. Load	
26	NR Level Condenser	
27	Weight of Condenser Kg	

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SCHEDULE OF COOLING COILS

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	No. Required	
4	Duct Size W & H (mm x mm)	
5	No. of Rows	
6	No. of Sections	
7	Position of Flow and Return Conns.	
8	Overall Size W x H (mm x mm)	
9	Overall Depth (mm)	
10	Air Volume m^3/sec	
11	Face Velocity m/Sec	
12	Air Resistance Pa	
13	On Coil Temp °C	
14	Off Coil Temp °C	
15	Load kW	
16	Chilled Water Flow and Return °C	
17	Chilled Water Velocity m/sec	
18	Chilled Water Flow Litres/sec	
19	Chilled Water Resistance KPa	
20	Chilled Water Conns.	
21	Material of Tubes/Header	
22	Test Pressure KPa	
23	Air Vent	
24	Drain Cock	
25	Working Weights Kg	

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SCHEDULE OF HEATING COILS (LTHW & MTHW)

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	No. Required	
4	Duct Size W x H (mm x mm)	
5	Overall Size W x H	
6	No. Rows of Coils	
7	Overall Depth	
8	Air Volume m^3/Sec	
9	Face Velocity m/Sec	
10	Air Resistance KPa	
11	Air Seal Required (High Velocity Systems)	
12	Flow Temperature Water °C	
13	Return Temperature Water °C	
14	Output kW	
15	Water Flow Rate Litres/sec	
16	Connection Sizes	
17	Position of Flow Conns.	
18	Position of Return Conns.	
19	Size of Tubes	
20	Material of Fins	
21	Fins Spacing	
22	Material of Tubes/Header	
23	Test Pressure KPa	
24	Air Vent	
25	Drain Cock	
26	Working Weight Kg	

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SCHEDULE OF AIR FILTERS

Item No.	DESCRIPTION	DETAIL
1	Type	
2	Location	
3	No. Required	
4	Type Main Filter	
5	Type Pre-Filter	
6	Total Flow m^3/sec	
7	Main Filter Pressure Drop Pa	
8	Clean/Dirty/Working	
9	Size	
10	Efficiency %	
11	Eurovent 4/5 Arrestance	
12	Filter Material	
13	Weight of Dust Collected Kg/m^2	
14	Expected Life Full Flow	
15	Pre-Filter Pressure Drop Pa	
16	Clean/Dirty	
17	Number of Cells per Bank	
18	Withdrawal Position	
19	Efficiency %	
20	Eurovent 4/5 Arrestance	
21	Filter Material	
22	Weight of Dust Collected Kg/M^2	
23	Expected Life Full Flow	

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SCHEDULE OF ELECTRIC HEATER BATTERIES - DUCT MOUNTED

Item No.	DESCRIPTION	DETAIL
1	Area Served	
2	Location	
3	No. Required	
4	Duct Size W x H (mm x mm)	
5	Overall Size W x H	
6	Overall Depth	
7	Volume m^3/sec	
8	Face Velocity m/sec	
9	Air Resistance Pa	
10	Air ON/OFF Coil °C	
11	Electricity Supply	
12	Total Load KW	
13	No. of Stages at KW per Stage	
14	Stages Wired 1 PH or 3 PH	
15	Elements Open/Sheathed	
16	Position of Terminal Box	
17	Position/Type Safety Cut-out	
18	Total Weight Kg	

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SCHEDULE OF REFRIGERATION UNITS (AIR COOLED CONDENSERS)

Item No.	DESCRIPTION	DETAIL
1	Description	
2	Location	
3	No. Required	
4	Type	
5	External Design Temp °C DB & WB	
6	Total Cooling Duty kW	
7	Pressure Drop Through Cooler Pa	
8	Condenser Fan(s)	
9		
10	Number of Fans	
11	Speed RPM	
12	Sound Power Level	
13	Class Insulation	
14	Compressor Motor	
15	Absorbed Power kW	
16	Actual kW	
17	Full Load Current	
18	Starting Current	
19	Power Factor	
20	Class Insulation	
21	Temp. at Continuous Operation °C	
22	Sound Power Level	
23	Total Weight of Unit Kg	

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SCHEDULE OF MOTORS

Item No.	DESCRIPTION	DETAIL
1	Driven Machine	
2	Location	
3	No. Required	
4	Type	
5	Frame Size	
6	Electrical Supply	
7	Type of Term Box	
8	Type of Enclosure	
9	Method of Starting	
10	Class of Insulation	
11	Speed at Rated Output RPM	
12	Starting Current (AMP)	
13	Full Load Current	
14	Power Factor at Rated Output	
15	Type of Bearings	
16	Efficiency °C	
17	Run up time (seconds)	
18	Weight of Motor g	
19	Temperature after 1 hr on Full Load	

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7111. DRAINAGE AND PUMPING

General

1 Surface water from tunnels which drain into sumps below the tunnel carriageway shall be equipped with pumping equipment to deliver the drainage water through rising mains to the impounding sump.

2 The capacity provided for each sump as stated in the contract specific documentation shall take account of:

i) Tunnel seepage and condensation

ii) Sprinkler system discharge and test discharge from sprinkler test valves, where applicable, eg services building

iii) Ground water lowering

iv) Surface water run off at portals and transported by vehicles

v) Fire hydrant discharge, water main leakage

vi) Washing water run off (Grey Water)

vii) Providing sufficient volume to prevent pump starts exceeding twelve starts per hour

viii) Minimising retained volume (see page rate below) to avoid septicity or stagnant water

ix) Sufficient depth to permit effective pumping, and pump cooling, where this is greater than viii) above

x) Benching

xi) Shape

3 Road drainage sumps shall incorporate sufficient capacity above the high level alarm point sufficient to accommodate a $50m^3$ road tanker spillage and provide sufficient space, over and above that for spillage, for the foam injection system to operate successfully.

4 Tunnel and shaft drainage sumps shall be able to store 48 hours seepage.

5 Sumps at tunnel portals shall be designed as special cases to cater for rainfall on the relevant open sections of highway or other external flows, ie streams.

6 Two stage sumps shall be installed where the normal inflow is substantially less than the maximum storage requirement.

7 At least two identical pumps shall normally be provided in each sump, a duty pump and a standby/ assist pump.

8 All sumps shall be provided with permanent access ladders.

9 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Pumps

10 The maximum rate of pumped discharge shall not exceed the local water authority's consent to discharge, ie number of pumps selected to average flow. Where this is not possible, then storage capacity shall be provided to limit discharge rate to the allowable maximum rate. In all cases pumping efficiency shall not be less than 85%.

Submersible Pumps

11 All submersible pumps shall be self priming and capable of running 'ON SNORE'.

12 Pumps motors shall be rated flame-proof. Pumps are to be designed to handle water containing abrasive particles with the minimum of wear on the impeller and pump casing. Impellers shall be single channel or vortex.

13 Pump units shall be guide rail mounted with an automatic connection bracket permanently attached to the discharge pipework. The guide rail shall permit the pump unit to be completely removed and refitted to the connection bracket without the need for maintenance staff to enter the sump chambers.

14 All pump units shall be complete with lifting lugs, eyebolts, chains, handles or other approved means necessary for the complete removal of the unit.

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15 Pumps shall be fitted with self adjusting mechanical seals to prevent leakage.

16 Pumps shall be complete with all necessary fittings including air release valves and drain plugs.

17 All pumps shall be capable of continuous automatic stop/start operation at rated output and up to twelve starts per hour.

18 Multiple pump sets shall be provided with manual controls to allow pump starting sequence selection. Each pump shall be provided with hours run meters at the control panel.

19 Pumps shall normally be capable of handling solids up to 100mm in diameter (for raw sewage, ie main pumps) without choking.

Method of starting (all pumps)

20 Up to 4.0kW direct on line, 4.0kW and above direct on line or Star Delta/assisted start.

Dry Well Submersible Pumps

21 Submersible pumps as specified may be used in dry well locations. The motor casing must be fitted with a cooling jacket which may be connected to an external cooling system or draw a proportion of fluid from the fluid pumped.

22 The pumps shall be complete with a purpose designed suction bend, flanged to comply with the appropriate British and/or European Standards.

23 Pumps shall normally be capable of handling solids up to 100mm in diameter (for raw sewage, ie main pumps) without choking.

Macerators

24 Macerators for sewage if needed as a result of services building requirements shall be capable of reducing rags, stringy matter (and raw sewage) to particles less than 6mm diameter.

Self Priming Positive Displacement Pumps

25 The pump shall be capable of self-priming up to 4m (below the inlet port), and shall be capable of handling raw sewage grit and solids of 6mm in diameter. The pump shall vent air via the discharge pipe.

Horizontal Pumps

26 Horizontal pumps shall be of the split case end suction, or in line design single stage and in line pumps shall be limited to capacities under 2000 l/min.

27 Pumps shall furnish not less than 150% of rated capacity at not less than 65 percent of total rated head. The shut-off head shall not exceed 140% of rated head for any type pump.

Vertical Shaft Turbine Type Pumps

28 Deep well, turbine type pumps shall be a vertical shaft centrifugal type with rotating impellers suspended from the pump head by a column pipe serving as a support for the shaft and bearings.

29 Fire pumps shall not be installed in a well where the pumping water level exceeds 61m from the surface of the ground when pumping at 150% of rated capacity. In all applications the draw down characteristics of the well and the pump performance shall be approved by the local authority.

30 Pumps shall furnish not less than 150% of rated capacity at a total head of not less than 65% of the total rated head. The total shut off head shall not exceed 140% of total rated head on vertical turbine pumps.

Pipework, Fittings & Valves for Pumping Stations

31 This section shall be used in conjunction with Series 7110 with special emphasis upon items of equipment within or adjacent to the station itself.

32 Materials used for pipework shall normally be of ductile iron with flanged joints and shall conform to Series 7109 and the Manual of Contract Documents for High Works 1500 Series. Flexible joints shall be incorporated immediately outside the pump station to accommodate any differential settlement.

33 Interconnecting pipework between pumps and associated equipment shall be sized to suit actual discharge rates and arranged such that connections to the 'discharge header' are horizontal to limit the build-up of debris and silt in the vertical pump connections.

34 Transverse intercepter drains under roadways shall not be permitted.

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35 All pipework and fittings shall be selected for the specific class thickness to withstand the maximum hydraulic system pressure, including any surge pressures and/or external pipe loadings.

36 The provision of tappings for the attachment of temporary or permanent pressure gauges shall be made to pipework on either side of the non-return valves fitted to delivery pipework. Consideration and written method statements shall be given with respect to replacement when selecting or specifying special fittings or items of equipment, these statements shall be included in the Operating and Maintenance manuals.

37 To avoid corrosion the use of dissimilar materials shall be avoided, or otherwise such materials shall be isolated from one another.

38 Pipes buried within concrete structures should be suitably lined with an abrasion resistant material.

39 Pipework layout shall not restrict the effectiveness of the sump pump discharge capabilities. Sharp changes in direction shall be avoided.

40 Due to a build-up of condensation in a corrosive environment, all pipework, valves and fittings shall be protected by coating or wrapping externally. All ferrous metals shall be galvanized where practical or painted with suitable paint. Tunnel drainage is liable to blockages by leachates from concrete linings, pipework shall be fitted with the provision for roding/cleaning at every 100m maximum. Pipework gradients shall be such that they are self cleaning and shall be sized such that their (3/4 filled) velocity does not fall below 1m/s.

41 System pipework, fittings and valves shall incorporate substantial supports (to prevent sagging, etc), restraints and anchors to resist thrust at all bends, tees and valves, joints and ancillary items without restricting access to plant and equipment.

42 Where pipework is water filled, above non-return valves for example, and is likely to be subjected to environmental conditions that could promote freezing, then trace heating or other means of protection shall be applied.

43 The pumping main and anchors shall be designed to withstand hydraulic test pressure of not less than 1.5 times that of either the maximum working pressure or maximum gauge pressure, whichever is the greater.

44 For isolating and maintenance purposes isolating valves shall be located, with adequate access, on the discharge face of the non-return valve.

45 A non-return valve shall be fitted to prevent backflow when pumping ceases. Non return valves shall be fitted with the position indicator.

46 Manually operated valves should be easily accessible for maintenance and allow for regular backwashing or drainage of the main.

47 Isolating valves shall normally be of the sluice ball or gate pattern. Valves shall be fitted with the spindle vertical, an extended spindle to ground level or with spindles inclined at a slight angle. Where required, valves shall be lockable.

48 Isolating and reflux valves for submersible pumps shall be located within a separate chamber protected from flooding.

49 Discharge pipework within the valve chamber shall incorporate a facility for the connection to a mobile tanker in the event of an emergency and pump failure.

50 All valves should be subjected to regular operation through normal use, or otherwise frequent maintenance to avoid seizure or breakage. All valves shall be adequately labelled.

Electrical Services, Controls and Alarms

51 The requirements relating to electrical services associated with drainage and pumping systems shall comply with the following Series of this Specification as relevant.

i) 7101 High Voltage Switchgear

ii) 7102 Distribution Transformers

iii) 7103 Low Voltage Switchgear

iv) 7104 HV and LV Cabling and Distribution

v) 7105 Standby Generators

vi) 7106 UPS Equipment

vii) 7109 Fire Safety Engineering

viii) 7110 Service Building

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52 A control panel to house starters, sequence controls, level sensing and other associated control and alarm equipment shall be provided for the drainage and pumping systems, and shall be fitted away from the immediate vicinity of the sump.

Gas Detection and Alarms

53 Gas detection and alarm systems shall be fitted to sumps. These are detailed in Series 7109.

Ventilation of Sumps

54 Closed sumps shall be provided with forced ventilation to prevent a build up of gases in the sump.

55 Sumps shall be fitted with separate mechanical ventilation systems, with supply and exhaust ventilating ducts to atmosphere. The exhaust ducts shall be fitted with in-line duct mounted duty and standby extract fans automatically alternated. The extract fans shall be timed to run intermittently sufficient to ensure six complete air changes per hour based on the sump being empty. Fans shall be suitable for use in hazardous area Zone 2 as defined by the relevant standards. Automatically operated gas tight dampers shall be provided for each duct.

56 A manual override, to continuously operate the fans, for use by the Fire Brigade or maintenance personnel shall be provided, this shall comprise of a red coloured IP65 Box (accessible via key or tool) fitted with a break glass, located outside the curtilage of the tunnel.

57 The ventilation system shall be provided with automatic controls linked to the sump gas detection system. See Series 7109 for details.

58 Closed sumps shall be totally independent and gas tight, ie no holes or openings. All pipes, ducts and cable conduit entries penetrating the sumps shall be fitted with gas tight seals.

59 The use of open sumps which are naturally ventilated are applicable in some instances, but it must be proven that natural circulation will take place continuously all year round without interruption.

In Sump Skimming Equipment

60 Skimming equipment shall be installed suitable to skim oils, petrol and toxic fluids. The systems may comprise a tethered floating unit with remote positive displacement pump units or floating pump units.

61 The skimming equipment shall be constructed from corrosion resistant materials and be complete with all flexible suction hose assemblies, electro-hydraulic or flame-proof electro-mechanical pumping units.

Level Regulators

62 Water level regulators shall be fitted to control the water levels within sumps, they shall utilise sensors of the (pairs of partially buoyant) tilt switch, ultrasonic, analogue DP cell, vibration, pressure transmitters or probe types.

63 Tilt switch level sensors shall comprise shock-proof micro-switches encased in watertight moulded plastic enclosures with eccentrically located weights to maintain the regulators in the correct attitude. The suspension/connection cables shall have copper stranded insulated cores with a nitrile rubber sheath overall and connect direct onto the control panel terminals without the use of joints or connectors.

64 Ultrasonic level sensors shall comprise a transducer unit located within the sump interconnected to a transient unit, located within or adjacent to the control panel, to receive the transducer output signals. The transducer to transient unit cable connection shall be run in earthed metal conduit to obviate electrical interference.

65 Probe type level sensors shall comprise stainless steel electrodes located within the sump.

66 In all instances the sensors shall have a measuring tolerance of +/- 10mm. Consideration and method statements shall be given/included on replacement/repair of faulty level sensors.

Lighting in Sumps

67 Where sumps are specified with lighting the luminaries shall be IP 65 suitable for Zone 2 or ‘Ex’ applications for use in hazardous areas as defined by the relevant standards. Remote indication that lights within sumps are illuminated shall be provided in the services building.

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68 A minimum average lighting level of 50 lux shall be provided on all platforms and access ladders. Emergency lighting shall be provided to allow safe evacuation of personnel in the event of mains failure.

69 Sumps control panels shall be illuminated to a minimum of 100 lux and shall be located outside the sump.

Foul Sumps

70 In normal operation, surface run off water is collected in the main sumps and pumped to normal watercourses. In the case of accidental spillage, skimmer pumps will discharge to tanker for off-site disposal. During tunnel washing operations, detergents or other chemicals must not be discharged to the main sumps. A system of changeover valves with electric or pneumatic actuators shall direct the drainage outfall to foul sumps. These will discharge to the foul water sewer subject to the consent of the local drainage authority.

Fire Precautions in Sumps

71 For specific ventilation and fire extinguishing requirements with respect to sumps, refer to Series 7109.

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A7111. APPENDICES

Standards and Codes of Practice

The following list covers the Standards and Codes of Practice applicable to the following equipment:

DRAINAGE AND PUMPING	
BS 416	Cast Iron, pipes and fittings
BS 437	Cast iron, spigot and socket
BS 750	Underground fire hydrants and dimensions of surface box openings
BS 874	Methods of determining thermal insulating properties with definitions of thermal insulating terms
BS 1710	Identification of pipelines and services
BS 2972	Methods of test for thermal insulating materials
BS 3958	Thermal insulating materials
BS 4211	Ladders for permanent access to chimneys, other high structures, silos and bins
BS 5153	Cast iron check valves for general purposes
BS 5155	Butterfly valves
BS 5316	Acceptance tests for centrifugal mixed flow and axial pumps
BS 5345	Section, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture)
BS 5501	Electrical apparatus for potentially explosive atmospheres
BS 5572	Code of Practice for foul water drainage
BS 5911	Precast concrete manholes
BS 5998	Valve castings, steel and quality levels
BS 6367	Code of Practice for rain water control systems
BS 8005	Sewerage
BS 8007	Code of Practice for design of concrete structures for retaining aqueous liquids
BS 8301	Code of Practice for building drainage
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas
BS EN 558	Valve flanged and built weld end dimensions
BS EN 752	Drain and sewer systems outside buildings
BS EN 50014	Electrical apparatus for potentially explosive atmospheres
	The requirements of: • National Rivers Authority • Local Water Undertaker (Water Byelaws)

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Sample Appendix : A7111 : Drainage and Pumping

Item No:	Description	Detail
1	**Pumps**	
	Pump manufacturer	
	Pump type and reference	
	Pump Duty	
	Number of stages	
	Speed (rpm)	
	Material of pump casing	
	Material of impellers	
	Material of pump shaft	
	Type of pump bearings	
	Method of lubrication	
	Type of thrust bearing	
	Type of coupling	
	Impeller diameter (mm)	
	Diameter of suction pipework	
	Diameter of delivery pipework	
	Maker of suction valve	
	Type and size of suction valve	
	Maker of delivery valve	
	Type and size of delivery valve	
	Maximum power absorbed by pump	
	Torque required by pump at 50%	
	Total weight of pumpset and bedplate	
	Maximum lift for maintenance	
	Maximum load on foundations	
	Horizontal thrust on foundations	
	Impeller running clearances	
	Maker of motor	
	Type and reference of motor (kW)	

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Item No:	Description	Detail
	Speed at full load	
	Connection of windings	
	Type of starter required	
	Torque given by motor at 50% speed	
	Maximum starting current with recommended starter	

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7112 COMMUNICATIONS

General

1 This Specification covers the requirements of telephone systems and radio rebroadcast equipment, located in road tunnels, underpasses and their associated access roads and buildings. The requirements specified herein are a minimum for all installations. Any deviation proposed due to local conditions shall be agreed before any deviation from the requirements of this Specification are implemented.

2 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Standard Telephone Systems

3 The type and locations of the standard telephone system shall be in accordance with the project specific documentation. The environment into which this equipment is installed shall dictate the standards to which these telephone systems and associated equipment shall conform. Telephones shall be installed in the communications equipment room, and other plant rooms as specified.

4 Connection to the Public Switched Telephone Network (PSTN) shall be at an approved box connection or distribution frame.

5 The telephone system shall provide clear and intelligible two way speech between the calling and called party.

6 Each telephone shall have unique number, within the range in accordance with the project specific documentation.

Emergency Telephones

Location of Telephones

7 Telephones shall be located in accordance with the project specific documentation. The environment into which these telephones are installed shall dictate the standards to which these telephones and associated equipment shall conform. The details of the environment are stated in Clause 7013.

Telephone Responders

8 Telephone responders for interface equipment shall be in accordance with the project specific documentation.

Housings and Enclosures

9 The type of telephone housing or enclosure shall be to IP65 and the location shall be in accordance with the project specific documentation.

10 Housings and enclosures shall be orange unless otherwise specified and provided with a sign of a telephone logo and the SOS legend in accordance with the Traffic Signs Manual. Adjacent to the telephone instrument shall be instructions for use in English, French and German; and a statement that the use of the phone is free.

Cabling

11 Cables shall be installed and terminated in accordance with the project specific documentation.

Performance

12 The hardware and software required shall be in accordance with the project specific documentation to be compatible with that elsewhere on the road and motorway network. Special attention shall be paid to this requirement due to the adverse environmental conditions encountered in tunnels.

13 The emergency telephone system shall continuously monitor for any fault on telephones or associated equipment.

Numbering

14 Each telephone and associated equipment shall have a unique number in accordance with the project specific documentation. This unique number shall be displayed on the equipment enclosure so that it is clearly visible from the carriageway.

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Signing

15 Where specified there shall be adequate signs to allow stranded motorists to locate an emergency telephone in accordance with the traffic signs manuals.

Smoke Control Telephones

Operation

16 The telephone system in the smoke control panels shall operate in accordance with the project specific documentation.

Location

17 Telephones shall be located in accordance with the project specific documentation. The environment into which these telephones are installed shall dictate the standards to which these telephones an associated equipment shall conform. The details of the environment is stated in Clause 7013.

Mounting

18 Telephones shall be mounted in the Smoke Control Panel, in there own suitably sealed equipment housing in accordance with project specific documentation.

Housing/Enclosures

19 Housings and enclosures shall be red unless otherwise specified.

Cabling

20 Cables shall be terminated in accordance with the project specific documentation.

Numbering

21 Each telephone shall have a unique number as defined in the project specific documentation. This unique number shall be clearly displayed on the Smoke Control Cabinet so that it is clearly visible.

Signing

22 There shall be adequate signs in accordance with the project specific documentation to allow the emergency services to locate a Smoke Control telephone with the minimum of effort. The telephones shall also provide visual and audible call facilities.

Maintenance Telephones

Operation

23 The maintenance telephone system shall operate in accordance with the project specific documentation.

Location of Telephones

24 Equipment shall be provided as specified in accordance with the project specific documentation. This shall be telephone jacks or telephone instruments. The environment into which this equipment is to be installed shall dictate the standards to which this equipment shall conform. The details of the environment are as stated in Clause 7013.

Housings/Enclosures

25 Housings or enclosures shall be in accordance with the project specific documentation. If telephones are used they shall be housed in sealed cabinets fitted with locks in accordance with the project specific documentation to prevent unauthorised use.

Cabling

26 Cabling shall be configured such that alternate telephones/jack sockets are served by different cables connected to different equipments.

Performance

27 The maintenance telephone system shall provide clear and intelligible communication.

Numbering

28 Each telephone/jack socket shall have a unique number in accordance with the project specific documentation. This unique number shall be clearly displayed on the equipment enclosure so that it is clearly visible.

Signing

29 There shall be adequate signs to allow location of an engineers telephone with the minimum of effort.

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Radio Rebroadcast Equipment

System requirements

30 Radio rebroadcast equipment shall consist of active equipment, radiating cables and feeder cables inter-connecting the active equipment to the radiating cables antennae as detailed in the project specific documentation. Radiating cables or antennae shall be mounted at high level, within the tunnels, in positions that do not present a hazard to high vehicles. The radiating cables shall be mounted on standoffs that securely support them without causing any crushing of the cable.

31 The active equipment shall be installed in a position that maximises its ability to receive radio signals "Off Air", and provide a clear passage and minimum distance for the feeder cable connecting it with the radiating cable.

32 Where more than one radiating cable is to be installed into one tunnel bore, then provision shall be made for eliminating or minimising any interference between the cables, or any other susceptible devices.

33 At both the design and commissioning stages, coverage details shall be considered to minimise any dual path propagation effects, from normal 'Off Air' signals and signals from the radiating cable.

34 Housing/enclosures shall be provided for the active equipment in accordance with the project specific documentation.

System performance

35 The performance of the radio rebroadcast equipment installed in tunnels shall provide clear and intelligible reception to the police, fire, ambulance and maintaining authorities mobiles or hand portables as required by the project specific documentation.

36 Rebroadcast of national and local radio broadcasts shall be provided in accordance with project specific documentation. The rebroadcast shall provide clear and intelligible reception to members of the public with no discernable drop in signal level. The frequencies to be rebroadcast shall be as specified in the project specific documentation. Rebroadcast of national or local radio broadcasts shall only be installed with the agreement and authority of the appropriate body. Within the UK the bodies are currently the BBC and IBA. Facilities shall be provided in accordance with the project specific documentation for the installation of rebroadcast equipment by either the BBC or an IBA member.

37 If required in the project specific documentation, provision shall be made for the rebroadcast for the mobile telephone networks.

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A7112. APPENDICES

Standards and Codes of Practice

All work to be undertaken on communications/Radio rebroadcast systems shall comply with the following documents:

Standards

i) Institute of Electrical and Electronic Engineering (USA) IEEE-383;
ii) International Electrical Code - IEC- 332;
iii) Radio Communications Agency Publication MPT 1367;
iv) Radio Communications Agency Publication MPT 1510.

MCE 0162	Emergency Telephones for All Purpose Trunk Roads Utilising the PSTN - Functional Specification
MCE 1188	Cabinet 609
MCE 1994	Equipment for Temporary Telephone System
MCE 1236	Telephone Housing 61 1
MCE 1242	Telephone Instrument 352
MCE 1255	Box 615 B
TR(MCE) 1329	NMCS2 - Phase 3 Telephone Data Transmission
MCE 1336	Line Transmission equipment for Use with Phase 3 Telephone System
MCE 1339	Modula Unit for use with Phase I Mark 2A Temporary Motorway telephone Systems
MCE 2063	Termination of Fibre Optic Cables
MCE 2065	NMCS 2 Cable Gland Reducing Kit (20-30 to 2 pair)
MCE 2082	Telephone Instrument Type 353
MCE 2083	Responder 704 Type
MCG 1070	Telephone Responder Acceptance Test Specification
MCH 1729	Motorway Communications Design Guide
MCX 0135	Installation Drawings -Telephones
MCX 0143	NMCS Post 71 & 611 Installation
MCX 0147	Emergency Telephone Labelling
TR 1100	Technical & Quality Control Requirements for Systems including parts of systems manufactured
TR 1153	Cabinet type 600
TR 1173	Multipair Comms Cable Polythene Insulated Polyethylene Sheathed Armoured
TR 1239	National Motorway communications System Installation Drawings

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TR 1330	NMCS2 Telephone Responder for 3 phase Telephone System
TR 1031	NMCS2 Telephone Installation
TR 2130	Environmental Tests for M-Way Comms Equipment and Portable and Permanent
	Road Traffic Control Equipment
TR 2150	NMCS Copper Communications Cable
TR 2151	NMCS Optical Fibre Communications Cable
TR 2157	NMCS Armoured Cables - Standards and Materials and Procedures
TR 2158	NMCS Armoured Copper Communications Cable
TR 2159	NMCS Armoured Optical Fibre Communications Cable
BS 6701	Code of Practice for Installation of Apparatus intended for connection to certain telecommunication systems
BABT	British Approvals Board for Telecommunications

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7113 CCTV

General

1 This Specification covers the requirements of CCTV cameras and CCTV controllers located in road tunnels or underpasses. The requirements specified herein are a minimum for all installations. Any deviation proposed due to local conditions shall be agreed before any deviation from the requirements of this Specification are planned or implemented.

2 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

System Requirements

3 CCTV cameras and associated equipment shall be in accordance with the project specific documentation. When all cameras are connected together to form a system, the system shall provide visibility of the total length of the tunnel or underpass. The visibility viewed from the system monitors, connected to the camera system shall meet the requirements of the specific application.

4 CCTV controllers shall be located at intervals in accordance with the project specific documentation within tunnels and in positions that do not impede the access-ways.

5 Cameras shall be mounted in an appropriate manner that allow easy and safe access for maintenance. Cameras and associated equipment shall be mounted in there own equipment housing and be easily removable for maintenance.

6 CCTV equipment shall be suitable for the harsh environments encountered in tunnels, and shall not impede the operation of the camera in any respect. The details of the environment are stated in Clause 7013.

7 CCTV equipment shall not impede on any personnel access, emergency escape route and shall provide required clearance to vehicle gauges.

8 Each camera and camera & controller shall have a unique number in accordance with the project specific documentation. This unique number shall be clearly displayed on the equipment enclosure so that it is clearly visible from the carriageway.

9 Interfaces shall be provided in accordance with the project specific documentation.

System Performance

10 The cameras installed in tunnels shall provide clear and intelligible pictures to the Tunnel Control Centre and Police Control Centre where specified..

11 All equipment shall be tested prior to any connection being made to the network. Each individual camera shall be tested against the appropriate Standards to ensure that it is fully functional and in accordance with the project specific documentation. Similarly each controller shall be tested. All tests shall be documented and testing documentation presented in accordance with the timescales stated in the project specific documentation.

12 After satisfactory testing, the local elements of the installed system shall be commissioned as a whole. After completion of commissioning the equipment can be integrated into the network under instruction. Following total integration the new equipment shall be commissioned as part of the total system.

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Standards and Codes of Practice

All work to be undertaken on CCTV cameras, and CCTV controllers, within approach tunnels and underpasses shall comply with the following documents:

HIGHWAYS AGENCY STANDARDS	
MCE 2014	CCTV camera housing mountings and mounting poles
MCE 2015	CCTV control systems
MCE 2016	Functional Specification for unit to mix video and data signals
MCE 2051	Coaxial cables for CCTV
MCE 2106	Maintenance of motorway CCTV systems by regional maintenance contractors
MCE 2121	NMCS2 - CCTV alert project outstation Specification
TR 1153	Cabinet type 600
TR 2013	CCTV colour monitor for road traffic surveillance
TR 2120	Monochrome CCD camera for m-way traffic surveillance
TR 2135	Colour CCD Camera for M-Way Traffic Surveillance
TR 2152	NMCS non-armoured coaxial communications cable
TR 2160	NMCS armoured coaxial communications cable
MCX 0552	NMCS2 - CCTV interfaces to share keyboards and monitor
MCX 0373	Coaxial cable terminations
MCX 0723	Installation drawing CCTV (3 sheets)
MCF 2336	Chigwell and Scratchwood CO upgrade Tunnel Sub System
BRITISH STANDARDS	
BS EN 60529	Degrees of protection provided by enclosures (IP Code)
BS 7671	Requirements for electrical installations, IEE Wiring Regulations 16th Edition
BS 7430	Code of Practice for earthing
HD 472-S1	CENELEC Harmonisation Document. Nominal voltages for low voltage public electricity supply systems.

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7114 TRAFFIC CONTROL

General

1 Where stated in the project specific documentation, the traffic control system shall conform to the Tunnel Sub System.

2 Where stated in the contract specific documentation, traffic control within tunnels shall be achieved by the use of variable message signs (VMS), enhanced message signs (EMS) and or lane control signals.

3 This Specification covers the requirements for VMS and lane control signals. All equipment shall comply with the project specific documentation and the relevant Specifications and standards listed in the appendices.

4 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Variable Message Signs

5 The type and location of variable message signs shall be in accordance with project specific documentation.

6 Where a VMS is of the rotating prism type it shall be manufactured in accordance with the project specific documentation. The VMS shall be controlled from the specified control system. Where the control system is National Motorway Communication System 2 (NMCS 2), The VMS shall be controlled via a common interface equipment, or it shall be able to receive an RS 485 signal, via a VMS driver from the NMCS 2 system transponder.

7 Where an EMS of the light emitting type is specified it shall comply with the project specific documentation.

8 All VMS and EMS units and all supports, structures, access walkways etc shall be designed and installed so that maintenance can be carried out safely and efficiently.

9 Where VMS or EMS units are required as defined by project specific documentation to have flashing amber lanterns control systems shall be designed so that all flashing is synchronised, between all sign units viewable from one location and with any flashing lanterns associated with motorway matrix type signals viewable at the same time.

10 The enclosures for VMS's and EMS's to be installed shall be IP65 manufactured from materials specified in the project specific documentation.

Lane Control Signals

11 Tunnel lane control signals shall be provided and located in accordance with project specific documentation.

12 The lane control signals shall be of the light emitting type.

Display Requirements

13 These shall comply with the following:

i) The standard signal shall display forward and for contraflow arrangements rearward faces with their optical axes nominally 180° apart but with adjustment as specified in (iii) below.

ii) With reference to the signalling requirements, it shall be possible to display a red cross without the applicable reverse green arrow, but green arrows shall not be displayed without a red cross on the reverse face.

iii) The optical axes of both forward and rearward faces shall be independently adjustable by ± 30° in both horizontal and vertical planes.

iv) The dimensions of the legends shall comply with the appropriate standards.

v) Upon power up and reset the signal shall display no aspects and shall respond to commands from the signal driver.

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Colours

14 These shall comply with the following:

i) The colour of the light emitted by the red cross shall be signal red. If narrow bandwidth emitters are used, the design shall maintain discrimination for those with colour blindness.

ii) Green arrows in accordance with the traffic signs regulations.

Luminosity

15 This shall comply with the following:

i) The signal's luminosity shall be in accordance with the appropriate standards.

ii) The signals shall have a bright mode and dim mode as specified in the appropriate standards. It shall be possible for the signal driver to select bright or dim mode as a result of a command received either over an RS 485 data link, or via hard wired clean contacts.

iii) There shall be a facility to adjust the light output of the signals when they are installed in the tunnel. The output in both dim and bright mode shall be field adjustable in steps of 10% down to 50% of the values in the appropriate standards.

iv) Intensity adjustment as in b) and c) shall be achieved without the use of moving parts. There shall be no visual flicker or other unwanted visual effects generated under any of the above described intensity adjustments.

v) The signal faces shall be constructed such that they minimise the reflection of incident light.

vi) Aspects not being displayed shall not be visible as a result of incident light.

vii) Aspects shall not be visible after being displayed for long periods and then extinguished. This requirement shall be met after the sign has displayed legends in the following cycle.

a) red cross displayed for one hour

b) green arrow displayed for 11 hours

16 This cycle shall be repeated 20 times consecutively.

Electrical Interface

17 The lane control signals shall operate from the declared voltage for the project tunnel and within the tolerances specified.

Signal Control

18 This shall comply with the following:

i) Where the tunnel control system is an NMCS2, the signal shall be monitored and controlled from a signal driver.

ii) The signal shall respond to the following control inputs from the signal driver:

a) four drive bits which shall select one of the faces defined;

b) a bright/dim control line which shall select bright or dim display levels.

iii) The signal control inputs shall be fully compatible with the control outputs of the signal driver . These control inputs shall utilise the isolated 0 V control return. The control outputs of the driver are in the 'on' state when they are capable of sinking a current.

iv) The signal shall provide monitoring outputs:

- four monitor bits which shall indicate the current face set, these outputs shall be derived from both current and voltage monitoring of each display and shall be tested for correct operation over the full operating temperature and input voltage range;

- a dimmer fault monitor (this shall not indicate a fault when the dimming function is disabled);

- a partial aspect failure monitor (this shall be used when lamp or LED section failures are monitored);

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- a heater/fan failure monitor (when fitted).

- a regular checking of interlocks shall be carried out as specified.

v) The signal monitor outputs shall be fully compatible with the monitor inputs of the signal driver. These monitor outputs shall utilise the common 0V control return.

vi) The signal shall provide 24V ac power to the signal driver.

vii) The signal shall be physically connected to the signal driver by one input socket and one flying lead.

viii) Signal drivers will be provided for each pair of back to back signals. The compatibility of signal interface with NMCS2 signal driver requirements of an indication of the signals aspect control and monitoring shall be in accordance with the project specific documentation.

Interlocking

19 This shall comply with the following:

i) All signals shall be interlocked by hardware, software or combination to prevent conflicting displays.

ii) An interface for the purposes of signal interlocking shall be provided.

iii) It is envisaged that the interlocking interface shall operate at a low dc voltage and employ high integrity relays and other components.

iv) The interface shall require no more than 2 No. 2 pairs of 0.9mm armoured communications cable to the appropriate standards to operate.

v) It shall be possible to link up to 30 signals over a distance of 4km for the purposes of interlocking.

vi) The interface shall include lightning protection.

vii) The signal shall not require isolation from the interlocking circuit to render it safe for maintenance.

viii) The interlocking interface and circuit for environmental tests and for electromagnetic compatibility and shall function correctly under all such conditions.

ix) The connection to this interface shall be via a military Specification connector unless otherwise stated in the project specific documentation.

Face Interlocking

20 The signal shall provide an interlock to prevent arrows being displayed on both forward and rearward faces simultaneously.

Signal Interlocking

21 This shall comply with the following:

i) Signals shall be interlocked to prevent the green arrow aspect being displayed unless all signals associated with a specific lane are displaying the red cross aspect on the reverse face. The interlock shall be implemented such that it is entirely independent on the NMCS 2 control system.

ii) A group of interlocked signals shall be linked via the signal interlocking interface on each signal as specified. The minimum number of signals in a group shall be one and the maximum 30.

iii) In the event of any red cross aspect failing while being displayed, all green arrow aspects being displayed on the reverse faces of the group of interlocked signals shall be removed.

iv) In the event of a fault in the signal interlocking system within a group of signals, the signals shall remove all green arrow aspects displayed and continue to display any red cross aspects set.

v) Intermittent faults (such as caused by bad connections) shall be detected and the arrow aspects removed until the intermittent fault condition is reset. This condition shall be reset by the signal when the drive inputs from the signal driver change.

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vi) In the event of the signal interlocking system preventing the setting of arrow aspects or removing arrow aspects displayed it shall be possible to set other allowable combinations of aspects. If a cross and arrow aspect is requested and not allowed due to interlocking the signal shall display the cross immediately, the arrow shall be displayed when the interlocking condition is satisfied providing no other aspect has been requested.

vii) The signal shall, at all times, report on its monitor lines the actual face number code of the face being displayed. Removal of an arrow aspect due to interlocking shall not generate a lamp or LED failure report.

viii) It shall be possible to remove a signal from an interlocking circuit by a simple means, such as linking through.

Mechanical Requirements

22 These shall comply with the following:

i) The enclosures for the lane control signals shall be of a material to suit the tunnel environment.

ii) A breather or similar approved method shall be fitted where necessary to enable pressure equalisation. The breather shall prevent the ingress of moisture and dust.

iii) Space shall be provided on each unit for a label to be fitted such that is visible from the nearside carriageway lane. Maximum label dimensions shall be 300mm x 80mm.

iv) All signal faces shall have a minimum impact resistance Category 1.

Reliability, Maintainability

23 This shall comply with the following:

i) The signal shall have a design lifetime compliant to the project specific documentation. A routine maintenance schedule shall be detailed within record documentation.

ii) The display and display drive circuitry shall be designed to provide a minimum of 3000 hours lamp operating life at the required light output where lamps are used. Where LEDs are used the display and display drive shall be designed to provide a minimum operating life of two years. The units shall be easily interchangeable.

iii) The nominal operating voltage of the lamp, where used, shall not exceed 97% of its rated voltage.

iv) Where back-up lamps are used, the light output of the legend displayed shall not deteriorate for more than 0.5 seconds if a lamp failure occurs.

v) the design shall be modular to assist spares holding and servicing operations.

vi) The design shall provide adequate access for repairs and routine maintenance. Any doors, hatches and fixings used during maintenance shall be captive and shall isolate the equipment exposed from mains power when opened. It shall not be necessary to dismount the equipment to perform repairs and routine maintenance.

vii) All materials shall be in accordance with the requirements of the project specific documentation.

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A7114. APPENDICES

Standards and Codes of Practice

All work to be undertaken on communication systems shall comply with the following documents.

HIGHWAYS AGENCY STANDARDS	
MCF 2336	Chigwell and Scratchwood CO upgrade Tunnel Sub System
TR 0102	DOT Standard Traffic Control
TR 0154	Electromechanical VMSs Functional Specifications
TR 2141	Motorway Signals Mark 2
TR 1100	Technical and Quality Control Requirements for Systems
TR 2130	Environmental Tests
TR 2136	Luminosity
TR G1068	Electromagnetic Compatibility Tests
BRITISH STANDARDS	
BS EN 60529	Degrees of protection provided by enclosures (IP Code)
BS 1376	Specification for colours of light signals
BS 5760	Reliability of Systems, Equipments and Components
BS 6667	Electro magnetic compatibility
HD 472-S1	CENELEC Harmonisation Document Nominal voltage for low voltage public electricity supply systems
MILITARY SPECIFICATIONS	
MS 3106	Multiple connectors

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7115 TRAFFIC MONITORING

General

1 Where stated in the project specific documentation the traffic monitoring systems shall conform to the Tunnel Sub System requirements to the appropriate standard.

2 The type of traffic monitoring systems required shall be in accordance with the project specific documentation.

3 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Vehicle Detection Loops

4 The spacing and type of loops to be installed shall be in accordance with the project specific documentation.

Above Ground Vehicle Detection Systems

5 Where above ground detection systems are required, the type and locations shall be in accordance with the project specific documentation.

Vehicle Detection Algorithm

6 The vehicle detection algorithm shall be in accordance with the project specific documentation.

7 The algorithm used in tunnels shall be capable of detecting the presence of a single stopped or slow moving vehicle in light traffic conditions. It shall also operate in contraflow and during periods while lanes are removed from public use.

Vehicle Counting

8 A dedicated traffic counting loop site shall be in accordance with the project specific documentation.

Vehicle Measuring

9 Location and number of vehicle measuring sites to be provided shall in accordance with the project specific documentation.

10 The measuring equipment shall be capable of providing:

i) a continuous count of the number of vehicles per hour in each lane in each of the categories:

- HGV's and other vehicles (as defined in project specific documentation)

ii) a continuous count of the total number of vehicles per hour in each direction, classified by speed band.

iii) The speed bands shall be:

- under 40kph
- 41 - 70kph
- 70 - 100kph
- over 100kph

Measurements Limits of Accuracy

11 The measuring equipment shall be capable of measuring to the following accuracy:

i) The count of the number of vehicles in each category in each lane plus or minus 3% the count of the total number of vehicles in each lane plus or minus 1% at (in both cases) 95% confidence interval, without bias to under recording or over recording. These accuracy levels shall be achieved over every period of 12 hours and at all speeds, including stationary

ii) The count of the total number of vehicles in each direction in each speed band plus or minus 5% over every period of 12 hours at 95% confidence interval for all speeds within the range 5kph to 160kph

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Availability

12 The measuring equipment at each measurement point shall operate in accordance with the above for not less than 99% of the time during every six month period.

Avoidance of Tampering

13 The measuring equipment shall include adequate devices to prevent persons tampering or interfering with it.

Traffic Census Equipment

14 Location and numbers of traffic census sites to be provided shall be in accordance with the project specific documentation.

15 The traffic census equipment shall be capable of providing:

i) a continuous count of the number of vehicles per hour in each direction in each of the eleven categories:

- Motor cycle
- Car
- Bus and Coach
- Van (light goods)
- 2 axle rigid HGV
- 3 axle rigid HGV
- 4 axle rigid HGV
- 3 axle rigid HGV
- 4 axle articulated or drawbar trailer HGV
- 5 axle articulated or drawbar trailer HGV
- 5 axle articulated HGV
- 6 or more axle articulated HGV

iii) A continuous count of the total number of vehicles per hour in each directIon classified by speed band. The speed bands shall be:

- under 40kph
- 41 - 70kph
- 71 - 100kph
- over 100kph

iv) A continuous count of the total number of vehicles per hour in each lane

Census Limits of Accuracy

16 The traffic census equipment shall be capable of measuring to the following accuracy:

i) The count of the number of vehicles in each category in each direction shall achieve the following accuracy:

Category	Accuracy
Motor Cycle	plus 10% or minus 20%
Car	± 1½%
Bus and Coach	± 15%
Van (light goods)	± 10%
Each HGV category	± 10%

In all cases at 95% confidence interval over every 12 hour period at all speeds, including stationery.

ii) The count of the total number of vehicles in each lane shall be accurate to ±1% over every 12 hour period at 96=5% confidence interval for all speeds including stationery

iii) The count of the total number of vehicles in each direction in each speed band shall be accurate to ±5% over every 12 hour period at 95% confidence interval for all speeds within the range 5kph to 160kph

Availability

17 The traffic census equipment shall operate in accordance with the above for not less than 95% of the time during every calendar month.

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Transmission Data

18 Data from the traffic census equipment shall be transmittable by public service telephone network (PSTN) in a format compatible with that from time to time used or specified by the Secretary of State for the collection, storage and analysis of data from road traffic census sites.

Avoidance of Tampering

19 The traffic census equipment shall include adequate devices to prevent persons tampering or interfering with it.

Overheight Vehicle Detection

20 The location of overheight vehicle detection systems shall be in accordance with project specific documentation.

21 Overheight detection systems shall comply with MCE 0156.

Toll Collection

22 The details for toll collection shall be in accordance with the project specific documentation.

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A7115. APPENDICES

Standards and Codes of Practice

All work to be undertaken on Traffic Monitoring Systems shall comply with the following documents.

HIGHWAYS AGENCY STANDARDS	
MCF 2336	Chigwell and Scratchwood CO upgrade Tunnel Sub System
MCH 1540	Specification for the installation of Detector Loop on Motorways and all purpose trunk roads
TR 0100	Inductive Loop Vehicle Detection Equipment
MCE 0156	Functional Specification for Vehicle Height Detection
Series 1200	Specification for Highways Works
BRITISH STANDARDS	
BS 6701	Code of practice for installation of apparatus intended for connection to certain Telecommunication systems
BABT	British Approval Board for Telecommunications

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7116. PLANT MONITORING AND CONTROL SYSTEM

General

1 The following sections specifies the performance of the control system. The control processes to be controlled and monitored are described in the individual system chapters.

2 All instrumentation and control devices shall comply with the below default values and accuracy requirements. Adequate consideration must be given to siting of instruments, calibration facilities and types of fluids to be encountered for all instruments.

Temperature - Resistance Bulbs

3 This shall comply with the following:

i) The accuracy shall be ±0.5% of span.

ii) The speed of response shall be a maximum of 5 seconds for a change of 63% span.

Flow - Differential Pressure Transmitters

4 The accuracy of measurement shall include hysteresis, non-linearity, repeatability and creep effect up to 1 hour after initial adjustment and shall be within ±0.2% of a span.

Flow - Variable Area

5 The accuracy at any point within the flow range shall be within ±2% of span.

Flow - Turbine

6 This shall comply with the following:

i) The rangeability turndown shall be 35:1 within a linear range.

ii) The accuracy at any point within the flow shall be within ±0.25% of the flow rate.

Flow - Electromagnetic

7 The accuracy at any point within the flow range shall be within ±0.75% of the span.

Flow - Ultrasonic Flowmeters

8 The accuracy shall be better than ±1.0% between full scale flowrate and 50% flowrate, thereafter decreasing progressively to not worse than ±2.0% at 10% flowrate.

Level - Head Measurement

9 The accuracy at any point within the level range shall be written ±0.5% of span.

Level - Ultrasonic

10 The accuracy shall be better than ±1.0% of full scale for both 0 and 100% level.

Level - Buoyancy Transmitters

11 This shall comply with the following:

i) The accuracy at any point within the level range shall be within ±1% of span.

ii) The zero and span shall not change more than ±0.1% of the span over an ambient temperature range of 0 - 60°C.

iii) Changes in the specific gravity adjustment shall not effect the accuracy by more than ±0.1% of span.

Level - Switch

12 This shall comply with the following:

i) The switching differential shall be ±10mm of the level change.

ii) The level switch shall be fitted with double pole changeover contacts rated at 5A, 240V ac non-inductive.

Pressure - Gauge

13 Accuracy of the pressure gauge shall be within ±1% of the span.

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Pressure - Transmitter

14 This shall comply with the following:

i) The accuracy at any point within the pressure range shall be within ±0.5% of span.

ii) Zero and span shall not change more than ±0.1 of the span per 10°C temperature change. The span of the transmitter should normally be such that the normal working pressure is approximately 60% of the maximum range.

iii) After a slowly applied pressure of 130% of the maximum range pressure has been held for 10 minutes, the change in zero and span shall not exceed ±0.1% of the span.

Pressure - Switch

15 This shall comply with the following:

i) The switching differential shall be better than ±1% of the maximum span.

ii) The repeatability shall be better than ±1% of the set value.

iii) The pressure switch shall be fitted with double pole changeover contacts rated at 5A, 240V ac non-inductive.

Panel/Control/Monitoring Room Indicators

16 This shall comply with the following:

i) The accuracy of a panel indicator shall be within ±1% of the span.

ii) The repeatability of a panel indicator shall be within ±0.25% of span.

Panel Recorders

17 This shall comply with the following:

i) The accuracy of a panel recorder shall be within ±0.25% of span.

ii) The repeatability of a panel recorder shall be within ±0.25% of span.

iii) The calibrated accuracy of a panel recorded shall be within ±0.25% of span.

iv) The sensitivity of a panel recorder shall be within ±0.1% of span.

Panel Controllers

18 This shall comply with the following:

i) The process indicator accuracy shall be within ±0.5% of span.

ii) The repeatability shall be within ±0.25% of span.

iii) The ambient temperature effect of zero and span will not change more than ±0.25% of the input value over 10°C change within the limits of 0 - 45°C.

Power and Signal Transmission

19 Power supplies for field-mounted transmitters shall be routed via the appropriate local control panel and any associated PLC. A two-wire system where transmitters receive power from the signal circuit is preferred.

20 Electronic analogue I/O transmission signals shall be either as in Clause 7216.64 or in such a form as to utilise a standard two-way digital communications protocol. Consideration shall be given to reliability and maintainability.

21 Signal cables shall be segregated as necessary (see Series 7104).

Temperature

22 Temperature measurement for indicating, controlling or recording shall normally be made by a Resistance Temperature Devices (RTD). The resistance type elements shall be Platinum with a 100W resistance at 0°C.

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Thermowells

23 These shall comply with the following:

i) RTDs may be inserted into wells or protective sheaths to suit conditions, to protect the thermal element and to permit removal of these elements during plant operation. Thermowells may only be specified following proper consideration of the thermal delay which is introduced to the measuring element. Direct insertion of a metal sheathed RTD element is only acceptable where proper consideration has been given to the requirements of maintenance and safety.

ii) Thermowells shall be screwed or flanged and sized as determined by design conditions.

Local dial thermometers

24 Local dial thermometers shall be of the bi-metallic, liquid, or liquid vapour in steel type with compression type adjustable gland fitting which can be tightened to secure the thermometer at the full thermowell depth. Liquid, or liquid vapour in steel type shall be rigid stem, with angled or straight dials to give an uninterrupted view to the operator. The dial diameter shall be approximately 150mm, however, smaller diameters may be accepted in some circumstances which shall require the engineer's approval.

Flow

25 Each flow measurement to be made shall be carefully considered to ensure that the most appropriate type of instrument is employed by the Contractor, bearing in mind the process fluid, the process conditions and the instrument environment. Consideration shall be given to the provision of line filters to protect meters with moving parts. Provision of facilities for calibration, inspection and maintenance, etc of the flow device shall be considered if the process demands continuous operation.

Differential pressure primary elements

26 These shall comply with the following:

i) Mounting flanges shall be supplied in accordance with the pressure and temperature conditions within the pipeline.

ii) Flanges and tappings shall be sited to allow room for instrument piping and shall have adequate clearance from walls and adjacent lines.

iii) Pressure tappings shall be ISO R_c½ where possible, unless conditions dictate the use of other connections, eg flanges.

iv) Primary elements shall be selected so that the normal flow rate lies between 75% and 80% of capacity provided that the anticipated minimum and maximum flow rates shall be 30% and 90% respectively. If a greater range is required, dual range measuring systems shall be considered.

v) Uncertainty calculations shall be carried out.

Differential pressure flow transmitters

457 These shall comply with the following:

i) Where local indicators are required to be fitted to flow transmitters they shall be located as close to their primary elements as is compatible with accessibility and readability.

ii) Where possible, full scale differential pressure shall be fixed at 2500mm water gauge.

Variable area meters

28 These shall comply with the following:

i) Variable area meters shall normally only be used for line sizes smaller than 50 mm and where process conditions allow.

ii) Variable area flow meters shall be selected so that the normal flow rate lies between 50% and 75% capacity, provided the anticipated minimum and maximum flow rates shall be between 20% and 100% capacity.

iii) Glass tubes shall only be used on water, air or inert gas, and then only when gauge operating pressures are less than 10 bar and temperatures less than 70°C and greater than 5°C.

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Electromagnetic flowmeters

29 These shall comply with the following:

i) The meter shall be suitable for the conductivity of the process fluid.

ii) Liner protection flanges shall be fitted.

Ultrasonic flowmeters

30 These shall comply with the following:

i) Ultrasonic flow meters may be considered for measurement of relatively clean fluids in closed conduits or fluids in open channels (in conjunction with flumes or weirs).

ii) The primary sensors for closed conduits shall preferably be of the type to simultaneously transmit and then receive short pulses of ultrasound on the 'time-of-flight' principle.

Level

31 Particular attention shall be paid to the provision of break flanges, isolation valves, etc on level measurements to facilitate the removal of equipment for maintenance, calibration, and servicing.

Head measurement

32 This shall comply with the following:

i) Pressure transmitters used for liquid head measurement shall be either flange mounted to the vessel (with a pressure balance signal connected to the low pressure side in the case of pressurised vessels), or connected to the vessel by purged 'bubble' pipe systems.

ii) Where 'bubble' pipe systems are installed the Contractor shall provide adequate means of ensuring a constant supply of purge air and shall ensure that in the event of air failure the contents of the vessel shall not adversely affect the transmitter or purge system.

Gauge glasses

33 These shall comply with the following:

i) Liquid level gauges may be used for local level measurement, and will be either the glass tube type for low pressure applications or the armoured reflex type for higher temperature and pressure applications. However, remote level measurement techniques are preferred for all level measurement applications and gauge glass meters will only be specified with the permission of the engineer.

ii) Gauge glasses shall be sized to cover operating levels.

iii) Multiple gauge glass assemblies shall be considered for applications requiring greater than 1600mm measurement range, and where employed shall be installed such that each assembly overlaps the other by at least 25mm.

iv) Provision shall be made on all through-vision type gauges for the fitting of an illuminator.

v) Connections shall be 40mm and be complete with isolating valves, drain valves and vent plugs.

Ultrasonic measurement

34 Consideration shall be given to the possibility of false readings due to foam or reflections from other objects. The designer shall consult the instrument supplier to obtain accurate application data to ensure correct use of this technique.

Level alarm and switches

35 These shall comply with the following:

i) Non-critical alarms will normally be derived using trip amplifiers connected to the level measurement system or switched signals from conductivity/ capacitance systems.

ii) Critical alarms shall be derived from ball or float type switches wherever possible. If turbulence is expected then stilling or damping devices shall be provided to eliminate adverse effects on the float.

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Pressure

36 All standard pressure instruments and gauges shall be furnished with full scale pressure ranges. The calibrated range shall be such that the normal working pressure is 60% of the maximum range. Suppressed range instruments will be furnished, where this is required for measurement sensitivity, for control purposes.

37 All pressure instruments shall be able to withstand an overpressure amounting to 150% of the full scale pressure (for a scale range of 0-600 kPa) or 125% (for higher scale values). In all cases the overpressure capacity shall not be less than the maximum pressure to which the instruments will be exposed during normal operating conditions without giving rise to calibration variations.

Pressure gauges

38 These shall comply with the following:

i) Local gauges shall be Bourdon tube type. The case shall be safety pattern and blowout discs shall be provided on all gauges other than those on air service not subjected to a gauge pressure exceeding 100 kPa.

ii) Pressure gauges shall be bottom connected, except where panel mounted, when they shall be back connected.

iii) Local gauges shall have nominal 100 mm diameter dials and ISO R_c¼ connections for pressures < 5000 kPa . ISO R_c½ connections shall be used for pressures > 5000 kPa. Smaller dials may be used for auxiliary services and gauges with 50mm diameter dials shall be used for pneumatic signal readings from transmitters, controllers and reducing valves. The dials shall be manufactured from corrosion resistant materials with white background and black lettering.

iv) Movements shall be robust, vibration resistant and constructed of corrosion resistant materials.

Pressure transmitters

39 Transmitter ranges shall be selected so as to be sure that the normal operation pressure lies within 40% to 80% of the calibrated range. Connections to the process lines shall be ISO R_c½, unless conditions dictate the use of other connections, eg flanges.

Pressure switches

40 Pressure switches shall be used for alarm signalling. Switch contacts shall be self wiping, snap acting and protected from the ingress of dust, dirt and moisture. The switch point shall be adjustable against a graduated but not necessarily calibrated scale. Connections to the process lines shall be ISO R_c½.

Analysis

41 An analyzer system will normally comprise a sample conditioning unit, the analyzer(s), manual calibration facilities, automatic calibration unit when available, correction unit for linearisation of output including the effects of temperature, pressure, etc, where applicable.

42 The analyzer system shall be installed strictly in accordance with the manufacturer's instructions.

43 Where necessary, double sampling systems shall be supplied which shall automatically switch to the alternative system in the event of sample failure.

44 Analyzers shall have short response time characteristics.

45 In locations likely to experience shock and vibration and hence noise on transmitted signals, anti-vibration mounting systems shall be used.

46 Analyzers shall have facilities for easy servicing and minimum warm-up time. Calibration systems shall be provided and designed to ensure quick and accurate checking of span and zero settings; additionally, where for example, calibration gas bottles are necessary, one operational and one spare shall be connected, with rapid changeover facilities.

Control Valves

47 Due attention shall be given to the selection of valve type and sizing of flow characteristic, materials, pressure and temperature rating to meet its application.

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48 The flow characteristic shall be equal percentage.

49 The method of actuation for modulating valves shall be electrical unless stated otherwise in the particular Specification.

50 Valve positioners shall normally be provided for modulating valve service (see below).

51 Positive indication of valve position shall be provided.

52 Limit switches shall be provided to indicate open and closed for all on/off valves.

Valve positioners

53 Positioners will ideally be electrically driven and digitally controlled to suit the application. Optional extras shall include a by-pass valve as applicable and where conditions permit and provided wherever a strong resistance to the valve stem stroke is anticipated, whenever a high degree of accuracy is required, whenever the actuator range is other than the default pneumatic control value, whenever it is necessary to reduce valve response time and whenever special valve opening characteristics are required.

54 Particular attention shall be paid to the loop time constant when valve positioners are employed. Positioners will reduce the overall loop time constant that could lead to instability in loops with a naturally fast response.

Local indication, recording and controller equipment

55 This section is applicable to panel-mounted equipment forming part of one measurement or control loop. Systems using shared display (ie computer based) are specified in the PLC/SCADA sections of this document.

56 Panel mounted equipment shall conform to DIN standards from a single manufacturer.

57 Panel instrument mounting arrangements shall be in 'multiple bin units' with a spare capacity of at least 20%, complete with appropriate terminals, extension leads and blanking plates. The use of single mounted units shall not reduce the requirement for overall spare capacity.

58 Local indicators, controllers or recording equipment shall accept the default analogue signal from field-mounted equipment. No individual item of equipment shall impose a load of greater than 250W on a 4-20 mA circuit and the total load shall not exceed limits imposed by the power supply. The removal of any piece of equipment shall not disrupt or effect the signal.

59 Scales on panel mounted instruments shall be white with black lettering, or black with white lettering. The same combination of colours and style shall be used throughout.

60 Indication of process variable values and set points shall employ a vertical analogue strip display on panel mounted equipment. Pointer and scale, light emitting diode (LED) or liquid crystal display (LCD) if back lit, displays are acceptable. A digital display of the value may be used to supplement the analogue indication.

Controllers

61 Controllers, whether panel mounted or forming part of a shared software based system, shall be of the deviation type and shall have auto/manual facilities, bump-less transfer and set point and output indication.

62 The following adjustments shall be operable from the front of the instrument in the case of a panel-mounted instrument or from an operator's keyboard in the case of a software based system:

i) set point change;

ii) manual/auto switching;

iii) output change in manual operation;

iv) remote/local switching, when provided.

63 Other adjustments shall be in a manner not normally accessible to the process operator.

64 Controllers shall provide complete input/output (I/O) isolation.

65 Controllers shall have protection against integral saturation, or shall be provided with adjustable high and low signal limits to prevent integral saturation.

66 The proportional band shall be continuously adjustable between 5 and 500%.

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67 The integral band shall be continuously adjustable between 1 second and 30 minutes.

68 The derivative band shall be continuously adjustable between 0.5 and 30 minutes.

69 All controllers shall be suitable for integration into a PLC system.

70 Controller output indication shall have horizontal or vertical scale, with the variable and set point displayed.

Indicators

71 Panel mounted indicator scales shall be fixed and calibrated 0-100 linear, unless otherwise specified.

72 Signals shall be linearised before indication.

General Control System Safety Requirements

73 All systems and control items, shall be designed such that any failure in the instrumentation or control system shall cause all associated plant and equipment to go into a safe state.

74 Any safety system shall be totally independent of software based products, ie shall consist of a hard-wired system of push buttons and relays etc. Examples include: an emergency push-button wired directly into the motor starter contactor; and an 'overflow' level switch to close the inlet valve.

75 Any critical alarm or safety system shall be independent of the main measurement and control system, and shall independently signal the alarm to the operator and the outstation, to effect the required outstation control response.

76 In all cases the operator and the systems shall have easy to use, ergonomically designed, man-machine interfaces to provide the highest levels of safety.

77 All measurement and control circuits shall be designed to 'fail safe', eg :

i) All control valves shall either move or remain in a safe position in the event of a failure of any signal or supply to them the most.

ii) All electrical equipment circuits shall be designed such that any equipment operated by the circuit shall either be moved to a safe position or remain in its present state in the event of a power supply or component failure.

78 Alarm and safety systems shall be initiated from switch contacts which are directly operated by the process. The systems shall be designed such that a breaking contact or power failure will initiate the alarm or safety consequences. The philosophy to be adopted shall be that all electrical contacts should be spring loaded to fail open and that the loss of a signal or power shall initiate a trip or fault condition.

79 All motors shall have a local, rotary, lockable means of isolation (see isolators section of this Specification) and a local emergency stop button positioned so that the operator does not have to lean over the motor to operate it. The function of such buttons shall be clearly identified.

Alarm annunciators

80 Where supplied on a control panel, locally or remotely, audio visual alarm systems (alarm annunciators) shall be of the solid state electronic type and shall be activated by breaking contacts. Alarm acceptance and lamp test buttons shall be included with the annunciator and shall be common for the whole unit.

81 Front access lamp boxes shall have easily replaceable identifying windows suitably engraved and/ or coloured with the alarm function. Each alarm window shall be fitted with at least two bulbs and consideration shall be given to a 'dim glow' feature for increased lamp life.

82 Each alarm annunciator shall have its own power supply.

83 Field mounted alarm contacts for connection to the annunciator shall be volt free.

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84 The preferred alarm sequence shall be as follows:

Condition	Annunciator	Audible
Normal	Off	Off
Alarm	Flashing	On
Accept	Steady	Off
Return to normal (auto reset)	Off	Off
Lamp test	Steady	On

85 The system shall incorporate facilities for other alarm sequences and shall include the following features:

i) first up detection;

ii) alarm on closed or open contact;

iii) serial communications to a host computer/PLC.

86 Where the annunciator is fitted remotely, on plant that does not warrant a SCADA system, a printer shall be fitted to the annunciator to log the alarms, and operator actions.

Equipment in Hazardous Areas

87 Instrumentation and cabling to be installed to and within hazardous areas, classified as zone 0, 1 or 2 shall conform to the appropriate British and/or European Standards.

88 The design shall ensure that these hazardous areas are taken into consideration in the selection of the control systems and equipment.

89 Intrinsically safe circuit cabling shall be readily identifiable from other instrument cables by the use of an outer blue sheath.

90 Areas that are categorised as hazardous shall have electronic barriers or certified isolators connected between the plant and all circuits in any safe area. To reduce possible confusion the barriers shall be located at the zone limits.

91 All equipment located within any hazardous area shall be suitably certified as intrinsically safe or explosion proof by the appropriate authorities and be clearly labelled as such.

Control System Outstations (Programmable Logic Controllers (PLCs)/ Remote Terminal Units)

92 Clause 7116.73 to 7116.91 details the general requirements for all the control system outstations. The system outstations shall be PLC's unless stated otherwise in the contract specific documentation.

PLC Modes

93 The system shall have the following modes of operation:

Start-up

94 On power restoration to an outstation this transitory start-up mode shall be performed, under which the self-diagnostics ensure the health state of the outstation. The outstation will then revert to the fully automatic mode.

Editing/commissioning

95 for editing the software running in the outstation to clear problems (ie in commissioning) and implement enhancements. This mode shall not be available to the operator.

Manual operation

96 where selected plant items shall be under manual control via local switches. All such operations shall be the responsibility of the operators.

Fully automatic

97 This shall comply with the following:

i) the normal mode of operation and which shall be split into the following sub-modes:

   a) remote isolated - SCADA (where there is no communications link or links to SCADA has failed);

   b) remote isolated - outstation (where there is no communications link or links to another outstation has failed);

   c) remote connected (where the link is active).

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ii) In the remote isolated mode the outstation shall continue functioning independently using either the latest remote information, or default values as appropriate. The outstation may be required to store some historical data locally for later transmission to the SCADA system.

iii) When the SCADA link is first active, the outstation will undertake a transitory mode whereby data or instructions are cross-loaded as necessary. The remote connected mode, with data transfer, will be the normal operational mode.

iv) If the connections to another outstation fails, the outstation will complete as much of the current task as possible, and then wait for the link to be restored. New tasks shall not be started.

v) Note: Where a remote outstation has been restarted, the interface software shall be written, so that the actiones of the outstation can be 'skipped' to re-synchronise the outstation.

vi) Under all modes the outstation shall continuously monitor its own operation through a self-test procedure and report faults to the operator. All items of plant affected by a fault condition shall be controlled to a safe condition and inhibited until the fault has cleared or an override command is issued by an operator.

Outstation Functions

98 The major functions of the system are:

i) control of the plant;

ii) plant status monitoring (including alarms);

iii) operator interface (see operational requirements below).

99 The PLCs shall directly handle all inputs from instruments and all outputs to final control elements. They shall carry out all analogue control algorithms, sequence control functions and data gathering. It shall not be possible for the SCADA package to directly control outputs.

100 Any initiating operation commands (local or remote) on plant items or process sequences will pass through a command arbitrator, that will check for the following:

i) plant item availability;

ii) safe to execute the command (both to plant and personnel);

iii) maintain control stability.

101 Should a command fail the above criteria, the arbitrator shall reject the command, giving the reason for rejection to the operator.

102 Operational commands include instructions like start/stop, open/close or set point adjustments (including proportional, integral and derivative (PID) values).

103 The system shall have the following secondary functions:

i) continuous status checks whilst a function is running;

ii) alarm handling.

Process description

104 The process description is as detailed in the contract specific documentation, to the performance requirements detailed.

105 Monitor emergency call point alarms, for remote immediate indication to the police authority.

Plant status monitoring

106 The status of the plant and its instrumentation shall be continuously monitored. The operator shall be informed of all alarms and changes of equipment states as they occur. This shall include the following.

i) Items with one output and two feedback inputs, (eg valves)

ii) This monitoring shall include a pre-set grace time before alarming to allow for item movement between the two states. Unexpected movement shall also raise an alarm.

iii) Items with two outputs and two feedback inputs, (eg latching relays)

iv) The monitoring requirement of above shall hold for these items. The algorithm shall also raise an alarm if an impossible request to open and close the device is simultaneously requested.

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Motor state monitoring

107 Motor state monitoring shall include running, stopped, tripped and emergency stop states. The running and stopped signals shall include a pre-set grace time before alarming during start up and shut down - as in (a) above.

108 Motor states shall be monitored to prevent attempting to run the motor in an unsafe condition, eg emergency stops activated.

Instrumentation condition monitoring

109 The outstation shall raise an 'Out of range' alarm if the analogue inputs are outside the input value range. The equivalent process value shall be displayed and not truncated to the input range.

110 Where instruments are purely to monitor the status of the plant (such as filters and services) they shall rise an appropriate alarm, and cause duty switching where standby plant is available, or effect a process change.

Process condition monitoring

111 Where there is a secondary means of checking the process, (eg a tank contents transmitter shows a level above a high level switch that is not in the alarm state), the system shall perform a cross-check. Alarms shall be raised if the check detects instrument or process errors.

Alarm masking

112 The outstation shall have the facility to temporarily mask alarms so that known alarm conditions that do not affect the process can be linked out until rectification can be completed. This facility shall not be available to the operator without some form of protection and logging. A list of masked alarms shall be available on demand when either a hard copy or operator control device is fitted to the system.

Plant duty/standby switching

113 Where plants have duty/standby equipment, duty switching shall occur upon duty plant failure, and on time usage bases, so that even use is made of the plant, and ensure that the standby will run when required. If the standby is unavailable at the time of duty switching, the operator shall be prompted.

114 Duty switching on time can occur either by starting the plant with the lower total run time, or after 'x' (a changeable variable) cumulative running hours. The former is probably better when the plant has lots of relatively short runs, and the latter when the plant has relatively long use and few starts.

Alarm handling

115 Safety type of alarms, like emergency stop push-buttons, shall cause the outstation to turn the control output(s) off, and wait for an operator signal (local or via SCADA system) to either abort the process sequence, or to recommence where it left off. Note: the emergency stop will have taken the power off the plant item, and this requirement is to ensure that the plant is restarted in a safe manner.

116 Where possible, process alarms shall be handled in the same manner.

Outstation Operational Requirements

Operator interfaces

117 These devices, are detailed under the type of equipment concerned.

118 Each outstation shall be provided with an interface for the occasional use of a portable terminal for use during commissioning, testing, maintenance, program changing and editing.

Hard copy devices

119 All data logging, alarm reporting, etc will be carried out by the SCADA system. A hard copy device shall not be permanently installed with the outstation.

Push button stations and interlocks

120 The installation of push-button stations and interlocks, where necessary, shall be as detailed in the Particular Specification.

Timing requirements

121 Outstation cycle time of under one second.

122 Response within the outstation to remote commands of under one second.

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123 Response to operator action of under one second.

124 The VDU and/or printer shall have a response of under three seconds.

125 Alarms must be latched for a minimum of five seconds.

Safety and security requirements

126 Fail safe logic.

127 All non-routine operator instructions are to have an operator password and identification which shall be logged.

Outstation Equipment

128 The PLC equipment shall, as a minimum, consist of:

i) central processing unit (CPU);

ii) outstation system software;

iii) user software;

iv) non-volatile and volatile memory;

v) interfaces as required;

vi) field power supplies;

vii) protective cabinet.

129 The outstation system software shall be in non-volatile memory like ROM or EPROM, ie shall be Firmware. At the end of factory testing, and prior to final handover, the application software written by the contractor shall be written into EPROM (or similar) and inserted into the outstation.

130 Each outstation shall be capable of processing at a rate at least twice that of the worst case design loading.

Field power supplies

131 All digital output supplies shall be separate from the digital and pulse inputs supplies. All analogue supplies shall be stabilised and separate from all digital supplies. There shall only be one analogue earth which shall be at the outstation.

132 The field supplies shall be galvanically isolated from the outstation supplies.

133 The field supplies shall be suitably rated for the installed I/O and an allowance for future needs as per power feed supply described above.

134 Instruments requiring mains power supplies shall take its feed from the control panel. As far as it is possible the phase used for the instrumentation shall be the same as that used by the outstation system.

Equipment design and construction

135 The outstation shall be mounted in a cabinet which shall fully protect the PLC from the environment in which it is situated and from radio interference when the door of the cabinet is open. The cabinet shall be built to the standards specified in Section 7103 of this document using the standard DIN rack mounting system. A separate cabinet shall be provided for all non electronic equipment such as marshalling racks, cable terminations, relays, etc

136 Hardware shall be modular in design and facilitate easy removal of circuit boards and components for maintenance and replacement.

137 Electronic assemblies shall be constructed using one or more printed circuit boards mounted in a purpose built enclosure. Assisted cooling shall be provided if necessary.

138 Electrical connections between circuit boards and other components shall be made using removable plug and socket connectors. Circuit board edge connectors, plugs and sockets shall be designed to prevent wrong insertion.

139 Electronic assemblies shall be calibrated and tested at works prior to installation on site.

140 Peripheral equipment and ancillaries shall be connected to the system with mechanically secured industry standard plugs and sockets and using industry standard signalling conventions.

Outstation Interfaces

141 The system interfaces are as follows:

i) digital inputs;

ii) analogue inputs;

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iii) pulse inputs;

iv) digital outputs;

v) analogue outputs;

vi) Fieldbus or similar standard communications;

vii) SCADA links;

viii) serial communications.

Functional groupings

142 A functional grouping is defined to be the smallest unit which can be switched on/off independent of other units. The definition of what is to be included within each function group, shall form part of the detail design, with special care taken with:

i) emergency containment boundary;

ii) material flow;

iii) redundancy.

143 To achieve simple software design, and simple repair and maintenance procedures, each functional group shall reside in a single outstation. There can be more than one functional grouping on each outstation.

Inputs/outputs general

144 Analogue-to-digital and digital-to-analogue signal conversions shall not introduce errors exceeding 0.5% of the difference between the minimum and maximum convertible values.

145 The digital and analogue inputs and outputs that have been identified are listed in the Particular Specification.

146 Each digital output shall be individually fused.

147 All pulse (digital) inputs shall be suitably rated for volt free contacts (or other solid state types of pulse switches) using digital field supplies. The system shall be able to respond to (count) pulses stated below.

148 Each I/O point can be considered a database item, that is manipulated through the outstations software.

Tag number system

149 All references to an item must use the site tag number. Any internal system numbers may be used provided that there is a translator to (and from) the site tag number. All interfaces with operators shall use the site tag number.

150 The documentation must include an outstation I/O item number translation list.

Signal isolation

151 Where a current loop signal is to be interfaced between systems which have or use separate analogue power supplies a signal isolator shall be installed.

152 Signal isolators shall also be fitted where insufficient isolation or incorrect earthing results in a poor signal. It is expected that few, if any, isolators shall be used for this purpose. The Contractor shall supply any isolators at no extra cost if isolators have to be fitted because of problems encountered during and after installation of the system. (Time limited until the end of warranty period.)

Instrument powered interfaces

153 Where instruments generate their own analogue signal supplies, the supply shall be used with the earth and/or screen earthed at the instrument. Note the outstation input must be floating to prevent earth loop problems, or a signal isolator shall be fitted.

154 Instruments and actuators associated with any single plant item or control loop shall be connected to the same outstation to prevent any dangerous open loop operation.

Fieldbus or similar communications

155 Fieldbus or similar communications between instrumentation and the PLC that are internationally recognised shall not be used, unless prior approval is given or as detailed in the Particular Specification.

SCADA communications

156 SCADA link shall be a form of serial link as detailed below. The protocol used shall be a proven, open standard within the SCADA control field and shall allow the easy expansion of the controls system without limiting potential supplies of additional equipment. The preferred protocol to be used is MOD BUS plus.

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157 The preferred method of data exchange, for information bound to and from the SCADA system, shall be via pre-defined data tables. This gives a concise data structure, to which the outstation and SCADA software can refer to independently of current processing requirements. It facilitates future enhancements, modifications or replacements to be quickly implemented. This gives a model where the outstation software sits between two databases, manipulating the data items to achieve the desired outputs.

Serial communications

158 Serial communications shall be controlled in an orderly fashion using proven protocols. The protocol shall ensure all transmissions are error free and without loss.

159 A outstation will have the following communication links:

i) programmer terminal;

ii) SCADA;

iii) visual display unit;

iv) occasional hard copy device;

v) any other serial data links (if required).

160 Any data links that may be required to other outstations, controllers or instrument systems will be detailed in the Particular Specification.

161 The Users' software required for data processing and control functions shall be loaded by using a programmer terminal locally, ie not remotely.

I/O Guideline

162 The following I/O requirement guidelines shall be used.

i) For each bank of lights these shall normally be:

O/P 2 on/off, and
L/P 1 undercurrent alarm

For variable level lighting the O/P shall normally be 420mA with a feedback of 4-20mA defining actual lighting levels achieved or current used. Where current levels are used this should be linearised to determine light levels.

ii) For each fan pump or motor there will normally be:

Outputs - 2 run/stop
Inputs - 5 emergency stop/local/ tripped/isolated for safety considerations/running for operational reasons.

iii) Where an instrument is required to totalise, (eg flows) a pulse input shall be supplied. If the instrument is also to be used to control and monitor, then an analogue input shall also be provided from the instrument. The analogue quantity shall not be integrated in the outstation to provide a total quantity.

iv) For each valve where feed backs are specified there will normally be:

outputs - 1 open/closed
inputs - 2 limit switch checking for open/closed status

Some control valves may be provided with an analogue signal to monitor its position. Where a latching valve is specified, an additional output is required.

Outstation Environment

Equipment location

163 Outstation shall generally be located in proximity of the plant or control items, ie within the pump station or in the lighting switchboard.

164 For limited number of non-related alarm sensors, (eg emergency call point) that are located within short distance of a process outstation, the outstation may be used as the interface.

Environmental requirements

165 All equipment supplied shall be fit for purpose, built to withstand the rigours of the tunnel environment and installed in cabinets where appropriate. This environment is detailed in Clause 7013.

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166 All equipment shall be protected against atmospheric corrosion, including saline atmospheres. Materials shall not be susceptible to mould growth, or attack by vermin or other life forms.

Health and safety

167 The contractor shall satisfy himself that the safety requirements of all programmable electronic systems, in safety critical applications are satisfied. Any aspects of the design which the Contractor finds does not conform to relevant safety regulations shall be brought to the attention of the Engineer for resolution.

Service capabilities

168 A UPS shall be provided for each outstation to maintain monitoring of the plant even though the main power supply has failed, (ie as a minimum, outstation and inputs power supplies only). Any specific associated field instruments that are required in monitoring the plant, may also be connected to this UPS.

169 Failure of the power supply to the control system (or part of) shall result in all control devices to go to their fail safe position. The status of the plant at the time of failure shall be stored in non-volatile memory.

170 Power supplies shall be conditioned to prevent malfunctions from voltage transients and other mains borne disturbances. Where field instrument and actuator power supplies are to share a UPS, the outstation equipment shall be galvanically isolated from field requirements.

Outstation Attributes

Availability

171 99.8% availability is required since a road tunnel must only be closed for planned maintenance.

Reliability

172 The equipment shall therefore, be designed to have a high reliability.

Maintainability

173 The installed system software shall be written in a manner that can quickly resolve any problems. To facilitate this, the operators shall be given prompts, alarms, etc. and access to investigate plant status so that the point of failure can be quickly identified.

Spare capacity

174 The resources of the outstation, as installed and commissioned, shall have a minium of 25% spare capacity of each type of resource available at each location. It is not a requirement however, that the non-rack hardware, (eg interface cards) for these resources are to be installed. However, a partly used rack shall have the full back-plane installed.

175 Resources here means I/O, memory, flags, registers, SCADA interface tables, rack capacity, etc The I/O count shall include any foreseen I/O prior to the calculation of the spare I/O.

Adaptability and enhancement potential

176 The software and data structure is required to be planned in a manner that will allow changes without affecting unrelated data items and the software control structure.

SCADA Systems

177 All executive and systems software shall be standard packages, fully proven for the intended application.

SCADA Privileges and Modes

Privilege levels

178 There will be a number of user groups that will have access to common data, but will not be able to access each others' privileged information. The following minimum user groups shall be provided:

i) highway authorities plant operators;

ii) police authority;

ii) local authority maintenance operators - where required.

179 The system users shall have the minimum following privileges levels (in order from lowest):

i) monitoring (operator CANNOT issue commands);

ii) control (operator CAN issue commands);

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iii) configuration/editing/engineering (no operator entry possible);

iv) system (from system terminal only).

180 The access privilege at any work station shall automatically revert to the lowest level three minutes after the last key stroke to prevent unauthorised use if left unattended.

181 The software shall permit these multiple security levels accessible only by password, or key-switch, giving each User certain privileges according to the User's status. Passwords and status shall be assigned to Users only from within the highest level of security. Passwords shall not be displayed during entry and shall not be accessible by unauthorised interrogation of the SCADA system. Only at the highest access privilege level shall passwords be accessible for alteration, but not inspection. The system must ensure that all uses change their passwords at regular, redefinable time intervals.

182 The lowest access privilege level 'monitoring' shall only allow operations concerned with the normal monitoring, control and data acquisition functions of the SCADA system. No Operator action shall be allowed that will alter software or data affecting the parameters and sequences by which the plant is controlled.

183 Software security screening shall automatically disallow commands issued by unauthorised Users. A password system shall restrict Operator access to allow control functions under the 'control' privilege level.

184 Alterations and additions to the software configuration shall be possible from the appropriate Engineer's access level without a total shut down of the SCADA functions.

185 Configuration/editing/engineering access privilege levels may be split into individual levels. The configuration level shall easily allow alteration of the following:

i) duties of multiple redundant plant items;

ii) ramp and dwell times;

iii) time delays;

iv) control set points;

v) analogue and digital input, output and virtual point configuration;

vi) internal calculations;

vii) mimic displays;

viii) historical displays;

ix) report formatting;

x) printer channel configuration;

xi) outstation configuration;

xii) alarm threshold limits;

xiii) selection of logged events;

xiv) user development of software routines for particular applications;

xv) time and date setting of system clock;

xvi) additional particular features required by a project.

System modes

186 There shall be the following system modes:

i) start-up;

ii) fully automatic - the normal operating mode;

iii) degraded - remote isolated from outstation;

iv) degraded - standby computer faulty;

v) editing/configuration;

vi) system (if the computer platform has a separate system terminal).

187 In a similar manner to outstations the SCADA system will go into a start-up mode when the power is restored to the system. In this mode the system will perform equipment self tests, check/reset the real-time clock, configure the system, load and run the SCADA software including the Users' configuration software. Restoration of power and normal operation shall be logged and reported.

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188 When communication links are restored, the SCADA will undertake a transitory mode whereby data (including any historical data), or instructions are cross-loaded as necessary. The SCADA will then go into the 'fully automatic' mode with the remote outstations in the remote connected mode, or the 'remote isolated from outstations' degraded mode if a outstation fails to respond.

189 At any time, should the communications link fail the status of plant items will revert to 'unknown'. The outstation will continue operations using the latest or pre-set default values as appropriate.

SCADA Functions

190 The major functions of the system are:

i) 'reflex' commands (ie automatic commands issued by the SCADA system to PLCs' as a result of a PLC event) and passing data between outstations;

ii) initiate control commands;

iii) plant and process status reporting;

iv) alarm and event monitoring, reporting and logging;

v) generation of plant performance and other reports;

vi) trending of analogue process variables;

vii) archiving of historical plant and process data.

Process description

191 The process to be monitored and controlled is as detailed in the rest of the Specification.

Initiate control commands

192 Provision shall be made for the Operator to initiate all control commands from the work station terminal. Control commands shall include but not be limited to:

i) alteration of all analogue set points;

ii) manual on/off control of all motors (outstation to determine if this is safe and allowable, before carrying out this request);

iii) duty/standby selection of all multiple redundant plant items;

iv) selection of all automatic control sequences;

v) single stepping through control sequences;

vi) manual operation of all final control elements through the full range of their mechanical movement, (again, outstation to determine if this is safe and allowable, before carrying out the request).

193 The control privilege level will be required for this function.

194 All control commands issued automatically or manually shall cause a response at the SCADA terminal acknowledging receipt.

Plant and process status reporting

195 Any fault, malfunction or condition, with plant or process, giving rise to a hazard, either to personnel or to plant, shall cause an alarm to be raised and logged. Conditions giving rise to alarms shall include but not be limited to the following:

i) failed instruments and sensors;

ii) failed plant items;

iii) failure of any item of SCADA system equipment;

iv) excursion of analogue variables beyond safe or acceptable limits;

v) rates of change of analogue variables beyond safe or acceptable limits;

vi) states and values of virtual (derived) I/O points beyond safe and acceptable limits;

vii) any condition degrading the integrity of plant and process data;

viii) any condition degrading plant and process controllability.

196 Where practicable, faults and malfunctions shall automatically be isolated to localise their effects.

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197 Provision shall be made for the Operator to monitor the state of all plant items and process variables. The provision shall include:

i) running status of all motors;

ii) duty/standby status of all multiple redundant plant items;

iii) position of all final control elements;

iv) value of all measured process variables.

198 The minimum possible states for a plant item are:

i) on/running, etc;

ii) off/stopped, etc;

iii) alarm;

iv) unknown;

v) local/remote.

199 The monitoring privilege level is sufficient for this function.

Alarm and event monitoring, reporting and logging

200 The SCADA system shall be capable of setting at least four static alarm levels and a rate of change alarm on all analogue input signals. A set point deviation alarm shall also be available on all analogue control loops.

201 Provision shall be made for assigning different priorities to alarm conditions. At least two priority levels shall be available for this purpose.

202 The occurrence of an alarm condition shall cause an immediate conspicuous animation or change of the current display on the work station VDU in a manner likely to attract the Operator's attention. An audible alarm shall also be raised and shall not cease until the Operator has accepted the alarm condition by interaction with the work station terminal.

203 The presence of an alarm condition shall always be visible on the work station VDU. As a minimum requirement, the presence of an alarm condition shall be identifiable from:

i) an alarm list showing in textual format the nature, priority and status of all alarms;

ii) a conspicuous change in the graphical appearance of the alarmed I/O point on the appropriate mimic display(s);

iii) an alarm banner, displayed at all times, indicating the presence of alarms with a simple and direct way of calling up the associated mimic display(s).

204 I/O points in alarm on mimic displays and entries in the alarm list shall indicate clearly the alarm status as unaccepted, accepted, uncleared and cleared.

205 Some process alarms, (eg power failure, or voltage drop) and all safety alarms, (eg fire alarms, emergency stop, etc), shall cause the outstation to switch the control output to the safe state, either on, off or remain as before, depending on alarm and item of equipment, and await for further instruction from the SCADA operator. All such alarms will require a alarm function in the SCADA system, through which the operator is given the choice of either aborting the process sequence, or to allow the process to continue, in operator selectable groups, or individually. Operator actions will be logged and printed against the each alarm. The control privilege level will be required by the operator. These alarms will form its own alarm classification which can be displayed.

206 The alarm list shall make clear distinction between different alarm priorities. Each entry in the alarm list shall indicate the precise nature of the alarm condition with the following information as a minimum:

i) date and time of the alarm;

ii) tag number;

iii) service;

iv) description of alarm condition.

207 All entries in the alarm list shall be listed in chronological order and removed only when accepted and cleared. All entries made in the alarm list and changes in status of alarms shall be simultaneously printed by the alarm/event printer and archived in a historical database.

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208 All alarms shall report by exception. Provision shall be made for buffering alarms during uninterruptible CPU activity.

209 Provision shall be made to allow selection of alarm conditions from analogue process variables to cause the archiving frequency of the analogue value to be increased to a minimum of once per minute until the alarm has cleared.

210 A facility shall be provided for the temporary masking of alarms to prevent repeated nuisance tripping due to a known fault with the control system equipment or during commissioning and testing. All masked alarms shall be clearly identifiable and formally logged. As a minimum the number of masked alarms shall be displayed at all times.

211 Acknowledgement of an alarm through an outstation shall mute the audible warning but shall not inhibit the audible warning operating upon the occurrence of further alarms.

212 The monitoring privilege level is sufficient for this function.

Event log

213 A facility shall be provided to allow alarms, changes in alarm status, operator log-on/log-off, operator control actions and events representing a change in the operating condition of any plant item to be logged chronologically in file(s) on to removable storage media, with time, date, tag number, service, description and value as and when appropriate.

214 A provision shall be made so the log can be displayed on screen and printed if required in whole or by type of event for a given time period. The monitoring privilege level is sufficient for this function.

215 The configuration/editing/engineering privilege shall be required to inhibit or not the printing of events as they occur.

216 Where two or more printers are specified, and a printer becomes ‘not available’, all its messages are to be sent to another printer after a delay of five minutes. This delay is to allow for the operator to change paper, etc without diverting the data.

217 Where required a separate printer shall be used to direct all manually and automatically initiated reports. All other messages shall be sent to the first printer in order of occurrence.

Generation of plant performance reports

218 Provision shall be made for generating reports containing information about the performance and operation of the plant. All current and historical data shall be accessible for this purpose.

219 The SCADA software shall be supplied with standard report proformas to generate reports. The monitoring privilege level is sufficient for this function.

220 Reports shall be invoked by:

i) a request from the user through the work station console;

ii) a programmable time schedule;

iii) occurrence of specific events.

221 Report output shall be directed to a printer for hard copy or to a non-volatile storage device for retrieval and printing later.

222 The SCADA software shall provide a comprehensive editing facility to allow the User to design and create custom report proformas or to alter the style and content of existing report proformas. The configuration/editing/engineering privilege level shall be required for this function.

Trending of analogue process values

223 Provision shall be made for displaying graphically a trend graph showing how any measured analogue process variable has changed with time. Both historical and real-time live data shall be accessible for this purpose. It shall also be possible to have derived data points such as a performance figure to be trended.

224 The time axis on the trend shall be variable to provide a range of scales. The full span of the time axis shall be variable, as a minimum range, between one hour and one week. The system shall allow the User to specify the time and date at which the trend begins.

225 The process variable axis on any trend shall be variable to provide a range of scales allowing close scrutiny of the transient response. The finest resolution attainable shall permit a one per cent deviation from set point to be clearly observable.

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226 A facility shall be provided for selecting a particular point on a trend and obtaining a numerical value of the variable at that point.

227 A minimum of four variables shall be capable of being displayed simultaneously to the same time axis with each trend being clearly distinguishable both on the screen and when printed out.

228 Provision shall be made to overlay the trend graph with grid lines extending from the graduations on both axes.

229 The monitoring privilege level is sufficient for generating trends, but the control privilege shall be required to alter items to be trended.

Archiving of historical plant and process data

230 Automatic storage and retrieval of selected data shall be provided through an historical database. The database shall be supported by a non-volatile storage device. Data selectable items for storage and retrieval shall include but not be limited to:

i) alarms;

ii) changes in alarm status;

iii) operator log-on and log-off;

iv) operator control actions;

v) changes in the operating condition of plant items;

vi) duty/standby changeover of multiple redundant plant items;

vii) counters;

viii) analogue input values;

ix) results of calculations;

x) events stated in the Particular Specification.

231 The time, date and, where appropriate, the tag number of the associated I/O point shall be logged against each entry into the historical database.

232 Digital data shall be stored in the historical database on each change of state.

233 Analogue data shall be stored either on an event driven basis (by exception) or on a regular timed basis, selection of either being configurable by the user.

234 When analogue point data is stored on an event driven basis, a facility shall be provided for placing a 'dead band' against variables. Only excursions of variables from their current value, outside the dead band, shall be stored in the historical database.

235 When analogue data is stored on a regular timed basis, a facility shall be provided for setting the frequency with which analogue point data is stored in the historical database. Provision shall be made for increasing the storing frequency for analogue points that have gone into an alarm condition. When this facility is initiated the increased storing frequency shall be invoked automatically when an input point goes into an alarm condition.

236 Provision shall be made for copying historical data to removable media for archiving. The computer equipment and removable media shall allow transference of data back to the SCADA system for inspection and manipulation through trends, reports and other standard formats.

Plant performance optimisation

237 Provision shall be made for tuning all control loops for the purpose of achieving optimum performance against any of the following performance indices:

i) minimum usage of energy;

ii) minimum usage of raw materials;

iii) maximum production;

iv) a transient response with characteristics defined in terms of rise-time, overshoot and settling time.

238 The configuration/editing/engineering privilege shall be required for this function.

Mimic build and I/O point configuration utility

239 A mimic build utility shall be provided allowing the User to create, edit, delete and copy mimics to enhance and modify the SCADA system. The mimic build utility shall provide a drawing/editing environment and an I/O point configuration facility, both to be under the editing/configuration/engineering privilege level.

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240 The drawing/editing environment shall allow the User to:

i) draw lines of different colour, style and width;

ii) draw rectangles, circles and polygons filled with different colours and patterns, with or without an outline;

iii) write text using different fonts and colours;

iv) select different coloured backgrounds;

v) create libraries of templates and symbols for reuse.

241 The I/O point configuration facility shall allow the User to define 'active' areas on mimic displays for live data points showing the most recently acquired analogue and digital input information and alarm states. Active areas shall also be used for selecting control functions and other mimics by means of a cursor positioning device or by touching the VDU display.

Watchdog and system resources monitoring

242 A watchdog timer shall monitor successful execution of one cycle of application software. This shall be via a hardware timer (adjustable) reset by a software application programme of lowest priority, maximum time shall be less than one second.

243 A watchdog shall monitor communications between the SCADA system and outstations. In the event of communications failure, an alarm shall be raised at the SCADA work station console.

244 Memory, data storage devices, and workstations shall be protected from data overflow. Memory and data storage devices shall be monitored to establish the free capacity available. Provision shall be made for raising an alarm shortly before data overflow occurs at such a time as will permit the Operator to take corrective action to avoid loss of data.

SCADA Operational Requirements

Operator interface terminals

245 Each work station terminal shall incorporate, as a minimum, the following equipment and features.

i) A VDU with high resolution (minimum of 1024 by 840 individually addressable pixels), flicker free screen with a minimum of 256 colours. Contrast, brightness and colour balance control shall be provided. The VDU shall have pan and tilt adjustment to obviate glare and discomfort from screen reflections.

ii) All display VDUs shall be clearly visible throughout the range of ambient light conditions which may be experienced at that location.

iii) Characters are to be available in colour, normal and reverse video, blink on/off and single or double height.

iv) A QWERTY type keyboard with function keys, cursor positioning and numeric keypad. The keyboard shall be separately cased and easily movable over the supporting work surface but shall be stable and resistant to slip or movement when in use. The keyboard shall be connected to the work station console by a robust flexible cable and locking plug and socket preventing accidental disconnection. Keys dedicated to a single specific function shall be engraved with their function. Key legends shall be clearly visible under the prevailing light and resistant to wear and abrasion. Keys shall have a tactile or audible response indicating a successful key operation.

v) The normal usage shall be by operators to perform process control and monitoring functions. If the SCADA platform does not require a system terminal then, via a keyswitch, this keyboard shall then be capable of performing the duties of an engineering keyboard enabling functions like diagnostics, software loading/dumping, configuration changes, etc.

vi) The keyboard shall be sealed with a protection index of IP 65 to prevent the ingress of dust, dirt and moisture and shall not be damageable by contact with solvents normally encountered in a plant room environment, or beverage spillage, (eg tea, etc). Key legends shall be clearly visible under the prevailing light and resistant to wear and abrasion.

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vii) The full ASCII character set with dollar sign shall be used for any device displaying or printing text. Characters shall be clearly formed and easily recognisable with clear distinction between, for instance, 'U' and 'V', '8' and 'B', '2' and 'Z'. Lower case characters shall be formed with true descendeurs.

Graphic mimic displays

246 The User terminals display shall be split into the following areas:

i) alarm banner;

ii) mimic and menu display area;

iii) command and acknowledgement line.

247 The Contractor shall provide an arrangement of graphic mimics to be displayed on the work station console VDUs. Each mimic shall model a logically partitioned sub-system of the plant and process showing all aspects of function relevant to the Operator's task of controlling the plant and acquiring data. The total arrangement of mimics shall cover all plant and processes within the scope of the SCADA system.

248 Mimics shall show all instruments, limit switches, final control elements, motors and any other plant for which inputs or outputs are required for the SCADA system. The values and states of all analogue and digital inputs and outputs associated with a sub-system shall be displayed on the corresponding mimic and may be displayed on other mimics where sub-system functions overlap.

249 The SCADA system shall be menu or hypertext driven which shall be selectable using a cursor positioning/pointing device, or by touching an 'active' area of the VDU display. It shall also be possible to select the item by using the keyboard.

250 Menus shall offer a logical grouping and progressively structured hierarchy of options and functions. Menus shall indicate those options available to the access privilege level of the operator; functions available to higher privilege levels shall be inhibited.

251 Dialogue between operators and work station consoles shall be in default language text stated below. Alphanumeric abbreviations will be allowed only to facilitate command entry as an option in addition to full default language menus or for entering security access codes. Interaction between the Operator and SCADA system shall be aided by a logically structured and progressive help facility to assist those unfamiliar with the system. Users with lower access privilege shall be able to operate the system without understanding coded/ abbreviated instructions and without reference to instruction manuals. SI units shall be used throughout.

252 The contractor shall give consideration as to how information is represented on mimics. Analogue and digital data should be displayed using any graphical aid that assists the Operator in assimilating rapidly the state of plant and process.

Hard copy devices

253 At each central control computer location tunnel service building, the alarm, event, screen dump and report printing functions shall be shared between at least two printers. At lest one printer shall be capable of printing screen graphic dumps in full colour to the standard specified for a VDU work station.

254 Remote terminals shall have a single monochrome printer with clear legible text on continuous paper for an office environment.

Timing constraints

255 Data acquisition from instruments shall be sufficiently fast to capture the most rapid process transients, excepting noise.

256 All changes of state, alarms and increments/ decrements of analogue variables shall be reported to the SCADA system with sufficient speed to allow the Operator to take corrective action should a condition arise endangering plant or personnel.

257 A VDU screen refresh shall occur at least once per second to update active data points showing state of plant and process.

258 A VDU display shall take not more than one second to appear on the screen following selection and be fully drawn within five seconds.

259 The maximum time between an event occurring in the field and the event being displayed and recorded in the SCADA system is to be less than 3 seconds.

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SCADA Equipment

260 The SCADA equipment, as a minimum shall consist of:

SCADA processing platform;

i) The SCADA computer(s) (platform) shall incorporate sufficient random access memory to support all software and dynamic data necessary for the full and correct functioning of the SCADA system.

ii) The maximum perceived loading on the platform CPU shall not exceed 50% of the CPUs capacity before the effects of spare capacity are taken into account.

iii) A hot standby and or fault tolerant platform is required to meet the availability targets.

SCADA system and platform operating system software;

i) user configuration and/or application software;

ii) work station terminals;

iii) non-volatile, high capacity mass data storage device which shall be sufficient to support all the required software and data for the normal and correct functioning of the SCADA system without recourse to removable storage media.

261 Non-volatile mass data storage system using removable media;

i) Which shall allow storage and retrieval of historical data and software for back-up purposes and installing new software and configuration versions.

ii) Interface and communications to outstations.

iii) Interface and communications to the traffic control system.

iv) Printers for alarms, events, screen dumps and reports.

v) Conditioned power supply.

262 Hardware design and construction:

i) Hardware shall be modular in design and facilitate easy removal of circuit boards and components for maintenance and replacement.

ii) Electronic assemblies shall be constructed using one or more printed circuit boards mounted in a purpose built enclosure; assisted cooling shall be provided if necessary. Electrical connections between circuit boards and other components shall be made using removable plug and socket connectors.

SCADA Interfaces

The system interfaces are as follows:

263 Each outstation shall conform to the requirements of the outstation section of this Specifications.

Operator interfaces

i) The simultaneous use of multiple work station terminals and printers, shall be provided for the minimum of the following distinctive groups:

i) highway authorities plant operators to be provided in each tunnel services building;

ii) police authority;

iii) local authority maintenance operators - where required.

Interface ports

264 Provision shall be made for the connection of a local printer, bulk memory device, portable terminal and separate connection of test equipment independent of other peripheral device ports. Connection and disconnection of any peripheral device or test equipment shall in no way interfere with communications between outstation and the SCADA system except where required as part of a specific test plan.

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Data communication equipment

265 A means of communication between the SCADA system, outstations and remote monitoring sites for the purpose of exchanging data, alarms, software and control commands shall be provided. Consideration shall be given into dual communications links to increase availability, particularly if the SCADA platform is split between two buildings.

266 All equipment, cabling and software necessary for communication between the SCADA and its outstations and remote monitoring sites shall be provided.

267 Communication shall be controlled in an orderly fashion using a proven protocol. The protocol shall ensure all transmissions are received error free and without loss. The preferred protocol is MOD BUS plus.

Optical fibre transmission

268 Optical fibre transmission systems may be considered for installations where:

i) unavoidable signal interference may be anticipated;

ii) intrinsic safety is required;

iii) a higher level of security is required;

iv) lower cost.

SCADA Environment

Equipment location

269 The SCADA system shall be located in an appropriate location such as a tunnel services building, with local and remote terminals. Where there is a building at each end of the tunnel, the dual SCADA platform is to be split between the two buildings to increase diversity and hence increase availability.

Environmental requirements

270 All equipment supplied shall be fit for purpose, built to withstand the rigours of the environment and installed in cabinets as appropriate.

271 All equipment shall be protected against atmospheric corrosion, including saline atmospheres. Materials shall not be susceptible to mould growth, or attack by vermin or other life forms. Under the operating conditions stated, all components shall have a design life of at least ten years.

Health and safety

272 The contractor shall satisfy himself that the safety requirements of all programmable electronic systems, in safety critical applications are satisfied. Any aspects of the design which the Contractor finds does not conform to relevant safety regulations shall be brought to the attention of the Engineer for resolution.

Service capabilities

273 A UPS shall provide the SCADA computer equipment and tunnel service building(s) work stations and printers with a source of electrical power of sufficient quality to prevent malfunctions from voltage transients and other mains borne disturbances.

274 Power supply failures to the UPS shall be logged as an alarm condition and immediately reported on the SCADA system.

SCADA Attributes

Availability

275 99.8% availability is required with a MTTR of 4 hours.

Reliability

276 The equipment shall therefore, be designed to have a high reliability.

Maintainability

277 All hardware and software installed as part of this contract shall provide forward compatibility with future software versions and upgrades.

278 The installed system software shall be written in a manner that can quickly resolve any problems. To facilitate this, the operators shall be given prompts, alarms, etc and access to investigate plant status so that the point of failure can be quickly identified.

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279 The SCADA system shall also be supplied with the following error handling and test facilities:

i) Test writes - During the coding phase of the software procedures test writes for controlling the program flow should be implemented. The test writes should be enabled and disabled by a software switch for every single process at runtime. In addition it should be possible to redirect the output data to a terminal or a file.

ii) Simulation - Software facilities should be available to simulate the communication of the computer system with the outstations's. The interface between the application software and the outstation simulator should be the same as that to the normal outstation communication driver. This software should enable the possibility to test the complete application control software without any physical outstation connection.

iii) Database Editor - If any part of the database is corrupted it is necessary to have the possibility to correct it without any programming. For this purpose a database editor should be available. With this tool it should also be possible to look for database information, which is not accessible by normal operation dialogue functions.

iv) Outstation message logging - It shall be possible to store any message that is sent to or received from/to outstations in a special logging file. A software switch shall be enable or disable this function at runtime.

280 These above functions described are not necessarily required for normal operations of the system. Nevertheless they are very helpful for test and maintenance procedures of the system. Functions shall only be available to privileged persons (system managers). They shall not form part of operating software and may only be loaded by Authorised Persons. Test programs for the application software and the usual test-tools like high level language symbolic debuggers, etc shall be included in the supplied system.

Spare capacity

281 The SCADA system, as installed, shall provide spare capacity in all aspects of hardware and software sufficient to support an additional 25% each of analogue and digital inputs and outputs. An additional 25% spare memory capacity shall also be provided to support software enhancements and upgrades.

282 The software shall support without modification the future addition or removal of I/O points and complete outstations up to the practical limit of the installed system.

The UPS shall also have a spare capacity 20%.

Adaptability and enhancement potential

283 The software and data structure is required to be planned in a manner that will allow changes without affecting unrelated data items and software control structure.

284 A programming utility shall be provided allowing the User to develop and test software routines to enhance and modify the SCADA system. The programming utility shall comprise an editing environment allowing the User to enter programming instructions and to execute these instructions for the purpose of testing and comparison.

285 The instructions shall take the form of a high level programming language using default language (see below) based commands and keywords, a full set of mathematical and logical operators including brackets, and functions to generate internal data values. The programming language shall allow all logical constructs of sequence, decision making and iteration to manipulate data and effect control of plant and process. The programming language shall allow inclusion of sub-routines by reference and without verbatim repetition of the instructions.

286 Programmes and sub-routines shall be executable against data from field instruments, data from the SCADA database and data retrieved from archives.

287 The programming utility shall check and prevent mixing of data types and ensure that only appropriate and sensible operations can be applied to any particular data type.

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288 Programmed routines shall respond conditionally; provision shall be made for invoking programmed routines following the lapsing of a time interval or the occurrence of a particular set of circumstances or events. Such events may relate to states and values derived directly from plant and process or from mathematic and logic functions within the software.

289 The programming utility and high level language shall allow programmes to be written using a modular composition of sub-routines. The programming utility shall support a library for storing and re-using sub-routines; library material shall be transferable to non-volatile storage media for archiving.

Installation

290 For the installation, setting to work and commissioning stages the Contractor shall submit a programmed schedule of works for approval, at least four weeks prior to the commencement of the works. He shall not operate any systems, plant or equipment without the prior consent of the Engineer. The Contractor shall ensure that any system which he intends to operate is in a safe and ready condition. Any damage to plant or equipment during commissioning by the tests shall be rectified by the Contractor at his own cost. All equipment in locations likely to express shock and vibration shall use anti-vibration mountings.

Impulse Pipe Work

291 Impulse pipe work shall be installed in accordance with the associated instrument manufacturers instructions. Material normally shall be stainless steel unless the process fluids react with stainless steel when an alternative, acceptable to the engineer shall be used.

292 Impulse piping is defined as that between the first isolating valve and the respective instrument. Impulse lines shall be protected from damage.

293 Impulse piping shall be bent using approved methods. The minimum bending radius shall be not less than three times the bore of the pipe.

294 Where freezing of impulse lines is likely, trace heating shall be provided.

295 The thermal insulation of impulse lines will be undertaken, if the process lines are so insulated.

296 Impulse piping for differential pressure instruments shall be installed with the two pipes parallel, and so positioned that a difference of head between the high and low pressure lines cannot occur. Whilst running parallel, the pipes shall be not more than 1 000 mm apart, centre to centre.

297 On draught lines, the pipe diameter shall not be less than 15 mm nominal bore. All changes of direction shall be accomplished by screwed crosses. The unused connections shall be plugged.

Instruments

298 All instruments shown on instrument location plans, instrument piping drawings and other instrument drawings shall be shown symbolically. For actual dimensions and locations of connections, reference shall be made to manufacturer's drawings or actual equipment.

299 Access must be provided around instruments to enable adequate maintenance to be carried out.

300 Field mounted instruments, where not close coupled, shall be bracketed, mounted in sub-panels or boxes or mounted on 50mm diameter pipe stands. All bare steel supports, brackets and supporting plinths shall be hot galvanised, and any cut on site shall be painted with a cold galvanised.

301 Dust and weatherproof housings shall be provided for field mounted instruments in the event that no other protection is provided.

302 All pressure instruments shall be installed with isolate-calibrate, 3 or 5 valve manifolds, etc , as appropriate, and manufactured from the same material as the instrument for which they are provided.

303 All instruments shall be installed according to the manufacturers instructions and particularly flowmeters shall have the recommended upstream and downstream length of pipe work observed.

Isolating Valves

304 Valves on instrument process service shall be of a type and material of construction and pressure rating determined by the process medium as detailed in the Particular Specification.

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305 Valves shall be mounted onto the process tapping point as close as is practical, with a maximum distance from the tapping point of 150mm. Vent valves shall be plugged.

Earthed Systems

306 Earthing throughout the installation shall comply with the relevant standards.

Instrumentation earthing shall be as follows:

i) the instrument earthing system shall avoid the creation of earth loops by ensuring that earth conductors do not contact earthed steelwork or duplicate other earth conductors;

ii) the instrumentation earths in each control centre enclosure, termination cabinet or outstation shall be connected to the electrical power earth system of the area at one point only. Safety earths of equipment chassis, panel frames and instrument AC power supplies shall be connected separately to the electrical power earth;

iii) the instrumentation earthing system shall utilise a central instrumentation earth point which shall comprise a bare copper busbar of 75mm^2 cross sectional area mounted on insulators and spaced at least 25mm from any earthed conducting surface;

iv) the conductor between the central instrumentation earth point and the electrical power earth system shall be of copper, insulated for its full length from contact with all other earth connections, and be protected where necessary against mechanical damage and corrosion, particularly at terminations;

v) each individual conductor connected to the central instrumentation earth point shall be individually terminated to allow ease of disconnection;

vi) all cable drain wires or screens shall be earthed at one point only. This shall be at the panel reference bar except where the instrument design demands earthing at source;

vii) continuity of drain wire or screen shall be maintained throughout the cable run. At no point shall drain wires or screens connect to or contact electrical power earths or structural steelwork;

viii) where jumpers are used to obtain earth continuity these shall be physically robust and positioned so as to avoid accidental damage. All incoming glands shall provide electrical continuity at the point of connection to the panel;

ix) electronic equipment shall be earthed in accordance with the manufacturer's requirements;

x) screening shall be earthed only at one point along its length from plant item to panel, this termination shall be within the panel. The metal braiding of the screen is to be neatly made off and insulated at the 'unearthed' end. Where the braid is drawn out into a pigtail, it shall be provided with an insulating sleeve.

Default Values

307 These industry standard values are to be utilised.

Power supplies general

308 These shall comply with the following:

i)	Panel instrumentation:	230V, 50Hz ac.
ii)	Field instrumentation:	
	- requiring mains:	230V, 50Hz ac.
	- otherwise analogue: regulated.	24V, dc
	- otherwise digital:	24V, dc.
iii)	PLC/SCADA equipment:	230V, 50Hz ac.
iv)	Motors - single phase:	230V, 50Hz ac.
v)	Motors - three phase:	400V, 50Hz ac.
vi)	MCC (interposing) control voltage:	230V, 50Hz ac.
vii)	Annonciators power supply:	24V, dc.
viii)	Lamps, indicators & LEDs:	24V, dc.

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Power supplies variances

309 These shall comply with the following:

i)	400 V, & 230 V ac	-6% to +10% 45 to 55Hz.
ii)	DC unregulated	-12% to +10%
iii)	DC Regulated	-1% to +1%

Instrumentation Input/output signals

310 The shall comply with the following:

i)	Analogue - input:	24V, dc. 4 - 20mA signal.
ii)	Analogue - output:	24V, dc. 4 - 20mA signal.
iii)	Digital drive/input:	external 24V, dc.
iv)	Digital signal/output:	Volt Free, contacts to be rated for 24V, dc.

PLC Input/Output

311 This shall comply with the following:

i)	Analogue - input:	24V, dc - regulated. 4 - 20mA signal.
ii)	Analogue - output:	24V, dc - regulated. 4 - 20mA signal.
iii)	Digital drive/output:	24V, dc.
iv)	Digital signal/input:	24V, dc.

Test signals

312 These shall comply with the following:

i)	Insulation resistance: Pass criteria:	500V dc. minimum 5MΩ.
ii)	Earth fault loop test:	50Hz, at 25A.
iii)	Instrument Pipework pressure:	700kPa.

Environment - Plant and field

313 These shall comply with the following:

i)	Temperature:	-15 to +50° celsius.
ii)	Humidity:	up to 95% RH non-condensing.
iii)	Ingress protection of equipment:	Minimum IP 55.

Environment - Control and equipment rooms, etc.

314 These shall comply with the following:

i)	Temperature:	10 to 30° celsius.
ii)	Humidity in control room:	40 to 80% RH non-condensing.
iii)	Humidity in enclosures, etc:	10 to 80% RH, non-condensing.
iv)	Ingress protection of equipment:	Minimum IP54.
v)	Ingress protection of MCC:	Minimum IP31.

Others

315 These shall comply with the following:

i) The language used shall be UK English.

ii) Soak test time be minimum of 60 Hours.

iii) UPS hold up time shall be a minimum of 2 Hours.

iv) Isolators will isolate all incoming supplies above 50V dc or ac.

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A7116. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

Institution of Electrical Engineers

- IEE guidelines for the documentation of computer software for real time and interactive systems (second edition).

Number	Title/Subject
BS 21	Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).
BS 89	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS 90	Specification for direct acting electrical recording instruments and their accessories.
BS 142	Electrical protection relays.
BS 2950	Specification. Cartridge fuse-links for telecommunication and light electrical apparatus.
BS 5584	Specification for low voltage switchgear and controlgear for industrial use. Mounting rails. Top hat rails 35mm wide for snap on mounting of equipment.
BS 5585	Specification for low voltage switchgear and controlgear for industrial use. Mounting rails. Top hat rails 75mm wide for snap on mounting of equipment.
BS 5824	Specification for low voltage switchgear and controlgear for industrial use. Mounting rails. C-profile and accessories for the mounting of equipment.
BS 5825	Specification for low voltage switchgear and controlgear for industrial use. Mounting rails. G-profile for the foxing or terminal blocks.
BS 5887	Code of practice for testing of computer based systems.
BS 5954	Specification for dimensions of panels and racks for electronic equipment.
BS 5992	Electrical relays.
BS 6272	Specification for low voltage switchgear and controlgear for industrial use. Terminal marking. Terminals for external associated electronic circuit components
BS 6273	Specification for low voltage switchgear and controlgear for industrial use. Mounting rails. Top hat rails, 15mm wide for the fixing of terminal blocks.
BS EN 60127	Miniature fuses.
BS EN 60269	Cartridge fuses for voltages up to and including 1000V ac and 1500V dc
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 60534	Industrial control valves.
BS EN 60898	Circuit breaker for overcurrent protection for household and similar installations

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VOLUME 5 CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITIES

SECTION 7 MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

PART 2

SERIES 7200

MECHANICAL, ELECTRICAL AND COMMUNICATIONS WORK FOR MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

Contents

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7200. INTRODUCTION

1 This Series of the Specification covers the mechanical and electrical performance requirements for the motive equipment associated with movable bridges and maintenance access gantries in the United Kingdom and is categorised under the following headings:

i) Electrical equipment

ii) Mechanical equipment

iii) Communications, Traffic and Shipping control

2 These performance specification clauses are intended to indicate the minimum standards for mechanical, electrical and communication services for:

i) movable bridges - swing, bascule or vertical lift type

ii) bridge maintenance access gantries - span or column type

3 They shall be used in conjunction with contract specific documentation which shall define the design, extent and type of plant and equipment for the proposed application.

4 Movable bridges shall be activated by hydraulic cylinders or motors driven from electro-hydraulic pump sets under the control of an operator, although activation by electronically controlled direct driven motors should also be considered.

5 Where bridge access gantries are required to be powered they shall be operated under the control of an operator by motorised pulley equipment or by transferring power to the driving wheels using electric or hydraulic motors. The operating mechanisms may be supplied from electric mains, generator, or hydraulic pump source.

6 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of each section of the specification.

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7201. ELECTRICAL EQUIPMENT FOR MOVABLE BRIDGES

General

1 The requirements and extent of electrical power distribution associated with movable bridges depends on the size, importance and type of drive selected in the contract specific documentation. Provision of High Voltage intakes may be applicable.

2 The electrical plant for the motive power for movable bridges shall be low voltage suitable for use on three phase and neutral 50Hz systems.

High Voltage Switchgear

3 The requirements for high voltage switchgear shall comply with Series 7101 of this Specification as applicable.

Distribution Transformers

4 The requirements for distribution transformers shall comply with Series 7102 of this Specification as applicable.

Low Voltage Switchgear

5 The requirements for low voltage switchgear shall comply with Series 7103 of this Specification as applicable.

HV and LV Cabling and Distribution

6 The requirements for HV and LV cabling and distribution shall comply with Series 7104 of this Specification as applicable.

Standby Generators

7 The requirements for standby generators shall comply with Series 7105 of this Specification as applicable.

Uninterruptible Power Supply Equipment

8 The requirements for UPS equipment shall comply with Series 7106 of this Specification as applicable.

Services Building

9 The requirements for mechanical and electrical services shall comply with Series 7110 of this Specification as applicable.

Bridge Control Systems

10 The requirements for controls associated with motor drives and control of the bridge shall comply with Series 7103 of this Specification with respect to equipment and construction of motor control centres and control panels.

11 The bridge shall be operated from a console located in a control room or other location defined in the contract specific documentation on which there shall be located controls for the operating motors; by-pass switches; instruments; position indicators or meters; indicating lights; and all other control devices and apparatus necessary or pertinent to the proper operation and control of the bridge and its associated safety, locking and braking systems.

12 Where feasible the console shall be located in a control room which has a clear view in all directions. Where not feasible CCTV shall be provided to provide views of the traffic.

13 The control system circuits may be individually wired or the system may be microprocessor PLC based.

14 Indicators shall be installed on the console which will show to the operator the various positions and status of the bridge, especially the fully closed, fully open, nearly closed, and nearly open positions, and also the closed and open positions of the traffic gates, bridge locks and end lifting devices as applicable. Indicators shall also be provided to show when the brake to each span is released, the overload or overheat tripping of drive motors and the status of other alarms as required to alert the operator to emergency conditions.

15 The control system shall operate at SELV DC or 110 volts AC and the system controls shall be backed with an uninterruptible power supply unit.

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16 The control system shall implement the following modes of operation:

i) Manual - for test running, maintenance or emergency

ii) Automatic - normal operation

iii) Semi-automatic - during failure of sub-systems

iv) Maintenance - planned bridge closures

17 The control console shall be fitted with key controlled master locks for overall control and switching modes to the remote control positions. Activation of all control systems and indicators shall be from the console incorporating the indicators and alarms, together with provision for testing all circuits. All barrier and light controls, telephone, radio and CCTV controls as applicable shall also be from the console.

18 Supervision of all emergency features shall be located at the console where override, indication and alarm facilities shall be incorporated. Indication of the main incoming power supply status shall also be from the main control desk, together with monitoring and transfer of power load to the standby generator.

19 In the event of failure of the main incoming power supply the bridge shall stop, the standby generator shall automatically start and automatically transfer the load to the standby generator. The bridge movement shall then be manually restarted by the bridge operator.

20 Controls, monitors and indicators for close monitoring and adjusting the operation of the bridge machinery shall be located in cubicles in the bridge machinery room.

21 Unless otherwise specified the electrical equipment shall be interlocked by suitable contactors, relays, limit switches etc., so that only the following general sequence of operation is possible for opening of the bridge.

i) Set traffic signals (lights and bells)

ii) Close incoming barriers for traffic.

iii) Close exit barriers and all pedestrian barriers.

iv) Pull locks or wedges (where applicable)

v) Release brakes (where applicable)

vi) Open span

vii) Lock span (where applicable)

22 For closing operations, the following sequence shall be used:

i) Release span lock (where applicable)

ii) Release brakes (where applicable)

iii)

iv) Insert locks or wedges

v) Open all traffic barriers

vi) De-energise traffic signals (lights and bells)

23 All limit switches and contacts shall be fitted in a fail safe mode. In general, for limit switches this will result in the limit switch breaking a circuit. The limit switch should be arranged such that the contacts are

Independent contacts for proving status of equipment shall be arranged such that contacts are normally open and closed when the barrier is in the indicated position.

Emergency switches shall be provided which shall free the various motors from the prescribed interlocking in case of an emergency. These switches shall be mounted on the console to be within convenient reach of the operator. Each such emergency switch shall be sealed or locked in the ‘off’ position.

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A7201. APPENDICES

Standards and Codes of Practice

Refer to the list of standards and codes of practice for the plant as applicable under:-

Series 7201 High Voltage Switchgear

Series 7202 Distribution Transformers

Series 7203 Low Voltage Switchgear

Series 7204 HV and LV Cabling and Distributors

Series 7205 Standby Generators

Series 7206 Uninterruptible Power Supply Equipment

Series 7210 Services Building

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Sample Appendices : A7201.2 Series

The Contractor shall insert details of the equipment proposed in accordance with the Sample Appendices under the following Series:

A7101	High Voltage Switchgear
A7102	Distribution Transformers
A7103	Low Voltage Switchgear
A7104	HV & LV Cabling and Distribution
A7105	Standby Generators
A7106	Uninterruptible Power Supply Equipment
A7110	Services Building

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A7201.2 : Control Equipment for Movable Bridge

The Contractor shall insert below details of the equipment proposed.

Item No.	Description	Detail
1	Manufacturer of bridge control system	
2	Type of bridge control system	
3	Bridge control system voltage	

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7202. ELECTRICAL EQUIPMENT FOR BRIDGE ACCESS GANTRIES

General

1 Electricity supply for the motive power of non-manual bridge access gantries shall be low voltage suitable for use on three phase and neutral low voltage 50 Hz systems.

2 Power for driving gantries shall normally be provided by a diesel engine, mounted on the gantry, or placed nearby on or below the bridge, or by mains electrical supply.

3 All electronic, electro-mechanical and electric systems shall comply with appropriate standards relating to electromagnetic interference emissions.

4 The list of the main Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Low Voltage Switchgear

5 The requirements for low voltage switchgear shall comply with Series 7103 of this Specification as applicable.

Low Voltage Cables and Distribution

6 The requirements for LV cabling and distribution shall comply with Series 7104 of this Specification, as applicable.

7 Unless otherwise indicated in the contract specific documentation, cabling to motor drives, limit switches and all electrical equipment situated outside the control cubicle shall be carried out in 1000 V grade XLPE insulated single wire armoured and PVC overall sheathed cable. Terminations shall be made using compression glands together with PVC shrouds and earth tags.

8 All cabling shall be securely cleated or clamped to equipment or structures. Armouring shall be securely clamped and bonded to the earth terminal of the equipment.

9 Control cabling shall normally be carried out in 1000V grade, circular multi-core cross linked polyethylene insulated (XLPE), single wire armoured (SWA), polyvinyl chloride (PVC) cable having a minimum core cross section area of 1.5 mm^2.

10 Cables for the connection of ground or bridge mounted equipment to the moving gantry shall be of a flexible type.

Generators

11 Where generators driven by diesel are used for driving bridge access gantries they shall comply with Series 7105 of this Specification as applicable.

12 Generators shall be floor mounted and be complete with fuel reservoir and battery powered starting gear suitable for remote control from the operating console. Local control by switching shall be possible for maintenance purposes. The fuel reservoir capacity shall be sufficient to allow for eight hours continuous running at maximum power.

13 The gantry drives and winch units and control systems shall be operated at 110V, 50Hz from an air cooled transformer and associated distribution board located adjacent to the generator. The power supply cables from the distribution board to the gantry shall be via a plug-in flexible type cable.

14 Generators shall be of sufficient rating to provide power for the full requirements of the gantry including for floodlights and socket outlets in addition.

15 Each generator and associated transformer unit will be subject to severe exposed weather conditions and shall meet the enclosure requirements of IP67 as defined in the appropriate standards.

Floodlights and Socket Outlets

16 The requirements relating to lighting and socket outlets shall comply with the requirements of Series 7110 of this Specification as applicable.

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17 To facilitate maintenance, floodlights shall be provided on the gantries. Floodlights shall be manufactured to meet the requirements of enclosure classification IP65 as defined in the appropriate standards.

18 The floodlights shall be mounted, via substantial brackets to the gantry parapets, to allow them to swivel both horizontally and vertically and enable a clear view of the underside surfaces of the bridge decks to be obtained and located not to cause dazzle to the adjacent environ.

19 Low voltage weatherproof socket outlets mounted on suitable backplates to the gantry parapets, shall be provided. They shall meet the enclosure requirements of IP65 as defined in the appropriate standards.

20 The socket outlets shall each be capable of supplying the operation of portable tools at 110V single phase from 55V earthed centre tap transformers.

Access Gantry Control Systems

21 The requirements for control shall comply with Series 7103 of this Specification as applicable.

22 Access gantries may be operated from consoles fixed on the gantry chassis and from remote control stations as specified. Consoles shall house all the switchgear necessary to control the required functions, including visual and audible warning devices. The warning device shall provide a sound level a minimum of 10 dB above background levels from any position on the appropriate gantry with any diesel generator, pumpset or other motor running.

23 Control consoles shall be lockable.

24 Consoles shall be designed for easy front access to the internal components for maintenance purposes, all hinged doors being lockable to prevent unauthorised access.

25 The consoles shall each be fitted with the following:

i) ON/OFF key switch with key removable only in the OFF position

ii) Control lever type switch to control longitudinal motion of the gantry. The lever shall be spring to neutral and operable in either of two directions for FORWARD/REVERSE or UP/DOWN travel, the speed being in nominal proportion to the lever position.

iii) Audible warning push button, non latching shielded type, which shall energise the warning device within the console prior to commencement of motion or any other warning.

iv) Emergency stop push button located at strategic location on the gantry of the latching and twist to release type, shall stop all motion in the event of failure of the levers to do so.

v) All control circuits shall be arranged for SELV AC operation derived from a double wound air cooled transformer.

26 The control system may be hard wired or microprocessor PLC based.

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A7202. APPENDICES

Standards and Codes of Practice

Refer to list of standards and codes of practice for the plant as applicable under:-

Series 7103 Low Voltage Switchgear

Series 7104 LV Cables and Distribution

Series 7105 Generators

Series 7110 Floodlights and Socket Outlets

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Sample Appendices : A7202.2

The Contractor shall insert details of the equipment proposed in accordance with the Sample Appendices under the following Series.

A7103	Low Voltage Switchgear
A7104	HV/LV Cabling and Distribution
A7105	Generators
A7110	Floodlights and Socket Outlets

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7203. MECHANICAL EQUIPMENT FOR MOVABLE BRIDGES

General

1 The mechanical equipment for movable bridges shall be of simple design and substantial construction suitable for the harsh environment and 120 year projected design life of bridges. The arrangement of parts shall permit easy erection, adjustment, replacement of defective parts and shall be accessible for inspection, cleaning, lubricating and repairing. Suitable drainage shall be provided to facilitate fluid changes.

2 The fastenings shall be adequate to hold the parts in place under all conditions of service. Each group of machinery shall be self-contained mounted on a rigid structural support.

3 The locations of the equipment shall allow easy access for maintenance, future removal and replacing. The equipment shall be located on the stationery parts of the bridge.

4 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Hydraulic Systems

5 Hydraulic systems shall permit the bridge operator to control from the console, the direction of hydraulic fluid flow for span movement and the operation of auxiliary equipment such as span locks, brakes, wedges, barriers and other devices associated with the movement of the span. Controls shall be of the type that will automatically maintain constant fluid flow, without operator assistance, regardless of normal operating pressure fluctuations, except during periods of acceleration and deceleration.

6 Methods of operating and controlling the hydraulic system may be manual, semi-automatic or automatic, as follows:

i) Manual control is defined as any system in which the operator must manually control the span acceleration and deceleration in addition to the initiation of each of several major interlocked functions to be carried out in sequence.

ii) Semi-automatic control is defined as any system where the fluid flow automatically increases from zero to the required operating rate and back to zero again for span acceleration and deceleration, by the single operation of a push-button or hand lever. However, the operator must initiate each of the several interlocked functions in sequence.

iii) Automatic control is defined as any system where the operation in sequence and the hydraulic system fluid flow automatically increases from zero to the required operating rate and back to zero again for span acceleration and deceleration, all by the operation of a single push button or hand lever.

7 Flows produced by fixed displacement pumps shall normally be controlled by varying the speed of the pump drive motors. If pressure compensated flow controls are specified to control fixed displacement pump flow, the hydraulic system shall be designed to minimise heat build-up.

8 Variable displacement pump flows shall normally be automatically controlled. If flows are specified as being remotely controlled, this shall be by a closed loop control system.

9 Closed loop control systems shall be analyzed to verify that the control system will perform as required. Each component manufacturer shall furnish all necessary instructions on how to adjust and maintain the individual components.

10 The control system supplier shall furnish all necessary details on how to adjust and maintain the control system.

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11 The hydraulic systems shall be designed, and hydraulic components proportioned, such that the maximum allowable system pressures shall not exceed the following :

Normal operation	200 bar
Operation against maximum specified loads	200 bar
Holding against maximum specified wind loads	350 bar

12 Minimum working pressure ratings for hydraulic components shall be as follows:

Pipe, tubing and their fittings	250 bar
Flexible hose and hose fitting For pressure lines:	350 bar
Cylinders, pumps, valves and all other components	350 bar

Hydraulic Motors

13 Hydraulic motors shall be of the fixed displacement type. Speed control of the motors shall be accomplished by controlling the volume of fluid to the motors.

14 Gear type hydraulic motors shall be of the hydraulically balanced type.

15 Hydraulic span driving motors shall be reversible and shall be provided with variable, stepless speed controls with smooth acceleration/deceleration characteristics.

Hydraulic Pump Sets

16 Hydraulic pumps sets shall comprise hydraulic pumps driven by electric motors complete with valves and interconnecting pipework all mounted on a common base frame complete with readily drainable drip tray.

17 Pumps shall be positive displacement of either the variable or fixed displacement type. Pumps shall be equipped with integral or add-on relief valves to prevent damage to pump and hydraulic system from high pressure. Relief valves shall not discharge into pump intake ports.

18 Piston type pumps shall be used in hydraulic systems where maximum operating pressures exceed 140 bar.

19 Where noise control is an important consideration, such as when the hydraulic power unit is to be located in the bridge control area. The system supplier should pay particular attention to attenuating hydraulic noise. This may involve the use of flexible hoses and anti-vibration mountings etc.

20 Electric motors used for driving of hydraulic pumps shall be AC squirrel cage induction types, types with embedded winding temperature sensitive devices as specified. Motors shall have grease lubricated anti-friction shaft bearings and shall be equipped with lubrication fittings.

Hydraulic Pipework and Fittings

General

21 Piping shall include all pipe, tubing and flexible hose. Piping, fittings and manifolds may be made of carbon steel, stainless steel or alloy seamless tube. The materials used shall be consistent with the pressures and environmental conditions to which the hydraulic system will be subjected. Steel fittings shall be used with steel piping, stainless steel fittings shall be used with stainless steel piping and ‘alloy’ fittings shall be used with alloy piping. Use of fittings which are of softer material than the piping shall not be permitted. Piping, fittings and manifolds shall not be galvanised.

22 Fittings used for piping connections shall be of the type to permit rapid assembly and disassembly of all components. Fittings shall also permit repeated disassembly and reassembly of a connection without loss of sealing quality or strength. Lockable facilities shall be provided for all valves and cocks to prevent unauthorised resetting.

23 Pipe shall have welded flange fittings. Use of threaded pipe fittings in pressure lines rated above 200 bar and/or 25mm diameter shall not generally be permitted.

24 Tubing shall have straight thread O-ring face seal, propriety sealing washer or flareless or welded flange fittings. Use of flared fittings will not be permitted. Straight thread O-ring face seal fittings may be used for tubing sizes up through 38mm nominal outside diameter. Welded flange fittings shall be used for tubing of greater than 38mm nominal outside diameter.

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25 Hydraulic velocity shall not exceed 4.5 metres per second generally in pressure and return line piping and pump suction line velocity shall not generally exceed 1.5 metres per second.

26 Test ports shall be provided to bleed the system of air, and to check system pressure at control valves as well as other locations where a pressure governing component is not so equipped.

27 Flexible hose shall be provided to connect the hydraulic power unit to the rigid piping system. Where separate valve stands are provided, flexible hose shall be used to connect the valve stands to the hydraulic power unit and to the rigid piping system.

Pipework

28 Pipe shall be seamless with plain ends. Use of threaded pipe ends will not be permitted, without prior written approval.

29 Welded flange fittings shall be 4-bolt minimum flanges, utilising a captive O-ring pressure sealing system. Socket or butt weld flanges shall normally be used.

30 Flange connection bolts shall have sufficient strength for the working pressure rating of the flanges. Stainless steel bolts shall be used with stainless steel flanges. A lockwasher shall be used at every bolt.

31 Threaded fittings and threaded flange fittings, used for field connections and field erected piping systems, shall utilise a gasket or other form of face seal.

Tubework

32 Tubing shall be seamless, have a carbon content below 0.25% and be annealed to facilitate bending. Straight thread O-ring face seal fittings shall use a captive O-ring pressure sealing system and designed for unlimited break and remake or tubing connections without springing or cutting lines.

33 Flareless fittings shall be of the type that bites into the outside surface of the tubing when the fitting assembly is tightened or of a welding nipple design.

Flexible Hoses and Fittings

34 Only extra high or high pressure hose and fittings having the working pressure ratings specified in Clause 7203.12 shall be used. Hoses shall be seamless, oil and weather resistant and have steel wire reinforcement.

35 Hose fittings shall be made of steel and be of the swaged (non-reusable) type. Hose fittings shall have flange style ends for connection to other hydraulic components. Flange head style fittings shall use split flanges with bolts and O-ring sealing. Threaded fittings may only be used for connection to threaded drain ports.

Hydraulic Reservoirs

36 Reservoirs shall be of heavy duty welded construction non-corrodible steel. They shall be structurally rigid to resist warpage and damage from the mounting of equipment on the reservoir top, handling during shipping to and erection at the bridge site.

37 Bladder type breathers, to prevent the mixing of outside air and reservoir air shall be provided for hydraulic reservoirs located in environments having airborne contaminants such as dust, chemicals and condensing water vapour which could damage the hydraulic system.

38 Reservoirs shall have drains which permit a complete hydraulic fluid change without disconnecting any components.

39 Reservoirs equipped with large removable covers shall have separate filler openings to permit the adding of fluid to the reservoir without removal of the cover.

Hydraulic Valves

40 To prevent unintentional misadjustment, adjustable valves shall be equipped either with protective caps, or with locking nuts on the adjusting screws.

41 Directional control valves and blocking valves may be provided with adjustable pilot control chokes to increase valve opening and closing time, for shock and surge pressure control.

42 Flow dividing valves used for actuator synchronisation shall be of the type that will always permit flow to all actuators simultaneously, regardless of the magnitude of pressure differential between the actuators being loaded.

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Rotary Actuators

43 Rotary actuators shall produce an output torque over a limited range of rotation and shall self-lock when the flow of pressurised fluid to the actuator is stopped or operating pressure is lost due to line leakage or breakage. Provision for manual operation of actuators shall be provided. Vane type rotary actuators shall be hydraulically pressure balanced.

44 Actuators shall have keyed output shafts and be connected to driven equipment with couplings.

45 Cylinder type rotary actuators having internal chain and sprocket mechanisms shall have automatic chain tensioning devices incorporated into the actuators.

46 Actuators shall be coupled to driven equipment in a manner that eliminates overhung and thrust loads on the actuator shaft bearings.

47 Self-contained hydraulic actuator units shall consist of a heavy duty cylinder or other type of actuator, electric motor, pump, reservoir and control valving. Units shall be completely closed systems, requiring no external piping to supply or remove hydraulic fluid.

48 Self-contained hydraulic actuators shall not be used for span operation. Such actuators may be used only to operate auxiliary equipment such as locks, lifting devices, wedges and barriers.

49 Protective flexible sleeves shall be provided for cylinder rods which are normally extended.

Hydraulic Cylinders

50 Cylinders shall have a minimum theoretical static failure pressure rating of 1.5 times the working pressure.

51 Cylinders shall have engraved permanent nameplates securely attached to the head of the cylinder. The nameplates shall clearly indicate as a minimum the manufacturer, model number, cylinder bore, rod diameter, stroke length, and theoretical static failure pressure rating symbol.

52 Protective flexible sleeves shall be provided for all cylinders that are oriented such that the rods are normally extended.

53 Piston rod seal assemblies shall be replaceable without cylinder disassembly.

54 Gland seals and wiper seal replacements shall be provided by removable rod end clevis or other compatible arrangement.

55 The use of rotating type or telescoping cylinder shall not normally be permitted.

Accumulators

56 Gas accumulators shall be charged with an inert gas. The use of oxygen, air or other active gases will not be permitted for accumulator charging.

57 Clamps or straps used for accumulator mounting shall not restrict thermal expansions, or distort the shell of the accumulator.

Pressure Gauges

58 Gauges shall be of durable construction. Dial faces shall be clearly calibrated for pressure ranges 50% beyond the maximum design operating pressures of the hydraulic system. Gauges shall be accurate and permit continuous monitoring. They shall have a minimum diameter of 100mm. Shut-off valves shall be provided at each gauge.

59 Portable gauges shall be provided for maintenance and adjustment of the hydraulic system. The pressure ranges shall cover all possible values that will be needed for the system. One gauge shall be provided for each pressure range such that the test pressure will be within the mid-half of the total pressure range of the gauge.

60 Connections for portable gauges shall be of the quick self-sealing disconnect type. Test ports in the hydraulic system shall be equipped with removable, protective caps, secured by chains to the component.

Hydraulic Fluids

61 Hydraulic fluid shall be suitable for the operating pressure, temperature and lubrication requirements of the system. The selection of the hydraulic fluids shall be based wherever possible on the performance data or actual experience in other heavy duty hydraulic systems subjected to similar operating pressures and temperatures and having similar hydraulic equipment.

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The fluid shall be that acceptable or recommended by the pump manufacturer and shall be compatible with all hydraulic components and seals.

62 Hydraulic fluid shall be either petroleum based oil type, or oil-water emulsion type fire resistant fluid type. Pure synthetic, high water contents fluids, synthetic blends or water glycol mixtures shall not normally be permitted.

63 Fluid systems shall not normally contain more than one fluid type. If more than one type is specified then the risk of adding the wrong fluid to a reservoir shall be minimised by warning labels.

64 Hydraulic fluids shall have the following properties:

i) the correct viscosity range for the operating requirements of the hydraulic system

ii) a high viscosity index to resist changes in viscosity due to anticipated temperature ranges

iii) prevent wear on working parts

iv) resist foaming

v) resist oxidation and formation of sludges

vi) retain original properties in use

vii) optimum service life

65 Provisions shall be made to collect or contain fluids from damaging the environment due to any leaks or line breakage.

66 Full flow and/or off-line filtration shall be provided

67 Filters, including pump intake strainers if required by the contract specific documentation, shall be equipped with an indicator to show when the filter needs servicing.

68 The degree and quality of filtration shall be determined by the control system supplier to ensure correct component function.

69 Filter flow capacity ratings shall be as recommended by the pump manufacturer.

70 Bypass valves should be provided on filters to limit the differential pressure across the filter elements. Bypass valves shall be sized for the maximum flow that could be expected through the filter without excessive differential pressure. Non-bypass type filtration shall be used only where required by the hydraulic equipment manufacturer, and shall be equipped with warning devices to provide remote indication at the operator's console of an impending clogged condition.

Safety Systems

71 Suitable interlocking arrangements shall be provided to ensure that operations can only be performed in a safe sequence e.g. operations to open the bridge cannot commence until all barriers are down.

72 Brakes shall be arranged to operate in a fail safe manner, eg spring on, power off.

Locking System

73 Movable bridges, depending on the type, shall be equipped with suitable mechanisms to align the bridge and roadway surface accurately and to fasten the bridge securely in position so that it cannot be displaced either horizontally or vertically under the action of traffic and wind loads etc. Effective end lifting devices shall be used for swing bridges and bascule bridges. Span locks shall also be provided for vertical lift bridges when specified.

Braking Systems

74 Provisions shall be made to hold the span stationary against unbalanced loads and the wind pressures specified. Cylinder locks shall prevent structural damage due to overloads.

75 The hydraulic system shall provide the necessary dynamic braking to stop the span as specified for motor brakes.

76 Machinery brakes, cylinder locks or counterbalance valving shall provide the static braking capacity as stated in the contract specific documentation for the combined motor and machinery brakes.

77 Spans normally left in the open position shall also be provided with locking devices to hold the span stationary at the fully open position, against the wind or water etc loads specified.

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A7203. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

	MECHANICAL EQUIPMENT
BS 2633	Specification for welding ferric steel pipework
BS 4375	Fluid power transmission and control systems
BS 4617	Methods of determining the performance of pumps and motors for hydraulic fluid power transmission

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Sample Appendices : A7203/2 : Mechanical Equipment

The Contractor shall insert below details of the equipment proposed.

Item No:	Description	Unit	Detail
1	Manufacturer of hydraulic system		
2	Method of operating the hydraulic system		
3	System pressures normal operation against maximum specified loads	 bar bar	
4	Component working pressures pipe, tubing etc flexible hose and fittings	 bar bar	
5	Type of hydraulic pump		
6	Manufacturer of pump		
7	Type and rating of motor	kW	
8	Type of pipework, valves and fittings		
9	Manufacturer of hydraulic reservoirs		
10	Manufacturer of Hydraulic cylinders		
11	Type of hydraulic fluid		

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7204. MECHANICAL EQUIPMENT FOR BRIDGE ACCESS GANTRIES

General

1 The mechanical plant for bridge access gantries shall be of simple design and substantial construction compatible with a projected design life of 35 years. The arrangement of parts shall permit easy erection, adjustment, replacement of defective parts and shall be accessible for maintenance inspection, cleaning, lubricating and repairing. Gantry components shall be suitably protected against the ingress of dirt and robust enough to resist damage caused by the envisaged bridge maintenance activities, eg blasting and painting. Suitable taps and/or tube extensions at drains shall be provided to facilitate hydraulic fluid changes.

2 The fastenings shall be adequate to hold the parts in place under all conditions of service. Each group of machinery shall be mounted on a self-contained cast steel frame or base; otherwise on a rigid structural steel support.

3 Provision shall be made for the gantry equipment to be readily and fully inspectable. This may be achieved by arranging that gantries are lowered to the ground by a winch unit or by providing a means of gaining temporary access around the gantries whilst they are in position on the bridge.

4 The list of the Standards and Codes of Practice to which the equipment shall comply is included within the Appendices at the end of this section of the Specification.

Hydraulic Systems

5 Hydraulic systems used for the access gantry operating mechanisms shall generally comply with manufacturer's recommendations and the requirements of Series 7203 of this Specification.

Gantry Hoisting Systems

6 Where stated in the contract specific documentation to allow access gantries to be lowered for maintenance purposes, a complete demountable gantry hoisting system, including electrically powered winch units, all necessary wire ropes, shackles, runway beam and track brackets, pulleys, and any other equipment required for lowering and raising the gantries shall be provided.

7 The system shall be capable of lowering and raising gantries of the deadweights specified, together with all gantry suspension and drive machinery, and control equipment deadweights.

8 The winches shall be suitable for control from a single console providing complete synchronisation to avoid tilt during raising or lowering movements. The console shall be constructed to meet the enclosure requirements IP65.

Safety Systems

9 Anti-crabbing devices to prevent misalignment of the gantry with its runway shall be provided as specified. For fully automatic systems sensors shall be provided to detect crabbing and provide inputs to a control system to adjust the motor devices to keep within pre-set limits.

10 Powered driving wheels shall incorporate automatic brakes and powered and suspension wheels local manually operated parking brakes as specified.

11 Powered and suspension wheels shall incorporate hand winding gear.

12 Proximity sensors and mechanical limit switches shall be provided where specified to prevent movement beyond safe limits. Sensors may be doppler sonic or infra-red type. Photocell incline sensors shall be provided for a gantry to safely travel longitudinally.

13 The gantry operator shall be able to override the device by pressing and holding a pushbutton and at the same time driving towards the obstruction at minimum speed only. On release, the override switch shall return to the normal 'on' position.

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14 Electrical interlocks, where specified, shall be provided to prevent personnel access gates on gantries from being opened until the gantries are in correct alignment. Gates shall unlock automatically, but not open, and be retained by a manual catch. It shall not be possible to carry out any powered movement if an access gate is not fully closed and locked.

15 A minimum of 2 no. 3kg dry powder fire extinguishers with proprietary mounting bracket suitable for fixing to the parapets of the gantries shall be fitted to each gantry adjacent to any diesel generator and hydraulic pumpset.

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A7204. APPENDICES

Standards and Codes or Practice

The following list covers the standards and codes of practice applicable to the following equipment:

Refer to list of standards and codes of practice for the plant applicable under:-

Series 7203 Mechanical Equipment

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Sample Appendices : A7204/1 Mechanical Equipment

Refer to sample appendices under Notes for guidance Series:-

A7203 Mechanical Equipment

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Sample Appendices : A7204/2 : Mechanical Equipment

The Contractor shall insert below details of the equipment proposed.

Item No:	Description	Unit	Detail
1	Manufacturer of hydraulic system		
2	Method of operating the hydraulic system		
3	System pressures normal operation against maximum specified loads	 bar bar	
4	Component working pressures pipe, tubing etc flexible hose and fittings	 bar bar	
5	Type of hydraulic pump		
6	Manufacturer of pump		
7	Type and rating of motor	kW	
8	Type of pipework, valves and fittings		
9	Manufacturer of hydraulic reservoirs		
10	Manufacturer of Hydraulic cylinders		
11	Type of hydraulic fluid		

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7205. COMMUNICATIONS, TRAFFIC AND SHIPPING CONTROL

General

1 VMS, automatic barriers, closed circuit television and their associated control systems to be used for movable bridges shall comply as applicable to the relevant parts of Series 7100 of this specification.

2 This specification covers the requirements of traffic control equipment located on and in the vicinity of any movable bridge in order to ensure its safe operation.

3 All installed equipment shall be supported by record documentation, to the requirements of Clause 7014, consisting of manufacturers technical literature, schematic drawings, testing and commissioning results. This documentation shall be contained in ring binders with rigid covers, be original documentation, not photo copies, and be in the English language. The quantity of copies of these documents will be indicated as a site specific instruction.

Wig-Wag Signals

4 Wig-wag signals shall be installed on the approaches to the movable bridge on both sides of the road next to the barriers complying to the relevant regulations listed in the Appendices. All wig-wag signals must be clearly visible to approaching traffic and must be accompanied by appropriate fixed signing prior to the wig-wag signals.

5 All signals must be installed with red lamp monitoring such that a major fault alarm will be communicated to the bridge operator if one or more of the lamps on a wig-wag fail.

6 The wig-wag controller shall be located at convenient locations near to the wig-wag signals, and in positions that do not impede the access-ways. Power shall be derived from a suitable source.

7 Wig-wag signals shall be mounted in an appropriate manner that allows easy access for maintenance. Wig-wag signals shall be of the appropriate size and colours.

8 Housings and enclosures shall comply with the harsh environments encountered in these exposed locations, and shall be of a distinctive colour for easy identification.

9 Cabling shall be laid such that it does not interfere with or it cannot be damaged by the movement of the bridge. Cables shall be terminated in the signal heads and wig-wag controller.

10 Each wig-wag signal and wig-wag controller shall have a unique number. This unique number shall be clearly displayed on the equipment enclosure, so that it is clearly visible from the carriageway.

11 A maintenance procedure shall be proposed for routine and breakdown requirements.

12 All equipment shall be tested prior to any connection being made to the network. Each individual wig-wag signal and each controller shall be tested to ensure that it is fully functional.

13 After satisfactory testing, the local elements of the installed system shall be commissioned as a whole. After completion of commissioning the equipment can be integrated into the network. Following total integration the wig-wag equipment shall be commissioned as part of the whole bridge system to insure correct interlocking with both the bridge control system and the barriers.

Automatic Barriers

14 Barriers are required at both ends of a movable bridge to prevent vehicles and pedestrians entering on to the bridge structure whilst the bridge is being moved. The barriers shall be located on the approaches to the bridge sufficiently far back from the bridge structure so as not to hinder the movement of the bridge. When the barriers are raised they shall not obstruct the flow of traffic across the bridge. When the barriers are lowered they shall close the road to prevent vehicles and pedestrians going around the barriers.

15 Barrier controllers shall be located beside the barriers, in a positions that do not impede the access-ways. Power shall be derived from a suitable source.

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16 Barriers shall be remotely monitored for failure and incorrect operation.

17 Barriers shall be of such height as to discourage persons from climbing over and shall be fitted with skirts to prevent persons from going under. Barriers part of the total system in accordance with Series 7300.

18 Barriers shall be positioned appropriately that allows easy access for maintenance. A means shall be provided of raising and lowering the barriers manually by means of a handle located in an easily accessible location.

19 Housings and enclosures shall be protected to classification IP65 as defined in the appropriate standards and suitable for the harsh environments encountered in these locations, and shall be of a distinctive colour for easy identification.

20 Cabling shall be laid such that it does not interfere with, or cannot be damaged by the movement of the bridge. Cables shall be terminated in the barrier control box.

21 A maintenance procedure shall be proposed for routine and breakdown requirements.

22 All equipment shall be tested in accordance with Series 7300 prior to any connection being made to the network. Each set of barriers shall be tested to ensure that it is fully functional. All tests shall be documented in an agreed format, and testing documentation presented within agreed time scales.

23 After satisfactory testing, the local elements of the installed barrier system shall be commissioned as whole. After completion of Commissioning the equipment can be integrated into the network. Following total integration the new equipment shall be commissioned as part of a total system in accordance with Series 7300 in order to insure correct interlocking with both the VMS and bridge controller.

Closed Circuit Television (CCTV)

24 Cameras shall be provided as an operational requirement where pedestrian, vehicle and shipping movement on or in the vicinity of the bridge cannot be clearly observed, without obstruction from the Bridge Control Office. When all cameras are connected together to form a system, the system shall provide visibility of the full length of the bridge and its approaches. The visibility viewed from the system video monitors, connected to the camera system shal meet the requirements in accordance with Series 7 11 3 of this specification.

25 Cameras shall be positioned to provide the bridge control office operator with 100 percent viewing coverage of the bridge and the bridge approaches. As a minimum, at least one camera should be provided at each end of the bridge to cover its approaches and traffic barriers, with further cameras provided on the bridge structure to provide full coverage of the bridge.

26 Additional cameras shall also he provided to where any obstruction hinders visibility or where there are separate pedestrian walkways across the bridge structure.

27 CCTV controllers shall be located at convenient locations next to the bridge structure, and in positions that do not impede the access-ways. Power shall be derived from a suitable source.

28 Cameras shall be mounted in an appropriate manner that allows easy access for maintenance. Cameras shall be mounted in their own equipment housing and be easily removable for maintenance.

29 Housings and enclosures shall be protected to classification IP65 as defined in the appropriate standards and suitable for the harsh environment encountered in these exposed locations, and shall be of a distinctive colour for easy identification. Housings and enclosures shall not impede the operation of the camera in any respect.

30 Cabling shall be laid such that it does not interfere with or cannot be damaged by the movement of the bridge. Cables shall be terminated in a junction box that shall allow the cameras to terminate.

31 Each camera and camera controller shall have a unique number. This unique number shall be clearly displayed on the equipment enclosure, so that it is clearly visible from the carriageway.

32 A maintenance procedure shall be proposed for routine and breakdown requirements.

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33 All equipment shall be tested prior to any connection being made. Each individual camera shall be tested to ensure it is fully functional. Each controller shall be tested. All tests shall be documented in an agreed format, and testing documentation presented within the agreed time scales.

34 After satisfactory testing, the local elements of the installed system shall be commissioned as a whole. After completion of Commissioning the equipment shall be integrated into the network. Following total integration the new system shall be commissioned as part of the total system in accordance with Series 7300.

Control and Safety System

35 Control and safety systems shall be as stated in the contract specific documentation. The traffic control system shall monitor the barriers and signals for faults and status and provide the information in a suitable format to the bridge operator. The control system shall ensure the safe interlocking for the operation of the wig-wag signals and the barriers with the bridge movement control system.

36 The traffic control system shall allow the bridge operator to safely control the opening and closing of the bridge with respect to boat traffic as well as vehicles and pedestrians.

37 The traffic control system shall only lower the barriers after the wig-wag signals have been flashing the red aspects for a defined period in accordance with the project specific requirements. Only when the barriers are fully lowered on both sides of the bridge shall the bridge be capable of being moved.

38 The traffic control system shall monitor the bridge movement and shall only raise barriers and turn off the wig-wag signals when the bridge is locked into the correct position on both banks.

39 When the red wig-wag aspects are flashing, the traffic control system shall sound an audible device to warn pedestrians that the barriers will be lowered.

40 The bridge shall be controlled by one of the following methods depending on the project specific requirements:

i) locally controlled from a control office building located at the bridge

ii) remotely controlled from a central office elsewhere from the bridge

iii) automatically controlled by a boater operating a keyswitch

iv) automatically controlled by the detection of boats requiring the bridge to be moved.

41 The traffic control system shall be used with the CCTV system to ensure the bridge is clear of traffic before opening and closing of the bridge. Separate monitors shall be provided in the bridge control office for each camera located at and on the bridge.

42 The supplier shall ensure the safety integrity on the traffic control system and its interface with the bridge control system.

43 A maintenance procedure shall be proposed for any routine and breakdown requirements.

44 The traffic control system shall be tested prior to installation on site. All tests shall be documented.

45 After satisfactory testing the system shall be installed, connected to the other traffic equipment and commissioned as a whole. Following this test the traffic control system shall be integrated into the bridge control system and shall be commissioned as part of the total system in accordance with Series 7300.

Shipping Control

46 Navigation lights for movable bridges as stated in the contract specific documentation shall be installed on the moving sections, landing piers and at the river approaches, controlled and monitored by appropriate status indicators from the control console.

47 Navigation lights for bridge access gantries shall be mounted on the lower parts of the gantry if required.

48 All lights and controls shall meet the requirements of enclosure classification of IP 67 as defined in the appropriate standards.

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Public Address System

49 A Public Address System suitable for external use, shall be provided if specified in the contract specific documentation for bridges which have pedestrian access. The system speakers shall meet the minimum enclosure requirements of IP65 as defined in the appropriate standards. The system console may be incorporated as part of the bridge control console.

Anemometers

50 Approved anemometer shall be provided to measure wind velocity and direction where specified.

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A7205. APPENDICES

Standards and Codes of Practice

i) All work to be undertaken on CCTV cameras, and CCTV controllers, on and around the approaches to the bridge shall comply with the following documents and any project specific requirements:

MCE 2014	CCTV Camera Housing Mountings and Mounting Poles 3/87;
MCE 2015	CCTV Control Systems 10/93;
MCE 2016	Functional Specification for Unit to mix Video and Data Signals;
MCE 2051	Coaxial Cables for CCTV 5/87;
MCE 2106	Maintenance of Motorway CCTV Systems by Regional Maintenance Contractors;
TR 1153	Cabinet Type 600 12/91;
TR 2013	CCTV Colour Monitor for Road Traffic Surveillance 6/92;
TR 2120	Monochrome CCD Camera for M-Way Traffic Surveillance 6/92;
TR 2135	Colour CCD Camera fro M-Way Traffic Surveillance 6/92;
TR 2152	NMCS Non-armoured Co-Axial Communicationa Cable 4/94;
TR 2160	NMCS Amoured Co-Axial communications Cable 4/94;
MCX 0552	Cable (Coaxial) termination Arrangement within M-Way Cabinet 609;
MCX 0373	NMCS2 - CCTV Interfaces to share Keyboards and Monitor;
MCX 0723	Installation Drawing CCTV (3 sheets)

ii) All work to be undertaken on barriers, and barrier controllers, on the approaches to the bridge shall comply with the project specific requirements.

iii) All work to be undertaken on wig-wag signals, and wig-wag controllers, on the approaches to the bridge shall comply with the following documents and any project specific requirements:

MCE 0109 Equipment to Control Traffic Signals (Wig-wag) Adjacent to Fire/Ambulance Stations;

A4/50318 Wig-Wag Controller for Swing Bridges;

TA 13/81 Requirements for the Installation of Traffic Signals and Associated Control Equipment;

TA 14/81 Procedure for the Installation of Traffic Signals and Associated Control Equipment.

Traffic Signs Regulations and General Directions 1994 Drawings:

i) Schedule 8, diagram 3014 Wig-wags;
ii) Schedule 3, diagram 773 Wig-wag Sign.

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Sample Appendices : A7205/2 : Communications, Traffic and Shipping Control

The Contractor shall insert below details of the equipment proposed.

Item No:	Description	Detail
1	Manufacturer of VMS	
2	Manufacturer of automatic barriers	
3	Supplier of CCTV system	
4	Manufacturuer of control and safety systems	
5	Manufacturer of PA System	

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VOLUME 5 CONTRACT DOCUMENTS FOR SPECIALIST ACTIVITIES

SECTION 7 MECHANICAL AND ELECTRICAL INSTALLATIONS IN ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

PART 2

SERIES 7300

TESTING AND INSPECTION FOR ROAD TUNNELS, MOVABLE BRIDGES AND BRIDGE ACCESS GANTRIES

Contents

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7300. INTRODUCTION

1 This Series of the Specification covers the testing requirements of mechanical and electrical components and systems associated with road tunnels, movable bridges and access gantries constructed in the United Kingdom and is categorised under the following headings:

i) Testing and inspection prior to delivery

ii) Testing inspection and commissioning at site

2 A list of the Standards and Codes of Practice to which the equipment shall comply is included in the Appendices at the end of each section of the Specification.

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7301. TESTING AND INSPECTION PRIOR TO DELIVERY

General

1 Testing and inspection of major components and systems may be witnessed by the Purchaser or nominated representative at the manufacturer's works, unless an alternative location is specified, in accordance with the contract specific documentation. A minimum of 28 days notice, in writing, of when and where the tests are to occur shall be given and all facilities for testing provided.

2 Tests shall be carried out by the manufacturer or testing agency in order to determine compliance with the specification and to provide the necessary operation data. All tests shall be arranged to represent the working conditions as closely as possible.

3 Facilities shall be provided to check the performance, dimensions, workmanship and finish of all equipment. As many tests as possible shall be arranged to be carried out in a trench. Certificates detailing records of all tests shall be clearly marked so that the contract equipment items or components to which they refer can be readily identified.

4 Type tests will not be required where certified evidence that the required type tests have been performed successfully on identical equipment. Type test certificates shall be submitted as soon as practicable.

5 Type tests are intended to verify compliance with the requirements laid down in the appropriate standards specified, they are generally carried out on a sample only, by the manufacturer, and include:

i) verification of temperature rise limits

ii) verification of the dielectric properties

iii) verification of the short circuit withstand strength

iv) verification of the effectiveness of the protective circuit

v) verification of clearances and creepage distances

vi) verification of mechanical operation

vii) verification of the degree of protection

6 Except where otherwise indicated all electrical tests shall be carried out at frequency rated by statute, and with the supply voltage waveform approximately sinusoidal.

7 The manufacturer's test equipment shall be of satisfactory quality and condition, with current test/ calibration certificates available for inspection.

High Voltage Switchgear

8 The manufacturer shall provide copies of certificates to verify that the following tests have been carried out, in accordance with the appropriate standards specified.

Type tests

9 The first production unit of each type and rating of any high voltage switchgear design for which type test data is not available.

10 The tests shall include the following.

i) Short-circuit performance

ii) Mechanical endurance

iii) Temperature rise

iv) Impulse voltage withstand

v) Oil or gas insulating medium

Routine tests

11 Each item of HV switchgear shall be subjected to routine tests at the manufacturer's works in accordance with the appropriate standards specified. The routine tests shall include the following:

i) Checks of control functions

ii) Mechanical interlocks

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iii) Electrical interlocks

iv) Relay settings

v) Over voltage test across open contacts

vi) Interfaces with plant monitoring and control systems

vii) Indicating and metering equipment

viii) Insulation resistance

ix) Secondary injection testing of protective devices

Transformers

12 The manufacturer shall provide copies of certificates to verify that the following tests have been carried out, in accordance with the appropriate standards specified.

Type tests

13 The first production unit of each type and rating of any transformer design for which type test data is not available.

14 The tests shall include the following:

i) Temperature rise

ii) Dielectric tests

15 Each transformer shall be subjected to routine tests at the manufacturers works in accordance with the appropriate standards specified.

16 The tests shall include the following:

i) Measurement of winding resistance

ii) Measurement of voltage ratio and check of voltage vector relationship

iii) Measurement of impedance voltage, short-circuit impedance and load losses

iv) Measurement of no-load loss and current

v) High voltage insulation tests, LV insulation tests and interwinding test

vi) Tests on-load tap-changers, if applicable

Low Voltage Switchgear

17 The manufacturer shall provide copies of certificates to verify that the following tests have been carried out, in accordance with the appropriate standards specified:

Type tests

18 The first production unit of each type and rating of any low voltage switchgear design for which type test data is not available.

19 The tests shall include the following:

i) Short circuit performance

ii) Mechanical endurance

iii) Temperature rise

iv) Impulse voltage withstand

20 Each item of LV switchgear shall be subjected to routine tests at the manufacturer's works in accordance with the appropriate standards specified.

21 The tests shall include the following:

i) Automatic control functions

ii) Manual control functions

iii) Local control functions

iv) Remote control functions

v) Mechanical interlocks

vi) Electrical interlocks

vii) Relay settings and secondary injection testing of protective devices

viii) Interfaces with plant monitoring and control system

ix) Indicating equipment and metering

x) Ratio and polarity tests to all current and voltage transformers

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xi) Visual inspection

xii) Insulation resistance

Standby Generators

22 The manufacturer shall provide copies of certificates to verify that the following tests have been carried out, in accordance with the appropriate standards specified.

Type tests

23 The first production unit of each type and rating of any standby generator design for which type test data is not available shall be subject to full type tests. The type tests shall include the following:

i) Cold electrical resistance of windings

ii) Electrical resistance and temperature rise of windings following hot shutdown

iii) Transient performance test to take place under varying load switching to measure voltage and frequency operation and overload performance

iv) Vibration tests

v) Noise tests

vi) Short circuit withstand tests

vii) Timed tests to measure acceptance of full loads

viii) Operation of all protective devices

Standard tests

24 Each item of generating plant shall be subject to standard tests at the manufacturers works in accordance with the appropriate standards specified. The tests shall include the following:

i) Check that plant conforms to specification

ii) Record rating and reference data

iii) Check that oil, coolant, fuel etc. fluid levels are correct and/or connections are satisfactory including exhaust, power and control wiring

iv) Ensure that necessary adjustments and checks are made during preliminary starting and running

v) Initial set up and performance tests

vi) Load acceptance tests

vii) Voltage regulation and governing (cold conditions)

viii) Load duration tests with detailed examination of set following hot shutdown

ix) Voltage regulation and governing (hot conditions)

x) Transient performance test

xi) Insulation tests

xii) Final re-run of set to observe correct running

xiii) Final check and clearance including draindown, disconnections and consumption of test certificates

Performance tests

25 The initial setting up checks shall include the following:

i) Run up and apply rated kW load at power factors 1.0 and 0.8 lagging

ii) Adjust engine speed and generator voltage to rated values and lock at these values

iii) Check that all control, indicating and safety equipment meet the functional requirements of the Specification

iv) Check that overload capability of 10% is available (some engines can attain 110% only after a satisfactory running-in period)

v) throw off rated load and check that frequency and voltage values remain within specified tolerances

Load acceptance tests

26 From cold start and no-load condition apply single step load in accordance with specified load acceptance category.

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Governing and voltage regulation tests

27 These tests shall be carried out under both cold conditions (before the load duration tests) and steady-state hot conditions (following load duration tests).

28 The load condition shall range from no-load to 100% plus the specified overload capacity at unit power factor by increments of 20-25% of rated kW load.

29 These tests shall be repeated at a power factor of 0.8 lagging using an inductive load bank where feasible.

Load duration tests

30 The load duration test shall comprise the following:

i) For plant rated at 100kW or more, run up generating plant and run at rated load (preferably at power factor 0.8 lagging) for a minimum of four hours to ensure that thermal equilibrium has been reached

ii) For plant rated at less than 100kW, run up generating plant and run at rated load (preferably at power factor 0.8 lagging) for a minimum of one hour

iii) For continuously rated sets a load of 100% of rated kW at unity power factor (or, preferably, at power factor 0.8 lagging) shall be applied for 15 minutes for sets up to 100kW and 60 minutes for sets above 100kW. This shall be carried out immediately after the above full load test

iv) Periodically record all instrument readings and plant and air temperatures

v) Check for leaks of fuel, oil or water during tests

vi) On completion of test, shut down plant and examine all components for excessive temperatures

Transient switching tests

31 The transient switching performance test shall be included in the works tests.

32 The test shall comprise the following:

i) Start set and apply a single step load in accordance with the specified load acceptance category (typically 60% of rated load) and record output voltage and frequency

ii) Switch off load and record maximum transient over-shoot values of output voltage and frequency before recovery to normal values

iii) Re-apply step load and record transient changes in output voltage and frequency before recovery to normal values

iv) Record final steady state values after recovery

Insulation test

33 The insulation test shall comprise the following:

i) Remove external wiring between plant and test panel

ii) Isolate sensitive electronic equipment in alternator and control panel (as recommended by manufacturer)

iii) Open any neutral earthing links

iv) Using an insulation resistance test instrument, measure and record values of insulation resistance(s)

v) Reconnect electronic equipment and neutral earth links

vi) Re-run set to check correct output voltage and frequency

Completion

34 On completion of the tests and final run, the plant shall be closed down and the following procedure carried out:

i) Drain cooling, lubrication and fuel system, attaching notices warning of this condition

ii) Disconnect batteries and any test cables

iii) Replace all covers and ensure their security

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iv) Check accessible bolts and connections

v) Check accuracy of rating Plates

vi) Complete and sign test record sheets

UPS Equipment

35 The manufacturer shall provide copies of certificates to verify that the following tests have been carried out, in accordance with the appropriate standards specified.

i) Correct operation of all controls, instruments and alarms

ii) Efficiency at 50%, 75% and 100% specified load and power factor

iii) Operation from the battery at no load with maximum battery voltage and at full Load with minimum battery voltage

iv) Operation on unbalanced load, two phase being fully loaded, the third being 75% loaded

v) Continuous supply of specified load in kW and kVA for four hours, unless a type test certificate is available

vi) Steady-state frequency regulation (no-load to full-load)

vii) Steady-state voltage regulation (no-load to full-load)

viii) Transient voltage and frequency regulation for 50% step load application at 0% and 50% of the specified load, and 50% load rejection at the specified load and 50% of the specified load

ix) Transient voltage and frequency regulation and waveform distortion on mains failure, mains return and by-pass switch operation (where applicable), with the set operating at specified load

x) Total and individual harmonic voltage content of output waveform at no load and specified linear load

xi) Input current harmonic content at specified load

xii) Correct operation of any current limiting circuits

xiii) Mains failure simulation

xiv) Simulate fault condition on UPS to check operation of automatic transfer device

xv) Insulation test

Tunnel Luminaires

36 A pre-production model of each type of luminaire, complete with mounting brackets, shall be tested at the manufacturers works in accordance with the appropriate standards specified. The tests shall include the following:

i) Ingress protection test with water jet pressure of 100 kN/m² for 15 minutes

ii) Satisfactory operation of luminaire and lamp at -15°C and 35°C. ie., comparison with published polar diagrams of light emissions and energy usage.

37 On successful completion of these tests the luminaire models shall be retained until completion of the Contract. Bulk production of luminaires shall not proceed until compliance with the requirements of Series 7107 has been verified. Bulk production of luminaires shall not proceed until authorised.

38 The following tests shall be carried out on luminaires randomly selected from the production lines:

i) Ingress protection test with jet pressure of 100 kN/m² for 15 minutes

ii) The thickness of the coated surface where applicable, shall be determined by the eddy current or ultrasonic methods

iii) Impact resistance comparable with the specified for the IP rating of the luminaire.

39 The number of luminaires selected shall be either 0.5% (rounded upwards) of the number of luminaires ordered, or two of each type in number, whichever is the greater.

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Fans

General

40 Each fan shall be performance tested to the appropriate standards specified.

41 The following tests shall be carried out for each fan unit:

i) Measurements shall be taken of flow rate, pressure head, speed of rotation and electrical power input, at a minimum of 6 points on the fan performance curve, including duty point for the proposed system. The manufacturer's recommended operating range of the fan shall be clearly indicated on the performance curves. At the duty point, additional measurements of noise level and vibration under agreed conditions, and starting and running current, shall be recorded.

ii) Testing of static and dynamic balancing of the fan rotor assemblies. The impeller shall be statically balanced to give a fan balance level of 4.5mm/s root mean square at the fan feet. When dynamic balancing is specified, the balancing shall be performed with the fan supported on anti-vibration mounts, during which the vibration level shall be measured at rotational frequency in the vertical, horizontal and axial directions at a point on the front and rear feet adjacent to the mounting hole.

iii) Measurement of noise levels. The fan shall give the sound power level specified when tested in accordance with appropriate standards specified. Inlet and outlet sound levels shall be measured and in the case of reversible fans, the sound level shall be measured in both directions of airflow.

42 The above tests shall be carried out over the full design duty range of each fan.

43 For standard mass produced fans, type tests may be acceptable in respect of the above mentioned tests.

Jet Fans

44 A prototype jet fan, complete with silencers fitted, if specified, shall be subject to the tests given below. The test measurements shall be made after the fan has reached steady operating conditions. The fans shall be tested at full speed in the forward operation and where reversibility is specified, in the reverse operation.

Axial Thrust

i) The jet fan assembly shall be tested for developed axial thrust in accordance with the appropriate British and/or European Standard.

ii) The test shall be carried out with the fans maintained in the horizontal orientation and in a still atmosphere, (ie air speed less than 0.3 m/s)

iii) The axial thrust shall be determined by means of a system of calibrated counter weights and an accurately calibrated spring balance/force transducer. The thrust shall be measured to the tolerance specified in the appropriate standards specified.

iv) The thrust measuring enclosure shall, as a minimum, provide the following clearances:

a) 3 fan diameters upstream of the intake silencer's bellmouth

b) 10 fan diameters down stream of the discharge silencer's bellmouth

c) 2.5 fan diameters radial clearance from fans axis for 3 and 10 fan diameters upstream and downstream respectively of the fan assembly

Motor Power and Speed

45 At the time of determining the axial thrust, the motor power and speed shall also be recorded.

46 Bulk production of the jet fans and silencers shall not proceed until compliance with the requirements of Series 7108 has been verified.

47 The specified sample quantity of production fans shall be subjected to the same tests as the prototype with the exception that the fan thrust shall be tested with the fans operating in the forward direction only.

Mobile Jet Fan Cradles

i) All functions of the mobile cradles shall be demonstrated using a production jet fan complete with silencers and mounting brackets

ii) The mobile cradles shall be tested for lifting capacity using a test load of at least twice the intended working load.

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Pumps

General

48 One unit of each pump/motor/impeller combination shall be subjected to tests in accordance with the appropriate standards specified. Measurements shall be taken of flow rate, pressure head, speed of rotation and electrical power input, at a minimum of 6 points on the pump performance curve, including the duty point for the proposed system. The manufacturer's recommended operating range of the pump shall be clearly indicated on the performance curves.

49 At the duty point, additional measurements of noise level and vibration under agreed conditions and starting and running current shall be recorded.

50 Pumps shall be tested complete with inlet and discharge fittings identical to those to be used in the final installation.

Pump Control Equipment

51 Equipment for the monitoring of water levels within the drainage sumps and the corresponding control of the drainage pumps, gas detection and ventilation shall be tested in accordance with the appropriate standards specified to confirm the correct, safe and accurate functioning of the devices including any interfaces with the Plant Monitoring and Control System.

52 The operation under simulated conditions representing as closely as possible the final pump installation shall be demonstrated.

Control and Communication Testing

53 The general testing and commissioning requirement is that a formal test will be performed once. Where a test fails it shall be logged, rectified and re-tested as necessary.

54 It is recognised that some tests will in fact be performed more than once. Where this is the case the repeat test will test aspects of the design and installation that could not be performed before, eg a functional test in the factory will test that the software runs in the predicted manner, the same test on the plant will demonstrate that the plant runs in the predicted manner.

55 All inspection, testing and commissioning will be subject to a written approval procedure and method statement with space for sign off and recording of test results. The procedure will cover all aspects of the system design and functionality, and shall include design values for provision of easy comparison.

56 All test results shall be recorded and collated into at least one test report, in an appropriate and approved format within two weeks of test completion. The accuracy of the test instruments and methods shall have been demonstrated.

57 The intention of these test procedures and reports is to fully demonstrate and record the manufacture, installation, testing and commissioning of the system to be supplied under the Contract. This documentation should not be an undue burden on the project as it represents the minimum that could be expected in order to conform to Quality Assurance requirements, and product liability regulations.

58 All systems to be operated shall be in a safe and ready condition. Any damage to plant or equipment during commissioning by the tests shall be rectified at no additional cost.

59 All work, activities, instrument serial numbers, adjustments, commissioning results, names of personnel, dates, times, etc. shall be scheduled throughout the duration of the testing works.

60 Commissioning shall include the initial and final setting and locking of valves, safety devices, dampers, etc. to specified requirements including setting to work and regulation of the installations.

61 All necessary test point holes and tappings within pipe work shall be provided and the positions marked on the physical layout drawings.

Monitoring and Control Testing Phases

62 Inspection, testing and commissioning shall be performed in distinct phases as outlined below:

i) intermediate manufacturing test;

ii) contractor's own factory tests;

iii) factory acceptance tests;

iv) site installation tests;

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v) loop tests;

vi) local functional test;

vii) remote functional test;

viii) production/performance trials;

ix) handover.

63 Each phase shall be completed prior to the commencement of the next, except where parallel works are undertaken and one test has no affect on the other. e.g. site cable insulation test can be performed at the same time as factory acceptance test.

64 At the time of formal inspections and tests all necessary drawings, and data together with all necessary test equipment shall be provided.

65 Any faults discovered during testing shall be rectified before proceeding further with the testing. All previously tested circuits and functions, affected by the repair work shall be retested.

Notification procedure

66 The Contractor shall submit full proposals prior to the commissioning date, giving as a minimum:

i) date and time of testing;

ii) extent of system or reference to plant for testing;

iii) method of test measurement or monitoring and range of operation;

iv) method of simulating normal operating conditions if they do not already exist;

v) confirmation that all testing is completed satisfactorily;

vi) proforma record sheet for each item of plant and system.

Instruments for testing and commissioning

67 All necessary test instruments required for the performance testing and commissioning of the system shall be provided.

68 In all cases to allow auditing a record shall be maintained on the test sheets of the make, model and serial number of the test equipment used at the time and place of testing.

69 All instruments shall have valid calibration certificates a copy of which shall be included in the test report. Where the test equipment cannot by its nature be calibrated, (eg a digital logic probe, but not an oscilloscope) then a calibration certificate is not required. The auditing record will, however, be maintained.

System log

70 A system log for each of the systems being provided shall be maintained from the outset.

71 This log shall record all significant events for each system (e.g. test of individual sub-systems), noting the test harness and the results obtained, faults noted, remedial action taken etc. This log shall form part of the documentation requirements of the contract to maintain a full history of significant events.

Defect logs

72 A record of defects noted with all the symptoms of the fault and the detailed actions taken to rectify the faults shall be kept for all instrumentation and control systems. Records of faults shall be maintained in accordance with the requirements of the appropriate standards specified.

Air Monitoring Equipment

73 Equipment for the monitoring of visibility, carbon monoxide and air flow within the tunnel and external wind speed and direction shall be tested to confirm the correct, safe and accurate functioning of the devices, including any interfaces with the Plant Monitoring and Control System.

74 Suitable translucent screens for testing the obscuration meters and supplies of carbon monoxide for testing carbon monoxide sensors shall be provided.

75 Manufacturers calibration certificates prior to testing shall be submitted.

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Control Panels

76 A prototype of each type of panel shall be constructed for approval.

77 Each prototype panel shall be tested for compliance with the specified degree of protection against the ingress of dust and water in accordance with the appropriate standards specified.

78 The illuminated sign associated with each emergency panel sign shall also be included within the above tests.

79 Where appropriate, every panel shall be tested to confirm the correct and safe functioning of the equipment installed within it, together with any external interfaces with the Plant Monitoring and Control System.

Communications Equipment

80 The complete communications system shall be assembled, including control and switching equipment and remote equipment.

81 Inputs from and outputs to external plant and interconnections between all components of the system (including those via the national public telephone network) shall be simulated to permit any combination of operating conditions to be reproduced.

82 The tests shall demonstrate the operation of the complete system including operation with simulated background traffic noise of 100dB(A) to demonstrate the ability of the system to allow clear audible speech under these conditions.

83 This test need not include the use of the external telephone network, although written confirmation to agreed procedures that the telephone systems are compatible with these systems and approved for connection to these systems will be required.

Traffic Control Equipment

84 The complete system for connection to loops shall be assembled at one location and shall be demonstrated to operate in accordance with the requirements. Every combination of events shall be tested to ensure all interlocks perform correctly. Any special requirements or rules built into the system shall be fully demonstrated.

85 This test shall include the operation of any signal transmission equipment to be employed to transit signals to remote monitoring stations. Any existing control systems shall be simulated to provide the necessary control signals.

CCTV Equipment

86 All equipment shall be tested to the appropriate British and/or European Standards, individually and as a system, using dummy lengths of cable as necessary.

Traffic Monitoring Equipment

87 The complete system shall be assembled at one location and shall be demonstrated to operate in accordance with the requirements.

88 This test shall include the operation of any signal transmission equipment to be employed to transmit signals to remote monitoring stations.

Plant Monitoring and Control Equipment

89 Factory intermediate manufacturing tests:

90 Intermediate manufacturing inspections shall be performed as detailed within this and the project specific documentation. These inspections shall include (as required):

i) panel construction conformity to drawings

ii) paint conformity

iii) electrical tests (see below)

91 The following electrical test shall be performed:

i) electrical insulation tests: All circuits shall be tested using the default voltage and between neutral and each phase conductor and between earth and non-earthed circuit conductors. Instruments and electronic equipment shall be isolated during such tests

ii) all circuit protective devices shall be checked for correct labels, rating and service

iii) all circuit protective devices and isolating switches shall be checked to ensure they are connected to the correct circuits

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iv) electrical faults on instruments and other circuits shall be simulated to prove the effectiveness of the protective devices

v) all circuits shall be checked for correct polarity.

Preliminary factory tests

92 Prior to undertaking formal factory acceptance tests preliminary factory tests shall be performed to verify that the system conforms to the specification and is ready for the formal tests.

93 During this period of time temperature cycling and the soak test will be performed.

94 Temperature cycling and/or elevated temperature test, if required by the project specific documentation, shall be performed for certain equipment or panels to demonstrated its capability of operating in the environment specified.

95 Soak tests shall be performed on all parts of the systems under supply. The test shall subject the system to the maximum operating temperature for a default period prior to the factory acceptance tests. During this period the system shall run the application software to demonstrate satisfactory operation.

96 During the soak test, all equipment shall be energised and remain energised for the duration of the test. This includes panel mounted indicators which are externally powered. Dummy loads shall be fitted in all loops where this is necessary for observing the correct functioning of the loop.

97 For the preliminary factory tests and the formal factory tests the tester shall:

i) undertake a visual check prior to, during and after the test to verify that all equipment is functioning correctly

ii) keep all panel doors closed and operate any forced ventilation under simulated load conditions

iii) test all equipment associated with a loop as a system

iv) connect test equipment to field terminals only

v) check indicators and recorders by varying the 'transmitter' output and observing that the correct receiver operates and there is no interaction with other circuits;

vi) similarly, controllers shall be checked and in addition these shall be checked to ensure the correct control action, correct operation of auto/manual switch, and correct operation of automatic sequence systems.

vii) test all alarms operated by transmitters by varying 'transmitter' output and not by adjusting alarm setting. The tests shall ensure that the correct alarm operates, there is no interaction with any other circuit and the alarm sequence is correct

viii) provide facilities for checking shutdown, and sequential control circuits. These shall simulate all interlocks and time delays in the system

ix) provide simulated inputs for external systems by devices mimicking the external systems. A simulation mimic with lamps or LEDs and switches, wired to the control panel should be considered for this purpose.

Factory acceptance tests

98 For each system comprehensive tests on a fully configured system at the factory shall be conducted.

99 Prior to these tests being undertaken records of the preliminary factory tests shall be provided.

100 These tests shall include:

i) visual inspection for physical defects and conformity to drawings

ii) manufacturer's standard tests

iii) system tests:

a) earthing and safety checks

b) full diagnostic tests on all hardware;

c) power compatibility tests, including determining the effects of power supply fluctuations;

d) power failure/recovery;

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e) auto-changeover from duty to standby and back to duty including reporting;

f) system reporting on board or channel failure;

g) system reporting on communication failures;

h) analogue input accuracy.

iv) integration tests shall be carried out to demonstrate that all sub-systems of hardware and software have been assembled into a complete and functioning whole.

v) functional tests:

a) full monitoring tests for every input including range (for analogue and pulse), sense (for digital) and reporting (on VDU, printers, logs etc)

b) full output tests for every output

c) full control tests for open/closed loop

d) process sequencing

e) reporting

f) alarm

g) trend

h) archiving

i) all other functions as detailed in this requirement and the project specific documentation

vi) operational requirements of specification.

101 The equipment shall not be shipped to site until the tests have been satisfactorily completed.

102 The validity of the System Operation and Maintenance Manuals shall be demonstrated.

Movable Bridges Mechanical Equipment

103 Pumps and hydraulic motors shall be tested by the manufacturer before units are assembled. Tests for pumps and hydraulic motors shall be conducted for 15 minutes continuously, at a minimum test pressure equal to the maximum peak or intermittent pressure rating of the component.

104 Pumps shall be checked during testing for external leakage, charge pump (ie a small pump which tops up pressure) pressure and flow (where provided), and main pump pressure and flow.

105 Integral relief valves shall be set at 207 bar maximum, and checked for proper operation.

106 Fluid motors shall be checked during testing for external leakage, pressure and flow.

107 Cylinders shall be tested by the manufacturer before shipment to the bridge site. Testing shall include a 30 minute static pressure test at a minimum pressure of 276 bar. The leakage rate past the piston during the static pressure test shall be no greater than 82 cubic cms per minute for span driving cylinders. Certified test data for span driving cylinders and catalogue rating certification for all other cylinders shall be provided.

108 Flexible hose and fittings shall be hydrostatically tested after assembly to 35 bar minimum.

Power Units

109 Assembled power units shall be tested for proper operation, and certified test data submitted before shipment to the bridge site.

110 Power units shall be tested at full drive motor speed under conditions of maximum design pressure at minimum fluid flow, and reduced pressure at maximum fluid flow. The maximum pressure test shall be conducted for one hour continuously.

111 During all tests, the power units shall be checked for fluid leakage, excessive fluid temperature, proper relief valve operation and proper operation of charge pumps.

112 Pump controls shall be tested for correct speed regulation, response time and direction of rotation.

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113 Associated communication equipment shall be tested and all electrical equipment to the appropriate standards specified and manufacturer's literature.

Shipment

114 Power Units, valve stands and cylinder assemblies shall be shipped fully assembled to the bridge site and installed at their final positions. Pumps, motors and couplings shall be checked for proper alignment and realigned if necessary. Disassembly will not be permitted for shipment, storage or during installation.

115 Hydraulic equipment fluid ports shall be securely sealed prior to shipment and shall remain sealed until final assembly of the hydraulic system. Seals shall not be removed until just before the connection of components.

Access Gantries Mechanical Equipment

116 Pumps and hydraulic motors, as specified, shall be tested by the manufacturer before units are assembled, to the recommended maximum pressures.

117 Pumps shall be checked during testing for external leakage and flow.

118 Certified test data shall be provided for approval before shipment to site.

Test Certificates

119 Original or certified copies of all test results and a certificates stating that the equipment and materials comply with the appropriate standards specified shall be submitted and/or included in the testing/operation/ maintenance manuals.

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7302. TESTING INSPECTION AND COMMISSIONING AT SITE

General

1 Testing shall be carried out during normal site working hours as far as practicable. Tests which involve existing apparatus and power outages may take place outside normal working hours. Testing of an item to be concealed or buried should be pretested in stages prior to concealment.

2 Adequate notification to all parties who may require to witness the tests shall be given. Reference should be made to consulting the operating authority if works involve existing road networks.

3 The requisite experienced testing personnel and all relevant test equipment shall be provided.

4 Details of the tests to be carried out and the methods to be adopted shall be in accordance with the contract specific documentation. A complete set of approved test forms shall be provided before testing commences.

5 A test form shall be provided for each item of plant and/or test. The test forms shall show the type of plant and serial number or other identifying mark. Test forms shall also show details of the test equipment and instruments used. Provision shall be made on the form for recording all the test results.

6 The results of the test shall be recorded clearly on the test form with clear references to the equipment and items to which they refer, so that the record form can be used as the basis for maintenance tests during the working life of the equipment. The required number of site test result records shall be provided as soon as possible after completion of the tests, and prior to offering the installations for acceptance and final inspection.

7 Test equipment shall be of satisfactory quality and condition and, where necessary, shall be appropriately calibrated to the appropriate standards specified.

8 The testing requirement details may be subject to some variation upon the instruction or agreement, where necessitated, by changed conditions at site or by differing design, manufacture or constructional techniques.

9 All tests shall be carried out and witnessed in accordance with the contract specific documents.

10 Any defects of workmanship, materials and performance, maladjustments or other irregularities which become apparent during testing and/or commissioning shall be rectified, then retested and/or recommissioned.

11 A method statement for the testing and commissioning of all life and health safety systems shall be provided.

12 All life safety systems shall operate in conjunction with all new and/or existing life safety systems. The life safety systems may include some or all of the following systems:

i) Fire Alarms

ii) Gas Extinguishing System

iii) Pressurisation of escape routes for smoke control

iv) Ventilation shut down

v) Mains failure back-up

vi) Stand by power

vii) Environmental monitoring

viii) Barrier closing

13 Operational tests of all life safety systems in association with all other systems shall be carried out to ensure compatibility and correct operation.

14 If the tests fail to demonstrate the satisfactory nature of the installation or portion of it, then alterations, or replacements as required to effect a further test when such alterations have been made shall be carried out.

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Electrical Services

15 All sections of the electrical services shall be tested as each section of the work is completed on site in order to verify that the results obtained are fully compliant.

16 Where the results are found not to comply with the requirements of the appropriate standards specified remedial work shall be carried out without delay.

17 A visual inspection of the remedial action shall be initially carried out. Any defects or necessary remedial action identified shall be put in hand immediately.

18 The following tests shall be carried out prior to the connection of the supply to the installation:

i) Continuity of ring final circuit conductors

ii) Continuity of protective conductors, main and supplementary bonding

iii) Earth electrode resistance

iv) Installation testing

v) Insulation resistance

vi) Insulation of site-build assembles

vii) Protection by electrical separation

viii) Insulation of non conducting floors and walls

ix) Polarity

19 The following test sequence shall be carried out after the supply has been connected:

i) earth fault loop impedance

ii) operation or residual current operated devices and fault-voltage operated devices

iii) operation of all plant and equipment

20 The testing requirements detailed may be subject to some variation upon the instruction or agreement where necessitated by changed conditions at site or by differing design, manufacture or constructional techniques.

Mechanical Services

Cleaning

21 Immediately prior to the testing and commissioning of the completed works or part of all parts of each system and related plant shall be thoroughly cleaned internally and externally.

22 Before commencing such work all equipment which could be damaged shall be isolated and all terminal points at ends of pipe circuits cross connected to ensure circulation during the cleaning process.

23 Attention shall be paid to the protection of plant, particularly sensitive or fragile items, from the activities of other trades during construction, from the ingress of dirt and from unauthorised operation during commissioning.

Site Tests

24 All pressure tests shall be carried out before the application of thermal insulation, but where this would prejudice the completion of the installation, the section concerned shall be individually tested before the application of insulation.

25 Due allowance shall be made for any sectional testing of the Works that may be required to suit the contract programme and, in the case of systems requiring hydraulic pressure testing, for any subsequent draining and refilling that may be required due to the ambient conditions.

Commissioning

26 Before any commissioning is commenced, it shall ensured that the installation has been cleaned, inspected and pressure tested.

27 Having ensured that electricity, water, fuel and other necessary supplies are available, the completed Works or part of it shall be set into operation, and all necessary adjustments to ensure correct functioning shall be made.

28 After the installation or part of it has been set into operation the operation of the installation shall be demonstrated.

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29 The tests shall demonstrate:

i) that the equipment etc. provided complies with the Specification in all particulars and is of adequate capacity for its full rated duty.

ii) that all items of plant and equipment meet the specified requirements for noise limitation.

iii) that all electrical circuits are properly fused and protected and conduit systems are electrically continuous and properly earthed.

Performance Testing

30 Performance testing may be required to demonstrate, by measurement and recording, that the installation functions correctly and maintains internal environmental conditions, within the specified limits, under varying plant loading.

31 Performance testing of an installation shall only take place on completion of commissioning.

32 The site tests shall be of the specified duration which shall be long enough to allow the taking of all measurements required and to demonstrate the performance of the installation.

High Voltage Switchgear

33 After completion of the installation tests on the complete switchboard assemblies shall be carried out in accordance with the appropriate standards specified. The tests shall also include, but not limited to, the following:

i) Measurement of the resistance of all parts of the main circuit

ii) Verification of correct wiring

iii) Dielectric tests on all auxiliary and control circuits

iv) Full operational check of local and remote control and monitoring functions, interlocks and relay settings

v) Functional tests of protection and circuit breaker operation, which shall include primary and secondary current injection tests as appropriate.

vi) Full operational check of all indicating and metering equipment.

Transformers

34 After installation on site, each transformer shall be subjected to the following tests:

i) Dielectric tests

ii) Measurement of sound level

iii) Check for correct operation of gas and oil actuated alarms, relays and indicating instruments

iv) Check for operation of interfaces with plant monitoring and control systems

Low Voltage Switchgear

35 Pressure tests in accordance with the appropriate standards specified shall be carried out on all distribution equipment. The insulation resistance of all secondary circuits shall also be measured and recorded.

36 Operation of all switches controls indicating and metering equipment shall be demonstrated.

37 Secondary injection tests shall be carried out on protection relays.

38 Tripping, closing at normal and reduced voltages, also other operational checks on all circuit breakers and associated secondary circuits.

39 Checks on all local and remote indication and alarm circuits shall be carried out.

40 Interlocks and intertrip sequence operations shall be carried out.

41 Recommendations and setting up of the time and current settings of all protection relays to provide satisfactory discrimination in each circuit. Calculations used to obtain settings shall be made available.

Standby Generators

42 The generator plant, including its associated fuel, cooling, exhaust, electrical and fire safety systems shall be thoroughly checked for correct operation in both manual and automatic modes during and upon completion of site installation. The initial checks will consist largely of static checks to ensure that installation has been carried out correctly in readiness for full testing and commissioning.

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43 The engine/alternator shaft alignment shall be checked where the set is not skid-mounted or where the assembly has been dismantled for transportation to the site.

44 The generator output voltage, frequency and phase rotation shall be checked before further tests are carried out and before final connection to the electrical distribution system.

45 A load test with the standby generator supplying the full site load shall be carried out. As an alternative to the full site load a multi-stage load bank capable of offering loads at power factor 0.8 lagging shall be used.

46 The duration of the site load test shall be at least 4 hours for all sets above 100kW. Sets rated at less than 100kW shall be tested for 1 hour.

47 In all cases, the test shall be carried out at varying loads up to the full rated load, with instrument readings recorded every 15 minutes. These readings shall include jacket water temperature, exhaust temperature, lubricating oil level, temperature and pressure, output voltage and frequency. The room temperature shall also be monitored.

48 Multiple set installations shall be commissioned to demonstrate synchronisation with any combination of sets available and, where appropriate and by prior agreement, in parallel with the supply authority.

49 All local/remote controls, emergency stop and all protection devices/interlocks etc. shall be proved during on-site commissioning tests.

50 The time interval should be noted between initial start up and load acceptance for the lead machine and, for multiple set installations, the time taken for the remaining sets to synchronise and accept load. Load sharing between sets shall also be checked.

UPS Equipment

51 Tests on the complete UPS system shall be carried out in accordance with appropriate standard specified.

52 These tests shall include, but not be limited to, the following:-

i) Functional check of the equipment, protective devices and instruments

ii) Operation from the normal mains supply, and from the standby supply (if this is available)

iii) Simulated mains failure and return at specified load

iv) By-pass switch operation at specified load (where applicable)

v) Verify battery discharge and recharge periods by carrying out a discharge/charge/discharge cycle.

Tunnel Lighting System

53 The completed tunnel lighting installation shall be subject to the following tests:

i) Operation of luminance meters

ii) Operation of the automatic lighting control system for all lighting stages

iii) Operation of emergency lighting system on failure of the mains supply

iv) Operation of manual override switching

v) Measurement of tunnel interior illuminance and luminance levels at road level, kerb and on the walls two metres above roadway for each stage of lighting

vi) Measurement of internal wall and road reflection values

vii) Measurement of external zone luminance at the adaptation point at the centre of the portal of the respective tunnel bores

viii) Measurement of external wall, portal and road reflection values

54 The interior measurements shall be carried out at night for the tunnel threshold zone.

55 The external measurements, wherever feasible, shall be carried out on a clear sunny day between June and August and the measurement repeated at hourly intervals between 10:00 and 16:00 hours.

56 The lighting levels achieved shall be recorded and the system shall be adjusted to ensure the specified levels are met.

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Tunnel Ventilation System

57 Tests shall be carried out to demonstrate that all jet fans are operating correctly with regard to direction, speed and absorbed power, in both forward and reverse modes. The system shall be tested on a calm day to determine the total effective thrust developed by the fans. The airflow rate along the tunnel shall be measured with all fans running. Static pressure measurements shall also be taken, relative to atmosphere, a short distance from each portal. From these measurements the tunnel system resistance shall be determined and the total effective thrust.

58 Tunnel average air velocity measurements shall be recorded for the specified range of ventilation levels, ranging from full flow to minimum flow of air through the tunnel.

59 Jet fan noise shall be measured with all fans operating to ensure that the specified noise level is not exceeded at a height of 1.5m above road surface at any position along the tunnel with no traffic; all other fans shall be measured 'in duct'.

60 Where transverse or semi-transverse tunnel ventilation systems are installed, the airflow rates shall be balanced to achieve the design flow rate through each supply and/or extract grille, and through each section of the air distribution system.

61 Smoke clearance tests shall be demonstrated as part of the overall tunnel performance testing procedures.

Fan Maintenance Cradles

62 The Principal Contractor shall demonstrate the safe operation of the fan maintenance cradles. Tests shall include the lowering and reinstatement of a tunnel jet fan and a demonstration of the manoeuvrability and stability of the maintenance cradle under site conditions.

Fire Main and Water Boosting Installations

63 The fire main installation complete with any booster pumps shall be tested to demonstrate compliance with the requirements. The testing and commissioning procedures shall meet the requirements of the Fire and Water Authorities.

64 Prior to the start of any tests on the completed fire main system, the system shall be purged of any foreign matter. The purging of the systems shall be carried out without the fire hose reels connected.

65 On completion of the purging process and before the trace heating and insulation are installed, all sections of pipework including joints and valves, (all joints, valves and components within the systems shall be leak free) shall be hydraulically tested to the specified pressure. Each section to be tested shall be isolated from the rest of the installation, pumped full of water to a minimum of 1.5 times the operating pressure or 4 bar whichever is the greater, and left without further pumping for the 2 hours. No loss of head shall be observed during this period.

66 A full record shall be provided of the water tightness of each section based on section water capacity, test pressure, rate of pressure drop and a visual inspection of all joints.

67 On completion of the static pressure test, a flow test shall be carried out. The flow shall be recorded at the requisite number of outlets to ensure compliance with the specified requirements. The outlets used shall be at the most remote end of the main from the water source.

68 Booster pump tests shall be conducted to demonstrate their operation and compliance with the specified requirements. Separate flow tests shall be conducted to demonstrate the individual performances of the duty and standby pumps. In addition a duty pump failure shall be simulated to ensure automatic operation of the standby pump.

169 The correct operation of each hose reel and hydrant shall be demonstrated.

70 All extraneous metalwork associated with the systems shall be tested for electrical continuity to verify that it is correctly bonded to earth.

Automatic Fire Extinguisher Systems

71 Tests shall be carried out in every area protected by automatic gas discharge equipment to prove the operation of the automatic and manual releases, the lock-off facility, the time delay between operation and gas release and the operation of all indication and other interlock facilities.

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72 All valves shall be tested to ensure free movement, and after connection of the final set of cylinders, contents shall be checked to ensure no loss of gas.

73 Any pressure switches, control or other switches shall be set and checked and all signalling operations shall be checked for correct operation.

74 A full discharge test shall be made in each protected area. A substitute test agent may be used as agreed.

75 Prior to making a discharge test, all functional tests shall be performed to ensure that a discharge test will not require repeating. During the tests, measurements shall be taken of:

i) Discharge time

ii) Extinguishant concentration achieved

iii) Extinguishant distribution throughout the hazard area

iv) Extinguishant holding time

76 If a substitute test agent is employed the amount used in the system tests shall be determined prior to the test so that the relationship of the test agent concentration to extinguishant can be determined. Containers charged with the substitute test agent shall be distinctly identified.

77 Nitrogen foam systems shall be checked before and after discharge to determine full coverage of foam and expansion rate in accordance with the specified requirements.

78 The integration of the ventilation systems with any gas extinguishing systems shall be demonstrated, eg by simulating a fire alarm following the alarm signal plant shall shut down and airtight duct dampers shall close.

Drainage Pumping System

79 Every pump shall be fitted with a calibrated pressure gauge and operated under normal working conditions to pump water from the sump from one pre-marked level to another with no inflow into the sump. The time taken and pressure gauge readings shall be noted and the water flow rate calculated. All readings shall be tabulated and worked out to demonstrate that the pump capacity and head meet the specified requirements.

80 The operation and calibration of the level control equipment over the complete range of water levels shall be demonstrated.

81 The operation and calibration of each gas detector as appropriate shall be demonstrated.

Heating Ventilation and Air Conditioning Systems

82 All heating ventilation and air conditioning systems shall be tested and commissioned to demonstrate correct operation of the installations in accordance with specified design criteria.

83 Commissioning will include for the advancement of the services installations from static completion to full working order and adjusting the system to the specified tolerances.

84 This may include, but not be limited to:

i) Pressure testing of pipework

ii) Setting to work of heating and cooling plant and making water circuits operational

iii) Inspection of plant under running conditions

iv) Air and water distribution system balancing

v) Calibration of controls

Air Monitoring Equipment

85 All equipment shall be tested on their final mountings. The environmental parameters and the measured readings shall be recorded.

Control Panels

86 Where appropriate, every panel shall be tested in accordance with the appropriate standards specified to confirm the correct and safe functioning of the equipment installed within it, together with any external interfaces with the plant monitoring and control system.

Communications Cabling

87 The communications cabling shall be tested both prior to and after terminations as defined in the appropriate standards specified.

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Communications Equipment

88 Inputs from and outputs to external plant and interconnections between all components of the system (including those via the national public telephone network) shall be simulated to permit any combination of operating conditions to be reproduced.

89 The tests shall demonstrate the operation of the complete system including operation with simulated background traffic nose of 100dB(A) to demonstrate the ability of the system to allow clear audible speech under these conditions.

90 All tests results shall be approved before connection to any existing system.

CCTV Equipment

91 All Testing shall be carried out to the appropriate standards specified and test results shall be approved prior to any connection to an existing system.

Traffic Control Equipment

92 The complete system shall be assembled and shall be demonstrated to operate in accordance with the specified requirements. Each conceivable combination of events shall be tested as far as reasonably practicable to ensure all interlocks perform correctly. Any aspect plants or rules built into the system shall be fully demonstrated.

93 This test shall include the operation of any signal transmission equipment to be employed to transmit signals to remote monitoring stations. Any existing control systems shall be simulated to provide the necessary control signals.

Traffic Monitoring Equipment

94 The system shall be tested as a whole. Vehicles and drivers to simulate trafficked conditions shall be provided.

Plant Monitoring and Control Equipment

Site installation tests

95 In a similar manner to the progressive factory testing, site testing shall be performed to ensure conformity of the installation, and to ensure that defects are uncovered as early as possible.

96 These tests shall include (but not be limited to):

i) Visual inspection for damage;

ii) Field cable core to core and core to earth insulation tests;

iii) Conformity to installation drawings;

iv) Equipment is properly secured and bolted down.

97 The whole of the electrical installation shall be tested at completion in the manner prescribed in the appropriate standards specified. The results of the tests shall be submitted on a certificate of the type described in the standards.

98 Insulation resistance tests shall be carried out.

99 Earth fault loop tests shall be carried out.

100 Cables shall be subjected to the test voltage as laid down in the appropriate standards specified.

101 All cables shall be tested before final making off ends and connecting up. The correct phase rotation of motors etc. shall be checked. Phase rotation tests shall be carried out and if found necessary, any reversal of phase connections shall be carried out.

102 Pre-commissioning inspections of the piping systems shall be carried out to ensure that the systems are ready to be commissioned.

103 The systems shall be filled with the appropriate fluid and all in-line equipment, e.g. pumps, fans, compressors etc. where relevant, activated.
Loop tests

104 Each control loop shall be fully tested from the sensing element to the actuator with all control functions operational as far as it is feasible. If the sensing element must have a particular process operational and this is not possible for loop testing then the process variable may be simulated to complete loop testing.

Local functional tests

105 Each PLC or controller element shall be functionally tested. This will include all the elements noted above for Factory testing.

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106 Adjusting, monitoring and tabulating results shall be carried out for the following, where applicable, in accordance with the design criteria:

i) Main and branch flow rates;

ii) Plant and terminal unit flow rates and pressure drops;

iii) Control valve flow rates and pressure drops;

iv) Bypass flow rates and pressure drops;

v) Plant, terminal unit, mains and branch temperature.

vi) Opening and closing times of valves;

vii) Process timers and PID values, set during commissioning;

viii) Any other process variables set during commissioning.

Remote functional tests

107 When local functional tests have been performed, then associated remote functions shall be tested. e.g. when a process in one or more PLCs has been commissioned, then the remote SCADA elements will be tested.

108 Similarly, should SCADA include an interface to a higher level system, then those interface tests shall start when all the affected SCADA and PLC processes have been commissioned.

109 Following completion of all construction and testing, the plant shall be demonstrated to meet its full performance requirements including maintaining peak production at the energy efficiency levels over a continuous period to be specified, (normally 30 days,). During this period the control systems shall be considered as part of these production trials.

Noise Tests

110 Noise tests shall be carried out to demonstrate compliance with the specified requirements. Sound measurements shall be made in clear calm weather under typical normal daytime conditions following completion of construction of the tunnel but prior to opening the tunnel to traffic.

111 As a minimum requirement, noise shall be measured with all tunnel ventilation fans operating at full speed.

112 Background noise shall be measured before and after readings including plant noise are taken, and the average of the two background levels used as a base against which the noise level with plant operating is assessed. Measurements shall be adjusted to compensate for the effect of any noise emitting construction plant which cannot be silenced during these tests.

113 Noise tests shall be carried out in areas other than in the tunnel, including:

i) Plant rooms

ii) Occupied area adjacent to plant rooms

iii) Outside plant rooms facing air intakes and exhausts and condenser discharge to access possible nuisance to adjacent accommodation. If the adjacent accommodation is residential, building tests may be required at night.

iv) In the space served by the first grille or diffuser after a fan outlet

v) In areas served by terminal units

Air Distribution Systems

Cleaning

114 Immediately prior to the testing and commissioning of the completed works or part of, all parts of the system and related plant, all air ducts including those constructed from builders work and any existing ducts which have been incorporated in the works shall be thoroughly cleaned internally and externally, before any fan is started.

Testing

115 Ductwork specified to the high pressure classification of HVCA Specification DW/142 shall be subject to air leakage testing.

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116 Any requirement for the air leakage testing of ductwork specified to low or medium pressure classifications shall be indicated in the particular specification.

117 Fan and other major air flow quantities where required shall be measured by pitot tube and inclined manometer using multi-point traversing techniques.

118 The following items shall be specifically checked and/or tested and recorded:

i) Outdoor air dry bulb temperature and relative humidity

ii) Air dry bulb temperature and relative humidity in each space

iii) Air dry bulb temperature and relative humidity in each main return duct

iv) Air dry bulb temperature and relative humidity before and after each air heater

v) Air dry bulb temperature and relative humidity before and after each air cooler.

vi) Air dry bulb temperature and relative humidity before and after a humidifying plant.

vii) Air dry bulb temperature and relative humidity after an outdoor and return air mixing chamber.

viii) Air dry bulk temperature and relative humidity in each main supply air duct.

ix) Outdoor air quantity (m^3/s).

x) Air flow (m^3/s) and pressure (Pa) across each fan.

xi) Air flow (m^3/s) and resistance (Pa) across each filter.

xii) Air flow (m^3/s) and resistance (Pa) across each heater.

xiii) Air flow (m^3/s) and resistance (Pa) across each cooler.

xiv) Air flow (m^3/s) and resistance (Pa) across each humidifying plant.

xv) Air flow (m^3/s) in each main supply and return air duct.

xvi) Air flow (m^3/s) at each supply grille and diffuser. On extensive systems and after comprehensive regulation, only selected outlets need be checked for air flow quantity.

xvii) Fan and motor speed, air quantity, dry bulb temperature and relative humidity, both on and off the cooling coil, for at least two of each size of fan cooler unit.

xviii) Main fan and motor speeds.

xix) Current taken under normal running conditions for each fan above 4kW and electric air heater, and maximum current for each electric air heater.

Pipework Systems

Cleaning

119 Immediately prior to the testing and commissioning of the completed works or part of, all parts of the system and related plant shall be thoroughly cleaned internally and externally. This shall include thoroughly flushing out all water installations with clean water and emptying all strainers, dirt pockets, etc. afterwards.

Testing

120 Where there is no applicable standard, all water filled equipment shall be subjected to a hydraulic test of 1.5 times the maximum working pressure, or 1.5 bar, whichever is the greater, for a period of not less than 30 minutes without measurable loss.

121 On completion of the pre-commissioning cleaning of each low, medium or high temperature hot water heating, steam, chilled or condenser water installation, each system shall be recharged with clean water and then subjected to a hydraulic test of 1.5 times the working pressure for a period of not less than 30 minutes without measurable loss. Items of equipment such as safety valves and bursting discs, set to operate at or below this test pressure shall be isolated or removed prior to applying the test. Selected points may be visually examined during the test period.

122 After the installation is proved pressure tight it shall, as appropriate, be drained and charged with treated water.

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123 On completion of the pre-commissioning cleaning of each hot and cold water installation, the systems shall be recharged with clean water and storage cisterns and distributing pipework shall be absolutely watertight under working conditions of pressure with all draw-off taps closed. Water mains and service pipework shall be subjected to a hydraulic test pressure of 900kPa or 1.5 times the maximum working pressure, whichever is greater. This pressure shall be maintained for a period of not less than 30 minutes without measurable loss. Selected joints may be visually examined during the test period.

124 Items of equipment likely to be damaged shall be isolated or removed prior to applying the pressure test.

125 Concealed or buried work shall be inspected and tested before any permanent covering is applied.

126 If required completed pipework on each service shall be opened up for inspection and replaced after inspection. In the event of an inspection revealing faulty workmanship and/or materials, further opening up and replacement may be required.

Disinfection

127 All cold water for domestic use shall be disinfected after cleaning and testing by the application of chlorine.

128 After dosing with the chlorinating solution, tests shall be carried out at random points to ensure that the chlorine concentration is at least equal to the minimum required but not in excess of 200 ppm.

129 At the conclusion of the required working period, tests shall again be carried out at further random points to ensure that a residual of at least 30ppm of chlorine is present. The systems shall then be drained and flushed until further tests indicate that no trace of chlorine remains.

130 An adequate supply of water independent of the incoming service and a point for disposal of effluent with all waste pipes connected to drain shall be provided.

131 At the conclusion of the chlorination, bacteriological tests shall be undertaken by an independent analyst to ensure that bacteria are not present.

Noise Tests

132 Unless otherwise indicated tests shall be carried out as follows:

133 Sound level readings shall be taken to give an octave band analysis of the sound spectrum. The spaces in which such readings shall be taken shall be agreed, but will in general include the following:-

i) Plant rooms.

ii) Occupied areas adjacent to plant rooms.

iii) Outside plant rooms facing air intakes and exhausts and condenser discharge to assess possible nuisance to adjacent accommodation. If the adjacent accommodation is residential building tests may be required at night.

iv) In the space served by the first grille or diffuser after a fan outlet.

v) Areas served by terminal units.

vi) In any space where, by the addition of special silencing material or techniques or by classification of use, a low level of noise is clearly required.

Movable Bridges Mechanical Plant

134 After final installation, but before connection to the piping system or valve stands, power units shall be checked for correct rotation of drive motors and pumps.

135 Reservoirs shall be hydraulicly filled with fluid to the correct level. Portable filtration units shall be used during reservoir filling.

136 After completion of all piping and tubing assembly work, the entire system shall be flushed prior to connection to the system operating elements.

137 All controls shall be tested for design intent.

138 Associated communication devices shall be tested and the electrical installation shall be tested to the appropriate standards specified.

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139 When the entire installation is completed, the movable span, including all accessories, shall be tested through not less than ten complete cycles using normal power, prime movers, and controls. These tests shall be repeated for alternate operating modes if provided.

140 During these tests, equipment shall be inspected for external fluid leakage, and to determine whether all features are in proper working order and adjustment, and whether they meet the requirements.

141 Portable pressure gauges shall be used at all test stations of the hydraulic system, including the power unit.

142 During all the above tests, the level of the hydraulic fluid in the reservoir shall be closely monitored. Proper fluid level shall be maintained at all times to prevent pump cavitation. Air shall be bled from the hydraulic system and make-up fluid added to the reservoir as required, using portable filtration units.

143 In the event tests show that any features are defective or inadequate, or function improperly, all necessary corrections, adjustments or replacements shall be made.

144 When all the components are in an agreed proper working order and adjustment, the pressure readings taken at each test station shall be recorded, and certificates provided.

145 After completion of final tests hydraulic fluid shall be removed, properly discarded, replaced with new fluid, and air bled from the entire hydraulic system. New fluid shall be added using portable filtration Units.

146 After completion of final hydraulic testing, and either fluid replacement or the continued use of fluid which has passed contamination level testing, filter elements shall be replaced and strainers and magnets cleaned.

Access Gantries Mechanical Plant

147 After final installation the entire installation including all accessories shall be tested to an agreed method statement.

148 The tests shall include full functional operational and checking of safety systems with the specified loadings and all controls/communication and electrical systems.

Test Certificates

149 Certified copies of test results and certificates stating that the plant and materials comply with the specifications and standards shall be provided for all mechanical, electrical and communications plant and insertion in the test/operation and maintenance manuals.

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7302. APPENDICES

Standards and Codes of Practice

The following list covers the standards and codes of practice applicable to the following equipment:

	TESTING
BS 171	Power transformers
BS 599	Methods of testing pumps
BS 923	Guide on high-voltage testing techniques
BS 3900	Parts O, General, and E2, Scratch testing of paint
BS 5000	Rotating electrical machines of particular types or for particular engines
BS 5227	A.C. metal-enclosed switchgear and controlgear for rated voltages above I kV and up to and including 52kV
BS 5306	Code of Practice for Fire Extinguishing Systems
BS 5316	Pumps centrifugal, mixed flow axial acceptance tests
BS 5489	Road Lighting
BS 5572	Code of Practice for foul water drainage
BS 5839	Fire detection and alarm systems in buildings
BS 6266	Code of practice for fire protection for electronic data processing installations
BS 6651	Protection of structures against lightning
BS 764()	Guide to high-voltage test techniques for low-voltage equipment
BS 7671	Requirements tor electrical installations (IEE Wiring Regulations)
BS EN 25136	Acoustics determination of sound power radiated into a duct by fan. In duct method
BS EN 30012	Quality assurance requirements tor measuring equipment
BS EN 30012-1	Metrological confirmation system tor measuring equipment
BS EN 60068-3-3	Environmental Testing (vibration)
BS EN 60439	Low-voltage switchgear and controlgear assemblies
BS EN 60439-1	Type tested and partially type tested assemblies
BS EN 60529	Degree of protection provided by enclosure (IP code)
BSRIA AG 81/91	Pre-commission cleaning of water systems
HVCA	Guide to Good Practice tor Site Pressure Testing of Pipework

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	TESTING
HVCA DW142	Specification tor sheet metal ductwork
HVCA DW 143	A practical guide to ductwork leakage testing
CIBSE	Commissioning Codes - Series W, Water Distribution Systems
CIBSE	Commissioning Codes - Series A, Air Distribution
CIBSE	Commissioning Codes - Series B, Boiler Plant
CIBSE	Commissioning Codes - Series R, Refrigerating Systems in buildings
CIBSE	Commissioning Codes - Series C, Automatic Controls
BSRIA AG 2/89	Application Guide, the commissioning of water systems in buildings
BSRIA AG 3/89	Application Guide, the commissioning of air systems in buildings
HSE GS4	Guidance note Safety in Pressure Testing

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