GENERAL SPECIFICATION

FOR

MECHANICAL INSTALLATIONS

IN

GOVERNMENT BUILDINGS

OF

THE HONG KONG SPECIAL ADMINISTRATIVE REGION

2007 EDITION
(INCORPORATING CORRIGENDUM NO. GSMI01)

ARCHITECTURAL SERVICES DEPARTMENT
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

PREFACE

This General Specification aims to lay down the technical requirements of materials and equipment, the standards of workmanship, the requirements on testing and commissioning as well as requirements on document submissions for mechanical installations in Government Buildings of the Hong Kong Special Administrative Region (HKSAR).

The 2007 edition (incorporating Corrigendum No. GSMI01) of this General Specification also comprises emphasis on green initiatives, e.g. reduction of construction waste and enhancement of client satisfaction on completed projects. This is in line with the department's endeavour to reduce the environmental burden on our neighbours and help to preserve common resources while improving the quality of our service.

With the benefit of information technology, electronic version of this new edition is to be viewed on and free for download from the Architect Services Department (ArchSD) Internet homepage. As part of the Government's efforts to limit paper consumption, hard copies of this General Specification will not be put up for sale.

The draft of this edition has been circulated to stakeholders within and external to the Government before finalization. Nevertheless, the Architectural Services Department welcomes comments on its contents at anytime since the updating of this General Specification is a continuous process for the inclusion of any developments that can help meeting the needs of our community.

DISCLAIMER

This General Specification is solely compiled for mechanical installations carried out for or on behalf of the ArchSD in Government buildings of the HKSAR.

There are no representations, either expressed or implied, as to the suitability of this General Specification for purposes other than that stated above. Users who choose to adopt this General Specification for their works are responsible for making their own assessments and judgement of all information contained here. The ArchSD does not accept any liability and responsibility for any special, indirect or consequential loss or damage whatsoever arising out of or in connection with the use of this General Specification or reliance placed on it.

The materials contained in this document may not be pertinent or fully cover the extent of the installation in non-government buildings and there is no intimated or implied endorsement of the sale, supply and installation of the materials and equipment specified in this General Specification within the territory of the HKSAR.

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PART A – SCOPE AND GENERAL REQUIREMENTS

SECTION A1

SCOPE OF SPECIFICATION

A1.1 INSTALLATION TO COMPLY WITH THIS GENERAL SPECIFICATION

The mechanical installations shall comply with this General Specification which details the intrinsic properties (including materials and workmanship) of the installation, in so far as it is not overridden by the General Conditions of Contract, Special Conditions of Contract, Particular Specification for the Works, Drawings and/or written instructions of the Architect.

A1.2 SCOPE OF THE WORKS

This General Specification, Particular Specification, Tender Equipment Schedule and Drawings detail the performance requirements of the Works. The Works to be carried out in accordance with this General Specification shall include the whole of the design, installation and supply of all materials necessary to form a complete installation including any necessary tests, adjustments, commissioning and maintenance as prescribed and all other incidental sundry components together with the necessary labour for installing such components, for the proper operation of the installation.

A1.3 TERMS AND DEFINITIONS

In this General Specification, the following words or expressions shall have the meanings assigned to them except when the context otherwise requires:

A1.3.1 Terms and Definitions

Architect	The Architect or the Maintenance Surveyor or the Supervising Officer as defined in the Contract
Building Contractor	The Contractor employed by the Employer for the execution of the Works as defined in the Contract or the Contractor separately employed by the Employer to execute the builder's work associated with the Works as appropriate
Contract	The Contract defined in the General Conditions of Contract for the Works or the Sub-contract defined in the Specialist Sub-contract for the Works or the Sub-contract defined in the Nominated Sub-contract for the Works as appropriate

Contractor	The Contractor employed by the Employer or the Specialist Sub-contractor employed by the Building Contractor or the Nominated Sub- contractor nominated by the Architect for the execution of the Works as appropriate
Tender	The Contractor's tender for the Works Contract or the Specialist Sub-contractor's tender for the Works Specialist Sub-contract or the Nominated Sub-contractor's tender for the Works Nominated Sub-contract as appropriate

A1.4 SINGULAR AND PLURAL

Words importing the singular only also include the plural and vice versa where the context requires.

SECTION A2

STATUTORY OBLIGATIONS AND OTHER REQUIREMENTS

A2.1 STATUTORY OBLIGATIONS AND OTHER REQUIREMENTS

The mechanical installations shall comply with the statutory obligations stipulated in the following Laws of the HKSAR and other documents currently in force:

A2.1.1 Statutory Obligations

(a) Electricity Ordinance, Chapter 406, and other subsidiary legislation made under the Ordinance;

(b) Fire Service (Installations and Equipment) Regulations, Fire Services Ordinance, Chapter 95, and other subsidiary legislation made under the Ordinance;

(c) Noise Control Ordinance, Chapter 400, and other subsidiary legislation made under the Ordinance;

(d) Water Pollution Control Ordinance, Chapter 358, and other subsidiary legislation made under the Ordinance;

(e) Air Pollution Control Ordinance, Chapter 311, and other subsidiary legislation made under the Ordinance;

(f) Ozone Layer Protection Ordinance, Chapter 403, and other subsidiary legislation made under the Ordinance;

(g) Waterworks Ordinance, Chapter 102, and other subsidiary legislation made under the Ordinance;

(h) Dangerous Goods Ordinance, Chapter 295, and other subsidiary legislation made under the Ordinance;

(i) Places of Public Entertainment Ordinance, Chapter 172, and other subsidiary legislation made under the Ordinance;

(j) Boilers and Pressure Vessels Ordinance, Chapter 56, and other subsidiary legislation made under the Ordinance;

(k) Factories and Industrial Undertakings Ordinance, Chapter 59, and other subsidiary legislation made under the Ordinance;

(l) Occupational Safety and Health Ordinance, Chapter 509, and other subsidiary legislation made under the Ordinance;

(m) Waste Disposal Ordinance, Chapter 354, and other subsidiary legislation made under the Ordinance;

(n) Environmental Impact Assessment Ordinance, Chapter 499, and other subsidiary legislation made under the Ordinance; and

(o) Gas Safety Ordinance, Chapter 51, and other subsidiary Code of Practices of the Gas Authority.

A2.1.2 Other Requirements

(a) Code of Practice for the Electricity (Wiring) Regulations published by the Electrical and Mechanical Services Department, the Government of the HKSAR;

(b) Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment published by Fire Services Department, the Government of the HKSAR;

(c) Requirements and Circular Letters of the Fire Services Department, the Government of the HKSAR;

(d) Code of Practice for Energy Efficiency of Electrical Installations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR;

(e) Code of Practice for Energy Efficiency of Air Conditioning Installations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR;

(f) General Specification for Electrical Installation in Government Buildings, Hong Kong, issued by the Architectural Services Department, the Government of the HKSAR (EE_GS);

(g) General Specification for Air Conditioning, Refrigeration, Ventilation and Central Monitoring and Control System Installation in Government Building, Hong Kong, issued by the Architectural Services Department, the Government of the HKSAR;

(h) Design Manual: Barrier Free Access 2008 published by the Building Department, the Government of the HKSAR;

(i) Code of Practice on Prevention of Legionnaire's Disease, by the Electrical and Mechanical Services Department, the Government of the HKSAR;

(j) Code of Practice for Wind Effects in Hong Kong;

(k) Technical Memorandum to issue Air Pollution Abatement Notice to control Air Pollution from Stationary Processes;

(l) Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites;

(m) Technical Memorandum on Noise from Construction Work in Designated Areas;

(n) Technical Memorandum on Noice from Construction Work other than Percussive Piling;

(o) Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste;

(p) Code of Practice on the Handling, Transportation and Disposal of Polychlorinated Biphenyl (PCB) Waste;

(q) Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes;

(r) Technical Memorandum – Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters;

(s) Technical Memorandum on Environmental Impact Assessment Process;

(t) General Specification for Liquefied Petroleum Gas Installation in Government Buildings, Hong Kong, issued by the Architectural Services Department, the Government of the HKSAR; and

(u) The General Specification for Building, issued by the Architectural Services Department, the Government of the HKSAR.

A2.1.3 Safety Requirements

(a) Occupational Safety and Health Ordinance, Chapter 509, and other subsidiary legislation made under the Ordinance;

(b) Factories and Industrial Undertakings Ordinance, Chapter 59, and other subsidiary legislation made under the Ordinance;

(c) Construction Site (Safety) Regulations;

(d) Public Health and Municipal Service Ordinance, Chapter 132, and other subsidiary legislation made under the Ordinance;

(e) Construction Site Safety Manual issued by the Environment, Transport and Works Bureau, the Government of the HKSAR;

(f) Boilers and Pressure Vessels Ordinance, Chapter 56, and other subsidiary legislation made under the Ordinance;

(g) Code of Practice for Safe Use and Operation of Suspended Working Platforms;

(h) Code of Practice: Safety and Health at Work for Gas Welding and Flame Cutting;

(i) Code of Practice: Safety and Health at Work for Electric Arc Welding;

(j) Code of Practice for Bamboo Scaffolding Safety;

(k) Code of Practice: Safety and Health at Work in Confine Spaces; and

(l) Code of Practice: Working with Display Screen Equipment.

A2.1.4 Technical Standards

BS, BS EN, ISO Standards, IEC Standards and Codes of Practice, etc. shall be deemed to include all amendments, revisions and standards superseding the standards listed herein, which are current at the closing date of the tender of the Contract unless otherwise specified.

A summary of technical standards quoted in this General Specification to which the Works shall comply with is listed in Annex I.

A2.2 CASE OF CONFLICT

The documents forming the Contract are to be taken as mutually explanatory of one another but in case of ambiguities or discrepancies the same shall be explained by the Architect who shall issue to the Contractor instructions clarifying such ambiguities or discrepancies.

SECTION A3

EXECUTION OF WORKS

A3.1 THE INTERNATIONAL SYSTEM OF UNITS (SI)

The International System of Units (System International d'Unites) of weights and measures shall be used for all materials, equipment and measurements.

A3.2 PROGRAMME OF WORKS

The Contractor shall submit to the Architect a detailed programme of the Works within 4 weeks from the acceptance of his Tender showing the intended method, stages and order of work execution in coordination with the building construction programme, together with the duration he estimated for each and every stage of the Works. The programme shall include at least the following:

(a) Dates for the placement of orders for equipment and materials;

(b) Expected completion dates for builder's work requirements, i.e. when work site needs to be ready;

(c) Delivery dates of equipment and materials to Site;

(d) Dates of commencement and completion of every stage of the Works in line with the building construction programme, i.e. each floor level and/or zone area;

(e) Dates of documents/drawings submissions to relevant Government departments to obtain the necessary approvals;

(f) Dates of requirement of temporary facilities necessary for testing & commissioning, e.g. electricity supply, water and town gas;

(g) Dates of completion, testing and commissioning; and

(h) Short term programmes showing the detailed work schedules of coming weeks and months shall also be provided to the Architect. Programmes shall be regularly updated to reflect the actual progress and to meet the Contractors's obligations under the Contract.

In addition, detailed submission schedules for installation drawings, equipment and testing and commissioning shall be submitted to the Architect for approval. The formats and information to be included in the schedules shall be as required by the Architect.

A3.3 BUILDER'S WORK

All builder's work including openings or holes through building structure or partition walls; trenches, ducts and cutting; and all plinths, concrete bases, supports, ducts, etc. required for the installation will be carried out as part of the building works by the Building Contractor at the expense of the Employer provided that the Contractor has submitted full details of such requirements within a reasonable time to the Architect for approval, so that due consideration may be given before the Building Contractor commences the building works in accordance with the building programme in the areas concerned. After obtaining the said approval of the Architect, the Contractor is required to mark out at the relevant locations of the Site the exact positions and sizes of all such works and to provide detailed information of such works to the Building Contractor to facilitate him to carry out the builder's works as the works proceed.

All 'cutting-away' and 'making-good' as required to facilitate the Contractor's works will be carried out by the Building Contractor, except for minor provisions required for the fixing of screws, raw plugs, redhead bolts, etc. which shall be carried out by the Contractor. The Contractor shall mark out on Site and/or supply drawings of all cutting-away to the Building Contractor within a reasonable time.

All expenses properly incurred and losses suffered by the Employer as a result of the Contractor's failure to comply with the above requirements are recoverable by the Employer from the Contractor.

The Contractor shall ensure that such works are essential for the execution of the Works. In the event that any of such works is proved to be non-essential, unnecessary and/or abortive, the Contractor shall bear the full cost of such works including but not limited to any unnecessary or incorrect cutting-away and making-good and shall reimburse the Employer for all cost incurred in this connection.

Upon completion of the builder's works by the Building Contractor, the Contractor shall forthwith check and examine that all builder's works so executed have been completed in accordance with his requirements. If at any time it becomes apparent to the Contractor that any builder's works completed by the Building Contractor does not comply with his requirements in any respect whatsoever, the Contractor shall forthwith give notice in writing to the Architect and specify in details the extents and effects of such non-compliance in that notice. The Contractor is deemed to have satisfied with the builder's works after a period of 14 days from the date of completion of the builder's works if the above notice is not served to the Architect within such period. All additional expenditure properly incurred and all loss suffered in this connection by the Employer in having such works re-executed and rectified shall be recoverable by the Employer from the Contractor.

A3.4 COORDINATION OF CONTRACT WORKS

The Contractor shall coordinate the Works with those works of the Building Contractor and any other contractors and sub-contractors.

The Contractor shall note that the Drawings supplied to him only indicate the approximate locations of the works. He shall make any modification reasonably required of his programme, work sequence and physical deployment of his work to suit the outcome of work coordination or as necessary and ensure that all cleaning, adjustment, test and control points are readily accessible while keeping the number of loops, cross-overs and the like to a minimum.

The Contractor shall pay particular attention to the building works programme and shall plan, coordinate and programme his works to suit and adhere to the building works in accordance with the building programme.

Any significant problems encountered during the coordination work, which are beyond the Contractor's control, shall promptly be reported to the Architect.

A3.5 COOPERATION WITH OTHER CONTRACTORS

The Contractor shall cooperate at all times with the Building Contractor and all other contractors and sub-contractors in order to achieve efficient workflow on Site.

Any significant problems beyond the Contractor's control shall promptly be reported to the Architect.

A3.6 SITE SUPERVISION

The Contractor shall keep on the Site a competent and technically qualified site supervisor to control, supervise and manage all his Works on Site. The supervisor shall be vested with suitable powers to receive instructions from the Architect.

The site supervisor shall be technically competent and have adequate site experience for the Works. The Contractor shall also refer to the Particular Specification for other specific requirements, if any, on site supervision.

Approval by the Architect shall be obtained prior to the posting of the supervisor on Site. The Contractor shall immediately replace any site supervisor whose experience, skill or competency is, in the opinion of the Architect, found to be inadequate for the particular work.

A3.7 SAMPLE BOARD

Within 6 weeks of the acceptance of his Tender and prior to the commencement of Works, the Contractor shall submit to the Architect for approval in a reasonable time a sample board of essential components proposed to be used in the Contract. However, the Contractor may request the Architect in writing for an extension of time, if 6 weeks are practically insufficient.

Items displayed shall be deemed to be adequate for the Works unless otherwise clearly indicated. Each sample, with clear numbering and labeling, shall be firmly fixed onto a rigid wooden or metal board. A list shall also be affixed on the sample board to show the item description, make and brand, country of origin and locations of installation (if not generally used). Samples rejected by the Architect shall be replaced as soon as possible. Upon approval of all items, the Architect will endorse the list on the sample board and the Contractor shall deliver the board to the site office for reference.

The board shall contain samples of all 'compact' sized materials and accessories to be used in the Works. Written approval of all samples and technical details shall be obtained from the Architect before commencement of any installation work.

In the context of this General Specification the term 'compact' means any item that will fit into a 300 mm cube.

A3.8 ADVICE OF ORDER PLACED

The Contractor shall submit copies of all orders placed for major items of equipment and materials to the Architect for record.

A3.9 RECORD OF MATERIALS DELIVERY

All materials and equipment delivered to Site shall be accurately listed and recorded in the site record books maintained by the representatives of the Architect on Site.

Materials and equipment delivered to Site and paid for in interim payment shall be the Employer's property. Such materials and equipment shall not be removed from Site without the approval of the Architect in writing and appropriate deduction shall be made in the next interim payment in accordance with the Contract.

Where the Building Contractor is in overall control of the Site, the Building Contractor may also be required to record details of all incoming/outgoing materials. In this case, the Contractor shall comply with the Building Contractor's arrangements.

A3.10 PROTECTION OF MATERIALS AND EQUIPMENT

Unless the responsibility is clearly defined in the Contract that the protection on Site for delivered equipment, materials and installation is solely by other contractors, the Contractor shall be responsible for the safe custody of all materials and equipment as stored or installed by him until finally inspected, tested and accepted. In addition, the Contractor shall protect all work against theft, fire, damage or inclement weather and carefully store all materials and equipment received on Site but not yet installed in a safe and secure place unless otherwise specified.

All cases of theft and fire must immediately be reported to the police, the Building Contractor, the Architect and the Architect's representatives on Site with full details.

Where necessary the Contractor shall provide lockable steel container or other equally secure enclosures placed within a securely fenced-in compound provided by the Building Contractor on Site for the storage of materials and equipment.

The Contractor shall co-ordinate and arrange with the Building Contractor who shall provide clean, reasonably finished and lockable secure accommodation for the storage of sensitive and/or expensive items before installation.

If there is no Building Contractor, all the storage facilities and spaces shall be provided by the Contractor.

SECTION A4

DRAWINGS AND MANUALS

A4.1 DRAWINGS IN ELECTRONIC FORMAT

The Contractor shall provide drawings in electronic format as required in the following clauses. These drawings shall conform to the latest version of CAD Standard of Works Projects (CSWP) as posted in the web site of the Works Branch, Development Bureau and in accordance with the latest version of CAD Manual for Architectural Services Department Projects. Should any technical conflict between the CSWP and the CAD Manual arise, the CSWP shall take precedence.

A4.2 INSTALLATION DRAWINGS

A4.2.1 Drawing Submission Schedule

The Contractor shall submit a detailed installation drawing submission schedule and programme to the Architect. The Contractor shall allow reasonable time in the programme for vetting of the installation drawings by the Architect and for drawing resubmissions as necessary.

The Contractor shall submit to the Architect a comprehensive "Submission Schedule" of installation drawings and builder's work drawings within 2 weeks after the acceptance of Tender, taking into account of the overall programme of the Works including any Specialist Works and works by the utility undertakings. No equipment shall be delivered to the Site and no works shall be executed until the installation drawings have been approved by the Architect. The Contractor shall ensure that the installation drawings and builder's work drawings are progressively submitted in accordance with the approved "Submission Schedule".

The Contractor shall provide at least 6 hard copies and one electronic copy, unless otherwise specified in the Contract, of the approved installation drawings to the Architect for distribution.

A4.2.1.1 Information To Be Provided

Within 4 weeks from commencement of Works, the following information shall be submitted:

(a) A technical specification of various equipment in duplicate including copies of manufacturer's descriptive literature;

(b) Detailed description of the safety features in operation complete with product catalogues;

(c) Full technical data of the equipment to be supplied and installed including performance curves, normal expected economic life, etc.;

(d) General arrangement drawings detailing the plant and ancillary equipment to be supplied under the Contract which shall include leading dimensions, weights and foundation details, etc.;

(e) Builder's work drawings indicating clearly the position and sizes of all holes and cuttings, bolt holes and bolts, loads on beam and structure, details of railing foundations, conductor anchors, rail mounting and suspension method and all other necessary information to enable the design and construction of the building to proceed; and

(f) Wiring diagram for each item of electrical equipment together with a cable schedule showing connections between the various items of equipment. The terminal markings on the diagrams shall correspond to those used on the equipment.

A4.2.1.2 During Works Period

During Works period, the Contractor shall submit monthly progress reports prior to the date for commencement of site work and fortnightly progress reports thereafter to show the progress of production, scheduling, any anticipated delivery delays, other relevant information against each activity reference and confirming that the agreed date of completion of each item of work will be met or give a detailed explanation shall there be any possibility of delay.

The birth certificates and test certificates of all the equipment / materials from the manufacturers shall be submitted to the Architect for record and information one month before shipment to site.

On the request of the Architect, the Contractor shall submit additional drawings and documents to the Architect for approval at no additional cost.

The Contractor shall not manufacture any items of plant until the Architect's written approval has been obtained.

The approval of the Contractor's equipment/materials and drawings given by the Architect does not relieve the Contractor from contractual responsibility to fulfil the requirements of the Contract.

A4.2.1.3 Before and After Commissioning Test

Eight weeks prior to the commencement of testing and commissioning, draft as-fitted drawings and 'Operation and Maintenance Manuals', in English and/or Chinese, bound in book form with hard plastic cover to withstand constant use and properly indexed to facilitate quick reference shall be submitted for the Architect's approval prior to producing formal copies of as-fitted drawings and O&M manuals.

Each manual shall include original copies of:

(a) General arrangement drawings of power supply, driving and control system including schematic drawings, control diagrams and wiring diagrams;

(b) Drawings showing the internal construction of all major items, with part lists and reference numbers for spare identification and ordering purpose;

(c) Principle of operations;

(d) Details of installation and setting up procedures;

(e) Details of specification, maintenance and operation instructions for all the equipment;

(f) Schematic diagrams for all electrical systems;

(g) The names and addresses of the manufacturers and their local agents for all the equipment; and

(h) List of recommended lubricants and other consumable materials.

Within 4 weeks after the commissioning test, three copies each of as-fitted drawings (plus onr set of CD-ROM) and O&M manuals bound in book form with hard plastic over to withstand constant use and properly indexed to facilitate quick reference shall be submitted. At least one copy of the O&M manuals must contain original documents from the original equipment manufacturers/suppliers.

A4.2.2 Size of Installation Drawings

Drawings submitted by the Contractor shall only be of standard sizes from A0 to A4 or B1 size as stipulated in ISO 5457:1999.

A4.2.3 Contents of Installation Drawings

The Contractor shall ensure all installation drawings are accurate representation of the Works, before submitting them to the Architect. All installation drawings shall be fully dimensioned and suitably scaled showing construction, sizes, weights, arrangements, operating clearances and performance characteristics.

A4.2.4 Builder's Work Drawings

Unless otherwise approved by the Architect, the Contractor shall submit to the Architect in accordance with the approved "Submission Schedule", 6 copies of drawings showing details of all builder's work required e.g. the weight and the load on each support of equipment. Such drawings shall clearly indicate the details and positions of all openings, trenches, ducts and cutting required and construction details for plinths and equipment bases.

A4.2.5 Manufacturer's Shop Drawings

The manufacturer's shop drawings are drawings for equipment or plant to be manufactured by a specialist manufacturing supplier in their own workshops and places away from the Site.

The drawings shall show detailed construction, principal dimensions, weights and clearances for maintenance, etc. Immediately after placing of any order or at any event within 4 weeks unless otherwise approved in writing by the Architect, the Contractor shall forward to the Architect for comment, 4 copies of manufacturer's shop drawings indicating detailed construction, principal dimensions and weights, clearances for withdrawals and/or cleaning, etc. No work shall proceed on or off Site unless drawings requiring approval are so approved in writing by the Architect.

A4.2.6 Drawings for Submission to Other Authority (FSD / Gas Standards Office / EMSD / WSD etc)

<u>Hot Water Installation</u>
4 sets of the schematic plumbing diagram shall be submitted to the Architect and 2 endorsed sets of drawings would be returned to the Contractor for onward submission to WSD for perusal. Works should only be commenced after the set of drawings are accepted by WSD and the Architect. 6 sets of all such approved drawings shall then be submitted to the Architect for record.

A4.3 AS-BUILT DRAWINGS

A4.3.1 Submission of As–built Drawings

The Contractor shall submit 3 sets of the first draft prints of as-built drawings within 28 days of the issuance of the certification of completion to the Architect for checking. The Architect after checking the above draft prints shall return one set of the marked up copies of these as-built drawings to the Contractor within 42 days from the date of submission of the Contractor's draft prints with comments. The Contractor shall within a further 28 days from the date of receiving the Architect's comments on the draft as-built drawings re-submit to the Architect for his approval another 3 sets of the second draft prints of as-built drawings with the Architect's comments incorporated. This process of submission and approval shall continue until the final approval of the Architect on these as-built drawing is obtained.

The final approved as-built drawings shall be in 3 sets of hard copy and 3 sets of electronic copies. These shall be submitted within 21 days from the date of final approval. Each electronic copy shall be in the form of CD-ROM, labelled, with cross reference to a printed list of files explaining the contents and purpose of each file and supplied in sturdy plastic containers.

The detailed requirements and the media of as-built drawings set out in the Preliminaries of the Bills of Quantities or the Specification Preliminaries shall be followed as appropriate.

A4.3.2 Size of As-built Drawings

As-built drawings shall only be of standard sizes of A0, A1 or B1 size as stipulated in ISO 5457:1999. Smaller size (A2 to A4) is accepted for installation drawings.

A4.3.3 Content of As-built Drawings

The Contractor shall ensure all as-built drawings are accurate representation of the Works, before submitting them to the Architect. The as-built drawings required to be provided by the Contractor for various types of BS/E&M installations shall include, but not limited to the following:

(a) Building services layout plans such as ducting arrangement, trunking arrangement, piping arrangement, etc;

(b) System schematic diagrams, control diagrams and wiring diagrams;

(c) Concealed work layout plan such as concealed conduit routing, etc; and

(d) Installation details and assembly drawings such as LV cubicle switchboard layout, motor control cubicle layout, etc.

A4.3.4 Framed Drawings

The Contractor shall provide framed drawings to each major control room showing the schematic wiring diagrams, tables or charts to indicate the type and composition of circuits.

A4.4 OPERATION AND MAINTENANCE (O&M) MANUAL AND USER MANUAL

A4.4.1 General

The Contractor shall provide two types of manuals to the Architect with all changes made to the installation during the course of the Contract suitably incorporated.

The O&M Manual is for use by the maintenance agent of the completed installation. It shall contain detailed technical information covering both operation and maintenance aspects of the installation.

The User Manual seeks to give users of the completed installation an overview of the essential information of the installation. The contents of the manual should be concise and succinct for ease of comprehension by people with a non-technical background.

A4.4.2 Presentation

All manuals shall be written in English, unless otherwise specified. The text of descriptive parts shall be kept concise while at the same time ensure completeness. Diagrammatic materials shall also be supported by comprehensive descriptions.

The manuals shall comprise A4 size loose-leaf, where necessary, A3 size folded loose-leaf. The loose-leaves shall be of good quality paper that is sufficiently opaque to avoid “show-through”. Unless otherwise specified in the Contract, the manuals shall be bound in durable loose-leaf four ring binders with hard covers. The manuals shall have labels or lettering on the front cover and spine. The Architect’s approval shall be obtained on this at the draft manual stage. The softcopy of manuals including the technical literatures, shall be in PDF format readable by Acrobat Reader Freeware.

A4.4.3 Checking and Approval

The Contractor shall submit 3 sets of the first draft of O&M Manuals together with a list of recommended spare parts for one year’s operation and a list of special tools, both complete with prices to the Architect for comment within 28 days of the issuance of the completion certificate.

The Contractor shall submit 2 sets of the first draft of the User Manual to the Architect for comment at least 56 calendar days before the date of completion.

The Architect will check the drafts and return them to the Contractor within 42 days from the date of submission with comments necessary for a final and approved set of document. The Contractor shall then make all necessary amendments to the documents and resubmit them to the Architect within 21 days from the date of receipt of comments.

The Contractor shall submit 3 sets of hard copies (one of which shall be the original) and one set of electronic copy of the final approved O&M Manuals in CD-ROM within 21 days from the date of approval by the Architect.

The Contractor shall submit 2 sets of hard copies and one electronic copy of the final approved User Manuals in CD-ROM within 21 days from the date of approval by the Architect.

A4.4.4 Structure and Content of O&M Manual

The detailed requirements, structure and contents of the O&M Manual shall be as specified in elsewhere in the Contract and shall include the following information under separate sections where appropriate:

(a) Project Information

This shall include:

Project title, site address, contract no., contract title, contractor/sub-contractor name, address, contact persons and their telephone/fax nos., contract commencement date, substantial completion date and end date of the Maintenance Period.

(b) System Description

(i) Type(s) of system(s) and equipment installed;

(ii) Design criteria, design data and parameters;

(iii) Locations of the system and major equipment, and what they serve;

(iv) Description of operation and functions of the system and equipment; and

(v) General operating conditions, expected performance and energy and resources consumption where applicable.

(c) List of Installed Equipment

Schedule of all items of equipment and plant stating the location, name, model no., manufacturer's serial or reference no., manufacturer’s design duties and data.

(d) Spare Parts and Special Tools Lists

(i) List of Spare Parts supplied by the Contractor:
Item descriptions, supplied quantities, model nos., manufacturer's serial or reference nos. and storage locations; and

(ii) Recommended Spare Parts List and Special Tools List:
Manufacturers'/suppliers' recommendations for spare parts and special tools with item description, unit rate, recommended stock quantities as well as the agents for the spare parts and special tools.

(e) Manufacturers' Certificates/Guarantees

(i) Manufacturers' certificates such as factory test certificate, laboratory test reports and guarantees and any others where required for the equipment and plants etc.; and

(ii) Originals of Statutory Inspection Certificate for various installations, including:

- Electrical installations (Work Completion Certificate Form WR1),
- Surveyor's test certificates for high pressure vessel,
- Surveyor's load certificates for lifting devices/appliances, etc.

[Note: Testing records & commissioning data (other than the types prescribed above), which are required under the Contract such as the T&C procedures, etc to verify the compliance of the BS/E&M system's/equipment's performance with the Contract requirements, are checked and endorsed separately by the Architect and do not form part of the O&M manuals.]

(f) Safety Precautions for Operation and Maintenance

State, where applicable, hazard warnings and safety precautions of which the operation and maintenance staff need to be aware:

(i) mandatory requirements relating to safety;

(ii) known hazards against which protection measures shall be taken; and

(iii) known features or operational characteristics of the installed equipment or systems which may cause hazard and the related safety precautions.

(g) Operation Instructions

Instructions for the safe and efficient operation, under both normal and emergency conditions, of the installed system which shall comprise:

(i) an outline of the operating mode;

(ii) control logic and data (sequence, effect, limits of capability, modes and set points);

(iii) procedures and sequences for start-up and shut-down;

(iv) interlocks between equipment/system;

(v) calling on of stand-by equipment;

(vi) precautions necessary to overcome known hazards;

(vii) means by which any potentially hazardous equipment can be made safe;

(viii) estimation of energy consumption and energy costs;

(ix) forms for recording plant running hours, energy consumption and energy costs; and

(x) operating data such as running current, operating pressure, operating flow rates etc.

(h) Maintenance

(i) Maintenance instructions

Manufacturers' and the Contractor's recommendations and instructions for the maintenance of the installed equipment. Clear distinction should be made between planned tasks (preventive maintenance) and fault-repair tasks (corrective maintenance). Instructions shall be given on each of the following, as appropriate :

- nature of deterioration, and the defects to be looked for;
- isolation and return to service of plant and equipment;
- dismantling and reassembly;
- replacement of components and assemblies;
- dealing with hazards which may arise during maintenance;
- adjustments, calibration and testing; and
- special tools, test equipment and ancillary services.

(ii) Maintenance schedules

Proposed maintenance schedules for all the preventive maintenance tasks identified above. The schedules shall be based on both manufacturers' recommendations and other authoritative sources (e.g. statutory or mandatory requirements) and should include :

- routine servicing;
- inspections;
- tests and examinations;
- adjustments;
- calibration; and
- overhaul.

The frequency of each task may be expressed as specific time intervals, running hours or number of completed operations as appropriate. Collectively, the schedules will form a complete maintenance cycle, repeated throughout the whole working life of the installation.

(i) Drawing Lists

(i) A complete list of as-built drawings identified with drawing number/reference;

(ii) A complete list of manufacturers' shop drawings with drawing number/reference, where applicable; and

(iii) A brief description of CD-ROM for these drawings.

(j) Technical Literatures

A complete set of manufacturers' literatures for all the plant and equipment installed in the system. The contents of these literatures shall cover the following areas where applicable:

(i) description of equipment with model numbers highlighted;

(ii) performance - behavioural characteristics of the equipment;

(iii) applications - suitability for use;

(iv) factory/laboratory test reports, detailed drawings, circuit diagrams;

(v) methods of operation and control;

(vi) operation instructions;

(vii) cleaning and maintenance requirements;

(viii) plants, materials and space required for maintenance;

(ix) protective measures and safety precautions for operation & maintenance; and

(x) part lists.

(k) Contact addresses and telephone numbers of suppliers of major equipment.

A4.4.5 Structure and Content of User Manual

The detailed requirements, structure and contents of the User Manual shall include, where applicable, the following information:

(a) Project Information

The following information shall be provided:

Project title, site address, contract no., contract title, contract commencement date, substantial completion date and end date of Maintenance Period.

(b) System Description

(i) Type(s) of system(s) and equipment installed, and their purposes;

(ii) Locations of major plant rooms and riser ducts;

(iii) Brief description of the operation and functions of the systems and equipment; and

(iv) Listing of set points which can be adjusted by the user to suit their operation needs.

(c) Schedule of Major Plant Rooms and Installed Equipment

(i) Schedule of major plant rooms and riser ducts including their locations; and

(ii) Schedule of major equipment and plants including their locations and serving areas.

(d) Safety Precautions for Operation

Any safety precautions and warnings signals that the users shall be aware of in the daily operation of the various systems and equipment in the installation including:

(i) mandatory requirements relating to safety;

(ii) features or operational characteristics of the installed systems or equipment which may cause hazard and the related safety precautions;

(iii) protective measures and safety precautions for operation; and

(iv) list of warning signals and the related meanings that the user shall be aware of and the actions to be taken.

(e) Operation Instructions

Instructions for the safe and efficient operation, under both normal and emergency conditions, of the installed system which shall comprise:

(i) an outline of the operating mode;

(ii) step by step operation instructions for systems and equipment that are to be operated by the user, including at least procedures for start-up and shut-down;

(iii) means by which any potentially hazardous situation can be made safe; and

(iv) cleaning and basic maintenance procedures.

(f) List of Statutory Periodic Inspections and Tests

A schedule of periodic inspections and tests that owner and/or user of the installation have to arrange to achieve compliance with the requirements stipulated in the relevant Laws of Hong Kong. The frequency of such inspections and tests shall be expressed in specific time intervals.

(g) Drawings

A set of selected as-built drawings which shall be able to illustrate to the user the general layout of the completed installation.

(h) Photographs

A set of photographs with suitable captions to illustrate to the user the appearance and locations of devices which require their setting and operation.

A4.4.6 Intellectual Property Rights

The Government shall become the absolute and exclusive owner of the Operation & Maintenance Manuals and the User Manual and all intellectual property rights subsisting therein free from all encumbrances.

In the event that the beneficial ownership of any intellectual property rights subsisting in the above Manuals are vested in anyone other than the Contractor, the Contactor shall procure that the beneficial owner shall grant to the Employer a transferable, non-exclusive, royalty-free and irrevocable licence (carrying the right to grant sub-licences) to utilize the intellectual property rights in the manuals for the purposes contemplated in the Contract. For the avoidance of doubt such purposes shall, but not limited to, include providing free copying of the materials in the manuals by any subsequent owner or user of the installation, and/or any party responsible for the operation and maintenance of the installation in connection with any subsequent alteration, extension, operation and maintenance of the installation.

PART B – GENERAL TECHNICAL REQUIREMENTS

SECTION B1

GENERAL

B1.1 DESIGN CRITERIA

Unless otherwise specified in the Particular Specification, the equipment to be supplied shall be suitable for climatic conditions of 0°C to 40°C with relative humidity of up to and including 100% and at an altitude of up to 100 m above mean sea level.

SECTION B2

PLANT REQUIREMENTS

B2.1 GENERAL

The equipment shall be new and of up-to-date model (but in general with proven design not less than 2 years) designed for a nominal serviceable life of 15 years. In general, the mechanical and electrical equipment shall be so designed as not to require frequent maintenance attention.

All the equipment and material supplied shall be proven products which shall have local agents or representatives. The Tenderers shall submit with their tenders full details of their offered equipment and material.

All items of equipment shall be rated for continuous service at the specified duties under the prevailing atmosphere and operational conditions on site.

All component parts of the equipment shall be manufactured to a strict system of tolerance limits so that complete interchangeability of similar parts is possible.

All items of equipment for which spare parts may be required shall have attached to them untarnishable metal plates clearly showing the manufacturer's name, serial numbers and basic information as to rating, etc., in sufficient detail to allow the unit or assembly to be identified in correspondence and when ordering spare parts.

All parts subject to wear shall be readily accessible for replacement.

Adequate and, as far as practicable, automatic means of lubrication shall be provided for all moving parts.

The position of all greasing and oiling points shall be arranged so as to be readily accessible for routine servicing. Where necessary, to achieve this, suitable extension pipes shall be fitted.

Lubrication grease points shall comply with BS 1486-1:1959 – Lubricating Nipples and Adaptors for Use on Machinery and Vehicle except where the lubrication required is of a special nature. In such event they shall be fitted with metal labels to indicate the special lubricant required.

Where continual grease or oil feeding is required, the capacity of the reservoir shall be sufficient for not less than seven days' continuous service with indicators in the form of meters or alarms.

In accordance with the Electricity Ordinance Chapter 406, all electrical works and electro-mechanical work on site and electrical tests shall be undertaken by registered electrical contractors/workers.

All machined surfaces which are liable to corrosion shall be appropriately wrapped or greased for protection after manufacture. Care shall be taken with the electrical control gear in order that the contacts or mechanisms remain in good working conditions.

B2.2 ELECTRICAL WORK

The Contractor shall supply, install and test all the electrical installation as required for the completion of work which includes:

(a) all necessary suitably sized switches, cables, cable conduits and trunking from supply source to the equipment; and

(b) Wiring up of the equipment including motor starters.

In accordance with the Electricity Ordinance Chapter 406, all electrical installation within the scope of this Contract shall be carried out by a Registered Electrical Contractor/Worker. After the electrical installation of the Contract is completed, it shall be inspected, tested and certified by a Registered Electrical Worker to confirm that the requirements of the Electricity (Wiring) Regulations have been met. The Registered Electrical Worker and Contractor shall sign the Work Completion Certificate for their individual electrical installation and submit it to the Architect before the electrical installation is energized.

All the equipment supplied shall be designed for operation on electrical supply of 380V, 3-phase, 4-wire at 50 Hz, and/or 220V, single phase, 50 Hz.

Unless otherwise specified in the Particular Specification, adequately sized multi-core armoured cables shall be supplied and installed in outdoor underground G.I. pipes provided by others with draw wire as shown in the Drawings. PVC cables of adequate size shall be used indoor and shall be run in concealed conduits provided by others with draw wires as shown in the Drawings.

Cable changing baskets shall be supplied and installed for connecting outdoor armoured cables with indoor cables. Cable entries into a building shall be resealed by approved means to prevent the ingress of moisture and vermin. Armoured cables shall be terminated in a gland fitted with an armour clamp. A watertight seal shall be made between the gland and the inner cable sheath. A shroud shall be fitted to cover the body of the gland and the armoured wires.

In case heavy gauge conduits or trunking system are used, all surface cable trunkings and conduits shall be supplied and installed in such a way as not to cause obstruction to water pipes, drainage and other services. Cable route must be approved by the Architect.

All metal work associated with the electrical installation including the metal casing of the equipment supplied under the Contract, not forming part of phase or neutral circuits, shall be bonded together and shall be solidly and effectively earthed.

Motors shall comply with IEC 60034-1:2004 and BS 5000-11:1973 or unless otherwise specified, and shall be of such size and type to adequately drive the equipment under all normal conditions of service without overloading. Insulation shall be of minimum Class F for tropicalised conditions.

The continuous rating of the motor is to be such as to cover the full specified range of duty plus a further 5% margin for compressors, 15% margin for fans and 10% margin for pumps.

Motor starters shall be rated to intermittent class 0.1 60% on-load factor and utilisation category AC-3 in accordance with IEC 60947-4-1:2009. Suitably rated thermal overload relays shall be incorporated into each starter circuit with inherent single-phase protection. Each starter shall incorporate fuse protection.

Each starter for the motor shall comply with IEC 60947-4-1:2009, and shall be provided with an adjustable motor overload protection device and under-voltage release suitable for the motor load and having manual resetting facilities. Direct-on-line starters shall be used for motors smaller than 3.8 kW and for motors over 3.8 kW, star delta starters shall be used unless otherwise specified.

All secondary wiring shall be complete with numbered ferrules for identification which shall be carried out in a neat and systematic manner and finished at a terminal board at the junction of small wiring and incoming cables.

All electrical testing of the installation shall be carried out by the Contractor and witnessed by the Architect. Any material or workmanship found not in accordance with the regulations specified above shall be rectified and completed in a satisfactory manner by the Contractor at no extra charge to the Employer.

B2.3 CONTROL PANELS

Each control panel shall be fabricated from galvanised steel sheet of thickness not less than 2.0 mm and ergonomically designed to suit the physique of the average Hong Kong operators.

Control panels shall be vermin proof and shall also meet the requirements of IP54 enclosures with interior finished to an approved matt white and exterior opaline green to BS 381C:1996, or any other colours as required by the Architect.

All control panels shall have labels made from laminated self-coloured materials and engraved with descriptions in both English and Chinese to be agreed by the Architect. Fixing of labels shall be by mechanical means.

The contactors, switch fuses, relays and all other necessary items shall be housed in the appropriate control panel which shall be arranged with front access for maintenance. It shall also be lockable to prevent unauthorised access and malicious damage to the equipment inside. Those conductive parts shall be protected and covered.

Each relay shall be labelled appropriately to its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

SECTION B3

INSTALLATION AND WORKMANSHIP

B3.1 STRUCTURE STEEL

Structural steel work shall comply with the provision of the following internationally recognized standards:

BS 7668:2004	Weldable Structural Steel: Hot Finished Structural Hollow Sections in Weather Resistant Steels
BS EN 10029:1991	Tolerances on Dimensions, Shape and Mass for Hot Rolled Steel Plates 3 mm Thick or Above
BS EN 10025:2004	Hot Rolled Products of Structural Steels. Technical Delivery Notes for Long Products, Thermomechanical Rolled Weldable Fine Grain Steels, Structural Steels with Improved Atmospheric Corrosion Resistance, Plates and Wide Flats of High Yield Strength Structural Steels in the Quenched and Tempered Condition
BS EN 10210	Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Structural Steels
ISO 14713:1991	Protection against corrosion of iron and Steel in Structures, Zinc and Aluminum Coating

All forms of steel used shall be of standard section with dimensions, tolerances and properties complying with BS 4-1:2005, BS EN 10210-2:2006, BS EN 10056-1:1999 and BS EN 10067:1997.

All exposed edges shall be ground to produce a chamfer of not less than 2 mm in width.

B3.2 FOUNDATION BOLTS AND GROUTING

Foundation bolts, nuts and lock nuts, etc. of adequate strength shall be supplied and fitted by the Contractor.

Grouting shall not be carried out until final agreement by the Architect is obtained.

Grout shall be composed of equal parts of cement and fine granular and mixed with fresh water.

B3.3 WELDING

All welding shall be carried out only by welders of the recognized proficiency, and to the satisfaction of the Architect. The welding electrodes, equipment and process shall also be subject to the Architect's approval and in accordance with:

BS 638	Arc Welding Power Sources, Equipment and Accessories
BS 2633: 1987	Specification for Class I Arc Welding of Ferritic Steel Pipework for Carrying Fluids
BS 2971: 1991	Specification for Class II Arc Welding of Carbon Steel Pipework for Carrying Fluids
ISO 2560:2009	Welding Consumables - Covered Electrodes for Manual Metal Arc Welding of Non Alloy and Fine Grain Steels – Classification
BS EN 1011:2009	Welding – Recommendations for Welding of Metallic Materials
IEC 60974-6:2003	Arc Welding Equipment. Limited Duty Manual Metal Arc Welding Power Sources

Welding shall not be carried out under unfavourable conditions. The Contractor shall make certain that all welded surfaces are clean and dry before any welding is done.

B3.4 PAINTING

In general, painting shall be carried out in accordance with the methods recommended in ISO 12944:1998 – Paints and Varnishes: Corrosion Protection of Steel Structures by Protective Paint Systems. Brushes, rollers and/or spraying equipment shall be of a grade suitable for the work and shall be kept in a clean condition throughout the work. Equipment shall be thoroughly cleaned if changing from one type of paint to another and/or from one colour to another. Welded joints and surfaces shall receive the same protection as what is applied to the parent metal surfaces.

All steel surfaces shall be thoroughly cleaned of all dust, oil, grease, scale, rust or other contaminants.

B3.4.1 Degreasing

Grease and dirt shall be removed by emulsion cleaners followed by thorough rinsing with water, or by steam-cleaning or by controlled high pressure water jets. When it is necessary to use turpentine or similar solvents to remove oil and grease, the use of detergent or emulsion cleaner shall follow and then by thorough rinsing with clean fresh water. Degreasing by washing in solvent shall not be used.

B3.4.2 Removal of Scale and Rust

Unless specially specified in the Drawings or elsewhere in this Specification, rust and mill-scale must be removed by manual cleaning before painting.

Manual cleaning shall be carried out by a power tool operated carborundum disc followed by steel wire brushing and dusting to remove all loosened material.

Excess burnishing of the metal through prolonged application of rotary wire brushes or carborundum disc shall be avoided. Visible peaks and ridges produced by the use of mechanical cleaning tool shall be removed.

If blast cleaning is required, it shall be carried out in accordance with ISO 8504:2000 – Surface Preparation Methods. The quality of blast-cleaning shall be to the preparation grade Sa 2.5 as given in ISO 8501:2007 unless otherwise specified. The Contractor shall select the most appropriate method of blast-cleaning according to the shape and size of the steel work and the type of surface deposit to be removed.

The maximum grade of metallic abrasive permitted shall be as specified in ISO 8501:2007. The abrasive used for blasting shall be free from harmful contamination and any recovered material shall be filtered and cleaned before reuse.

The blast-cleaned surface shall have a small profile size. Blast-cleaned surfaces shall be dusted by brush or vacuum and shall not be touched by hand or other contaminated materials.

B3.4.3 Painting Application

No painting shall be carried out during wet weather, when condensation has occurred or is likely to occur on steel. Paint film shall be free of embedded foreign metallic particles.

All pipework and surfaces other than plated surfaces including the hangers, supports and brackets etc. shall be painted immediately after installation with at least one coat of rust inhibitive primer, one undercoat and 2 finishing coats of best quality paint to be approved by the Architect. Colour will be determined on site. All pipes and supports shall be lifted clear to apply the paints.

The Contractor shall also furnish the Architect with duplicate copies of the paint manufacturer's data sheets. The Contractor shall use paints which are readily mixed for use in sealed containers bearing the manufacturer's name, properly labelled as to its contents. The Contractor shall use paints from a single manufacturer. All paints shall be applied strictly in accordance with the direction of the manufacturer's data sheets by experienced painters supervised by competent staff. Only those paints with a Volatile Organic Compound limit lower than 420 g/l will be allowed.

Immediately after erection, damage to shop coating on machines/equipment shall be made good in a manner approved by the Architect and compatible with the paint system. Damage to galvanised or metal sprayed coating shall be made good by wire brushing followed by phosphate wash and 2 coats of zinc or aluminium suspension paint. Damage to coating occurring at any time shall be made good within 7 days.

The Contractor shall ensure:

(a) that the surfaces are cleaned before they are painted;

(b) that those parts of the installation required to be left unpainted (e.g. brass work) shall be so left; and

(c) that the pipework services are correctly identified to comply with BS 1710:1984, BS 4800:1989 and the Architect's instructions.

PART C – TECHNICAL REQUIREMENTS

SECTION C1

STEAM BOILER

C1.1 SCOPE OF SECTION

The Section shall cover the design, supply and installation of steam boiler complete with the associated pipework and accessories.

C1.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

In addition to the Section A2.1, the installation shall comply with all relevant statutory regulations, in particular

(a) Boilers and Pressure Vessels Ordinance, Chapter 56, and other subsidiary legislation made under the Ordinance.

C1.3 DESIGN

C1.3.1 Boiler

The steam boiler shall be constructed to BS 2790:1992 for a maximum working pressure of 800kPa gauge and tested to 1200kPa gauge at the manufacturer's works unless otherwise specified in the Particular Specification. Manufacturer's test certificate in quadruple is required. The boiler shall be of the genuine 3-pass wet back, radiant heat type with a combustion chamber concentric with the horizontal cylindrical shell and complete with a purpose made fully automatic burner. Non 3-pass boilers are not acceptable and reverse flame is counted as one pass only.

Cradles or footings shall be designed so that no distortion of the boiler shell and footings will take place due to thermal expansion or any static or dynamic loads.

The boiler shall have front tube removal facilities and shall not be supplied with swinging back door. Inspection door shall, however, be fitted at the back of each boiler. Boilers that required a space in the boiler room for fire tube removal larger than available shall not be accepted. Connections shall be flanged to BS EN 1515:2000, BS EN 1092-1:2007, BS EN 1092-2:1997, BS EN 1092-3:2003 as appropriate.

C1.3.1.1 Boiler Rating

The boiler rating shall be as given in the Particular Specification. The overall thermal efficiency to BS 845-1:1987 & 845-2:1987 of the boiler shall not be less than 80% fired by the specified fuel over the whole operating range.

C1.3.1.2 Boiler Controls

Each boiler shall be equipped with a full set of automatic controls in accordance with the requirements of the Boilers and Pressure Vessels Ordinance and the following protection controls:

(a) Extra Low Water Level Cut-out Protection

It shall be set to cut off the burner fuel supply when the boiler water level drops below the heating surfaces of the fire tubes and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display. The operating principle shall be different from the High & Low Water Level Control so as to enhance the degree of safety.

(b) Overpressure Cut-out Protection

It shall be set to cut off the burner fuel supply when the steam pressure rises to 10% above the safety valves operating pressure and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(c) Automatic Firing Controls

The burner firing shall be controlled by steam pressure transducers with capability of 30% adjustment about the nominal working pressure.The firing of the burner shall be fully automatic and of either the high/low/off type or the modulating type depending on the rating of the boiler. The automatic firing controls shall comprise auto sequence controller, pre-and post-purge timer units, flame establishment unit, ignition transformer, burner motor starter with adjustable overload protection, photo-electric flame-failure device, burner run indictor, audible and visual lockout alarm with manual reset, high/low fire indicator (for high/low/off type burner only), automatic draught regulator, and ON/OFF switch gear with indication lamp.

(d) High and Low Water Level Control

A high and low water level control with alarm shall be fitted with sequencing blow down valves and lockable steam isolating valves. Alternative direct mounted internal controls incorporating a testing device may be fitted on boilers up to 2250 kg/hr steam output if this is the boiler manufacturer's standard arrangement. The foregoing boiler controls shall be housed in a local control panel on each boiler, together with steam/pressure gauge and thermometer, mounted as an integral part of the boiler package. The control panel shall be mounted on the boiler in such a manner as to be completely free of vibration, heat and moisture and to preclude damage to contactors and electronic devices. All controls shall be configured to fail-safe.

C1.3.1.3 Boiler Insulation

The cylindrical boiler shell shall be efficiently insulated with asbestos free mineral wool mattresses of minimum 50 mm thick wound closely to the shell and enclosed in a galvanised sheet steel casing of sufficient rigidity with suitable top coating. The touch temperature of the boiler anywhere shall not be higher than 60^{o}C. (Climatic temperature being 40^{o}C)

C1.3.1.4 Boiler Accessories

Each boiler shall be provided with the following accessories suitable for the working pressures and temperatures stated:

(a) Blow-down valve. It shall be so designed that the hydraulic gradient of pipeline is continuously decreasing and trapping of water is avoided;

(b) Stop valve complete with non-return valve;

(c) Double safety valves shall be of the enclosed spring type with padlock and discharge pipe;

(d) Thermometer - 200 mm dial and fixed red pointer indicating the normal boiler operating temperature;

(e) Steam pressure gauge with 200 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure of the boiler;

(f) Boiler feed pump, check valve, controls and necessary piping;

(g) Two water level gauge glass (independent of any water level control);

(h) A high and low water level control (refer to the clause on Boiler Controls for details);

(i) Fully automatic burner and controls (refer to the clause on Boiler Controls for details);

(j) Local control panel and protection (refer to clause on Boiler Control for details);

(k) A drip tray with sand for each oil burner (if applicable);

(l) Combustion chamber, tubes, flue cleaning tools; and

(m) Boiler water sampling valve & fittings and chemical dosing equipment as specified in the relevant part of this Specification.

All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the boiler. All controls and instrument shall be so chosen that the operating range lies between 40-70% of the full scale range, calibrated in S.I. Units and accurate to within 5% of the controlling or measuring point.

C1.3.1.5 Boiler Instrumentation

The following instruments shall be mounted on a self-contained central boiler control panel common to all boilers with all necessary connecting pipes, cables and sensing elements associated with the instruments for monitoring boiler performance. Instruments provided shall be suitable for continuous use at their respective operating temperatures and pressures. All scale shall be so chosen that the operating range lies between 40-75% of the full scale range and accurate to within 5% of the readings.

(a) Smoke Density Meter –

In each boiler flue, between the boiler and the first expansion joint as indicated in the Drawings, a smoke density detector of the approved manufacture shall be fitted to monitor the smoke density leaving each boiler. Appropriate tubes shall be installed diametrically opposed for mounting a light source monitoring unit. Both tubes should be readily accessible for cleaning. The detector shall be wired in conduit to the smoke density meter on the boiler control panel. A smoke density meter

shall be provided for each boiler together with indication lights and audible alarm. Each meter shall be calibrated to energize a green light when operating at normal smoke density and a red light and audible alarm when smoke density exceeds Ringelmann(s) number 1 to BS 2742:2009 "Notes on the Use of the Ringelmann and Miniature Smoke Charts". In addition, the smoke density meter shall be installed with self-cleaning facilities by means of blowing of air.

(b) Draught Gauge –

Each boiler shall be provided with a draught gauge to be mounted at a suitable location on boiler flue for measuring draught at boiler flue outlet.

(c) Percentage Carbon Dioxide Meter –

One for each boiler and of the thermal-conductivity type for flue gas sampling at each boiler exit should be provided.

(d) Flue Gas Temperature Indicator –

One for each boiler and of the thermal-electric type for indicating the flue gas temperature at each boiler exit shall be provided.

(e) Steam Supply Pressure Indicator –

One set for each boiler shall be provided. Each with its pressure tapping installed at the steam flow riser of each individual boiler.

(f) Steam Mass Flow Integrating Meter –

One set for each boiler shall be provided. Each shall consist of an orifice plate or equivalent sensor installed at the steam flow riser of each boiler and a signalled to an integrating device (with compensation for steam density variations) at the central boiler control panel to give steam delivered in kilograms with at least 6 digits display.

(g) One Ambient Temperature Indicator

(h) One Digital Quartz Clock

(i) Flowmeter

C1.3.2 Burner

Burner shall be diesel oil fired, gas fired or dual fuel as specified in the Particular Specification. Design & construction shall meet with the relevant parts in this Specification. Rating shall match with the maximum output of the boiler and with efficiency compatible to the stated boiler overall thermal efficiency over the whole range of firing.

Level of smoke, dust and grit emission shall meet with the current requirements of the Air Pollution Control Ordinance Chapter 358.

C1.3.2.1 Diesel Oil Burner

The burner shall be designed and constructed to BS 5410-2:1978 for boilers firing with light diesel oil to BS EN 590:2009 class A2. It shall be designed for force draught, of the pressure jet type with suitable automatic air/fuel ratio control to achieve maximum fuel economy throughout the entire operating range of the equipment served. Firing sequence controls shall be fully automatic with appropriate safety timers and controls for pre-purge, post-purge, ignition, flame establishment to BS EN 303-1:1999 and 303-4:1999. Flame detector shall be of the photo-electric type. Failure of the safety timers or malfunction of the burner shall cause fuel shut-off and lock-out. Lock-out shall be manual reset and shall have audible-visual alarm. A burner 'normal' indicator shall also be incorporated. The diesel oil pump shall be of the positive displacement type, have built-in pressure relief, oil pressure adjustment, inlet strainer, integrating oil meter in litres, necessary valves and fittings.

Burner motor shall be rated at 380V/3/50 ±2% Hz, of insulation class F to BS 4999, type of protection IP54 to IEC 60947-1:2004, with motor starter to BS EN 1906:2002 and have low volt release, adjustable thermal overload protection and manual re-setting facilities.

C1.3.2.2 Towngas Burner

The Towngas Supply

The towngas pipe distribution system will be provided by others up to the plugged point left for the burner as shown on the Drawings. The Contractor shall make connection of the burner to the plugged point including all necessary isolating valve, gas booster, gas pressure regulating & safety devices, gas pipe, valve train, fittings, supports, etc. for a complete installation. The towngas piping installation including testing and commissioning shall be carried out by an approved competent personnel employed

by the Contractor and selected from the list of the Gas Supply Company's authorized dealers.

The connection work shall be carried out in accordance with the Code of Practice for Installation of Pipe and Meters for Towngas (Hong Kong). Upon completion the Contractor shall be responsible for testing his section of gas pipework for leakage and setting to work of the burner in conjunction with and in the presence of the Gas Supply Company or its authorized representative.

The followings are properties and composition of towngas produced in Tai Po Gas Production Plant for reference. Figures for pressure mentioned are gauge values unless otherwise specified.

Chemical Composition

- Carbon Dioxide	CO_2	19.5
- Unsat. Hydrocarbons	C_nH_m	-
- Oxygen	O_2	-
- Carbon Monoxide	CO	3.0
- Methane	CH_4	28.4
- Hydrogen	H_2	48.9
- Nitrogen	N_2	-
- Propane	C_3H_8	0.06
- Butane	C_4H_{10}	0.14
- Enrichment Naptha		-
- Vapour		-

Wobbe Number

- (MSC dry) MJ/m^3	23.95
- (ISC Sat) BTU/ft^3	631

C1.3.2.3 Supply Pressure

The supply pressure of the town gas shall be 7.5 kPa (30" W.G.) unless otherwise specified in the Particular Specification.

The burner and equipment installed shall be suitable to work on the above towngas supply. Close coordination shall be maintained with the Gas Supply Company and the towngas contractor so as to ensure that the meter, the associated controls and installation pipes will provide a complete gas fuel service for his supplied equipment.

C1.3.2.4 The Gas Burner System

The burner shall be designed and manufactured to BS EN 676:2003 and BS 5885-1:1988 "Specification for industrial gas burners of input rating 60 kW and above". The burner shall be fully automatic with modulating air/fuel control, fail safe and fool proof.

Each gas burner system shall be provided with a quick acting manual isolating valve upstream followed by a gas booster or compressor with its protection devices, governor, safety shut-off valves system, gas modulating butterfly valve, pilot ignited burner with combustion air blower & modulating air damper for multi-stage burner and all accessories & control suitable for use with towngas and complying also with the regulations and requirements of the Gas Supply Company.

The main gas and start-gas supplies shall be under the control of constant pressure governor(s) to BS EN 88:2007 or BS EN 12864:2001, BS EN 13785:2005 or BS EN 13786:2004 as appropriate. All flow setting restrictors shall be downstream of the governor.

Separate pilot burner shall be provided with the start-gas supply taken from such a position as to avoid starvation of the pilot.

The safety shut-off system shall comply with BS EN 676:2003 and BS 5885-1:1988: Clause 4.6. The main gas safety shut-off valve system shall be of the double block type including suitable system check or proving systems to the requirements in BS ISO 10770:1998. Separate safety shut-off valve(s) or start-gas rate controlling device to BS EN 676:2003 and BS 5885-1:1988 Clause 4.6.2.2 shall be provided for the pilot burner. To facilitate commissioning and testing of the safety system, a manual valve downstream of the main gas safety shut-off valves to isolate the main gas flow other than the start-gas flow shall be provided. Another manual valve to isolate the gas supply to pilot burner independently of gas supply to the main burner shall also be provided. Inlet strainer to BS EN 676:2003 and BS 5885-1:1988 Clause 4.1 shall be provided for each safety shut-off valve.

A sequence controller and all necessary timers, relays, contactors, wirings, flame detectors, sensors and switches for temperatures, pressures, positions and flow shall be provided to effect all the pre-start system checks or proving for safety shut-off valves, combustion air and air/fuel ratio; the safety timers for pre-purge, post-purge, start-gas flame and main flame establishment; and the safety shut-down and lock-out for supply gas over pressure, gas booster/compressor inlet low pressure, air flow failure, loss of pilot flame or main flame, electric power failure, failures of the system checks or proving or safety timers, and other system faults all in accordance with BS EN 676:2003 and BS 5885-1:1988.

Control, wring and electrical components shall comply with BS EN 676:2003 and Clause 6 and 8 of BS 5885-1:1988. Audible and visual indications shall be provided for individual fault conditions and lock-out to enable easy fault diagnosis. The combustion air blower motor shall be suitable for operation on 380V, 3 phase, 4 wire, 50 +2% Hz, of insulation Class F to BS 4999, and with type of protection IP54 to BS EN 60947-1:2004. Motor starter shall comply with BS EN 1906:2002 and shall have low volt release, adjustable thermal overload protection, phase failure protection and having manual re-setting facilities. There shall be earthing continuity throughout the gas pipework.

The air/fuel ratio control for two or multi-stage burner shall be fully modulating with the air damper and the butterfly gas flow valve linked pneumatically, electrically or mechanically. The air/fuel ratio system shall be designed to minimize the risk of off-ratio firing. Suitable pressure or temperature transducers shall be provided with the firing modulating control to give maximum efficiency of the equipment served throughout its entire operating range.

C1.3.2.5 Gas Boosters and Compressors

Gas boosters or compressors are required for the equipment serviced when the specified gas supply pressure is insufficient for the burners supplied.

The pressure delivered shall be stable without any surging throughout the whole operating range of gas flow rates. Provision shall be made in the pipework for any oil carry-over that may occur.

Booster & compressor motors shall be suitable for operation on 380V, 3 phase, 4 wire, 50 ±2% Hz, of insulation class F to BS 4999, and with type of protection IP44 to BS EN 60947-1:2004. Star-delta starters shall be used for boosters and compressor motors and shall comply with BS EN 1906:2002 and shall have low volt release, adjustable thermal overload protection, phase failure protection and having manual re-setting facilities. Boosters and compressors shall run continuously as long as the equipment served is on demand and sufficient cooling shall be designed. They should not start and stop in conjunction with thermostatic burner control as this increases wear and tear on motors and drives and can cause frequent pressure fluctuations in the gas supply. Overheat thermistor protection or equivalent shall be incorporated in the motors.

Suitable control and protective devices shall be fitted with each gas booster or compressor to prevent pressure fluctuations in the supply mains and any other inconvenience or danger to other users. The control & protective devices shall include those specified in the following clauses where appropriate.

A low pressure cut-off switch shall be impulsed from the booster or compressors gas supply inlet and suitably wired to prevent the booster or compressor causing a reduced or negative pressure at the meter and in the gas supply system. The wiring of this switch shall cause safety shut-down and lock-out of the burner system in the event of reduced gas supply pressure.

The relief valve shall be set to operate at not more than the maximum allowable working pressure and not less than 110% of the rated discharge pressure.

Provision shall be incorporated for a positive displacement compressor to prevent depression in the gas supply during the compressor starts up.

C1.3.2.6 Purge and Leakage Test

The gas pipework on the complete burner assembly shall be subjected to a leakage test under an air or inert gas pressure of at least 1.5 times the maximum stated working pressure, or 4 kPa, whichever is the greater. The leakage rates shall not exceed 25 mm^3/s of air equivalent under metric standard reference conditions for a burner of up to 300 kW. An additional leakage rate of 1 mm^3/s is permitted for each 20 kW above 300 kW.

Metal armoured flexible pipes shall be certified to withstand at least 3 times the working pressure with a minimum of 350 kPa at both maximum and minimum service temperature.

Means such as a valved and plugged small bore off-take shall be provided to purge and commission the burner pipework and controls. During any purging operation, gas shall not be allowed to accumulate in a confined space. Electric switches shall not be operated and no smoking or naked lights shall be permitted in the vicinity.

C1.3.2.7 Requirements on Dual Fuel Burners

(a) In addition to the requirements for gas flow pipework and controls in BS EN 676:2003 and BS 5885-1:1988, the design of dual fuel burners when operating on light diesel oil (BS EN 590:2009 Class A2) shall comply with BS EN 230:2005, BS 799-3:1981, 4:1991 and BS 5410-2&3:1978, and the British Gas Publication No. 1M/7 "Code of Practice for large gas and dual fuel burners";

(b) The dual fuel burner shall be fully automatic with modulating control of air/fuel ratios on either towngas or light diesel oil. The burner shall be capable of switch-over to either fuel without burner shut-down. It is essential that the fuel not being fired to be proven isolated prior to the commencement of the ignition sequence. The burner design shall also ensure that failure of this proof of isolation at any time causes safety shut-down followed by lock-out. The dual fuel burner shall have separate safety shut-off systems and indications for each fuel. When a fault condition occurs on one of the two fuels, the burner shall be so designed that start-up on that fuel is prevented and the fault condition is indicated; and

(c) It is acceptable to have a common air system for both fuels provided that the modulating air/fuel control can be automatically adjusted to maintain a good combustion to the specified efficiency and performance throughout the whole operating range of the burner.

C1.3.3 Condensate/Feed Tank and Make-up Water Demineralisation

Make-up water from a water break cistern shall be demineralised through an ion exchange resin filtering equipment before passing into the condensate/feed tank. The ion exchange resin filtering equipment shall be of a packaged design with twin resin columns, automatic regeneration associated controls, water T.D.S. meter, valves, piping, pumps and chemicals for regeneration. The water break cistern shall be galvanised, constructed to BS 417-2:1987 or equivalent with cover and of capacity not less than 50 litres. The cistern shall be installed with necessary supports at high level so that the make-up water can flow by gravity through the demineralizing equipment to the condensate/feed tank. A make-up water integrating flow meter shall be installed in the treated water outlet pipe at an accessible position.

C1.3.4 Chemical Dosing and Boiler Water Sampling Equipment

Chemical for initial start up shall include dosage for prevention of water scaling and corrosion. A nitrite-borate-organic non-toxic corrosion inhibitor shall be used for this application.

Individual chemical dosing and water sampling equipment shall be provided for each steam boiler.

The chemical dosing equipment shall comprise a chemical injection pump, a mixing tank, necessary controls and pipework. The chemical injection pump shall be of either the reciprocating or diaphragm type, capable of metering adjustments up to 100 litre/hr. and controlled by an adjustable timer up to 24 hours. The pump shall be manufactured from stainless steel or other non-corrodible materials. Chemicals shall be injected direct to each boiler through stainless steel tubings, check valve & diffuser. The mixing tank shall not be less than 100 litre capacity fitted with a gauge glass, drain, supports, and mechanical agitation.

Boiler water sampling device, complying with ISO 5667-7:1993 and BS 6068 Section 6.7:1994 shall be provided for each boiler. The device shall consist of a small closed cylinder fed with cold mains water in which is immersed a stainless-steel coil. The coil shall be connected to the water space of each boiler by means of a valved connection not less than 10 mm size. The jacket of the sampling device shall have a 15 mm size valved cold-water inlet and a 15 mm size drain line carried to waste.

Field-test kit shall be provided in the chemical dosing package including portable PH meter, TDS meter, corrosion inhibitor ppm test kit, etc.

The system water shall be treated to comply with the following requirements:

(a)	PH value	8 – 10
(b)	Total dissolved solids	Below 5500 ppm
(c)	Total hardness (as $CaCO_3$)	Below 10 ppm
(d)	Iron, increment	Below 1.0 ppm
(e)	Copper, increment	Below 0.2 ppm
(f)	Corrosion inhibitor, CWT110	3000 - 4500 ppm

Suitable quantities of chemical shall be provided for the purpose of testing and commissioning.

C1.3.5 Pressure Reducing Valves

Each pressure reducing valve set shall be duplicated for standby purpose and shall comprise the following:

(a) Steam Separator

(b) Parallel Slide Valve

(c) Strainer

(d) Pressure Reducing Valve

(e) Pressure Gauge and Cock

(f) Parallel Slide Valve

(g) Relief Valve

(h) 25mm Plugged Branch

Each set shall be preceded by a steam separator installed in the common high pressure steam main, upstream of the reducing valve set.

C1.3.6 Steam Trap Assemblies

All condensate connections from steam equipment shall be provided with steam trap.

Steam traps shall be capable of handling the full volume of condensate discharged from the equipment, when starting from cold.

Each trap set shall be preceded by a dirt pocket and shall comprise:

(a) Globe Valve

(b) Strainer

(c) Spira-tec Trap Failure Sensor Chamber complete with Blanking Plug

(d) Float Operated Steam Trap

(e) Sight Glass

(f) Check Valve

(g) Gate Valve

(h) All Unions

All steam trap assemblies which are not readily accessible, e.g. ceiling voids shall be provided with a remote test point complete with cable and sensor wired to the spira-tec.

C1.4 EQUIPMENT AND MATERIAL

C1.4.1 Towngas Piping Materials

All pipework fittings, accessories, joints and joining media used shall be suitable for the substance conveying in the pipes and shall not deteriorate due to chemical or atmospheric action.

All pipework, fittings and valves must be suitable for the system test pressure.

Pipework materials for the various services shall comply with the following:

(a) Steam

Steam supply pipe up to and including 50 mm dia.	Black mild steel to BS EN 10216-1:2002 and BS EN 10217-1:2002 with cast steel (class 2000) fittings to BS EN 10242:1995 and BS 143:2000.
Steam supply pipe above 50 mm and up to 150 mm dia.	Black mild steel to BS EN 10216-1:2002 and BS EN 10217-1:2002 with flanged joint to BS EN 1092-1:2002 and BS EN 1092-2:1997.
Condensate return pipe	Black mild steel to BS EN 10255:2004 heavy grade with malleable iron fittings to BS EN 10242:1995 and BS 143:2000.

(b) Hot and Cold Water

Hot water supply pipe up to and including 65 mm dia.	Copper pipes to BS EN 1057-1:2006 Table X and non-dezincifiable compression type fittings to BS EN 1254:1998 and BS EN 1254-2:1998.
Hot water supply pipe above 65 mm and up to 150 mm dia.	Copper pipes to BS EN 1057-1:2006 Table X and flanged fittings.
Cold water supply pipe	Copper pipes to BS EN 1057-1:2006 Table X and fittings to BS EN 1254-2:1998 (up to 65 mm dia.) and BS EN 1254:1998 Flanged compression type fittings for sizes above 65 mm dia.

(c) Compressed Air System

Compressed air pipe up to and including 150 mm dia.	Galvanized steel pipe to BS EN 10255:2004 heavy grade with malleable iron pipe fittings to BS 143 and 1256:2000, BS EN 10242:1995 (up to 50 mm dia.). Galvanized flanged fittings for 65 mm dia. and above.

The valve manufacturer's name and figure nos. given below, indicate the required minimum acceptable standard. Alternatives may be offered on an equal basis always subject to the valves having equivalent functions or performance.

(a) Steam – General Isolating

50 NB & below	Bronze Globe Valve	Fig. No. Biseat Two Stop IMI Bailey BS 5154:1991
65 NB & above	Cast Steel Parallel Slide	Fig. No. 7609 IMI Bailey BS EN 1984:2000

(b) Steam – for Connection to Equipment

50 NB & below	Bronze Globe Valve	Fig. No. Biseat Two Stop IMI Bailey BS 5154:1991
65 NB & above	Cast Steel Parallel Slide	Fig. No. 7609 IMI Bailey BS EN 1984:2000

(c) Condensate – General Isolation

50 NB & below	Bronze Globe Valve	Fig. No. 33 Hattersley N.H. BS 5154:1991

(d) Condensate – HWS Check Valves

50 NB & below	Bronze Globe	Fig. No. 47 Hattersley N.H. BS 5154:1991
65 NB & above	Cast Iron Check	Fig. No. M651 PN16 Hattersley N.H. BS EN 12334:2001

(e) Drain Valves

50 NB & below	Bronze drain valve with hose union ends and loose key	Fig. No. 81 HU Hattersley N.H.

Safety and relief valves shall be suitable for the operating conditions of the systems and as required by ISO 4126-1:2004 and the relevant International Standards for pressure vessels to which they are connected unless otherwise indicated. They shall be of the totally enclosed spring-loaded type with padlocks. Safety valves and relief valves shall have a full-bore discharge connection and where any low point occurs in the discharge run it shall be fitted with a 15mm size waste pipe carried clear of the insulation for drainage. The discharge and waste pipes shall be run to visible safe position.

C1.4.2 Pressure Reducing Valves

Pressure reducing (P.R.) valves up to 50mm size shall have bronze or malleable iron bodies and may have taper screwed ends. Valves 65mm size and over shall have cast-iron bodies with end flanged. Flanges for bronze and iron valves shall comply with BS EN 1092-2:1997; bronze valves table 16/21, cast iron valve tables 6/11, 10/11, and 16/11 and malleable iron valves tables 6/12 and 16/12, each according to the maximum working pressure.

Valves for reducing the steam-pressure shall be of an approved spring-loaded relay operated type. The valve seats and discs shall be of nickel-alloy or stainless steel and shall be renewable. Each valve shall be capable of maintaining a reduced outlet gauge pressure within ±34 mbar of the set pressure and shall be installed with an excess pressure isolating protection valve on the low pressure side.

C1.4.3 Steam Trap Assemblies

Ball float type steam traps, shall be suitable for operation at the line pressure on which it is installed, to facilitate drainage of condensate from the steam equipment.

Thermodynamic steam traps will NOT be accepted.

C1.4.4 Strainer

Strainer shall be Y type with stainless steel screen to BS EN 10048:1997 and cast iron body. It shall be suitable for operating temperature up to 250^{o}C on the steam and condensate pipeline.

C1.4.5 Sight Glasses

Sight glasses shall be of the double window type toughened glass with SG iron body suitable for operating temperature up to 200^{o}C on the condensate pipeline.

C1.4.6 Pressure and Temperature Gauges

Pressure gauges fitted to equipment and pipework shall comply with BS EN 837-1:1998 but shall have dials calibrated both in kPa from zero to not less than 1.3 times and not more than twice the operating pressure.

Where fitted on pressure vessels, the gauges shall be as required by ISO 4126:2006 and ISO 4126-1:2004 with dials not less than 150mm diameter and with cases of polished brass or chromium-plated mild steel.

Where fitted elsewhere, the dials of gauges shall not be less than 100mm diameter and the cases shall be of polished brass or chromium-plated mild steel.

Gauges used solely to indicate the altitude or head and pressure of water shall have dials not less than 100mm diameter, calibrated both in kPa and meters head. In addition, they shall be provided with an adjustable red pointer set to indicate the normal working pressure or head of the system. The cases shall be as for the 100mm diameter pressure gauges as specified above. Gauges shall be fitted with lever handle cocks.

Temperature gauges shall be suitable for 1.5 times the working pressure of the system.

Temperature gauges shall be insertion type complete with a stainless steel pocket/immersion type for pipe entry. Sensor pocket shall be filled with suitable liquid.

Temperature gauges shall have scales properly selected for the system with adjustable read pointer.

C1.4.7 Insulation Material

Insulation for pipes shall be rigid glass or mineral fibre preformed sections finished with 0.8 mm thick hammered aluminium sheeting and all joints overlapped and secured with pop rivets.

Insulation for flanges and valves shall be hammered aluminium removable boxes lined with insulation to same specification as for pipework and fixed with quick release clips.

The maximum moisture absorption shall not be greater than 0.2% by volume.

All insulating, finishing and painting materials shall be selected from types suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

All equipment and materials used shall be fire resistant and comply with the requirements of the National Fire Protection Association (NFPA) and the Hong Kong Fire Services Department.

The minimum thickness of insulation and 'K' value shall be applied to services as follows:

Service	Thickness (mm)	"K" Value (w/m^oK)
(a) Steam		
15 mm - 40 mm bore	32	0.035
50 mm - 65 mm bore	38	0.035
80 mm bore	44	0.035
100 mm - 150 mm bore	63	0.035
200 mm - 300 mm bore	75	0.035
(b) Condensate, LPHW Heating Hot Water Service (HWS)		
15 mm - 20 mm bore	25	0.035
25 mm - 80 mm bore	32	0.035
100 mm bore	38	0.035
125 mm - 200 mm bore	44	0.035
250 mm and above	63	0.035

C1.4.8 Condensate Return Pump and Receiver

The condensate return pump shall be of ogden automatic pump or product having equivalent functions or performance with compatible capacity to cope with the complete steam system. The condensate return pump shall be capable of transferring the condensate collected from the steam traps to the steam boiler room condensate/feed tank through various piping for which gravity return of condensate is impossible.

The body and cover of the pump shall be made of cast iron with gunmetal check valves, mild steel float and non-ferrous working parts. The mild steel receiver of suitable capacity shall be incorporated with suitable overflow and vent pipe. The pump operating pressure shall not be less than the steam mains supply pressure. A pump counter which counts the strokes of the pump is also required for calculating the quantity of condensate handled.

C1.4.9 Condensate/Feed Tank and Make-up Water Demineralising

The condensate/feed tank shall be mild steel and fabricated in accordance with the Drawings. The tank shall be painted internally and externally with 2 coats of anti-corrosion solution.

The mixing tank of the chemical dosing system shall be constructed of heavy-duty polyethylene.

Materials used for towngas service riser and pipes at pressure exceeding 7.5 kPa but not exceeding 200 kPa shall comply with the following requirements where appropriate.

(a) BS EN 10255:2004: Steel tubes and tubular (heavy) suitable for screwing to BS 21:1985 pipe threads.

(b) BS EN 1092-2:1997: Flanges and bolting for pipes, valves and fittings.

(c) BS 21:1985: Pipe threads for tubes and fittings where pressure tight joints are made on the threads. (metric dimensions)

(d) BS EN 10242:1995, BS 143 and 1256:2000: Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil.

(e) ISO 4145:1986, BS EN 10241:2000: Wrought steel pipe fitting. (screwed BSP thread)

(f) BS 1552:1995: Control plug cocks for low pressure gas.

(g) BS 6956:1988: Jointing materials and compounds for water, low pressure steam installations, 1st, 2nd and 3rd family gases.

(h) BS 3063:2005: Dimensions of gaskets for pipe flanges.

(i) BS EN 1514:1998: Dimensions of Gaskets for pipe flanges to BS EN 1092-1:2002 and BS EN 1092-2:1997 Part I Dimensions of non-metallic gaskets for pressure up to 64 bar.

All materials used for gas installation pipes and fittings at pressure not exceeding 7.5 kPa should comply with the requirements of the Standards listed below and any relevant International Standards, in addition to those stated above where appropriate. Where no such standard exists, materials used should be as specified by the Gas Supply Company.

(a) BS EN 1057:2006: Copper and copper alloys tubes.

(b) BS EN 12449:1999: Copper and copper alloys. Seamless, round tubes for general purposes.

(c) BS EN ISO 9453:2006: Soft solders.

(d) BS EN 1254-2:1998: Capillary and compression tube fittings of copper and copper alloy.

(e) BS EN 1254-1:1998 & BS EN 1254-2:1998 Part 2 Metric units.

(f) BS 2051-1:1973 & BS 2051-2:1984: Tube and pipe fittings for engineering purposes.

(g) BS EN 10312:2002: Light gauge stainless steel tubes.

(h) BS 61:1969: Threads for light gauge copper tubes and fittings.

(i) BS 7786:2006: Unsintered PTFE tape for thread sealing applications.

C1.4.10 Pressure Gauge for Use with Towngas

Pressure gauges of the approved type shall be installed across the gas booster or compressor and governor to read the gas static pressure. Accessories such as valves, cocks, tubing, fittings, protective casings, and supports shall be provided for a complete installation. Pressure gauges provided shall suitable for continuous use at their respective operating temperatures and pressures. All reading scale shall be so chosen that the operation range lies between 40-75% of full-scale range and shall be calibrated in S.I. units with accuracy to within 5% of the readings. All mountings shall be so fitted as to permit ready replacement without venting the gas line.

C1.4.11 Towngas Meter

A Towngas meter of the approved type shall be installed for each burner to measure the Towngas consumption of the burner. The meter shall be suitable for use with the local Towngas supply and conform to the Gas Supply Company's standard. Units of the totalizer shall be in Mega Joules. The meter shall be accurate to the nearest Mega Joule or better. The meter shall be installed at an easily accessible position.

C1.5 ERECTION AND INSTALLATION

C1.5.1 Boiler

(a) The maximum room length available, allowing for fire tube withdrawal from front of boiler, shall be as indicated in the Drawings;

(b) The boiler shall be properly levelled and installed on its concrete plinth to ensure it is in a horizontal position; and

(c) Thermal expansion slot for bolts joining the boiler and concrete plinth shall be provided.

C1.5.2 Gas boosters and compressor for towngas burner

Boosters and compressors shall be installed in well-ventilated locations. The location should be clean, dry, and accessible for maintenance and sited near to the equipment being served thus minimising the length of pipework operating at the higher pressures.

C1.5.3 Towngas Pipe Connection

Suitable anti-vibration mounting shall be used to reduce noise and vibration. Both the inlet and outlet connections shall incorporate a suitable length of flexible metallic tube to eliminate strain on the booster or compressor and to minimise the transmission of vibrations. Connecting pipework shall be adequately supported independently of the booster or compressor. Where the pipework diameter differs from the connections to the booster or compressor properly designed taper pieces or concentric reducers shall be inserted as close to the unit as is practicable to prevent turbulence.

All the control and protective devices specified that are fitted on the inlet of the booster or compressor shall be fitted between the inlet gas isolating valve and the booster or compressor. No other shut-off valve shall be fitted in the pipework between the machine and its inlet isolating valve. The pressure delivered shall be stable without any surging at all operating gas flow rates.

C1.5.4 Control for Towngas Connection

A non-return valve of the approved type shall be installed between a compressor inlet and the low pressure cut-off switch and capable of withstanding a back pressure equal to the maximum compressor discharge pressure.

A suitable relief valve capable of by-passing the full rated output shall be fitted immediately around a positive displacement compressor to relieve excess gas pressure from the outlet to the inlet to maintain a constant outlet pressure.

A resonator shall be installed on the inlet of a reciprocating compressor to damp down pressure fluctuations.

Where gas is supplied to a gas compressor or compressor type mixer, notices similar to the following should be affixed with suitable Chinese translation to be approved by the Architect:

(a) Near the meter inlet valve

WARNING

GAS

The gas meter inlet valves must be fully opened before starting any gas compressor or gas engine and must not be shut or partially closed while any such plant is in operation, otherwise meter and plant will be damaged.

(b) Near the gas compressor and compressor type mixer

WARNING

GAS

Before starting this gas compressor always see that the meter inlet valves are open, otherwise the meter will be damaged.

(c) On the installation

Notices shall be displayed to indicate the presence of gas at high pressure.

C1.5.5 Pipework

All screwed joints shall be made in compliance with BS 21:1985 using jointing compounds carefully selected to suit the type of service.

All pipe runs shall be installed in accordance with the Drawings with allowance for future removal of the work.

Pipework shall be installed with correct falls to ensure adequate venting and draining.

Welding shall not be permitted on galvanized pipework under any circumstances whatsoever.

All pipework shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

During the course of the construction, all open ends shall be plugged or capped to prevent ingress of dirt.

Where two or more pipe runs follow the same route, care shall be taken to ensure that all are parallel to each other and to the building structure, except for the required allowance for venting etc. Pipework which is to be subsequently insulated shall be spaced to allow an individual finish to each.

Tundishes shall be provided for collecting drip pipes and run therefrom all drain piping to discharge over a floor gully or other drain.

C1.5.6 Pipe Fittings

Pipe fittings for different pipe material shall be provided as specified.

Long sweep bends shall be used in preference to round elbows wherever practicable. Square elbows shall not be used. Tees shall be of the easy sweep or twin elbow pattern except where square tees are required for venting or draining etc.

Bushes shall not be used and where a reduction in pipe size is required, reducing sockets or tees shall be used. Eccentric reducing sockets shall be used wherever necessary to ensure proper drainage or elimination of air pockets.

C1.5.7 Welding

All welding on pipework shall be carried out generally by the electric arc process to BS 2633:1987. Where steel pipework of 50mm dia. and below is to be welded, gas welding by the oxy-acetylene process to BS 2640:1982 may be used. Gas welding on pipework 65mm and above will not be permitted unless prior permission is obtained.

Where brazing or bronze welding is undertaken, such welding shall be carried out in accordance with, and satisfy the testing procedures described in BS EN 14324:2004. In all other respects, particulars relating to the welding of steel pipework shall apply equally to copper.

Test welds on both steel and copper by each welder employed on the site shall be carried out in the presence of the Architect prior to the operator undertaking any work on the Contract. All such test welds must be made in position as directed by the Architect and shall be subjected to visual examination and bend tests in accordance with BS 2971:2006. Each weld shall be given a suitable mark enabling the operator to be identified.

The quality of welding in steel or copper shall be subjected to careful inspection and testing by the Architect and where so deemed necessary may be subject to non-destructive and/or destructive tests under the supervision of the Architect.

C1.5.8 Pipe Supports

Pipe supports shall be provided as required for the stable and sufficient support of the pipework. These supports shall allow free movement for expansion and contraction and shall be graded to required levels for air elimination and drainage.

Pipework supports shall be arranged as near as possible to joints, valves and changes in direction.

Pipes shall be arranged so as to provide subsequent access to any pipe for maintenance or removal purposes.

Brackets for mild steel pipework shall be mild steel or malleable iron while those for copper pipework shall be cast brass or bronze with brass fixing. Screws shall be chromium plated or stainless steel where they are securing chromium plated or polished stainless steel tube.

Brackets screwed to walls shall be secured by expanding plugs or other purpose designed fixing devices; softwood plugs will not be permitted.

Hangers suspending pipework which is subject to movement shall be complete with swivel joints at pipe rings and spherical washers at the top of the hanger rods, which shall have a reasonable screwed length for adjustment, the adjusting screw shall be of the self-locking type or be complete with locking backnut. Hangers suspending pipework not subject to movement shall have swivel joint omitted.

Pipework subject to movement which is supported at the bottom shall be fitted with rollers, chairs and guides, while that which is not subject to movement and supported at the bottom may rest directly on one of the horizontal flats of the brackets, unless the pipe is copper when a lead strip shall be securely wrapped round the pipe to interpose between the two surfaces.

Pipe rings on mild steel pipework up to and including 50mm shall be of malleable iron, while on copper pipework pipe rings shall be of cast brass or bronze except where they are normally exposed to view in rooms and corridors where they shall be of polished finish. Hinged pipe rings will be allowed but calliper hooks will not be permitted.

Pipe rings on 65mm mild steel pipework and over shall be of fabricated mild steel, made in halves and secured by bolts. Fabricated rings shall be used on 67mm copper tube and over, in which case the pipe rings shall be fabricated from sheet or strip brass or copper with brass or bronze bolts. Details of all purpose made brackets shall be submitted to the Architect for approval before manufacture commences.

The spacing of pipe supports shall not exceed the centres given in Tables 1.5.1(a) and 1.5.1(b) below.

TABLE 1.5.1(a) - SUPPORTS FOR FERROUS PIPES

Normal Size of Pipe	Intervals for Horizontal Runs		Intervals for Vertical Run Bare or Lagged
	Bare	Lagged	
mm Bore	Metres	metres	metres
15	2.0	2.0	2.4
20	2.4	2.4	3.0
25	2.4	2.4	3.0
32	2.7	2.4	3.0
40	3.0	2.4	3.6
50	3.0	2.4	3.6
65	3.7	3.0	4.5
100	4.0	3.0	4.5
125	4.5	3.7	4.5
200	7.5	6.0	6.0
250	8.0	6.5	6.0
300	8.5	7.0	6.0

TABLE 1.5.1(b) - SUPPORTS FOR LIGHT GAUGE COPPER PIPES

Normal Size of Pipe	Intervals for Horizontal Runs		Intervals for Vertical Run Bare or Lagged
	Bare	Lagged	
mm. o/s dia.	metres	metres	metres
15	1.4	1.4	2.0
22	1.4	1.4	2.4
28	1.7	1.5	2.4
35	1.7	1.5	3.0
42	2.0	1.8	3.0
54	2.4	1.8	3.0
65	2.4	2.0	3.6
76	2.4	2.0	3.6
108	2.7	2.4	3.6
133	2.7	2.4	4.5
159	3.0	2.7	4.5

C1.5.9 Pressure and Temperature Gauges

Pressure gauges shall be fitted with lever handle cocks and, where appropriate, siphon pipes or snubber.

C1.5.10 Valves and Cocks

All valves shall be installed with the valve stems truly vertical or horizontal.

Where flanged valves, etc. are specified, details of flanges shall correspond to the appropriate specification. Valve flanges and counter flanges shall be to the same Standard.

C1.5.11 Labelling of Valves

Every valve shall be supplied with a plastic sandwich (traffolyte) disc engraved or stamped with the valve reference number and secured to the valve with stainless steel chain.

Valve labels shall be a minimum of 50mm diameter.

Valve reference numbering system shall be agreed with the Architect before construction.

A schematic diagram of the system shall be provided and fixed at suitable locations to indicate the reference numbers, type and purpose of the valves. The diagram shall be fade-proof and mounted in a polished hardwood frame with glazed front. Position shall be agreed with the Architect. Dye line prints will not be accepted.

C1.5.12 Insulation

Pipework insulation shall be deemed to include all open vents, cold feeds, valves, flanges, fittings, heat exchangers, equipment items whether specifically mentioned or not.

All thermal insulation, including fixings shall comply with ISO 12241:1998, BS 5970:2001 and BS 5422:2009. All surface finishes shall comply with Class 0 surface spread of flame.

No insulation shall be applied before the relevant service has been satisfactorily tested, cleaned and painted.

Each pipe/duct shall be separately insulated with a minimum space of 50 mm between finished services.

All materials of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

All materials delivered to site shall be new, and where appropriate, colour coded and labelled at the factory to identify different grades, sizes and types.

Before ordering any insulating materials, the co-efficient of thermal conductivity for each of the materials being supplied for the Works shall be stated and shall allow for carrying out tests on representative samples (of each material) taken at Site and/or at markers' works as

directed by the Architect and tested in accordance with the methods laid down in relevant Standards. In the event of test results not being in the Architect's opinion satisfactory, the Architect shall have the right to order the removal and replacement of all material represented by the unsatisfactory samples.

Before ordering any painting materials, the Contractor shall submit to the Architect for approval the type and manufacture of materials.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc. shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to protect them from damage or deterioration before fixing.

Where a pipework or ductwork system or item of equipment is listed in the schedules in this Section or otherwise requires to be insulated, then the entire system or items shall be insulated to prevent condensation and reduce heat loss or gain.

All valves, flanges, strainers, expansion joints, etc., for heating system shall be insulated in conformity with the pipework in which they are incorporated, and to the same thickness all such items shall be provided with fibreglass filled 0.8 mm thick hammered aluminium split boxes, arranged for easy removal, the box to enclose valve handle and to have a lid for valve access.
All insulation shall be applied so as to give a smooth, homogeneous and lineable surface. All rigid sections shall be concentric, and accurately matched for thickness. Steps and undulations in the surfaces shall not be acceptable. Any sections or slabs having damaged ends or edges shall be rejected.

All insulation shall fit tight to surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary. Any minor interstices left in insulation shall be filled and sealed.

Insulation shall be applied to clean and dry surfaces, free of foreign material such as oil, grease, rust, scale or dirt.

Any surface to be insulated, which shows any signs or rusting or damage shall, prior to insulating, be thoroughly scraped and wire brushed as necessary to remove all rust, scale, etc. Surfaces shall then be solvent cleaned to remove all oil, grease, salts and dirt prior to the application of a coat of primer. Application of primer shall be as specified in the Clause B3.4 of this Specification.

Only clean and dry insulation shall be used. Insulation shall generally be applied in accordance with the manufacturers' recommendations.

Continuous insulation shall be provided through all sleeves and insulation joints shall be staggered with respect to joints on the associated pipework or ductwork system.

The insulation on the pipes immediately adjacent to such flanges, etc., shall be neatly terminated to allow for easy removal of bolts. A canvas insertion shall be provided to allow the insulated boxes to be removed without damage to the pipe insulation.

C1.5.13 Labelling and Identification

All piping, plant and equipment provided under the Contract shall be labelled in both English and Chinese as to duty or services. All such labelling shall correspond to schedules, diagrams, etc.

All services shall be colour coded in accordance with the Government standards.

Colour banding shall be provided at intervals not exceeding 5 m and wherever necessary at bends, tees, etc., and where pipes pass from one room or zone to another. Where two or more pipes run in parallel, then the colour banding for each pipe shall be at the same locations.

Colours not covered by this Specification shall be agreed with the Architect before work commences on site.

At intervals approved by the Architect on straight pipes and adjacent to valves and tees, coloured arrows shall be stencilled to the insulation or pipework to indicate direction of flow. In addition, the pipe mains are to be painted using stencils to indicate the circuit or system. Where the finish is unpainted, metal bands and discs shall be fitted for colour identification specified above.

C1.5.14 Extent of Painting

All plant, materials and equipment forming part of the Works shall be painted as specified in this Section, with the sole exception of items specifically excluded in this Specification.

Items which do not require to be painted shall include:

(a) Insulated ductwork with aluminium or hammerclad finish;

(b) Copper pipework and fittings; (except where specifically stated);

(c) Galvanized pipework, ductwork, conduit or cable trays where concealed within duct shafts or false ceilings;

(d) UPVC pipework, ductwork or conduit; and

(e) Materials with a factory applied anodized, baked enamel or painted finish, provided that the colours are approved prior to application.

The requirement for painting of all pipework and ductwork is in addition to the colour coding or banding specified in this Section.

All finishing to factory assembled plant or equipment shall be factory applied in accordance with the manufacturers' normal practice and to a standard suitable for the duty and location of the plant.

Where factory applied finishes are approved, the Contractor must obtain from the plant manufacturers touch-up paint kits and detailed instructions for making good after completion any damage to finishes which may occur during transportation, storage, installation or commissioning.

C1.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

Factory test shall be carried out for the boiler plant, tanks, cylinders and pumps, the test reports shall be submitted to the Architect.

Installations or sections which will be embedded in the structure or concealed in permanently sealed ducts, trenches, roof spaces, etc., shall in addition to the above specified tests be individually tested as they are laid and before being embedded or concealed.

All pressure tests shall be carried out before the application of thermal insulation, where this would prejudice the completion of the installation the section concerned shall be individually tested before the application of the insulation.

The Steam Equipment including safety valves and accessories after completion shall be subject to the inspection and approval by the Commissioner for Labour and Director of Water Supplies. The examination of the plant by approved independent Surveyor(s) or Laboratories is required if deemed necessary by the above relevant authorities. The contractor is required to obtain the respective Certificates of Approval or Fitness and registration on behalf of the Employer for those equipment or systems which fall within the Boilers and Pressure Vessels Ordinance Chapter 56, and other relevant statues. Original certificates should be framed and posted conspicuously near the respective equipment or systems on site. Four copies of these certificates shall be submitted to the Architect.

All pipework, vessels and boilers shall be clean up thoroughly before subject to inspection, both internally and externally.

All associated pipework, fitting and valves shall be completely drained after hydraulic test and shall be blown with compressed air to remove any trace of water and dirt.

After being dried, the pipework, fitting and valves shall be flushed with oil to prevent rusting.

Before commissioning, the whole system pipework shall be chemically pre-cleaned. Adequate amount of defoamer shall be applied to control foaming throughout the cleaning process.

SECTION C2

MILD STEEL CHIMNEY

C2.1 SCOPE OF SECTION

The Section shall cover the design, supply and installation of a mild steel chimney complete with the accessories.

C2.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with all relevant statutory regulations, in particular

(a) BS 4076:1989 - Specification for Steel Chimneys;

(b) BS 4872-1:1982 -Fusion Welding of Steel (for approval testing of welders);

(c) BS EN 62305:2006 - Protection Against Lightning;

(d) United States Environmental Protection Agency (USEPA) Reference Method 5 - Determination of Particulate Emission from Stationary Sources;

(e) Air Pollution Control (Furnaces, Ovens and Chimneys) (Installation and Alternation) Regulations and Environmental Protection Department's Approval under the Regulation 10;

(f) Code of Practice on Wind Effects in Hong Kong 2004.

C2.3 DESIGN

The chimney shall be suitable for the rated capacity of flue gases discharging from the firing equipment mentioned in the Particular Specification. The chimney stack shall be connected to the firing equipment e.g. boiler or incinerator.

The chimney shall be designed to cater for part-load operation without cold-air inversion.

Flue gas sampling connections to 'USEPA Reference Method 5' shall be provided in accordance with the Air Pollution Control Ordinance Chapter 311. "Cone" shape exit nozzle shall be provided to the chimney, where applicable, so that the flue gas

efflux velocity can meet with the requirements of the Environmental Protection Department at all loading conditions. Flue gas ejector shall be included if necessary. Flue gas temperature shall be higher than the acid dew point even at part-load.

Explosion doors, soot removal door, expansion joints, dampers and other accessories shall be provided to the flue gas system according to design conditions.

As the chimney effect (pressure difference) will likely affect the design performance of the chimney, the calculation of the chimney effect, in mm of water gauge, taking the average temperature of the flue gas and air temperature outside the chimney shall be submitted for the approval of the Architect. The overall design of the chimney shall be favourable for all atmospheric conditions. Attention shall be drawn in designing the size and location of the explosion doors and soot removal doors so that the difference between the local static pressure inside the chimney and the atmospheric pressure shall not cause a suction force to blow the outside air back into the plant room through these doors.

The calculations, shop drawings and other relevant information shall be submitted to the Director of Environmental Protection for approval in accordance with the Air Pollution control (Furnaces, Ovens and Chimneys) (Installation and Alteration) Regulations. This shall be done immediately after the Acceptance of Tender in view of the time required by the Director of Environmental Protection in processing the application prior to commencing the site installation work.

The design life of the chimney stack and supporting structures shall be 20 years.

Suitable expansion bellows or compensators shall be installed to diffuse the stresses caused by thermal expansion. The chimney shall be supported by suitable sliding or roller supports to allow for longitudinal and vertical movement due to thermal expansion. Supports for exposed portions of chimney shall be secure enough to withstand the strongest wind loadings in Hong Kong.

The stability of the chimney in respect of its dead weight and wind loading shall be considered in accordance with Clause 5 of BS 4076:1989 and the Code of Practice on Wind Effects in Hong Kong 2004.

Appropriate maintenance platform and access to top of the chimney shall be provided for inspection and servicing works.

Provisions shall be made to prevent ingress of rainwater into the combustion chamber through the chimney. Rain caps or cowls shall not be used at the chimney top.

For multiple-firing equipment sharing a common chimney system, a flue gas exit damper with a heat resistant limit switch shall be provided at each flue connection so that the burner will not be energized unless the damper is fully open.

BS 4076:1989 shall be followed, wherever applicable, for requirement of corrosion protections of chimney stacks.

C2.3.1 Exterior Insulation

The chimney shall be properly insulated to maintain the flue gas temperature above 150^{o}C throughout the entire length of the stack during normal operation at all loading levels to prevent acid condensation and smutting.

C2.4 Equipment and Material

The chimney connections and supports shall be of mild steel grade 43 to BS EN 10029:1997 and to BS 4-1:2005 and BS 7668:2004 for dimensions.

The minimum thickness of steelwork fabricating the brackets and supports shall be as tabulated below:

Type of Steelwork	Minimum Thickness	Working Environment
Hot rolled sections	8 mm 6 mm	exposed to weather not exposed to weather
Hollow sections sealed at end	4 mm 3 mm	exposed to weather not exposed to weather
Angle flanges	6 mm	--

The interior and the exterior surfaces of the steel chimney shall be protected with one coat of primer, which shall be of pure silicone resin to provide protection to surfaces subject to temperature between 260^{o}C to 600^{o}C, and designed for use on chimney stacks. The dry film thickness (DFT) per coat shall not be less than 2.0mm. The recommended heat resistant coating shall be a self-priming and a two-coat application system good for both interior and exterior of any chimney stacks. Heat resistant aluminium coatings shall be used. The finish coating may be of the same paint as the primer as said above.

C2.4.1 Interior Lining

The interior lining of the chimney stack, where applicable, shall be castable refractory or firebrick in accordance with BS 4076:1989.

C2.4.2 Exterior Insulation

All thermal insulation, including fixings shall comply with BS 5970:2001, ISO 12241:1998, BS 5422:2009 and ISO 12241:1998. All surface finishes shall comply with BS 476 Class 0 surface spread of flame.

Insulation shall be mineral wool of approved quality, suitable for use up to 300^{o}C and having a thermal conductivity of not greater than 0.06 W/m^{o}C. The thickness of insulation shall be properly selected for personal protection.

All materials of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

Before ordering any painting materials, the type and manufacture of all materials shall be submitted to the Architect for approval.

All insulating, finishing and painting materials shall be suitable for the surfaces to which they are applied and for the environmental conditions in each area.

No asbestos based insulation shall be used.

All equipment and materials used shall be fire resistant and shall comply with the requirements of the National Fire Protection Association (NFPA) and the Hong Kong Fire Services Department.

C2.5 Erection and Installation

Anchor bolts, nuts and lock nuts for the chimney shall be supplied and installed by the Contractor. Grouting shall be carried out by builder.

The chimney shall be fabricated and installed with all supports, brackets, anchors and ancillary components in accordance with BS 4076:1989: Specification for Steel Chimneys, and as specified in the design. Connection shall suit the firing equipment offered.

The vertical riser shall be installed in sections of about three meters to allow the removal of a section at any time without the necessity for extensive dismantling of the flue system. All joints shall be flanged with high-temperature gaskets. Horizontal sections shall be installed with a rising slope towards the vertical riser and shall be connected to the vertical section in an angled bend of 30 deg. to 60 deg. normal to the riser to allow for proper flue gas flow.

Immediately before applying any protective treatment to all the exterior or the interior surface of the steel chimney, the surface shall be cleaned by chipping, scraping and wire brushing to removal all dirt, loose scale, grease or rust and shall be abrasively blasted to a minimum near White Grade.

C2.5.1 Application of Interior Lining

Immediately before applying refractory lining, the interior surface of the steel chimney shell shall be cleaned and freed from loose rust and scale by wire brushing and painted as per Section B3.4 of this Specification.

C2.5.2 Exterior Insulation

The mineral wool shall be covered with 1.6 mm thick hammered aluminium cladding. The cladding sheets shall overlap each other to prevent water ingress into the insulation.

All materials delivered to site shall be new, and where appropriate,

colour coded and labelled at the factory to identify different grades, sizes and types.

Before ordering any insulating materials, the co-efficient of thermal conductivity shall be stated for each of the materials being supplied for the Works. Representative samples (of each material) shall be taken at Site and/or at makers' works as directed by the Architect and tested in accordance with the methods laid down in the International Standards. In the event of unsatisfactory test results, the Architect shall have the right to order the removal and replacement of all material represented by the unsatisfactory samples.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc. shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to protect them from damage or deterioration before fixing.

All insulation shall be applied so as to give a smooth, homogeneous and lineable surface.

All insulation shall fit tight to the surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary.

Only clean and dry insulation shall be used. Insulation shall generally be applied in accordance with the manufacturers' recommendations.

C2.5.3 Lightning Protection

Suitable protection against lightning, in accordance with the recommendations of the relevant clause of BS EN 62305:2006 shall be provided for the chimney.

C2.5.4 Welding

All welding shall be carried out only by experienced welders with recognised certificate of proficiency, and to the satisfaction of the Architect. The welding electrodes equipment and process shall also be subject to the Architect's approval and in accordance with the relevant International Standards.

Upon the Architect's request, the quality of the welder's work shall be demonstrated in accordance with BS 4872-1:1982.

When visual tests on completed work indicate that the quality of welding could be below specification, the Architect shall be entitled to have the welds examined by means of non-destructive tests (NDT) for acceptability at no additional cost to the Employer.

Welding shall not be carried out under unfavourable weather conditions.

C2.5.5 Verticality of the Chimney

The verticality of the chimney shall be checked by optical tooling method. The recommended instruments used for surveying shall include the alignment telescope or jig alignment telescope, jig transit and precise level. These three instruments shall be self-checking and can be tested quickly and adjusted exactly.

C2.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The Contractor shall notify the Architect and arrange site inspections for the Architect during the following four stages of works:

(a) Complete fabrication of the chimney stack in manufacturer's works (prior to delivery to site);

(b) Complete erection, painting but prior to application of thermal insulation materials;

(c) Complete insulation but prior to fitting protective cladding; and

(d) Complete protective cladding but prior to removal of scaffolding.

When the firing equipment is at steady full-load conditions the Contractor shall measure the gas temperatures and velocities at the entry and the exit of the chimney stack to verify the design criteria are fulfilled.

SECTION C3

CRANE AND HOIST

C3.1 SCOPE OF SECTION

The Section shall cover the design, supply and installation of crane, hoist and trolley complete with the accessories.

C3.2 COMPLIANCE WITH SPECIAL REGULATORY EQUIREMENTS AND STANDARDS

The installation shall comply with all relevant statutory safety requirements stated in Section A2.1.

C3.3 DESIGN

C3.3.1 Crane

C3.3.1.1 General

The crane shall be designed in accordance with BS EN 13001-1:2004 and BS EN 13001-2:2004 and the electrically operated cranes shall also be in accordance with ISO 4301-1:1986. For the crane and mechanism as a whole, the class of Utilization, Stage of Loading and Group Classification shall be in accordance with BS EN 13001-1:2004 and BS EN 13001-2:2004 and ISO 4301-1:1986.

The crane shall either be of a double-girder construction with the crab travelling on the girder rails, or a single-girder construction with the hoist hanging onto the girder. The girder(s) complete with end plates shall be designed to withstand maximum lateral and vertical stresses and be within the permissible deflection ratio in accordance with ISO 4301-1:1986.

The crane bridge shall be carried on end carriages of ample size to carry the rated load when lifted at one end of the crane bridge. The end carriages shall be fabricated, welded and stiffened internally throughout their length to produce a box section of high torsional resistance and shall be of approved design.

The track wheel, reduction gear and motor shall be combined to form one assembly. The end carriages shall be designed so as to enable the track wheels to be withdrawn

or mounted readily. The wheelbase of an end carriage shall be not less than 1/7 of the crane span.

The electric overhead travelling cranes shall be carried on four roller-bearing double-flanged wheels mounted on steel axles driven by two geared motors simultaneously. The end carriage front plates shall be fitted with resilient buffers to absorb the shock in case of collision with the end stops of the gantry rails. The end carriages of the cranes shall be designed so as to give at least 100mm clearance from the nearest structure during operation.

The universal beams complete with gantry rails shall be designed in accordance with ISO 4301-1:1986. The beams shall be secured onto the steel brackets or reinforced concrete corbel provided by the builder with spans as shown on the design. The gantry rails shall be complete with end stoppers and limit switches at the extreme ends of travel. Access to the crane shall be by ladder with necessary safety hoop to be installed at a corner of the building.

The capacity of the drum shall be sufficient for the height of lift designed. The hoist drum shall be accurately machined to contain the hoist rope in a single layer. The drum shall have flanges at both ends and the flanges shall not project less than two rope diameters above the rope. No fewer than two and a half dead turns shall remain on the drum at each anchored end at the lower limit of hoisting. The drum shall accommodate one further turn of rope at the upper limit of hoisting. Rope guides and hardened pressure ring/rollers shall be provided to ensure correct rope reeving during operation.

C3.3.1.2 Gearbox

The gearbox shall be of rigid construction and comprise of an oil-immersed multi-reduction gear train totally enclosed in a cast housing. High-speed gears shall be of helical teeth configuration. Each geared shaft assembly shall be supported on ball or roller bearings.

The gearbox shall be designed so that the gears which they enclose will be automatically lubricated at all operating speeds. The box shall prevent escape or contamination of the lubricant and breathing shall be provided.

Where oil replacement is necessary, facilities for filling, drainage and means of indicating clearly the correct level shall be provided. Gearing shall comply with BS 436, BS 545:1982 and BS 721 as applicable. Lifting lug(s) shall be provided for the gearbox where deemed necessary.

C3.3.1.3 Brakes

(a) Automatic spring held brakes shall be provided for all drives. Release of brakes shall be by electromagnetic means, designed for fail-safe operation. The brakes shall be applied smoothly and automatically without snatching when the power supply to the driving motor is cut off and the braking torque shall be at least 200% of the full load torque of the motor;

(b) Where more than one motor is used to control motion in any direction each motor shall have an individual brake with its release coil energized from the supply to that motor. Brakes with more than one shoe shall be self-centering such that wear of the brake linings is evenly distributed between shoes. Means shall be provided for adjusting the brakes to compensate for wear on the linings. Long travel (downshop) and cross travel brakes may either be integral with each driving motor or be separated drum brakes; and

(c) Hoist brake shall incorporate mechanical or hydraulic manual release facilities. Hoist motor with integral brakes shall incorporate manual release devices for use during maintenance.

C3.3.1.4 Manual Release

The hoist shall be equipped with a brake release by hand wheels or levers to allow manual lowering of the load in the event of power failure. This brake release shall not affect the clearance adjustment during normal operation.

Facilities for converting down-shop and cross-shop travel from electrically operated to manually operated on power failure shall also be provided. Conversion to manual operation is by hand wheel or lever. Details of conversion to manual operation should be submitted with the tender.

Where hydraulic manual release mechanism is specified, it shall be operated by a foot pedal, depressing of which will release the brake to enable the lowering of the hook by gravity or by hand-winding, in an emergency. When the pedal is released the brake shall be re-applied automatically.

Electromagnetic release coils shall be continuous rating and shall be suitable for a 380V 50 Hz supply unless otherwise stated in the design. It shall be possible to

replace a defective coil without dismantling the brake mechanism.

C3.3.1.5 Hooks and Ropes

Top hooks if required to swivel shall be fitted with plain bearings; bottom swivel hook shall be free to rotate under load. The hook shall be tested to 150% full load before assembly and complete with safety catch.

Rope and rope sheaves shall conform to BS EN 12385 . The wire rope must be replaced if a wire is broken or if it is found to suffer from swelling, fraying bruises, kinks, permanent bends, damage or corrosion.

The steel rope sheaves shall revolve on anti-friction bearings and shall be guarded for protection against rope displacement and completely protected by steel casings. Where two or more ropes are used in a system, means shall be provided to ensure that the tensile forces in the ropes are distributed in the designed proportions.

The factor of safety of the wire rope, which is determined by dividing the product of the minimum breaking strength of the rope and the number of falls by the safe working load for the crane, shall be not less than 5.

C3.3.1.6 Safety Facilities

(a) An overload protection device of the mechanical load measuring type with processing electronics shall be provided to prevent damage to the crane and its lifting mechanism. The device shall cut the lifting movement off if the Safe Work Load (SWL) is exceeded. However, the lowering movement shall remain operative. This device shall be of the fail-safe type and shall not reduce the maximum height of lift. Normal setting of the device shall be within 90% to 110% of SWL;

(b) All cranes shall comprise an automatic safe load indicator, which shall automatically give an audible and visible warning at the control panel or pendent control of an approach to the safe working load and a further warning when an overload occur;

(c) The testing requirements for this automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gears) Regulations and BS 7262:1990;

(d) Where specified, a working platform of steel chequer plate shall be provided to enable access to the front and to both sides of the electrical control cubicle, motors, brakes and other areas where maintenance or inspection will be required; and

(e) Steel plating shall be provided between the access point and the equipment over the whole of the exposed area. The platform shall be securely fenced with tubular steel guard rails 1000 mm high and toe boards provided along the outer edges of the platform.

C3.3.1.7 Power Collector

Power shall be supplied to the crane through a system of copper bar conductors enclosed in an earthed galvanised steel track or a PVC insulating shroud. Alternatively, a trailing cable fixed to a system of cable trolleys, run on a fixed rail may be used.

The current collectors shall be of the sliding contact type with replaceable contact shoes. The contact head shall be shrouded to prevent accidental contact and mounted on self-adjusting spring-loaded arms to maintain constant contact with the conductor bars. The capacity of the contact head shall be compatible with the conductor. The supply conductor/collector system shall have five conductors - three for the phase supply, one for the earth and one for the neutral connection. Electrical connections between crane platform and the cross travel hoist assembly shall be with insulated flexible cables on rail-runners.

The crane structures, motor frames and metal cases of all electrical equipment shall be effectively bonded to earth.

C3.3.1.8 Controls

(a) Each movement of the crane shall be operated by a separate motor. All movements shall start smoothly and inching in either direction shall be possible. If more than one driving motor is used for motion in any direction, the motors shall be synchronised. Limit switches shall be provided for limiting long (downshop) travel, cross travel, and for vertical hook travel in both directions. Limit switches shall reset automatically on reversal of motion. Control of travel shall be by means of push buttons in the pendant control unit.

(b) Latching contacts shall not be provided in the motor starter circuits to bridge the control push buttons; i.e. constant pressure on the corresponding push button shall be required for the entire duration of travel in any direction. A self-latch type emergency push button to interrupt the control supply to all motor circuits shall be provided. After the emergency stop button is pressed, the pendant unit shall only be operated after it is reset manually.

(c) The pendant control unit shall have a die-cast metal or glass fibre reinforced polyester enclosure rated IP 54 to IEC 60529:2001. The enclosure shall be resistant to mechanical shock. Push buttons shall be provided for the following functions:

(i)	Main Hoist:	Fast Raise, Slow Raise, Fast Lower, Slow Lower
(ii)	Cross Travel:	Left, Right
(iii)	Long Travel:	Forward, Reverse
(iv)	Control:	Stop, Reset

(d) The push button, of hold-on control type, shall be electrically interlocked to prevent inadvertent operation of opposite motions. Control voltage at the pendent unit shall not exceed 50V in accordance with IEC 60439-1:1999 class 3 or equivalent. Labels in English and Chinese shall be approved by the Architect.

C3.3.1.9 Electrical Installation

(a) The control cubicle for a crane shall be to a degree of protection of IP 54 to IEC 60529:2001. The control cubicle and the components shall be of bulk manufacture with endurance and reliability test records. The panels shall be suitably braced to form rigid structures, taking due account of the vibrations that may be encountered during the operation of the crane;

(b) The arrangement of the equipment within the cubicle shall be such that all normal maintenance work can be carried out through a hinged and lockable front access door. Components shall be of robust construction, to withstand the effects of intense vibration;

(c) The control voltage shall not exceed 50V nominal and shall be supplied either by a rectifier unit fed from a double-wound transformer having the mid-point of its secondary winding earthed, or directly from double wound transformer. The transformer (and where applicable, the rectifier) shall be mounted inside the control panel. Rectifiers shall be of adequate capacity to supply the full d.c. load continuously. The insulation level of the cubicle shall be 660V;

(d) The control cubicle shall be fitted with anti-condensation heater and a thermostat. A control push button, lockable with a key, shall be provided on the cover of the electrical control cubicle to de-activate the pendant control unit while retaining the main power supply to the control cubicle for circuit checking;

(e) A lockable isolator shall be provided for the isolation of the main power supply. Labels in both English and Chinese shall be approved by the Architect. To enable quick and easy maintenance and servicing, the components shall be grouped to form sub-assembly units;

(f) Electric motors shall comply with IEC 60034:2004 and BS 5000-11:1973 as appropriate. Motor enclosures shall have a degree of protection of IP 54 to IEC 60529:2001. Motor bearings shall be with minimum working life of 40,000 hours. Bearings shall be arranged so that thermal expansion of the motor shaft does not impose thrust loading unless they are designed to accept thrust. Motor winding shall be of Class F insulation in operation at rated operating conditions;

(g) Motors shall be rated for intermittent duty type S3 to IEC 60034:2004, with a cyclic duration factor of not less than 40% at rated output. Motors fed from 380V 3 phase mains supply (unless otherwise stated in the design) shall operate within ±6% of the nominal supply voltage at motor terminals prior to the starting of motor, and ±2% of the supply frequency;

(h) The starting kVA shall not exceed the figures specified in IEC 60034:2004. D.C. motors supplied from rectifier equipment connected to a.c. mains power supply shall meet the service conditions of voltage and frequency specified for a.c. motors and shall also be capable of continuous operation

without causing excessive temperature rise. The rectifier equipment shall be provided with any necessary current limiting devices;

(i) Brushgear, commutators and slip-rings shall be designed to operate without excessive sparking and to run for long periods without the need for adjustment or replacement of brushes. Adequate protection shall be provided for the windings against deposits of carbon dust. Removable covers shall provide access to the brushgear, commutator or slip-rings;

(j) Starters shall be of air-break contactor type rated for Class B operation. Reversing contactors shall have mechanical and electrical interlocks. Contactors shall comply with IEC 60947-4-1:2009 with assemblies to IEC 60439-1:1999. Direct-on-line starters shall comply with IEC 60947-4-1:2009;

(k) The utilization category for contactors shall be AC4 for induction motor starters, DC3 for shunt motor starters and DC5 for series motor starters. The duty rating shall be not lower than intermittent class 0.3, 30 operating cycles per hour and 30% on-load. Thermal overload and unbalanced protection shall be provided for each motor, and their settings shall be compensated for ambient temperature of 40^{o}C;

(l) Cables shall be sized as required for each particular circumstances and the design. Cables for intermittent duty shall have a minimum one-hour rating to ISO 4301-1;

(m) Miniature circuit-breakers shall comply with IEC 60947-2:2009. Triple pole MCBs shall be integral units and shall not be comprised of three single phase units mechanically strapped together; and

(n) Fuse switchgear and isolators shall comply with IEC 60947-3:2008. Fuses and fuse holders for short circuit protection shall be high breaking capacity (HBC) fuses to BS 88:1998. Indicating lamp units shall have a degree of protection of IP 54 to IEC 60529:2001. Push button units and limit switches shall have a degree of protection of IP65 to IEC 60529:2001.

C3.3.2 Hoist

C3.3.2.1 General

The hoist shall be to BS EN 13157:2004 or equivalent. The frame of the hoist shall maintain alignment under all expected conditions of service. The reduction gear shall be incorporated inside the hoist unit. The casing shall be strong and rigid. It shall be sealed for protection against dust and dirt.

All gears sprockets and shafts shall be of strength commensurate with the working load and shall be mounted on anti-friction bearings and sealed against ingress of dirt/moisture or leakage of oil. Adequate facilities for lubrication shall be provided, unless equipment with lifelong lubrication is used. All suspension fittings shall be detachable without damage for inspection.

The load chain shall pass through close-tolerance guide to minimise wear. Slack chain collecting bag to hold all the length of slack chain shall be provided for all hoists. The hook shall comply with EN 1677-5:2001 complete with safety catch. Top hooks if required to swivel shall be fitted with plain bearings, bottom swivel hook shall be free to rotate under load. The hook shall be tested to 150% full load before assembly.

C3.3.2.2 Safety Facilities

The automatic safe load indicator shall be as indicated in Clause 3.3.1.6(b)

Manual chain hoist shall be equipped with automatic cam-operated brake to arrest and sustain any load up to and including the test load at any position of lift when the hand chain effort is released and to permit smooth controlled lowering of all working loads without serious overheating. It shall be fabricated to the length required in this application with no unauthorized alterations.

For electrically operated hoist, the motor and other electrical components shall comply with Clauses 3.3.1.9(a) to 3.3.1.9(n). The brake shall comply with Clause 3.3.1.3(a) The pendant control shall comply with Clause 3.3.1.8(c) where applicable. Limit switches shall also be provided for limiting the travel of trolley when it approaches to stoppers at both ends of I beam.

C3.3.2.3 Trolley

The travelling trolley shall be of normal headroom type unless otherwise specified in the design. The 2-speed electric travel shall be achieved by gear chain system. The manually operated travelling trolley shall either be hand-geared on hand-pushed type as specified in the design. The trolley shall be maintenance free and run on steel runner wheels. The wheels shall be fitted with precision anti-friction ball bearings, pre-lubricated for life, to absorb both radial and thrust loads. Trolley shall be suitable for mounting onto the Rolled Steel Joist (RSJ) provided by others.

C3.4 EQUIPMENT AND MATERIAL

C3.4.1 Crane

The end carriages shall be fabricated from rolled steel plate.

High tensile bolts and tapered washers etc. shall be used to secure the beams onto the steel brackets or re-enforced concrete corbel provided by the builder.

The hoist drum shall be manufactured from heavy duty, seamless steel tube supported on high quality anti-friction journals fitted into the main frame side plates.

All gears shall be heat treated for maximum wear and fracture resistance. All gears shall be machine cut and of hardened steel.

All brake linings shall be asbestos free.

Coils shall be vacuum impregnated with a non-hygroscopic insulating varnish or shall be epoxy resin encapsulated.

The hook shall be made of forged steel to EN 1677-5:2001.

The steel plating of the working platform shall not be less than 6.5 mm thick and not less than 600 mm wide.

The labels of the pendant controls shall either be engraved and filled with white paint or be of sandwich type plastic laminate such as trafrolyte with black lettering on a white background.

The control cubicle for a crane shall be fabricated of sheet steel of minimum thickness 2 mm. Cubicle doors shall be fixed with chromium plated or stainless steel knurled nuts of minimum dia. 16 mm.

Motor bearings shall be of ball or roller type.

Cables shall be sized as required for each particular circumstances and the design. Minimum cross-sectional areas of conductors shall be 2.5 mm^2 for power cables and 1.5 mm^2 for control cables.

C3.4.2 Hoist

The casing shall be of high tensile aluminium alloy lightweight. The hook shall be made of forged steel to EN 1677-5:2001.

For manual operated chain hoist, the hand chain shall be of mild steel to BS 6405:1984.

C3.4.3 Trolley

The trolley shall have a minimum of four ball bearings, single flange runner wheels. Couplings and shafts shall be of high quality steel and suitably heat-treated. The trolley structure shall be of folded steel plate construction and welded throughout.

C3.5 ERECTION AND INSTALLATION

C3.5.1 Crane

The crane shall be erected and installed in accordance with BS EN 13001-1:2004 and BS EN 13001-2:2004 and the electrically operated cranes shall also be in accordance with ISO 4301-1:1986.

The high tensile bolts and tapered washers etc. shall be supplied to the builder for installation of the bolts into the reinforced concrete corbel. The gantry rails shall be supplied, installed and secured onto the steel brackets or reinforced concrete corbel provided by the builder with spans as shown in the Drawings.

Wire rope and its tensioner shall be cleaned before the grease is applied.

The constructional and testing requirements for this automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gears) Regulations and BS 7262:1990.

Electrical connections between crane platform and the cross travel hoist assembly shall be with insulated flexible cables on rail-runners. The crane structures, motor frames and metal cases of all electrical equipment shall be effectively bonded to earth.

The control pendent shall be suspended from a stainless steel wire to prevent any strain on the supply/control cable at a height suitable for operation from the ground level. If this straining wire is integral with the cable, the wire must be terminated in a crimped-on ring terminal rigidly fixed at both ends such that the weight of the pendent is not carried by the conductors of cable at any time. Where remote control pendent is specified, it shall be free to move along the crane girder by the operator but independent of the movement of the hoist unit.

Epoxy resin based paint shall be used for the finish. Doors shall be fitted with gaskets. Each component within the control cubicle shall be identified with an engraved label which shall be fixed directly to or adjacent to the component.

C3.5.2 Hoist/Trolley

Prior to installation of the lifting appliance, the associated structural lifting facilities such I-beam /eyebolt shall be checked to ensure the suitability of lifting assembly in terms of safe working load (SWL) in accordance with Factories and Industrial Undertakings (Lifting Appliances and Lifting Gears) Regulations.

The constructional requirements for the automatic safe load indicator shall conform to the requirements in the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gears) Regulations and BS 7262:1990.

C3.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

Valid test certificates from the manufacturers for the hook and rope shall be submitted to the Architect.

The crane, hoist and the associated structural lifting facilities such as I-beam/eye bolt shall be tested and examined by an approved independent Surveyor. The Contractor is required to obtain the respective certificates in accordance with the Factories and Industrial Undertaking (Lifting Appliances and Lifting Gears) Regulations.

SECTION C4

FUEL SUPPLY SYSTEM

C4.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of fuel supply system with the associated electrical and control system.

C4.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with all relevant statutory regulations, in particular

(a) The Institute of Petroleum Model Code of Safe Practice (Electrical) (IPMCSP);

(b) BASEEFA (British Approvals Services for Electrical Equipment in Flame Atmosphere); and

(c) Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

C4.3 DESIGN

C4.3.1 General

The fuel supply system to plants and appliances shall consist of underground horizontal diesel fuel storage tanks, fuel transfer pumps, daily fuel tanks, the associated pipeworks, electrical power, controls and accessories. Bulk storage tanks and transfer pumps may not be required for smaller installations.

The fuel supply system for vehicle refueling shall consist of underground horizontal storage tanks for diesel fuel, jet fuel and/or petrol, fuel transfer pumps, fuel dispensers, the associated pipeworks, electrical power, controls and accessories. Vapour recovery system(s) shall be provided for all petrol storage tanks and dispensers.

The fuel storage and transfer facilities, including layout, etc. shall be designed to the appropriate standards, submitted to, and approved by the Director of Fire Services. All works shall be carried out according to the approved drawings.

C4.3.2 Underground Horizontal Fuel Storage Tank

The construction of the underground fuel storage tank shall comply with EN 12285-1:2003 or other technically equivalent national or international standards.

All joints in the tank shell and dished ends shall comply with BS EN 1011-1 and ISO 2560:2009.

Tank shells shall be made of rings and each ring shall be formed from a single plate or from not more than two plates welded together, rolled into a true circle. No longitudinal weld in any ring shall lie within the bottom third of the tank circumference EN 12285-1:2003. Longitudinal seam welds in adjoining rings of plate shall be staggered from one another by a minimum of 45 degrees. Joints or seams shall not be placed in the positions of the cradles. All openings in the tank shall be located clear of the welding seams.

An end plate shall be made up from two smaller plates and the welded joint between which shall be horizontal and above the centre of the tank.

The internal surfaces of the tank shall be smooth and free from any obstruction apart from essential pipe connections. No internal bracing or gusset plate shall be permitted inside the tank.

Tank-hole covers and all flanges and pads associated with each manhole cover shall be provided and completed with bolts, washers and joint rings.

C4.3.3 Daily Service Fuel Tank

The daily service fuel tank shall be fitted with the following standard accessories:

(a) A tapped filling socket connection on the top of the tank completed with all the necessary fittings and union coupling for connection to the filling pipe;

(b) A tapped overflow socket connection close to the top and on the side of the tank completed with all the necessary fittings and union coupling for connection to the overflow pipe or plugged with a brass screw cap if it is not used;

(c) A tapped outlet socket connection close to the bottom and on the side of strainers, and union coupling for connection to the delivery pipe strainer must be submitted for approval before installation;

(d) A tapped drain socket connection at the bottom of the tank completed with all necessary fittings and connected a 20 mm gate valve with plugs;

(e) A tapped return socket connection on the top of the tank completed with all the necessary fittings and union coupling for the connection to the return pipe; or plugged with a brass screw cap if it is not used;

(f) A tapped vent socket connection on the top of the tank completed with all the necessary fittings and union coupling for the connection to the vent pipe;

(g) One quick closing valve installed on the delivery pipe completed with all necessary linkage for operation from outside of the building. If steel wire and pulleys are used, the wire must be properly adjusted in length and protected; and the pulleys must be securely anchored; and

(h) The tank shall be fitted with an approved content gauge unit. An accurate measuring device shall be provided as may be deemed necessary for the calibration of the content gauge together with a supporting stand which shall be fabricated form angle iron complete with strut and tie members. They shall be designed in such a way that it will be possible to remove the tank without first lifting it. A mild steel oil drip tray welded to the angle bracket or stand shall also be included. Exact height of the frame shall be determined to suit site requirement.

C4.3.4 Fuel Transfer Pumping System

The fuel transfer pumping system shall have rotary fuel transfer pumps completed with all necessary accessories including strainers, check valves, gate valves etc.

Each fuel transfer pump shall deliver the maximum design capacity of 'light' diesel/jet fuel at 300 kPa at a speed of 950 rpm. For each pair of pumps a manual switch shall be provided to select the pump running mode as 'duty' or 'standby' respectively.

A composite pump control cubicle in the pump room incorporating the starters, safety and protection devices, all necessary wiring work, relays, fuel level control and alarm, push button and indication lights shall be provided.

The pump shall have a manual/auto/off switch with connections for remote start/stop operation by the level switch at the daily service tank. The duty pump shall be actuated when the fuel level in the daily service tank fall below 30% of the tank capacity, cut off automatically when the tank is 90% full. The pumps shall also be inoperative when the fuel level in the underground storage tank falls below a pre-set level.

Audible alarm shall be given off under the following conditions:

(a) underground storage tank fuel level low; and

(b) pump fail to start.

The following controls and indicator lights shall be incorporated on the control cubicle:

(a) A suitably rated main supply door-interlocked isolator with 'Supply On' indicator light;

(b) An 'Automatic/Off/Manual' selector switch;

(c) Push button manual 'start/stop' of each of the pump set, and the corresponding indicator lights;

(d) Indicator lights showing 'pump running';

(e) Selector switch to select duty pump;

(f) Clean contacts for connection to CCMS for the status monitoring of the pumps; and

(g) Engraved labels in both English and Chinese for all control operations shall be incorporated on the composite control cubicle.

C4.3.5 Vapour Recovery System

(a) A vapour recovery system shall be provided for the petrol storage, transfer and dispensing system in accordance with the Drawings. The vapour recovery system shall be designed, supplied, installed and tested in full compliance with the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation and other relevant regulations.

The following definitions are only applicable to Clause C4.6:

(i) 'Competent examiner' means a registered professional engineer in the building services, gas, chemical, environmental, marine and naval architecture or mechanical discipline under the Engineers Registration Ordinance (Cap. 409);

(ii) 'Pressure/vacuum valve' means a dual valve with pressure settings in accordance with the manufacturer's specifications, and which allows relatively small pressure increases or decreases to occur within a petrol storage tank or pipe to which it is connected without allowing vapour venting to the atmosphere or air in-breathing into the tank or pipe; and

(iii) 'Vapour recovery system' means a system by which petrol vapour displaced from a petrol storage tank receiving petrol is recovered in the petrol tank from which petrol is being unloaded**.**

C4.4 EQUIPMENT AND MATERIAL

C4.4.1 Daily Service Fuel Tank

The daily service fuel tank shall be fabricated from mild steel plate welded onto a mild steel frame. To stiffen the tank, mild steel flat bars are to be intermittently welded on the inside of the tank. The mild steel plates shall be to Schedule 42 while the mild steel frame and flat bars shall be to ISO 657:2000.

C4.4.2 Fuel Transfer Pumps

The fuel transfer pumps shall be of the positive displacement type, with high quality cast iron body, high tensile steel shafts and built in internal relief valve.

The coupling motor shall be flame proof with no volt release and with overload protection.

C4.4.3 Control Equipment

The cubicle shall be of the wall-mounted type, type of protection EEx d flameproof enclosures for operation in Zone 1 hazardous area as classified in IPMCSP and IP 65 enclosure to IEC 60529:2001. The drawings and the official certificate issued by BASEEFA or equivalent certification body of the cubicle shall be submitted.

C4.4.4 Level Switches

(a) The level switches shall be manufactured to

(i) IEC 60079 Electrical Apparatus for Explosive Gas Atmospheres; and

(ii) The Institute of Petroleum Model Code of Safe Practice (Electrical) (IPMCSP).

(b) The level switch shall be of Group IIA and Temperature Class T1 in accordance with IEC 60079-0:2007.

(c) The electrical components of the level switch installed in the vapour space above fuel and inside the fuel tank shall be of the type of protection of EEx ia which is suitable for installation in Zone 0 Hazardous Area as classified in IPMCSP.

(d) The electrical components of the level switch installed outside of the fuel tank shall be at least of the following type of protection suitable for installation in Zone 1 Hazardous Area as Classified in IPMCSP:

(i) EEx ib

(ii) EEx d

(iii) EEx P

(e) Unless otherwise stated, the level switch (in general accompanied with a controller) shall be capable to control on/off operation of a remote system when a preset level of the fuel in the storage tank is reached. Details of the operation and the exact control level settings shall be as stated in the Particular Specification. The level switch shall be suitable for on-site calibration of the level settings.

(f) The level switch shall consist of two major components - a level sensor and a switch unit, both of which shall meet the classification as specified in Clauses C4.4.4(c) and C4.4.4(d) Where applicable, the level switch shall be accompanied with a controller to perform the function as stated in Clause C4.4.4(e).

(g) The level sensing element shall be installed in a stainless steel tube and placed inside the fuel storage tank. It shall be mounted horizontally or vertically depending on the principle of operation.

(h) The switch unit shall be mounted on the tank and with the level sensor to form an integral set. The unit shall be housed inside a casing made of cast iron or aluminium alloy. It shall be capable of detecting the signal from the sensor and transmitting it (in general through a controller) to control the on/off operation of a remote system.

(i) A copy of certificate to prove the apparatus rating shall be submitted. Certificate issued by authorities other than BASEEFA shall be furnished with details of relevant standard.

C4.4.5 Fuel Dispensing Unit

The dispensing unit shall be of a type approved by F.S.D. The dispensing pumps shall be integral units, non-computing, suitable for dispensing petrol and diesel oil and complete with:

(a) 0.4 kW 220V single phase 2-hour rated flame proof motor, tropicalised winding, suitable for ambient conditions;

(b) Rotary vane type pump unit delivering an output of not less than 50 litres per minute;

(c) Positive displacement type piston meter complete with air release valve and drain line eliminator;

(d) Housing - completely of stainless steel with exception of lower front and rear panels, which shall be of a glossy high-baked enamel;

(e) 10-micron filter with extra large surfaces;

(f) Motor switch shall be a mechanical operating switch that turns on the pump motor and control the flow of fuel oil, shall be built in the handle of the nozzle;

(g) Emergency hand drive;

(h) 4 metres gasoline resistant, rubber anti-static hose and complete with rigid tube control nozzle;

(i) Flexible connector;

(j) A filter in the inlet of the dispensing unit;

(k) Air separator, air release valve and all necessary control;

(l) Finishing colour to be in Brunswick Green to colour reference number 227 specified in BS 381C:1996 unless otherwise specified;

(m) Sight glass, complete with full and uniform dial illumination, light switch shall be inside housing;

(n) An emergency shut-off valve installed in the fuel supply line at the base of each dispensing unit to automatically close the supply in the event of severe impact or fire exposure;

(o) A breakaway connector at the dispensing hose nozzle to stop flow of fuel in the event of the vehicle moving while the nozzle remains in the filling pipe;

(p) The display of the fuel dispenser shall be of the LCD crystal type. All characters on the display shall be clearly and readily readable during day and night times. The height of character shall not be less than 19mm;

(q) The display shall contain 6-digit of volume (in litres), 5-digit for amount, 4-digit for unit price, 8-digit for totalizer and a 8-digit mechanical totalizer for volume for backup;

(r) The dispenser shall contain an electronic computer unit with self-diagnostics feature. The dispenser shall be able to upgrade with communication between fuel management system in future;

(s) The dispenser shall have a numeric keypad to preset the amount of fuel oil to be dispensed in terms of volume or money.

(t) The pump unit shall be connected to a piston meter in litre measure with accuracy of ±0.25%;

(u) The whole dispenser including the electronic part shall be of the weather-proof type and suitable for use under outdoor conditions;

(v) The Contractor shall also supply and install all necessary conduits, electrical wirings, controls and switches between the electricity supply switch and the dispensing unit including earthing electrodes and protection, if any; and

(w) Petrol dispensing unit used for vehicle refueling has to install vapour recovery system, which shall be of vacuum assisted type with coaxial dispenser hose to comply with the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

C4.4.6 Air/water Meter

The pedestal air/water meter shall comprise an internally illuminated white dial gauge with 0 to 1000 kPa single scale, a pressure regulator, a built-in filter, an 8-meter air hose fitted with a screw-down water dispenser, accessories, and associated pipe work

The finishing colour for the meter shall be in Brunswick Green to colour reference number 227 specified in BS 381C:1996.

C4.4.7 Hand Pump

A semi-rotary double acting hand pump shall be provided for each daily service tank and consist of 25 mm diameter inlet and outlet and a 25 mm diameter flexible oil resistant inlet pipe of adequate length to suit site conditions.

C4.4.8 Pipeworks and Fittings

All pipes up to 80 mm diameter shall conform to ISO 65 heavy quality and pipes 80 mm diameter and above with BS 1600:1991 or other technically equivalent national or international standards.

Flanges shall be of the slip-on-welding type in accordance with ISO 7005:1992 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1:1999.

All screwed joints shall be cleaned, threaded and pulled up tightly. All jointing materials shall be resistant to the type of fuel to be conveyed. Gaskets made of rubber or compressed asbestos fibre shall not be used.

Square elbows shall not be used. Where practicable, long sweep bends shall be used in preference to round elbows.

Valves shall be of the 'full way' type to allow free flow of fuel. A sample valve shall be submitted to the Architect for approval before installation. Valves shall be made of bronze or cast steel.

C4.5 ERECTION AND INSTALLATION

C4.5.1 Underground Horizontal Fuel Storage Tank

(a) After the construction of the underground fuel storage tank has been completed, it shall be thoroughly cleaned and all loose debris removed. It shall than be tested hydraulically at a pressure of 70 kPa, measured at the top of the tank. The pressure shall be maintained for a period of 2 hours to ensure that the tank is sound and shows no leaks or undue distortion. The test shall be carried out in the presence of and to the satisfaction of the Architect;

(b) The pressure gauge employed for the test shall be tested and calibrated by approved laboratory before use. Pressure gauge with full-scale deflection readings more than 3 times the test pressure shall not be used;

(c) Immediately after hydraulic test of the tank, the tank shall be drained and dried out it and a thick coat of linseed oil shall be applied on the interior surfaces of the tank to prevent rusting;

(d) All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust free and dry surface. The painting procedures shall comply with ISO 12944:1998. The condition of the painting shall be checked after installation and repaired as required;

(e) The tank shall be calibrated after it has been installed in the tank chamber, by dipstick. The measuring device shall be calibrated;

(f) The dipstick shall be made from 20 mm diameter brass pipe. When the tank has been calibrated, the dipstick shall be marked on all faces by clearly scribed lines of 100 litres intervals for the tanks up to 10000 litres in capacity and of 250 litres interval for those above 10000 litres, and have the volume in figures stamped on two opposite faces at interval of 1000 litres;

(g) After calibration, the tank shall be thoroughly dried and applied with a thick coat of linseed oil on the interior surface to prevent rusting; and

(h) The results of calibration shall be tabulated and submitted for record purpose.

C4.5.2 Pipeworks and Fittings

(a) Particular care shall be taken to ensure that all pipes and fittings are carefully reamed to ensure that the full bore of the pipe is maintained and where necessary cleaned out before erection; and

(b) Round piping supports and anchors as necessary shall be suitably placed to the instruction of the Architect, in order to provide rigidity to reduce stresses due to unstable ground.

C4.5.3 Protection of Buried Pipe

The procedures for protection of the buried pipes shall be as follows:

(a) Clean the outer surface of the pipe to remove all rust, mill scale, grease and other foreign matters to achieve a rust free and dry surface;

(b) Apply one layer of Denso Paste or approved equivalent as primer to give a thin continuous coating over the area to be protected;

(c) Apply Denso Tape or approved equivalent spiral on the pipe with minimum of 55% overlap. Care shall be taken to ensure the tape is in contact with the underlying surface of the pipe and to smooth out any wrinkles or air pockets; and

(d) Apply Densopol 60 Tape or approved equivalent on the pipe with minimum of 55% overlap as an outerwrap.

C4.5.4 Painting of Pipeworks

All pipeworks, other than the buried pipes, shall be painted according to requirement in Clause B3.4.

C4.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

(a) A competent examiner shall be employed by the Contractor to test and examine the storage tanks, pipeworks and the vapour recovery system upon the completion of the installation and before the system is put into use for the first time.

(b) The vapour recovery system shall be tested by the competent examiner in accordance with the test requirements specified in Schedules 1, 2 and 3 of the Air Pollution Control (Petrol Filling Stations) (Vapour Recovery) Regulation.

(c) The medium of test for the vapour recovery system shall be nitrogen as specified in Schedule 2 of the Regulation.

(d) After satisfactory completion of the tests, certificates in a form specified by the Authority duly signed by the competent examiner shall be submitted to the Architect.

(e) A test certificate and a certified true copy of the drawings of the vapour recovery system installed to the petrol filling station shall be delivered to the Authority for registration. The drawings shall clearly indicate, but not be limited to the following: the locations and sizes of the inlets, vents, pressure/vacuum valves, safety valves and petrol storage tanks.

(f) The endorsed certificate of the vapour recovery system shall be issued to the Architect within 14 days after receipt from the Authority.

(g) The certificate with suitable protection shall be displayed at a conspicuous location in the petrol filling station.

(h) The Contractor shall be responsible for taking all possible safety measures before and during the test with particular attention to be paid, but not limited, to the following:

(i) The work area shall be blockaded;

(ii) All the identifiable sources of ignition, including electrical power to electrical devices associated with vacuum-assisted systems, if installed, shall be eliminated;

(iii) The pressure/vacuum valves serving the petrol storage tanks shall be working properly before commencement of the test;

(iv) The pressure relief valve to be used in the test shall be checked to be working properly before commencement of the test; and

(v) All the connection and fittings shall be checked and secured properly.

SECTION C5

GARAGE EQUIPMENT

C5.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of the garage equipment as specified in the following clauses.

C5.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with the relevant Regulatory Requirements as stipulated in Section A2.1.

C5.3 DESIGN

The garage equipment shall be designed to provide a fast, safe and accurate operation. If faults are indicated they shall provide information to assist the operator to locate the sources of trouble in the shortest possible time.

The design of all garage equipment shall be in accordance with the current international standards.

C5.3.1 High Pressure Grease Pump, Grease Storage Drum with Adjustable Drum Lid and Cabinet Grease Hose Reel with Manometer

C5.3.1.1 High Pressure Grease Pump

The high pressure grease pump shall be pneumatically operated, suitable for a maximum operating air pressure of 1000 kPa. The grease pump shall be equipped with a screen filter at the grease inlet, a 1.5 m steel braided rubber delivery hose with terminating unions, a 1.5 m flexible nylon hose with taper insert and quick fix coupler, a 1 m suction tube, a lifting eye bolt and an adjustable drum lid.

(a) Adjustable Drum Lid

The drum lid shall be adjustable and suitable for a 180 kg grease drum. It shall be completed with a tank mounting plate on which the high pressure grease pump can be mounted.

C5.3.1.2 Cabinet Grease Hose Reel

The cabinet grease hose reel shall be a self-contained unit comprising the followings:

(a) 6 mm. dia. 34 MPa (min.) delivery hose of not less than 9 m. in length;

(b) a control valve completed with a built-in manometer and a nozzle for dispensing grease under high pressure;

(c) a swivel coupler for universal pivoting between the control valve and its hose; and

(d) a wall mounting plate.

C5.3.2 Low Pressure Oil Pump and Cabinet Hose Reel with Manometer

C5.3.2.1 Low Pressure Oil Pump

The oil pump shall be of the air operated low pressure type suitable for a maximum operating air pressure of 1000 kPa. It shall be suitable for handling lubricating oils. In particular, it shall be fitted with the followings:

(a) sufficient length of nylon delivery hose with end fittings;

(b) sufficient length of flexible nylon air hose with taper insert and quick fix coupler;

(c) a rise tube suitable for the oil tanks stated in section C5.3.3;

(d) float valve assembly to prevent entry of air into the system;

(e) a mounting plate and the associated accessories; and

(f) a lifting eyebolt.

C5.3.2.2 Cabinet Hose Reel

The cabinet hose reel for lubricating oil and water shall be a self-contained unit comprising the followings:

(a) For lubricating oil, 10 mm dia. 20 MPa (min.) delivery hose of not less than 9 m in length; for water, 6 mm dia. 2000 kPa (min.) delivery hose of not less than 9 m in length;

(b) a manometer/hose-end meter;

(c) a trigger controlled inlet valve capable of locking in open position; and

(d) a wall mounting plate.

C5.3.3 Lubrication Oil Tank

The lubrication oil tank containing 4 separate compartments of capacities 2 x 750 and 2 x 250 litres shall be fabricated from mild steel. Each compartment shall be provided with a suitable handhole for cleaning tank interior, a filling port with a water-tight-cap, a weatherproof air breather and a removable lid with suitable accessories for mounting the L.P. oil pump. Painting of the lubrication oil tank shall be in accordance with Section B3.4.

C5.3.4 Waste oil System

C5.3.4.1 Waste Oil Tank

The design of the underground waste oil tank shall be in accordance with Section C4 'Fuel Supply System' in this General Specification.

C5.3.4.2 Waste Oil Transfer Pump

The rotary oil transfer pump shall be completed with all necessary accessories including a simplex suction strainer, a check valve, a gate valve and a starter.

The pump shall be of the positive displacement type, with high quality cast iron body, high tensile steel shaft and built in internal relief valve. It shall be capable of delivering 250 1/min of lubricating oil at 350 kPa.

The coupling motor shall be of the flameproof type completed with no volt release and with overload protection.

C5.3.4.3 Waste Oil Trolley

A waste oil trolley, funnel and the associated pipe work which will carry the waste oil from servicing vehicle to the underground waste oil tank shall be provided.

The trolley shall be of metal structure, with supporting wheels resting on the edge of the inspection pit. It shall be installed such as not to obstruct the free movement of the servicing vehicle above the inspection pit.

C5.3.5 Tyre Shop Equipment

C5.3.5.1 Tyre Inflator with Gauge

The tyre inflator shall be of the wall mounted type suitable for inflating tyre automatically to preset pressure. It shall comprise an internally illuminated easy-to-read white dial with 0 to 1000 kPa adjustable single scale, a built-in air filter, a built-in hose reel completed with a 15 mm diameter bore x 8 metre air hose, a twin hold-on connector and all wall mounting accessories. The hose reel shall be self-retracting so that when the pull on the hose is released, the hose will rewind automatically.

C5.3.5.2 Safety Cage

A safety cage shall be provided for truck tyre inflation. It shall be made of tubular steel welded to a steel base with dimensions as specified in the Particular Specification and shall withstand great exploding force. The Contractor is required to submit details and relevant drawings for the safety cage and approval from Architect must be obtained before fabrication.

C5.3.5.3 Truck Tyre Remover

The tyre remover shall be of the electro-hydraulic type completed with bead lifting lever, ring removing lever and clamp pliers suitable for fast and safe operation on tubeless and ring wheels with a maximum diameter of 9.150 mm.

The mounting, demounting and bead-breaking tools shall be located in a revolving turret. The clamping head shall be of the hydraulically operated self-centering type capable of clamping all kinds of rims from 356 mm to 635 mm both on centre hole and rim inside.

The equipment shall be able to run on 220/380V. 1-ph./3-ph. 50 Hz supply and completed with pedal control to give operator maximum working freedom.

C5.3.5.4 Water Tank

A suitably sized water tank for detecting air leak from the inflated tyre shall be provided at a location where the tyre remover can be worked on conveniently.

C5.3.5.5 Vulcanizer

The vulcanizer shall be of the bench mounted type capable of repairing any type of tube. It shall be suitable for 220V single phase 50 Hz AC supply.

Basically, it shall comprise a manual quick clamping device and a suitably rated heating unit completed with an adjustable timer. The clamping device shall be designed to exert a constant pressure on the tube during operation. The heating unit shall provide an operating temperature of not less than 140^{o}C.

C5.3.5.6 Wheel Balancer

The wheel balancer shall be capable of detecting the vibration of an unbalance or non-concentric rotating wheel with a maximum weight of up to 200 kg, and a maximum tyre width of 500 mm.

The wheel balancer shall be operated with 380 volts 3-phase, 50 Hz AC supply and equipped with a 350 mm video display unit which shall indicate the magnitude and location of the counter weight required to balance the unbalance wheel.

The balancer shall be incorporated with pneumatic lift, drum brake and other operation accessories such as cone adaptor for various central holes of wheel, lockring etc. for fixing the testing wheel onto the balancer shaft.

C5.3.6 Battery Room Equipment

C5.3.6.1 Battery Charger

The bench mounted type battery charger shall comprise two independent circuits capable of charging two banks of batteries at different rates.

The battery charger shall be induced air cooling and complete with the followings:

(a) Ammeter for charging current;

(b) Normal rate / High rate charging selector switch;

(c) Selector for 6V, 12V or 24V batteries;

(d) Timer for high rate charging;

(e) Solid-state diode assembly;

(f) Overload protection with re-set; and

(g) Polarity protection.

The charger shall operate on 220V, single phase, 50 Hz AC supply. It shall be capable of charging 6 batteries of 24V connected in series with a maximum charging time of 7 hours.

C5.3.6.2 Busbar System

The busbar system for each battery charging circuit shall include independent base plate, side plates and copper rods.

The base plate shall be made of high insulating 'Bakelite' sheet of 5 mm thick. It shall be fixed to the bench top wall using long galvanised bolts holding the base plates at both sides.

The busbar supports shall be constructed of 40 mm square hardwood coated with insulating varnish supporting the two copper rods as shown in the Drawings. Two pieces of 9 mm diameter copper rod shall be provided for each busbar system. Connection and/or provisions for connections between the battery chargers and the cells and between the chargers and the busbars, where appropriate, shall be provided and made in accordance with the relevant standards.

C5.3.6.3 Water Distiller

The water distiller shall be of the storage type and be fully automatic in operation. It shall comprise electric heating element, boiling vessel, distillate storage vessel, safety valve and the associated controls.

The heating element shall be cut-out automatically to protect against overheating and low water level condition. The element together with the cooling water supply shall also be cut-out when the distillate storage vessel is full and cut-in automatically when the distillate has been taken.

The distiller shall have an output of not less than 4 litre/hour. Water supply to the distiller shall be from a ball-valve operated header tank of 200 litres capacity fitted with a level gauge, a 'filter' and the associated pipe work.

The distiller and tank assembly shall be suitable for wall mounting with ample clearance beneath it for collecting distilled water.

C5.3.7 Hydraulic Trolley Jack

The hydraulic trolley jack shall be as follows:

(a) The trolley jack shall be capable of lifting a load up to 13,000 kg with a minimum lift of 450 mm;

(b) The jack shall comprise a long handle and a large swivelling crutch for easy and safe positioning. It shall be of such design that it would provide easy and stable jacking close to obstruction;

(c) It shall incorporate both overload and stroke limiting facilities to protect the operators and the equipment itself; and

(d) Positive means of lowering device shall be built into the handle to control the lowering action and to prevent accidental lowering.

C5.3.8 Side Slip Tester

The side slip tester shall be as follows:

(a) The side slip tester shall be used for inspecting the wheel alignment of the vehicle's front steering wheels and shall consist of tread plates and a lateral slip amount detecting device;

(b) The side slip test shall be conducted when the front steering wheels of the testing vehicle pass through the side slip tester. The lateral slip detected shall be transmitted to control panel, data processing and storage system;

(c) The test results shall remain visible in the display instrument of the control panel until the instrument is reset automatically or manually;

(d) Maximum per axle loading of the tester is given in the Particular Specification;

(e) Test range of the tester is from IN 10 metre/km to OUT 10 metre/km with a measuring accuracy within ±0.2 metre/km (i.e. ±2%);

(f) The display meter shall be of the digital or analogue display type with a maximum indication for IN and OUT of 10 metre/km; and

(g) The analogue display meter shall have graduation colour as follows:

(i) Lower range - green,
(ii) Middle range - yellow, and
(iii) Upper range – red.

C5.3.9 Roller Brake Tester

C5.3.9.1 Capacity

The brake tester shall be able to measure and calculate the following items:

(a) Front axle weight and braking forces of right and left wheels and percentage of deviation of braking forces;

(b) Rear axle weight and braking forces of right and left wheels and percentage of deviation of braking forces;

(c) Sum of all braking forces divided by the sum of both axle weights; and

(d) The braking efficiency of each wheel.

The technical particulars, such as maximum axle load, wheels width of an axle etc., of the roller brake tester shall be given in the Particular Specification.

The limit of error for the indication of the measured value at any point must be within ±3% of the full scale deflection.

C5.3.9.2 General Design

The brake tester shall be of the roller driven type and shall be suitable for:

(a) Rear drive - rear parking brake vehicles;

(b) Front drive - rear parking brake vehicles; and

(c) Front drive - front parking brake vehicles.

It shall be pit-installed and shall be suitable for testing large passenger carrying and heavy goods vehicles with single and multiple axles of the trailing or tandem driven type without a third differential.

The brake tester shall consist of braking force detecting rollers, a braking force measuring device, an axle weight measuring device and a detecting device which confirms the vehicle entry and departure from the tester.

The brake tester shall include two separate pit units which when bolted together, allow both wheels of an axle to be tested at the same time. Each unit shall consist of a welded

steel frame carrying two rollers which shall have a specially roughened surface for maximum tyre adhesion. A slip sensing/shut off system comprising an additional spring-loaded roller between the two testing rollers shall be provided. The spring-loaded roller shall be rotated by the wheel under test and shall automatically stop the testing rollers to avoid damage to tyre should the wheels under test lock or the vehicle wheels not be correctly located on the rollers. Each set of testing rollers shall be driven by a separate electric motor through a reduction unit. The torque arm pressure on the load cell shall be relayed electrically or hydraulically to the control panel where the operator can read the gauge best suited to the vehicle on test.

C5.3.9.3 Power Drives

One electric motor shall be provided per pair of rollers for nearside and offside wheels. Nominal rating of each motor shall be suitable to drive vehicle with a maximum axle weight as given in the Particular Specification and able to react the applied braking force up to (3 times the axle load in tonnes) kN.

Motors shall be to BS 4999 and shall be protected up to a minimum of IP 44 of IEC 60034-5:2006. Cooling of motor shall be to IEC 60034-6:1991 Class IC0A1 and motor windings insulation shall be Class F to IEC 60085:2007. The roller drive is to be via a gear box to give an equivalent road speed of 2-3 km/hr.

The roller brake tester shall operate on a 380 V 50 Hz 3-phase AC supply. To avoid heavy starting current, suitably rated star-delta starter with overload protection shall be provided.

The roller brake tester shall be suppressed against electro-magnetic interference to BS EN 55014:2006.

Means shall be provided to enable a vehicle to be driven off the machine with the rollers stationary or with the rollers turning in the opposite direction to that used for a brake test (vehicle driving off forwards) or turning in the same direction to that used for a brake test (vehicle reversing off).

C5.3.9.4 Brake Rollers and Roller Surface

The rollers shall be supported in self-aligning sealed for life bearings and shall be able to withstand axle loads up to the capacity as given in the Particular Specification.

The effective width of the rollers shall accommodate all tyre width of vehicles having track widths up to 2,600 mm plus a vehicle misalignment allowance of 150 mm at the ends of each roller. The roller width shall not be less than 900 mm and the outside diameter of the rollers shall not be less than 150 mm.

The protrusion of the brake tester relative to the surface of the test lane shall be protected by safety guard rails.

The roller surface shall provide a minimum coefficient of friction of 0.6 between the road wheeled tyre and the brake roller under both dry and wet conditions. If the rollers are epoxy coated, the gritted surface shall be capable of being resurfaced without the need for special equipment. The design of the roller surface shall be governed by the need for long periods of service without frequent maintenance and attention. For the purpose of this Clause, long periods shall mean a period of not less than 3 years.

C5.3.9.5 Control Panel and Instrumentation

The control panel shall be of the totally enclosed, flush-fronted pattern, having concealed hinges and comprising all necessary instruments specified herein in a multi-layer arrangement.

The instruments shall be so arranged that there is at least 300 mm clearance between floor level and any control, indication or hand operated component.

The control panel shall be floor mounted with all cable access at the bottom of the panel. It shall be robustly constructed on a rigid steel frame and sectionalised to facilitate handling.

The enclosures shall be protected to IP 44 of IEC 60034-5:2006 and be constructed of sheet steel, minimum thickness of 2 mm.

The control panel shall incorporate a complete set of instrumentation (including indicating lamps, push buttons, L&R On/Off, emergency shut off etc.) so that both brakes on an axle can be tested simultaneously and their performance can be directly compared.

The torque arm pressure on the load cell of the brake tester shall be transmitted electrically or hydraulically to the local control panel. The braking force shall be measured and displayed by means of a separate analogue indicator for each pair of rollers. Each indicator shall have low and high scale readings automatically selected to indicate the braking efforts.

The indicators shall be either analogue or digital with readings in kN and can measure up to a maximum of 3 times the axle load. Analogue indicators shall have scale divisions of at least 1/10th of full scale. Point zero for the indicator shall only be set at no load. The indicators on each side of the tester shall be able to operate separately.

A peak hold facility shall be provided to hold the readings until the operator cancels them. A slip warning light shall be provided at the panel for each side. The brake tester shall have provisions for visual indication of individual wheel braking efficiency and of wheel locking whilst under test.

C5.3.9.6 Calibration

The brake tester shall be designed and mounted such that calibration is simple and easily done over the whole range. The means of calibration as well as all other necessary equipment shall be supplied with the brake tester.

C5.3.9.7 Maintenance

The roller brake tester shall be so designed and mounted in its location pit as to enable easy access for regular maintenance of its equipment and the replacement and repair of parts.

C5.3.9.8 Safety Features

The roller brake tester shall incorporate all the necessary safety equipment to ensure that it operates as a safe installation. Safety guard rails and vehicle sensing device (to ensure that the motors cannot be started unless both third rollers are depressed by vehicle wheels) shall be included.

C5.3.9.9 Load Simulator

The load simulator shall work in conjunction with the roller brake tester to apply a known, variable, downward force to the axles of vehicles being tested in the unladen condition.

The equipment shall be capable of simulating an axle load up to the capacity of the roller brake tester as given in the Particular Specification. Loads shall be simulated by two double acting heavy duty hydraulic cylinders which apply load to each side of the vehicle being tested through the medium of nylon straps.

The equipment shall comprise a hydraulic pump with air or electric motor; two double acting hydraulic cylinders; all the associated accessories including hydraulic valves, pressure gauge, hoses etc; and two pairs of nylon straps.

The oil pressure, which in turn determines the simulated axle load, shall be adjustable through a remote control device.

C5.3.9.10 Accessories

The following accessories shall be provided for the installation:

(a) Roller cover plates - to cover rollers when the roller brake tester is not in use.

(b) Safety guard rails - for keeping people away from rollers.

(c) Suitable wheel chocks - to ensure the wheels of vehicle rest on the rollers.

(d) Complete set of calibration equipment (including calibration weights) of the dead weight type - to allow calibration of the brake tester over the whole range.

(e) Simple-to-use calculating disk for the supplied brake tester.

The above are the minimum requirements of the accessories to be provided. The Contractor shall provide any other items that are considered necessary for the complete, safe and satisfactory operation of the brake tester supplied.

C5.3.10 Speedometer Tester/Distance Counter

The speedometer tester/distance counter shall consist of rotation transmitting rollers, a rotation detecting device, a digital display unit and facilities to allow the vehicle to leave the rollers after the test.

The rotation transmitting rollers shall be supported in self-aligning sealed for life bearings and shall be able to withstand axle loads up to the capacity as given in the Particular Specification.

A rotation detecting device shall be installed at the rotation transmitting rollers. It shall generate signal in accordance with the rotating speed detected and the signal shall be transmitted to the digital display unit which shall display the linear speed of the rotating rollers as well as the distance travelled by the rotating rollers for a certain period of time.

The display unit shall be incorporated with the followings:

(a) A 4-digit illuminated display calibrated to measure speed and distance up to 120 km per hr and 9999 metres respectively;

(b) Selector switch for speed and distance measurements;

(c) A timer which shall cut-in and cut-out the distance measuring display for a pre-set period of time; and

(d) Other technical particulars such as maximum per axle load on the rollers, the minimum and maximum acceptable wheel diameter as shown in the Particular Specification.

The rotation transmitting rollers shall also be provided with roller locking device to facilitate testing vehicle leaving the rollers, rollers cover plates, safety guard rails, wheel chocks and any other items which are considered necessary for the complete, safe and satisfactory operation of the speedometer tester and distance counter supplied.

C5.3.11 Diesel Smoke Tester

The diesel smoke tester shall measure the black smoke emitted by diesel engines and shall be of the fully automatic type.

The smoke tester shall consist of a smoke sampling probe which is fixed in the adaptor of the smoke collecting funnel and shall be connected to a smoke meter through a sampling tube with minimum length of five metres.

The smoke collecting funnel shall be capable of being clamped onto the exhaust pipe of the engine running vehicle being tested and such that smoke can be sucked through the sampling probe into the analyzer.

The analyzer shall be of an approved type under the Road Traffic (Construction and Maintenance of Vehicles) Regulations and shall be able to operate from 12 or 24 volts DC and 220 volts AC. The smoke sucked in shall be analyzed by comparing with certain type of standard gas and its hydro-carbon level shall be indicated by an analogue meter scaled in Hartridge units.

Measuring range of the tester shall be between 0 to 99% with an indication accuracy of not exceeding ±5%. Analogue voltage output shall also be available for hard copy record purpose.

C5.3.12 Headlight Tester

The headlight tester shall mainly consist of a system of lens to project the light distribution (light/dark limit) from the headlights and a marked screen to check the inclination of the beam.

The lens of the tester shall be capable of projecting on the screen a picture equivalent to the one which would be obtained on a wall at 10 metres distance. The quality of the pictures should be in conformity with the national regulations.

The screen shall be marked with vertical and horizontal centre lines in such a way that the adjustment of the beam patterns for the following types of headlamp can be checked on all vehicles: headlamps with asymmetrical dipped beams, headlamps with symmetrical dipped beams, fog lamps, headlamps with main beams.

The centre of the screen shall be fitted with photo-electric cell to determine the high intensity zone or 'hot spot' position of the headlamp. The cell shall be connected to a light intensity meter mounted on the tester.

The tester shall be capable of moving on rails traversely in front of the vehicle. It shall be vertically adjustable to measure headlamps with centres between 500 mm and 1200 mm above ground level.

The equipment shall be capable of being accurately aligned with the vehicle. It shall allow small vertical and horizontal adjustment of up to 2^{o} each side of the center. The overall accuracy of the equipment shall be not less than $\pm 0.1^{o}$.

Calibration of the headlight tester shall be simple and easily done. The calibration kit shall be supplied with the tester.

C5.3.13 Joint Play Detector

The joint play detector shall be flush-mounted on the floor and shall be working in conjunction with the rail-mounted pit jack (Clauses C5.3.14(a) to C5.3.14(e)) on inspection pit.

The joint play detector shall apply stress hydraulically or pneumatically to the suspension and steering systems through movable steel plate beneath the vehicle wheels in order to check wear and play in steering linkages, brake plate, spring anchorage points of front and rear axles.

The joint play detector shall be controlled from a low voltage (24V, 50 Hz) control/hand inspection lamp. The inspection lamp shall incorporate a double-acting centre-biased electrical switch on its handle and controlling power to the double acting hydraulically or pneumatically rams that move the plates beneath the wheels.

The plates on either side of the inspection pit shall move in opposite directions during both transverse and longitudinal motions. Forward pushing on the switch shall operate outward transverse motion of the plates, and backward pushing on the same switch shall trigger movement of the two plates forward and backward respectively, imparting a twisting couple on the axle. The inspection lamp shall also be used to light up various areas susceptible to defects.

The joint play detector shall comprise two surface mounting plate units (one on each side of the pit), double-acting pneumatic or hydraulic rams and controls, 220V/24V transformers, low voltage control/hand lamp(s), cable of 5 m long, oil mist lubricators, fuses. The joint play detectors shall be suitable for 220V 50 Hz. single phase AC electrical supply and compressed air at 1000 kPa.

C5.3.14 Pit Jack

(a) The pit jack shall have rollers resting on rails on top of the inspection pit.

(b) They shall be safe, easy-to-operate, fast travel and robust with a carrying capacity for axle load as given in the Particular Specification.

(c) The width of the supporting rollers for the proposed pit jack shall be adjustable and shall match the respective pit width.

(d) The pit jack shall be pneumatic operated with a maximum operating pressure of 1000 kPa. In particular, the pit jack shall comprise the following items:

(i) Compressed air operated hydraulic pumps;

(ii) Two hydraulic cylinders with a minimum lifting height of 300 mm;

(iii) Mechanical locking device on each cylinder to enable the load to be taken off from the hydraulic system for prolonged working periods;

(iv) Built-in relief valve to prevent overloading the cylinders;

(v) Flow control valve to control the descending speed of the cylinders;

(vi) Steel rollers at each end of the frame to support the assembly on the pit edging; and

(vii) Sufficient length of flexible air hose complete with quick fix coupler.

(e) When the hydraulic cylinders are fully retracted, the pit jack shall not obstruct the free movement of the inspection vehicle above the inspection pit.

C5.3.15 Engine Analyzer

C5.3.15.1 General Description

The engine analyzer shall be of micro-computer based design capable of diagnosing engine faults up to a maximum of 8 cylinders. The equipment shall be fitted with printing facility to produce printed record of test results for evaluation.

The analyzer shall be able to test all vehicles in a conventional manner and accept different 'plug in' connection compatible with various manufacturer's timing methods. For this purpose, the timing lead shall be automatically converted to monolithic mode.

The equipment shall be compact and mounted on a sturdy, mobile wheeled cabinet for easy handling and shall be operated on the car battery (i.e. on 12 volts d.c.) of the vehicle under test.

The equipment with appropriate software and accessories shall be capable of diagnosing/analyzing traditional petrol engines and computer based engines, exhaust gas emission level and diesel engine injection timing.

C5.3.15.2 Features

The equipment shall be constructed to meet the following requirements:

(a) Test Sequence

The programmed test sequence shall be incorporated to facilitate the following tests:

(i) The analyzer shall be self tested when switched on and shall prompt the user when self test is completed or prompt the user if fault on the unit is located;

(ii) Fully automatic comprehensive check - the analyzer shall sequentially proceed with all the test items. Printouts shall be produced upon completion of test;

(iii) Semi-automatic measurement - the analyzer shall conduct different groups of test out of automatic mode which shall be selected by pressing coded push button. The test result can be confirmed with the printer; and

(iv) Individual test measurement - specific item of function check shall be manually selected at the time of any specific adjustment. Test result can be confirmed with printer.

The selected measurement mode shall be displayed in the front panel with high brightness digital read out.

(b) Range of Test

The engine analyzer shall be capable of conducting the following tests:

(i) Battery terminal voltage under no load condition

(ii) Battery terminal voltage at starting

(iii) Battery current at starting

(iv) Battery terminal voltage at charging

(v) Engine cranking R.P.M. at starting

(vi) Ignition primary coil voltage

(vii) Engine idling R.P.M.

(viii) Individual dwell angle

(ix) Contact point voltage

(x) Charging current

(xi) Diode test

(xii) Ignition spark voltage

(xiii) Acceleration performance

(xiv) Power balance for individual cylinder

(xv) Ignition timing

(xvi) Emission content analysis for CO, CO2, HC and optional for O2. Calibrating graduation for CO and CO2 shall not be greater than 0.1

(xvii) Pulse length at cranking, idling & acceleration

(xviii) Injection cycle

(xix) Injection voltage

Measurement of exhaust emission content against engine speed shall be made by means of infra-red carbon monoxide analyzer. Results shall be displayed in high brightness digital readout.

C5.3.15.3 Calibration

Engine analyzer shall incorporate a built-in automatic calibration checking device to facilitate quick and accurate adjustment.

C5.3.15.4 Accessories

The engine analyzer shall comprise:

(a) A remote handset which gives a full readout of test results. The handset shall also be able to give command for automatic test procedure; and

(b) A full range of timing adaptors for vehicles equipped with diagnostic plug.

C5.3.16 High Pressure Vehicle Washing Equipment

The high pressure vehicle washing system supplied shall consist of a high pressure washing machine, 30 metre high pressure water hose, retractable hose reel, lance, water pipe work and all accessories.

The washing machines shall be capable to provide a flow rate of not less than 13 litre/minute in a pressure range adjustable from 0 to 9000 kPa by means of pressure regulator.

The pump shall be directly driven by a three phase, 380 Volt, 50 Hz totally enclosed fan-cooled motor with direct on line starter and built-in overload protection. The starter shall be equipped with on/off push buttons.

The machine shall be incorporated with a built-in water tank of minimum capacity of 65 litres in which a ball valve shall be provided for control of the flow of water from a water supply tank. A low level cut-off shall also be built in the water tank to stop the pump when the water level reaches a preset level.

The washing system shall be suitable for operation with addition of detergent. A detergent tank of minimum capacity of 8 litres shall be provided. Control of the detergent shall be made by means of a control valve in the machine.

The high pressure water pipe work shall have a minimum working pressure of 9000 kPa. 30 metres of suitably sized high pressure water hose completed with washing gun and accessories shall be connected to the water pipe work with suitable couplings. The water hose shall be housed in a wall mounted or floor mounted self-retracting hose reel.

The washing gun shall be of a straight twin lance type of length not less than 1 metre. A trigger shall be built in the handle of the washing gun to control the water flow. A set of four easily changed nozzles of different spray angles of 0^{o}, 15^{o}, and 45^{o} shall be provided.

Upon completion of the installation work, the high pressure water pipe work shall be tested hydraulically to 1.5 times of the working pressure for 30 minutes without undue leaking. The hydraulic test shall be conducted in the presence of the Architect.

C5.3.17 Portable Battery Charger

The battery charger shall be designed for vehicle battery charging and engine starting. The required duty of the battery charger shall be as follows:

(a) output up to 100A for 6 volts and 12 volts batteries;

(b) output up to 60A for 24 volts batteries;

(c) engine starting current up to 600A for 6 volts and 12 volts starters; and

(d) engine starting current up to 300A for 24 volts starter.

The battery charger shall be of the mobile type with a maximum weight of 40 kg. The charger shall be suitable for operating on power input of 220 volt single phase 50 Hz. The battery charger shall comprise the followings:

(a) ammeter showing charging current;

(b) normal rate/high rate charging selector switch;

(c) selector switch for 6 volt, 12 volt and 24 volt batteries;

(d) timer for high rate charging;

(e) overload protection with reset;

(f) polarity protection;

(g) 10 metre a/c power input cable; and

(h) 3 metres leads c/w heavy duty battery clamps with insulated grips and steel spring jaws.

C5.3.18 Cabinet Grease Hose Reel and Cabinet Hose Reel

The reel shall be easy to use, self-retracting and can be held at full or intermediate extension. The hose outlet guide shall be fitted with a steel roller cluster to allow hose withdrawal from any angle and preserve correct alignment for 'winding on' during retraction.

C5.4 EQUIPMENT AND MATERIAL

C5.4.1 Pipes and Fittings

All pipes less than 80 mm diameter shall conform to ISO 65/ BS EN 10255:2004 heavy quality and pipes of 80 mm diameter and above shall be to BS EN 10216-1:2002 and BS EN 10217-1:2002 with dimensions to BS 1600:1991.

Flanges shall be of the slip-on-welding type in accordance with ISO 7005:1992/BS EN 1759:2004 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1:1999/BS 21:1985.

All jointing materials shall be oil resistant for the respective lubricating oil systems. Gaskets made of rubber or compressed asbestos fibre shall not be used.

Square elbows shall not be used, where practicable, long sweep bends shall be used in preference to round elbows.

Valves shall be of 'full way' type to allow free flow of waste oil. A sample valve shall be submitted to the Architect for approval before installation.

C5.4.2 Valves for Compressed Air

The requirements stipulated in Section C8 shall be followed.

C5.4.3 Valves for Water

The requirements stipulated in Section C7 shall be followed.

C5.4.4 Valves for Lubrication Oil

Valves shall be of 'full way' type to allow free flow of lubrication oil and made of bronze.

C5.5 ERECTION AND INSTALLATION

C5.5.1 General

The Contractor shall be fully responsible for the interfacing works between the individual equipment and the builder's works. The particular requirements of each individual equipment shall follow the manufacturers' recommendations.

C5.5.2 Waste Oil Tank

Fabrication, painting, installation, inspection and testing of the waste oil tank shall be in accordance with Clauses C4.5.1(a) to C4.5.1(h) and C4.6(a) of this Specification.

C5.5.3 Pipeworks

Fabrication, painting, installation, inspection and testing of all pipeworks shall be in accordance with Clauses C4.5.2(a) to C4.5.4 and C4.6(a) of this specification.

C5.5.4 Roller Brake Tester

The Contractor shall also be responsible for the installation of all the equipment associated with the brake tester, including the electrical wiring, control console and other accessories mentioned in the Particular Specification.

SECTION C6

GONDOLA

C6.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of gondola installations complete with the associated electrical control wiring and cradle restraint system.

C6.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with all relevant statutory safety requirements stated in Section A2.1,

(a) BS 6037-1:2003 - Code of Practice for the Planning, Design, Installation and Use of Permanently Installed Access Equipment. Suspended Access Equipment;

(b) BS EN 1808:1999 - Safety Requirements on Suspended Access Equipment; and

C6.3 DESIGN

C6.3.1 System Requirements

(a) The gondola system shall be designed to achieve maximum safety and the driving system shall be reliable with minimum risk of tilting the cradle;

(b) Except allowed in Clauses C6.3.1(c) and C6.3.1(d), drum type with single layer cable wiring design shall be adopted to gondola installation for all building height;

(c) Drum type gondola with multi-layer cable wiring design may be considered for building height exceeding 60 m; and

(d) Dual traction hoist type gondola may be considered only for building height not exceeding 30 m where the building shape is irregular and drum type gondola cannot be adopted.

C6.3.2 Hoisting Operation for Gondola Cradle

The gondola cradle shall be capable of being lifted up and lowered down in the following manner to the appropriate levels including the roof for carrying out the required maintenance services on the curtain

walls, windows and other working areas on the building facade.

(a) The vertical movement of the gondola cradle shall be smooth and free from lateral and rotational motions;

(b) At any maintenance level, the gondola cradle shall be held securely. It shall also be possible to carry out luffing operation on the jib arms to permit the gondola cradle to be moved back and forth for contact with the building facade and warrant safe boarding of gondola cradle on the roof inside the parapet; and

(c) Gondola cradle shall be designed for a net safe working load of 250 kg excluding power cables and accessories. The safe working load shall be clearly marked on the cradle at a position approved by the Architect.

C6.3.3 Travelling Operation on Roof

C6.3.3.1 Track type Gondola installation

The requirements for track type gondola installation shall be as follows:

(a) The whole carriage of the gondola system shall be able to travel along the rails on the roof. The travelling system shall be effected through powered wheel drives along the rail nearer to the parapet. Free running rear wheel(s) with self pivoting and self alignment bearings shall be mounted on the carriage and sit on the other rail to take in slight but unavoidable rail misalignment and to ensure smooth corner movement;

(b) The roof carriage shall be able to travel on steel rails on the roof so as to bring the gondola cradle to any maintenance position of the building; and

(c) The travelling wheel shall be powered by either geared motor or hydraulic power pack and secured to the bottom of the carriage. Horizontal side guide wheels shall be installed to ensure the travelling wheels run on the centre of the rail surface and prevent overturning at all times. Each wheel shall be installed with self lubricated bearings. Each drive shall be complete with a brake which is engaged automatically when power is cut. Drive units shall be detachable from the carriage and easily accessible for maintenance or replacement.

C6.3.3.2 Trackless type gondola installation

The requirements for trackless type gondola installation shall be as follows:

(a) Guide rails shall be provided for trackless type gondola installation. The roof carriage shall be capable travelling on the flat roof along the guide rail within the travelling boundary limits;

(b) The roof carriage shall be powered by wheel drives running within boundary limits set by the horizontal guide rail. Free running rear wheel(s) shall be equipped with self pivoting and self alignment bearing mounted on the carriage; and

(c) The travelling wheels shall be equipped with self lubricated bearing and with a braking system which shall be activated automatically in case of power failure.

Electrical motor shall meet the requirements similar to those for the hoisting system as specified in C.6.3.11 whenever applicable.

The wheels shall be designed to withstand the total dynamic load from the gondola system when travelling.

C6.3.4 Slewing Operation of Roof Carriage

The roof carriage shall be able to rotate by $\pm 180^{o}$ and to suit site conditions.

The slewing operation shall be power operated by an electric motor. The roof carriage shall be suitably designed so that it will be clear from any obstruction such as parapet during slewing. It shall be possible to slew the roof carriage at any position along the rail.

C6.3.5 Luffing Operation of Jib Arm

The luffing of the jib arms of the roof carriage shall be power operated.

The outreach of jib arms shall comply with the requirements as specified in the Particular Specification.

It shall be possible for the jib arms to luff to the back of the roof carriage for the safe boarding of personnel from the roof.

The movements of the jib arms shall be synchronised mechanically.

C6.3.6 Operating Speeds

The traversing speed of the roof carriage shall not exceed 20 m/min.

The hoisting and lowering speed shall not exceed 20 m/min.

In luffing operation, the speed of the jib head shall not exceed 20 m/min.

In slewing operation, the linear speed of the cradle shall not exceed 20 m/min.

C6.3.7 Cradle Restraint System

Cradle restraint system shall be designed, supplied and installed for the gondola installation. Otherwise, the cradle restraint system shall be of the wire rope type. Mullion Guide shall be preferred to other cradle restraint system.

C6.3.7.1 Wire Rope Restraint System

The design of the restraint system shall base on a plug-in mechanism. The anchor point forms the male part and the connection socket acts as the female part of the system. The system shall be designed to provide suitable locking facilities to prevent the connection socket from coming loose or falling out. The dimension restriction of the connection socket including baseplate of 100mm (length) x 50 mm (wide) x 8 mm (thickness) and M12 bolts shall be met.

The restraint system shall comprise restraint wires, sliding rings, connection plug/sockets, anchor points and other necessary accessories. The system shall be designed to provide suitable locking facilities to prevent the connection socket from coming loose or falling out.

Each set of restraint wire, sliding ring and connection sockets shall form an entity.

The connection sockets of the restraint system shall be supplied and fixed on the building facade. These connection sockets shall be flush-mounted and recessed into the building facade. The restraint sockets shall be installed at external RC structure or curtain wall with a horizontal distance ranging from 2.3m to 3.0m and a maximum vertical distance of 15m.

The restraint wire shall be designed for a safety working load of 2.4 kN and shall comply with other requirements applicable to the steel wire rope of the hoisting system.

The anchor point and connection socket shall be galvanised for corrosion protection.

The design and installation method (including the precautionary measures) of the restraint system, as well as the related structural calculation of the restraint system, shall be submitted to the Architect for approval before manufacture and installation.

C6.3.8 Cradle

The cradle shall include the following features:

(a) All side boards of the cradle shall be of open mesh of aperture of 25mm x 25mm covering the full height of the cradle;

(b) A solid toeboard of 200 mm height from platform level shall be provided around the cradle;

(c) A trip bar shall be provided under the cradle and across the whole length of the cradle to stop the descent of the cradle when it strikes an obstacle. The trip bar shall be the lowest part of the cradle;

(d) One end of the cradle shall be partitioned off by wire mesh to form a storage space for the power cable where required and a control panel shall be provided inside the cradle;

(e) Suction cup system shall be provided to supplement the cable restraint system to prevent undue lateral movement of the cradle during operation and to hold the gondola cradle close to the curtain wall. Interlock shall be provided to stop the operation of the gondola cradle during the engagement operation at the suction cup onto the wall. The details of the system shall be submitted for approval by the Architect; and

(f) The cradle shall complete with all the necessary accessories for the restraint system.

C6.3.9 Roof Carriage

Where appropriate, ballast weight shall be provided to ensure absolute system stability. The arrangement of drives shall ensure easy maintenance access, and removal without the necessity of dismantling other parts or components as far as possible.

The counterweights shall not be less than 3 times the weight necessary to balance the load on the projecting part of the outrigger when the platform is fully loaded to meet the statutory requirement as stipulated in Factories and Industrial Undertakings (Suspended Working Platform) Regulations.

C6.3.10 Carriage Enclosure

There shall be enough louvres or openings in the carriage enclosure to allow heat dissipation. A lockable door shall be provided for easy access to the manual brake release mechanism.

C6.3.11 Hoisting System for Gondola Installation

C6.3.11.1 General

The hoisting system shall comprise an electric motor driven drum type winch system installed in the roof carriage with fail safe primary and secondary brakes and all the associated wire rope, sheaves and pulleys for hoisting the cradle.

C6.3.11.2 Suspension of Cradle

The cradle shall be suspended by 4 wire ropes. The anchoring position shall be suitably designed such that when one of the wire ropes breaks, the cradle shall remain reasonably stable and the tilting of the cradle shall not cause the material and tools such as water barrel inside the cradle to fall out.

The 4 wire ropes shall pass through the jib arms and wound on the winch drum installed in the roof carriage.

C6.3.11.3 Winch Drum

The winch drum shall be grooved and designed for single layer spooling. A roller pressing the wire rope on the drum or other equivalent device shall be provided to prevent the rope from leaving the drum inadvertently. The end of the wire rope shall be securely fastened onto the drum. Under all operating conditions, the rope anchorage shall be protected by not less than two full dead turns remaining on the drum when the cradle is at its lowest position. The diameter of the drum shall be such that the pitch circle diameter of the rope when wound onto the drum is not less than 23 times the nominal diameter of the wire rope used.

A wire rope spooling device synchronised mechanically with the rotation of the winch drum shall be provided to guide the wire rope positively so that the wire rope is accurately wound and channelled in the grooves.

If wire ropes are wound on more than one winch drum, the rotation of the winch drums shall be synchronised mechanically to ensure that the cradle remains level at all operating positions.

C6.3.11.4 Wire Ropes, Shackles and Pulleys

The factor of safety of each suspension rope shall be not less than 8 based on the maximum rope tension when related to the minimum breaking load of the rope.

The nominal diameter of each wire rope shall be not less than 8 mm.

The strength of rope termination shall be not less than 80% of the minimum breaking load of the rope.

Shackles and end fittings for ropes shall comply with the appropriate British Standards or other International Standard.

The wire ropes shall be properly guided throughout the path of travel. Pulleys shall be provided for all bends. All pulleys shall be fitted with self-lubricated bearings. The diameter of each pulley shall be compatible with the wire rope used. Suitable guidance device shall be provided to prevent the wire rope from slipping off the pulley.

C6.3.11.5 Braking System

The hoisting system shall be complete with a primary brake and a secondary brake. The primary brake shall be:

(a) capable of stopping and sustaining the cradle even when the cradle is overloaded by 25%;

(b) released when electrically energized; and

(c) capable of being released manually in the event of a power failure or emergency. The means of releasing the brake shall ensure its immediate reapplication as soon as the control is released.

The secondary brake shall be mechanically operated independently of the primary brake. It shall be capable of arresting and sustaining the platform if the primary braking system fails and the cradle descents at a velocity of 10% above the rated value.

C6.3.12 Control

C6.3.12.1 Control Panel

One control panel shall be provided in the cradle. One control panel and one pendent controller shall be provided on the roof carriage.

The control panel at the cradle shall be fabricated from stainless steel to IP54 enclosure and complete with a lockable door for front access. The control panel at the roof carriage shall be fabricated from sheet steel to IP54 enclosure and complete with a lockable door for front access.

All contactors, switches, fuses, relays and all other items of equipment necessary for the proper control and operation of the gondola system shall be housed in the control panel. The control voltage shall not exceed 50V.

All control signals between the cradle and roof carriage shall be transmitted via the suspension wire ropes or suitable metal cores incorporated inside the suspension ropes. Separate control cable hanging from the roof carriage will not be accepted.

C6.3.12.2 Control Function in Cradle

It shall be possible to carry out the following control functions using the control panel in the cradle.

(a) Cradle Ascent and Descent -

Dead man type push buttons shall be provided to raise and lower the cradle.

(b) Luffing of Jib Arm -

Dead man type push buttons shall be provided to luff the jib arm in and out.

(c) Cradle Parking -

A dead man type push button shall be provided to by-pass the operation of the trip bar during cradle parking. It shall be possible to lower the cradle down fully until all castors rest on the floor by pressing this push button and the cradle descent push button simultaneously.

(d) Emergency Stop -

A self-latch type emergency stop push button shall be provided to stop all operation of the gondola and activate an audio alarm and visual indication on the roof carriage. The emergency stop push button shall be reset by rotating the push button. The push button shall be in red colour. The emergency stop could be by-passed under maintenance or emergency recovery operations by a key switch housed inside the control panel on the roof carriage.

Such key switch should be operated by a separate key normally kept in the Building Management Office.

(e) Intercommunication between Cradle and Roof Carriage -

An alkaline battery operated telephone suitable for outdoor use shall be provided. The telephone shall be detachable and connected to the control panel via a flexible cord.

C6.3.12.3 Control Function on Roof Carriage

Control Panel

The following control switches and indication lamps shall be provided on the control panel on the roof carriage.

(a) Mains ON/OFF Switch -

A key operated mains ON/OFF switch shall be provided.

(b) Operation Mode Selection Switch -

A key operated operation mode selection switch shall be provided for selecting the position of control from the cradle to the roof carriage and vice versa. However, the emergency stop push buttons and the intercommunication telephone in the cradle and on the roof carriage shall be functionable at all times independent of the position of the operation mode selection switch.

(c) Emergency Stop Push Button -

A self-latch type emergency stop push button shall be provided to stop all operation of the gondola and activate an audio alarm and visual indication. The emergency stop push button shall be reset by rotating the push button. The push button shall be in red colour. The emergency stop could be by-passed by a key switch.

(d) Mains ON Indication Lamp -

A green mains ON indication lamp shall be provided.

(e) Intercommunication between Cradle and Roof -

An alkaline battery operated telephone suitable for outdoor use shall be provided. The telephone shall be detachable and connected to the control panel via a flexible cord.

(f) Alarm

Red indication lamps shall be provided for the indication of each of the following faults:

(i) Hoist motor trips ;

(ii) Emergency stop push button is activated ;

(iii) Cradle is overloaded ; and

(iv) Overspeed occurs.

An audio alarm shall be activated if one or more of the above faults occurs. The alarm and indication lamps shall be reset automatically when the above fault is cleared.

C6.3.12.4 Pendent Controller

A pendent controller connecting the control panel on the roof carriage via a 2 m long cable shall be provided. The pendent controller shall be suitable for outdoor use. A storage space shall be provided on the roof carriage for the controller.

It shall be possible to carry out the following control functions using the pendent controller:

(a) Cradle ascent and descent with same requirements as specified for the cradle in Clause C6.3.12.2(a);

(b) Luffing of jib arm with same requirements as specified for the cradle as specified in Clause C6.3.12.2(b);

(c) Cradle parking with same requirements as specified for the cradle as specified in Clause C6.3.12.2(c);

(d) Emergency stop with same requirements as specified for the cradle as specified in Clause C6.3.12.2(d);

(e) Dead man type push buttons shall be provided to control the roof carriage to travel in both left and right directions; and

(f) Dead man type push buttons shall be provided to control the roof carriage to rotate in both clockwise and anti-clockwise directions.

C6.3.13 Safety Devices and Interlocks

C6.3.13.1 Safety Devices

The following automatically operated safety devices shall be incorporated:

(a) Overload Device -

A mechanical overload device shall stop and sustain the cradle if the cradle is overloaded by 10%.

(b) Primary Brake -

The brake shall be applied automatically when the city mains fail.

(c) Secondary Brake -

The secondary brake shall be applied when the cradle overspeeds by 10%. The brake shall only be reset manually.

(d) Uppermost Travel Limit -

Limit switch shall be provided to stop the ascent of the cradle when it reaches its uppermost travel limit.

(e) Trip Bar -

A trip bar mounted at the bottom of the cradle shall stop the descent of the cradle when it strikes an obstacle. If wire rope restraint system is specified, a trip bar mounted at the top of the cradle shall also be provided to stop the ascent of the cradle if a restraint socket is not detached as required.

(f) Roof Carriage Travel Limit -

Limit switches shall be provided to stop the roof carriage when it reaches its travel limits at the ends of the rail.

(g) Jib Arm Luffing Limit -

Limit switches shall be provided to stop the luffing of the jib arm at its travel limits.

(h) Power Supply Cable Limit

Limit switch shall be provided to stop the travel of the roof carriage to prevent the power supply cable connecting the roof carriage and the power socket on the roof from being pulled beyond its limit.

(i) Slewing Limit -

Limit switches shall be provided to stop the slewing of the roof carriage when the slewing limits are reached.

(j) Anemometer -

An anemometer shall be provided at high level on upper roof for detection of wind speed. In case the current wind speed is exceeding 14m/s, an audio and visual alarm shall be activated to alert the nearby operator.

C6.3.13.2 No power Emergency Descent

Facilities shall be provided in the roof carriage to lower the cradle safely without tilting to its lowest landing level at a controlled speed when the power supply fails or in emergency.

The above facilities shall be accessible through a lockable door or access panel at the sides of the roof carriage. The operation instructions of the no power emergency descent shall be clearly indicated on the roof carriage.

C6.3.13.3 Interlocks

The following interlocks shall be provided for the gondola operation:

(a) Travel of Roof Carriage -

The roof carriage can only travel on the rail when the cradle is at its uppermost position.

(b) Slewing of Roof Carriage -

The roof carriage can only be slewed when the cradle is at its uppermost position.

(c) Direction Control -

All push buttons that control gondola movements in two opposite directions shall be electrically interlocked.

C6.3.14 Electrical Installation

C6.3.14.1 Power Supply

The power cable connecting the carriage to the power socket on roof shall be wound on a cable drum with self-rewinding device or equivalent to ease the rewind of the cable when the carriage is travelling on the roof. The minimum cable length shall be 20 to 30 m subject to the site conditions and approval by the Architect.

The power supply cable connecting the roof carriage and the roof socket outlet and the cable suspended from the roof carriage to the cradle shall be PVC insulated and steel wire armoured to BS 6346:1997. It shall comprise with earthing conductor for connecting the roof carriage and the cradle to earth. All control cables shall be properly labelled with ferrules.

The supply voltage is 380V, 3 phase, 50 Hz. All equipment shall be suitable for use at the supply voltage.

Eye bolt on the wall 500mm beside the power plug for cable fixing sleeve shall be provided. The power plug for the gondola shall be of 3 phase 5 wire type and of enclosure of IP54 and with independent interlocking switches. The plug to the respective gondola system shall be provided.

C6.3.14.2 Electrical Safety Precaution

Protection shall be provided for all electrical parts, motors, cables etc. against accidental or environmental damage. All circuit panels shall be lockable by key.

Motors shall be individually protected against overloads, undervoltage and short circuits.

Provision shall be made to ensure that in the event of the power supply being interrupted on one phase, no damages shall occur to the equipment and no uncontrolled movement shall be possible.

All electrical equipment shall have adequate mechanical strength and shall be adequately protected against mechanical damages and water ingress. Adequate mechanical strength refers to the ability to withstand all

static and dynamic loads under the design operation conditions. In addition, design calculation taking into account of the wind load, building structure and the counterweight etc. should be submitted for our approval. The gondola should be designed against ingress of water due to inclement weather. In addition, the enclosure of power plugs (provided by gondola contractor) and sockets (provided by electrical contractor in general) should have the rating of IP54.

For carriage type system, the termination at the power plug shall be safeguarded against the pulling force of the cable rewinding drum on the roof carriage. Hanging loop or equivalent device for relieving the pulling force shall be provided.

C6.3.14.3 Earthing

All exposed metal parts of the roof carriage and the gondola cradle shall be connected together and earthed in accordance to BS 7671:2008: and BS 7430:1998.

C6.3.14.4 Lightning Protection

All parts of the gondola system shall be designed to have good electrical conductivity and shall comply with BS EN 62305:2006 or other relevant international standards.

All sections including movable sections of the rail tracks shall be bonded together using soft annealed copper strip of 25 x 3 mm or flexible copper strand of 475/0.5 mm diameter. The rail tracks shall be connected to the roof lightning protection conductor using soft annealed copper strip of 25 x 3 mm. All connections shall be of negligible resistance, metal to metal and mechanically sound with non-ferrous nuts, bolts and washers using clamps where necessary.

C6.3.15 Special Requirement for Dual Traction Hoist Type Gondola

The design on the dual traction hoist type gondola installation shall be equipped with but not limited to the following features:

(a) The dual traction hoist system shall consist of two traction systems connected on the same shaft. Each traction system shall consist of two adhesion pulleys located one above the other and each formed by a pressure disc and a driving disc pressed against one another by pre-adjusted heavy duty springs. The wire rope shall travel around each pulley in form of ‘S’ shape and shall be seated on the bottom of the groove so as to eliminate differential traction caused by V-shape grooves;

(b) The traction hoist system shall comply with all other features in this section except for winch drum as stated in Clause C6.3.11.3;

(c) Anti-tiling protection device shall be provided to stop the traction hoists should the inclination of the cradle exceed 5 degrees from the horizontal position. Separate push buttons shall be provided at the control panel such that function of the push button that would cause further titling of the cradle shall be inactivated;

(d) Final upper limit safety device shall be provided to the cradle to cut all the electrical controls of the machine should the upper limit switch fail; and

(e) A slack rope safety device shall be provided to detect the tension of the wire rope and stops further lowering of the hoist should the tension falls.

C6.4 EQUIPMENT AND MATERIAL

C6.4.1 Cradle

The cradle shall be of an integral construction of aluminium framework. The floor shall be made of non-skid aluminium plate suitably constructed to prevent accumulation of water. All side boards of the cradle shall be of open mesh of aperture of 25 mm x 25 mm covering the full height of the cradle.

Protective rubber cushion strips shall be fixed around the cradle at high and low levels and on all protruding parts of the cradle to minimise possible damage resulted from the bumping of the cradle against the curtain wall, window and building facade.

Non-marking soft rubber rollers shall be provided at each side of the cradle facing the curtain wall so that the cradle can travel vertically in close contact with the curtain wall without scratching or damaging the latter.

C6.4.2 Wire Ropes

The suspension ropes shall be of galvanised steel. The construction details of the wire ropes shall comply with C6.3.11.4. Each rope shall be in one continuous length and free from joints or repairs.

C6.4.3 Carriage

The travelling wheels shall be made of steel for track type gondola. For trackless type gondola, an outing coating of composite polyamide or equivalent shall be provided. The wheels shall be powered by either geared motor or hydraulic power pack and secured to the bottom of the carriage. Horizontal side guide wheels shall be installed to ensure the

travelling wheels run on the centre of the rail surface and prevent overturning at all times.

Each wheel shall be installed with self lubricated bearings. Each drive shall be complete with a brake which is engaged automatically when power is cut. Drive units shall be detachable from the carriage and easily accessible for maintenance or replacement.

C6.4.4 Carriage Enclosure

The carriage shall be of a welded assembly and hot dip galvanised with suitable reinforcements to provide a common chassis supporting the cradle hoisting equipment and the carriage drive unit.

The enclosure of the carriage shall be fabricated from 2 mm thick galvanised steel sheet or equivalent with reinforcement as necessary to provide the necessary strength to withstand the windload. It shall be secured to the carriage with galvanised or stainless steel screws. The enclosure shall be of suitable dimensions to allow easy access to the internal parts of the gondola for maintenance purpose.

C6.5 ERECTION AND INSTALLATION

C6.5.1 Installation of Track Rail

The track rail installation for gondola system shall be supported on the concrete plinth and secured by stainless steel foundation bolts. The size of foundation bolt shall not be less than M16.

The track rail fixed onto the supporting the concrete plinth shall be on the same level and in parallel within the tolerance as recommended by the gondola manufacturer. The concrete plinth supporting track rail shall be at intervals between 2m and 3m depending on the wheels loading.

Stainless steel foundation bolts, lock nuts and washers shall be installed by the Builder without damaging the waterproof layer on the roof.

Rubber pad shall be provided between the rail clip and the mild steel plate on the track rail for absorbing vibration.

A minimum of 5mm expansion gap shall be provided along the track rail at a minimum length of 6m to allow thermal expansion. The rail sections shall be joined together using bolted or welded fishplates.

Turning of track rail shall be in easy bending radius in accordance with the gondola manufacturer's recommendation.

C6.5.2 Erection of Gondola

Method statement for delivery and positioning of the gondola onto the roof shall be submitted to the Architect for approval prior to erection.

C6.5.3 Installation of Restraint Socket System

When carrying out drilling for restraint socket installation and other builder's work at the building facade, precautionary measure shall be taken to prevent debris, hand tools and equipment etc. from falling onto the ground so as to avoid danger to human life.

Prior to installation of the restraint system, at least 5 complete sets of restraint system (together with the curtain wall portion) or 10% of the total complete sets of restraint system, whichever is greater, shall be tested in an approved and recognised laboratory in Hong Kong.

The original (and in triplicate) full laboratory load test report shall be submitted to the Architect. The laboratory load test shall show that the restraint system is designed for a safety working load of 2.4kN and complies with all other requirements applicable to the restraint system. All costs involved in the laboratory load testing including provision of official laboratory load test report shall be borne by the Contractor.

C6.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The suspended working platform shall be inspected and tested in accordance with the relevant statutory requirements under the "Factories and Industrial Undertakings (Suspended Working Platform) Regulation where the load tests shall be carried out by a competent examiner immediately after installation.

Functional tests including all safety devices shall subsequently be carried out.

C6.7 PARTICULAR REQUIREMENTS ON OPERATION AND MAINTENANCE

The Contractor shall provide free maintenance of 12 months for the gondola system covered in this part of the Contract from the Date of Substantial Completion. The work shall include both routine maintenance services and emergency call-out services. The Contractor shall provide all resources inclusive of a maintenance gang, equipment, tools, materials and spares necessary for the satisfactory performance of the installation.

C6.7.1 Routine Maintenance

The Contractor shall carry out all preventive maintenance work in accordance with Manufacturer's recommendation to ensure that the gondola system operates safely, economically, free of faults, at the designed capacity and duty and in accordance with good trade practices, recommendations of the equipment manufacturers and statutory requirements. In particular, all maintenance work shall

comply with the requirements of the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation. The requirements specified in the subsequent clauses are the minimum requirements for the routine maintenance service.

C6.7.2 Weekly Check

The Contractor shall carry out visual and physical inspection and test on the state of individual items of the gondola system to find out if there are any items having abnormal wear and tear, malfunction, oil leakage, overheating, corrosion, unusual noise, dislocation, misalignment, visual cracks, overloading, abnormal slackening or elongation, and excessive vibration etc. and to carry out subsequent remedial work such as repair and replacement of defective parts, re-inspection and test to ensure that the gondola system operates effectively and safety. Any defect which has been rectified shall be recorded in the maintenance log book.

Under Section 19(1) of the Factories and Industrial Undertakings (Suspended Working Platform) Regulations, Chapter 59AC, a statement to the effect that it is in safe working order shall be entered into an approved form (Form 1 - Certificate of Weekly Inspections of Suspended Working Platform) by the competent person who shall have substantial training, practical experience and competent to perform the duty. The Form 1 shall be completed immediately 7 days preceding the gondola is put into use.

In particular, the following items shall be carried out.

(a) Inspection of

(i) hoist mechanism, wire ropes and shackles;

(ii) life lines and safety belts;

(iii) power cable and plug;

(iv) braking system;

(v) locking devices; and

(vi) guide rail and toe-board of working platform.

(b) Functional test of

(i) all operational control including emergency stop;

(ii) telephone;

(iii) manual descend facility;

(iv) all limit switches;

(v) fall arrest device if installed;

(vi) braking system; and

(vii) electrical wiring and earthing component.

(c) Lubrication of moving parts

(d) Reconditioning or replacement of rusty parts

(e) General cleaning

C6.7.3 Six-monthly Check

Under Section 19(1) of the Factories and Industrial Undertakings (Suspended Working Platform) Regulations, Chapter 59AC, a through examination on the gondola shall be performed by the Competent Examiner in the immediately preceding 6 months before it is put into use. A certificate in the approved form (Form 2 - Certificate of Thorough Examination of Suspended Working Platform) shall be completed by the Competent Examiner to certify that the gondola system shall be in safe working order.

The Competent Examiner shall be a registered professional engineer registered under the Engineers Registration Ordinance (Cap. 409) within a relevant discipline specified by the Commissioner.

The following functional test items shall be carried out under maximum safe working load:

(a) Operational control including emergency stop;

(b) Manual descend facility;

(c) Limit switches;

(d) Automatic safety devices; and

(e) Braking systems.

The following visual inspection item shall be carried out:

(a) Inspection and adjustment, if necessary, of all brakes;

(b) Re-tightening of all load bearing bolts;

(c) Inspection of rollers and guide pulley are free to rotate; and

(d) Inspection of anchorage system for any corrosion and defect.

C6.7.4 Annual Check

In addition to the items in six monthly check, a load test and a thorough examination on the gondola system shall be performed by the Competent Examiner in the immediately preceding 12 months before it is put into use. A certificate in an approved form (Form 3 - Certificate of Load Test and Thorough Examination of Suspended Working Platform) containing the statement to the effect that the gondola system is in safe working order made by the Competent Examiner shall be obtained.

The following items shall be carried out.

(a) Re-tightening of all roof track anchor bolts;

(b) Overhaul or replacement of worn out parts;

(c) Proof load* for testing on suspended working platform in the gondola shall be 150 percent of the safe working load.

(d) Proof load* for testing on the wire rope shall be at least twice of the safe working load;

(e) Overload* device function test shall be carried out in accordance with the manufacturer's instruction. The amount of the overload used shall be in line with manufacturer's recommendation;

(f) Drop test* shall be carried out at the safe working load on the suspended working platform in order to ensure the automatic safety devices shall be capable of stopping and holding the load on the suspended working platform specified by the manufacturer;

(g) Touching up painting; and

(h) Repair of damaged or worn out galvanized coating of the system including tracks.

* The proof load test, overload device function test and drop test shall be conducted at or near ground or landing level. Before conducting the tests, a thorough examination shall be carried out by the Competent Examiner to ensure that no defective parts, malfunction of devices or loose components are present in the suspended working platform.

C6.7.5 Record of Routing Maintenance

After each check, if the gondola is safe for operation, the Contractor shall submit a copy of Form 1 to the management office of the building for record purpose. If it is necessary to put the gondola out of service for repair, the management office shall be informed immediately. The Contractor shall also inform the Architect of the fault occurred and the expected date on which the gondola can be put back into service. When the repair work is completed and the gondola is safe for operation, the Contractor shall submit Form 1 to the management office and a report to the Architect regarding the cause of the fault and the repair work carried out.

C6.7.6 Stocking of Maintenance Spares for 12-month Free Maintenance

The Contractor shall stock up reasonable quantity of spares to meet the routine and emergency maintenance requirements.

C6.7.7 Emergency Call-out

The Contractor shall provide an emergency call-out service to attend to, immediately, any breakdowns or faults in the system irrespective of the causes of the damage or faults. For causes falling under the Contractor's liability the costs of repairs shall be borne by the Contractor under the scope of this maintenance work.

For other causes, the cost shall be determined in accordance with Clause 56 of the General Conditions of Contract. Where an immediate complete restoration to the failed item is impractical or may cause inordinate disruptions to the operation, the Contractor shall carry out any work necessary to ensure that the system is safe and, where possible, can be operated. The Contractor shall obtain the agreement from the Architect on the work to be carried out and the cost involved before he commences work.

C6.7.8 Staff Requirements

The Contractor shall have enough appropriately qualified staff on standby at all time, to respond to summons for emergency services promptly. The response time shall in no case be longer that one hours. Response time is defined as the period between the placement of a summons for service and the arrival on Site of a full strength repair team with the appropriate tools and necessary spares.

C6.7.9 Call-out Procedures

The Architect shall place a telephone call to an approved telephone number to summon for emergency call-out services. As far as practical, the site conditions, the nature of the faults or damages will be given in the summon. The time such summon is placed will be recorded by the Architect. When the Contractor arrives on Site, the time of arrival, the relevant details of staff and the accompanying equipment and tools, shall be verified by the Architect.

C6.7.10 Claims for Work Done not Falling within Contractor's Liability

The Contractor shall submit his claim for reimbursement to the Architect within one month after the completion of the associated breakdown repair. The claim shall itemise the labour and material costs and with supporting documents in his submission.

C6.7.11 Failure to Respond

If the Contractor fails to respond as prescribed in Clause C6.7.8 above within 4 hours, the Architect may seek alternative service to remedy the fault. Any costs so incurred in connection with breakdown and repair irrespective of whether the Contractor is liable shall be charged to the Contractor or deducted from monies retained for the part of the Contract.

C6.7.12 Record of Service

After each service, the Contractor shall provide a report to the Architect regarding the cause of the fault and the repair work carried out.

SECTION C7

HOT WATER SYSTEM

C7.1 SCOPE OF SECTION

The Section shall cover the design, supply and installation of hot water system complete with the associated pipework and accessories.

C7.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with the relevant regulatory requirements, in particular,

(a) Boilers and Pressure Vessels Ordinance, Chapter 56, and other subsidiary legislation made under the Ordinance;

(b) Code of Practice on Prevention of Legionnaire's Disease, by EMSD; and

(c) Air Pollution Control (Furnaces, Ovens and Chimneys) (Installation and Alteration) Regulations.

C7.3 DESIGN

The hot water system shall comprise a combination of the following equipment depending on the design:

(a) Low pressure hot water boiler;

(b) Semi-storage type water-heated hot water calorifier; and

(c) Non-storage type water-heated hot water calorifier.

C7.3.1 Low Pressure Hot Water Boiler

The hot water boiler shall be constructed to BS 855:1990 for a maximum working pressure of 1000 kPa and tested to 1500 kPa at the manufacturer's works, unless otherwise specified in the Particular Specification. Manufacturer's test certificate in triplicate is required. The boiler shall be of the genuine 3-pass wet back, radiant heat type with a combustion chamber concentric with the horizontal cylindrical shell and complete with a purpose made fully automatic burner. Non-3-pass boilers are not acceptable and reverse flame is counted as one pass only.

An internal water circulator in the form of a guide vane shall be incorporated to provide positive circulation within the boiler, thus ensuring a more uniform temperature gradient within the shell. The hot water boiler shall have a hydraulic resistance compatible to the hot water system. Cradles or footings shall be designed so that no distortion of the boiler shell and footings will take place due to thermal expansion or any static or dynamic loads.

The boiler shall be designed for front tube removal unless otherwise specified, and facilities should be provided for this purpose. Inspection door shall be fitted at the back of each boiler. Swing type back door shall not be provided. The maximum room length available, allowing for fire tube withdrawal from front of boiler, shall be as indicated in the Drawings. Boilers that require a space larger than available in the boiler room for fire tube removal will not be accepted. Connections of 50 mm N.B. or smaller shall be screwed to BS 21:1985 and connections of 65 mm N.B. or larger shall be flanged to BS EN 1092-1:2002, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate.

C7.3.1.1 Boiler Rating

The boiler rating shall be as given in the Particular Specification. The boiler water flow temperature shall not be less than 85^{o}C with the return temperature approximately 15^{o}C below the flow temperature. The overall thermal efficiency of the boiler to BS 845:1987shall not be less than 80% fired by the specified fuel as stated in the Particular Specification over the whole operating range.

C7.3.1.2 Boiler Insulation

The cylindrical boiler shell shall be efficiently insulated with mineral wool mattresses of minimum 50 mm thick wound closely to the shell and enclosed in a galvanised sheet steel casing of sufficient rigidity with suitable top coating. The touch temperature of the boiler anywhere shall not be higher than 60^{o}C. (Climatic temperature being 40^{o}C.)

C7.3.1.3 Boiler Accessories

Each boiler shall be provided with the following accessories suitable for the working pressure and temperatures stated:

(a) Drain valve;

(b) Double safety valve shall be of the enclosed spring type with padlock and discharge pipe;

(c) Altitude/pressure gauge with 100 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working head of the boiler;

(d) Burner thermostat;

(e) Open vent which shall be taken to a point above feed tank sufficient to overcome pump head at that point;

(f) Fully automatic burner and controls;

(g) A drip tray with sand for each oil burner;

(h) Thermometer - with 100 mm diameter dial, and fixed red pointer indicating the normal boiler operating temperature;

(i) Combustion chamber, tubes, flue cleaning tools;

(j) Boiler water sampling valve & fittings;

(k) Boiler controls; and

(l) Fuel oil/gas consumption meters.

All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the boiler. All controls and instrument shall be so chosen that the operating range lies between 40 to 75% of full scale range, calibrated in S.I. Units and accurate to within 5% of the controlling or measuring point.

C7.3.1.4 Boiler Instrumentation

The following instruments shall be mounted on a self-contained central boiler control panel with all necessary connecting pipes, cables and sensing elements associated with the instruments for monitoring boiler performance. Instruments provided shall be suitable for continuous use at their respective operating temperatures and pressures.

(a) Smoke Density Meter - In each boiler flue, between the boiler and the first expansion joint as indicated in the Drawings, a smoke density detector of the approved manufacture shall be fitted to monitor the smoke density leaving each boiler. Appropriate tubes shall be installed diametrically opposed for mounting a light source monitoring unit. Both tubes shall be readily accessible for cleaning. The detector shall be wired in conduit to the smoke density meter on the boiler control panel. A smoke

density meter shall be provided for each boiler together with indication lights and audible alarm. Each meter shall be calibrated to energize a green light when operating at normal smoke density and a red light and audible alarm when smoke density exceeds Ringelmann(s) number 1 to BS 2742:1969 "Notes on the Use of the Ringelmann and Miniature Smoke Charts".

(b) Draught Gauge - Each boiler shall be provided with a draught gauge mounted at a suitable location on the boiler flue for measuring draught at boiler flue outlet.

(c) Percentage Carbon Dioxide Meter - One for each boiler, complete with necessary piping, valves and fittings between water supply point and the meter, and of the thermal-conductivity type for flue gas sampling at each boiler exit shall be provided.

(d) Flue Gas Temperature Indicator - One for each boiler and of the thermal-electric type for indicating the flue gas temperature at each boiler exit shall be provided.

(e) Boiler Water Flow Temperature Indicator - One for each boiler and of the thermo-electric type for measuring the boiler water flow temperature shall be provided.

(f) Boiler Water Return Temperature Indicator - One for each boiler and of thermo-electric type for measuring the boiler return temperature shall be provided.

(g) One ambient temperature indicator.

(h) One quartz clock.

(i) One hot water consumption flow meter.

C7.3.1.5 Boiler Controls

Each boiler shall be equipped with a full set of automatic controls in accordance with the requirements of the Boilers and Pressure Vessels Ordinance of Hong Kong and the following protection controls:

(a) Automatic Low Water Level Cut-out - It shall be set to cut off the burner fuel supply when the boiler water level drops below the heating surfaces of the fire tubes and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(b) Over-temperature Protection Thermostat - It shall be set to cut off the burner fuel supply when the boiler temperature rises to 10% above the normal nominal boiler operating temperature and shall activate an audible and visual alarm. Control shall be of the lockout type with manual reset. Each boiler shall have its own alarm display.

(c) Automatic Firing Controls - The firing of the burner shall be fully automatic and of either the high/low/off type or the modulating type depending on the rating of the boiler. The automatic firing controls shall comprise auto sequence controller, pre-and post-purge timer units, flame establishment unit, ignition transformer, burner motor starter with adjustable overload protection, photo-electric flame-failure device, burner run indicator, audible and visual lockout alarm with manual reset, high/low fire indicator (for high/low/off type burner only), and ON/OFF switch gear with indication lamp.

(d) A manual temperature setting device for adjusting the nominal boiler water temperature from 0 to 100^{o}C.

The foregoing boiler controls shall be housed in a local control panel on each boiler, together with altitude/pressure gauge and thermometer, mounted as an integral part of the boiler package. The control panel shall be mounted on the boiler in such a manner as to be completely free of vibration, heat and moisture and to preclude damage to contactors and electronic devices. All controls shall be configured to fail safe.

C7.3.1.6 Burner

Please refer to Clause C1.3.2 in Section C1 for diesel/towngas burner.

C7.3.2 Semi-Storage Type Water-Heated Hot Water Calorifier

The semi-storage type water-heated hot water calorifier (hereinafter referred to as semi-storage calorifier) shall be manufactured to BS 853-1:1996 to a Grade as specified in the Particular Specification. The maximum working pressure in the shell and battery shall be as specified in the Particular Specification. The semi-storage calorifier shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively for both shell and heater battery at the manufacturer's works. Manufacturer's test certificate of each semi-storage calorifier shall be submitted, in triplicate, to the Architect before the equipment depart the factory and prior to shipment.

The shell of the semi-storage calorifier shall be mild steel to BS EN 10028:2009, BS EN 10029:1991, BS EN 10048:1997, BS EN 10051:1992, BS EN 10258:1997 and BS EN 10259:1997. The mild steel shell shall be lined internally with copper to BS EN 1172:1997, BS EN 1652:1998, BS EN 1653:1998 and BS EN 1654:1998/C106. The copper lining shall have a minimum thickness of 1.2 mm. The copper lining shall be constructed in such a way that no part of the mild steel shell shall come into contact with water. The mild steel shell and the copper lining shall be accurately rolled to shape and the ends shall be formed in presses with generous heel radii.

The heater battery shall be copper to BS EN 1057:2006 and shall be formed from solid drawn fined copper U-tubes with brass tubeplate to BS EN 1652:1998 and BS EN 1653:1998/CZ123 or CZ112. The heater battery shall have tube removal arrangement to facilitate cleaning and inspection of the battery. The position of the heater battery shall be designed to give proper access for inspection/maintenance.

The semi-storage calorifier shall be configured to horizontal or vertical type as specified in the Particular Specification. Cradles or footings shall be designed so that there shall be no distortion of the calorifier due to thermal expansion or any static or dynamic loads.

A bolted inspection opening of minimum 455 mm in diameter shall be provided. Manhole shall be provided at suitable position to give proper access for inspection/maintenance.

Connections of 50 mm N.B. or smaller shall be screwed to ISO 7-1:1999/BS 21:1985 and those above 50 mm N.B. shall be flanged to BS EN 1092-1:2002, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate. Sparge pipe fittings shall be installed for maintaining good thermal stratification of secondary water to ensure effective heat exchange.

The semi-storage calorifier shall be designed to combat the development of Legionnaires Disease. It shall be fitted with a built-in heater battery and an integral circulating pump to circulate water from the storage section through the heater battery and back into the storage section such that no stagnant cold water areas shall exist in the storage section during the operation of the calorifier.

The water shall be heated from cold to the set temperature in a single pass through the heater battery. The set temperature shall be regulated by a direct acting thermostatic control valve fitted on the primary side, which shall have quick response and modulation.

C7.3.2.1 Rating

The rated hourly output of the semi-storage calorifier shall be as specified in the Particular Specification. The heater battery shall be rated to bring the whole calorifier with secondary supply water from 10^{o}C to 65^{o}C with primary heating water at 82^{o}C and with corresponding primary return water not lower that 71^{o}C. The recovery time period of the semi-storage calorifier is specified in the Particular Specification.

C7.3.2.2 Insulation

The calorifier shall be insulated with mineral wool mattresses of minimum 50 mm thick wound closely to the shell and covered with galvanised sheet steel of sufficient rigidity with suitable top coating.

C7.3.2.3 Semi-storage Calorifier Accessories

(a) The semi-storage calorifier shall be provided with the following accessories suitable for the working pressure and temperature as specified:

(i) An integral pump which circulates water between the storage section and the heater battery section. The integral pump shall operate in such a way that hot water inside the storage section of the semi-storage calorifier shall achieve a temperature of 65^{o}C during the operation of the calorifier;

(ii) The temperature of the calorifier water shall be controlled at 65^{o}C by means of an approved 3-way hot water flow control valve and an immersion thermostat. This control valve shall be in the by-pass position when de-energized. The 3-way hot water flow control valve shall be designed to be fail safe;

(iii) Drain valve;

(iv) Safety valve which shall be of the enclosed spring type with padlock and discharge pipe;

(v) Open vent;

(vi) Pressure gauge with 125 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure in S.I. units;

(vii) Thermometer with 125 mm diameter dial and fixed red pointer indicating the normal working temperature in S.I. units;

(viii) Anti-vacuum valve;

(ix) A high limit thermostat connected to an independent hot water isolating valve for protection against overheating of the calorifier; and

(x) Control panel for integral pump.

(b) All mounting for controls and instrument shall be so fitted as to permit ready replacement without emptying the calorifier. All controls and instrument shall be so chosen that the operating range lies between 40 to 75% of full scale range, calibrated in S.I. units and accurate to within 5% of the controlling or measuring point.

(c) The semi-storage calorifier, including heater battery, shell, pressure gauge, integral pump, 3-way hot water flow control valve, immersion thermostat, drain valve, safety valve, open vent, pressure gauge, anti-vacuum valve, high limit thermostat, pump control panel and all other necessary valves and accessories, shall be of the packaged type manufactured by a single proprietary manufacturer.

(d) The semi-storage calorifier including all equipment as mentioned in C7.3.2.3(a) shall be wholly imported and factory-built, assembled, piped and fully tested by a single proprietary manufacturer to form a "complete" set before shipment. The only field connections required on Site shall comprise external control circuitry, electrical power supply, and system external pipework and fittings as appropriate.

(e) Official manufacturer certificate shall be submitted to the Architect, in triplicate, for each semi-storage calorifier before the equipment depart the factory and prior to shipment .

C7.3.3 Non-Storage Type Water-Heated Hot Water Calorifier

The non-storage type water-heated hot water calorifier (hereinafter to be referred as non-storage calorifier) shall be manufactured to BS 853-1:1996 to a Grade as specified in the Particular Specification. The maximum working pressure in the shell and the maximum design pressure in the heater battery shall be as specified in the Particular Specification. The non-storage calorifier shall be hydraulically tested to 1.5 times the maximum working and design pressure respectively for both shell and heater battery at the manufacturer's works. Manufacturer's test certificate of each non-storage calorifier shall be submitted, in triplicate, to the Architect before the equipment depart the factory and prior to shipment.

The shell of the non-storage calorifier shall be mild steel to BS EN 10028:2009, BS EN 10029:1991, BS EN 10048:1997, BS EN 10051:1992, BS EN 10258:1997 and BS EN 10259:1997. The mild steel shell shall be lined internally with copper to BS EN 1172:1997, BS EN 1652:1998, BS EN 1653:1998 and BS EN 1654:1998/C106. The copper lining shall have a minimum thickness of 1.2 mm. The copper lining shall be constructed in such a way that no part of the mild steel shell shall come into contact with water. The mild steel shell and the copper lining shall be accurately rolled to shape and the ends shall be formed in presses with generous heel radii. Connections of 50 mm N.B. or smaller shall be screwed to ISO 7-1:1999/BS 21:1985 and those above 50 mm N.B. shall be flanged to BS EN 1092-2:1997 and BS EN 1092-1:2002, BS EN 1092-2:1997 or BS EN 1092-3:2003 as appropriate.

The calorifier shall be configured to horizontal or vertical type, unless otherwise specified in the Particular Specification. Cradles of footing shall be designed so that there shall be no distortion of the calorifier due to thermal expansion or any static or dynamic loads.

The heater battery shall be copper to BS EN 1057:2006 shall be formed from solid drawn fined copper U-tubes with brass tubeplate to BS EN 1652:1998 and BS EN 1653:1998/CZ123 or CZ122. The heater battery shall have tube removal arrangement to facilitate cleaning and inspection of the battery. Manhole shall be provided at suitable position to give proper access for inspection/maintenance.

C7.3.3.1 Rating

The non-storage calorifier shall provide an output as specified in the Particular Specification when heated by primary heating water from 71^{o}C to 82^{o}C and supply hot water at temperature as specified in the Particular Specification.

C7.3.3.2 Insulation

The calorifier shall be insulated with mineral wool mattresses of minimum thickness of 50mm wound closely to the shell and covered with galvanised sheet steel of sufficient rigidity with suitable top coating.

C7.3.3.3 Non-Storage Calorifier Accessories

(a) The non-storage calorifier shall be provided with the following accessories suitable for the working pressure and temperatures stated:

(i) The temperature of hot water at secondary flow of the non-storage calorifier shall be controlled at 82^{o}C by means of an approved 3-way hot water flow control valve and an immersion thermostat. This control valve shall be in the closed position when de-energized and shall be designed to be fail safe;

(ii) Drain valve;

(iii) Safety valve which shall be of the enclosed spring type with padlock and discharge pipe;

(iv) Open vent;

(v) Pressure gauge with 125 mm diameter dial, level gauge cock and fixed red pointer indicating the normal working pressure in S.I. units;

(vi) Thermometer with 125 mm diameter dial and fixed red pointer indicating the normal working temperature in S.I. units;

(vii) Anti-vacuum valve; and

(viii) A high limit thermostat connected to an independent hot water isolating valve for protection against overheating of the calorifier.

(b) All mountings for controls and instrument shall be so fitted as to permit ready replacement without emptying the calorifier. All controls and instrument shall be so chosen that the operating range shall lie between 40 to 75% of full scale range, calibrated in S.I. units and accurate to within 5% of the controlling or measuring point.

(c) The non-storage calorifier, including heater battery, shell, pressure gauge, integral pump, 3-way hot water flow control valve, immersion thermostat, drain valve, safety valve, open vent, pressure gauge, anti-vacuum valve, high limit thermostat and all other necessary valves and accessories, shall be of the packaged type manufactured by a single proprietary manufacturer.

(d) The non-storage calorifier including all equipment as mentioned in C7.3.3.3(a) shall be wholly imported and factory-built, assembled, piped and fully tested by a single proprietary manufacturer to form a "complete" set before shipment. The only field connections required on Site shall comprise external control circuitry, electrical power supply, and system external pipework and fittings as appropriate.

(e) Official manufacturer certificate for each non-storage calorifier shall be submitted to the Architect before the equipment depart the factory and prior to shipment.

C7.3.4 Hot Water Circulating Pumps and Pipeworks

For each hot water boiler and hot water calorifier, one pair of standby and duty hot water circulating pumps shall be provided as generally indicated in the Drawings for hot water circulation. The capacity of these pumps shall be as specified in the Particular Specification. The piping layouts and hydraulic calculations shall be submitted for approval in selecting the suitable pump heads.

The circulating pump shall be efficiently balanced. Suitable vibration isolation shall be provided to eliminate noise and vibration from transmitting to the pipe system or floor.

Pump control panel shall be provided at locations as indicated in the Drawings for control of the circulating pumps. ON/OFF switch, power-on indication and hour-run meter shall be provided on the panels for each pump. Emergency stop push button shall be provided adjacent to each pump.

Valves shall be provided for the proper completion, working, isolation, regulation and control of the installations whether or not they have been specifically named.

Isolating valves shall be provided for all items of plant and equipment to ensure that each item can be removed, replaced or repaired without draining the pipework.

Isolating valves shall also be provided for all risers and droppers for the sectional isolation and draining of the pipework.

Calibration valves shall be provided at suitable locations for effective balance of water flow through the pumps and the calorifiers.

C7.3.5 Pipeworks

Provision shall be made in the piping system for movement due to expansion and contraction by changes in direction of the pipework, by loops or by special expansion joints.

Supports, steadiers and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework loop or joint. Where pipework is required to be prestressed for the purpose of reducing expansion stress under working conditions, the extent of the cold pull shall be as recommended by the manufacturer and submitted for approval.

All expansion bellows shall be supplied and carefully installed at suitable positions of the hot water system. The expansion joints or changes in direction of the pipework shall be correctly aligned and functional. Support at such joints shall be arranged to ensure that all expansion or contraction is taken up by the expansion joint or change in direction of the pipework. Expansion joints shall be prestressed for the purpose of reducing the expansion stress under working conditions, the extent of the cold draw shall be as recommended by the manufacturer and submitted for approval.

Expansion bellows for angular movements shall be provided with tie rods or hinges to take end thrust.

All expansion bellow joints shall be provided with external protection where exposed to damage. For axial bellows this shall comprise an external sleeve.

C7.3.6 Thermal Insulation

Thermal insulation shall be applied to all pipework and fittings carrying hot fluid.

Pipework insulation shall include all pipework, valves, flanges, fittings, pumps and other plant items whether specifically mentioned or not.

All thermal insulation, including fixings shall comply with ISO 12241:1998, BS 5970:2001 and BS 5422:2009. All surface finishes shall comply with Class O surface spread of flame.

Thermal insulation shall be preformed rigid sections or slabs of glass or mineral fibre, protected and finished by fabricated hammered aluminium casings.

Preformed rigid insulation of glass or mineral fibre for hot fluid pipes shall comply with ISO 12241:1998 and BS 5422:2009.

C7.3.7 Dual Feed and Expansion Tank

Duplicate dual feed and expansion tanks shall be provided. Dimensions and construction details shall comply with BS 417-2:1987, Galvanised Mild Steel Cisterns and Covered tanks and Cylinders, Type SCM 270 with capacity 191 litres each.

The tanks with covers should be positioned above the level of the highest point of the primary hot water system. Open vent pipes from boilers shall be returned to the top of the tanks. The cold feed connection to the boilers shall be taken from the side of the tanks. The tank inlet connection shall be fitted with a ball float valve and stop cock. The lever of the copper float shall be adjusted so as to accommodate the expansion volume.

The tanks shall also be provided with the followings:

(a) A drain valve at the bottom with drain pipes leading to the nearest floor drain;

(b) An overflow which discharges in a visible external position; and

(c) A glass water level sight gauge protected by copper shield complete with cocks.

The tank shall be insulated with mineral wool mattresses of minimum 50mm thick wound closely and covered with galvanised sheet steel of sufficient rigidity painted with suitable top coat. Shop drawings shall be submitted for approval prior to fabrication of the tanks.

C7.3.8 Water Treatment Equipment

A chemical water treatment equipment kit shall be provided and installed for the hot water system and boilers. Dosing shall be applied to the return header of the hot water boilers.

The water treatment facility shall include dosage for prevention of water scaling and hot water corrosion. A nitrite-borate-organic non-toxic corrosion inhibitor shall be used for this application.

The chemical dosing equipment shall consist of a suitably sized chemical pump, housed in a pump box and controlled by a timer and a level controller. Chemicals shall be stored in a polyethylene tank of approximately 200 litres capacity. Chemical feeding pipework shall include a check valve, a gate valve and a diffuser. All pipes for delivery chemicals in the water treatment system shall be of stainless steel Grade 316.

Before commissioning, the whole system pipework shall be chemically pre-cleaned by using high efficiency sequestrant and dispersant. Adequate amount of defoamer shall be applied to control foaming throughout the cleaning process.

Field-test kit shall be provided in the water treatment package including portable pH meter, TDS meter, corrosion inhibitor ppm test kit, etc.

The system water shall be treated to comply with the following requirements:

pH value	8 - 10
Total dissolved solids	Below 5500 ppm
Total hardness (as $CaCO_3$)	Below 10 ppm
Corrosion inhibitor, CWT110	3000 - 4500 ppm

Sufficient quantities of chemical shall be provided for testing and commissioning and the initial half-year operation.

C7.4 EQUIPMENT AND MATERIAL

C7.4.1 Pipework

C7.4.1.1 General

(a) All pipework and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition;

(b) All pipework delivered to site shall be new and shall be colour banded at the factory to identify different grades, materials and manufacturers;

(c) All pipework and fittings, accessories, joints and joining media used shall be suitable for the substance conveying in the pipes and shall not deteriorate due to chemical or atmospheric action;

(d) All pipework, fittings and valves must be suitable for the system test pressure;

(e) Welding shall not be permitted on galvanized pipework under any circumstances whatsoever; and

(f) In general, all ferrous piping systems shall comply with BS EN 13480-1:2002, BS EN 13480-2:2002, BS EN 13480-3:2002 and BS EN 13480-4:2002.

C7.4.1.2 Hot Water Pipe

Hot water pipes shall be of half hard copper to BS EN 1057-1:2006 Table X.

Fittings for copper pipework of up to and including 67 mm size shall be of the capillary or compression type BS EN 1254:1998 and BS EN 1254-2:1998.

Fittings for copper pipework of 76 mm and 108 mm shall be of the flanged compression or capillary type. Fittings for pipework above 108 mm shall be flanged.

C7.4.1.3 Cold Water, Drain, Vent and Overflow Pipe

Cold water, drain and overflow pipes shall be mild steel to BS EN 10255:2004, galvanised medium grade, except for those screwed in the 20 mm and 40 mm sizes which shall be heavy grade. Buried pipes shall be to BS 10255:2004 heavy grade.

Vent pipes for hot water calorifiers shall be half hard copper to BS EN 1057-1:2006 Table X.

Galvanised steel pipework shall have taper screwed joints and the jointing between them shall be made with approved jointing material, the fittings shall be galvanised.

C7.4.2 Thermal Expansion Bellow

Expansion loops shall be of the same material as the pipeline and of a thickness suitable for bending without undue thinning and formed from one single length of pipe or welded fittings but not by means of screwed fittings. The loops shall be either lyre or 'U' type and terminating in straight lengths not less than 15 pipe diameters long. The rated pressure of each loop shall be at least equal to that of the pipeline.

Expansion bellows shall be axial pattern with screwed or flanged ends and installed at suitable positions of the hot water system. They shall incorporate internal liners and shall be manufactured from Grade 304 stainless steel. It shall be designed to withstand the test pressure of the system. Bellows shall have a designed life of not less than 2000 complete cycles of movement over the working range without failure.

Expansion joints of a particular type (e.g. loop and lyre, bellows, articulated and telescopic) shall be by the same manufacturer.

C7.4.3 Thermal Insulation

All materials supplied of the same type shall be supplied by a single manufacturer to ensure uniformity of standards and appearance.

All materials delivered to site shall be new, and where appropriate, colour coded and labelled at factory to identify different grades, sizes and types.

Samples and a full specification of the insulation material shall be submitted to the Architect for approval.

Before ordering any insulating materials, the co-efficient of the thermal conductivity for each of the materials being supplied for the Works shall be stated. Tests shall be carried out on representative samples of each material taken at Site and/or at makers' works as directed by the Architect in accordance with the methods laid down in International Standards. In the event of test results being not satisfactory, the Architect shall have the right to order the removal and replacement of all materials represented by the unsatisfactory samples.

All equipment and materials used shall be fire resistant and shall comply with all relevant regulations issued by the Hong Kong Fire Services Department.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc. shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to protect them from damage or deterioration before fixing.

All insulating, finishing and painting materials shall be suitable for the surfaces to which they are applied and for the environmental conditions in each area.

Thermal insulation materials and their finishes shall be asbestos free.

Thickness of thermal insulation for pipework carrying hot fluids shall be in accordance with Table C7.4.1.

Table C7.4.1 - Thickness of Thermal Insulation

Size of Pipe/mm	Declared Thermal Conductivity / (W/mK)		
	Hot Water Pipe		
	Up To 0.040	0.041 to 0.055	0.056 to 0.070
	Minimum Thickness of Thermal Insulation / mm		
15	25	32	32
20	25	32	32
25	32	32	32
32	32	32	32
40	32	32	32
50	32	32	38
65	32	32	38
80	32	44	44
100	38	44	44
125	44	44	63
150	44	63	63
200	44	63	75
250	63	63	75
300	63	63	75
Flat Surface	63	63	75

C7.4.4 Valves

All valves shall be of a rating suitable for the design working pressure of the system.

Where flanged valves, etc. are specified, the flanges shall comply with the appropriate specification. Valve flanges and counter flanges shall be to the same International Standards and shall be of the same rating.

Isolating valves for hot water pipework shall be fullway gate type with solid taper wedge.

Combined stop and automatic isolating valves shall be of the dashpot type with bronze piston and dashpot and nickel alloy valves seat and disc.

The following valve schedule shows the type and the standard to which all valves shall comply:

(a) Check Valves for Hot Water Pipeworks

Size	Valve Type	Standard
54 NB and below	Bronze Check	BS 5154:1991
67 NB and above	Cast Iron Check	BS EN 12334:2001

(b) Hot Water - General Isolating

Size	Valve Type	Standard
54 NB and below	Bronze Gate valve	BS 5154:1991
67 NB and above	Cast Iron Gate Valve	BS EN 1171:2002

(c) Hot Water - For Water Flow Modulating

Size	Valve Type	Standard
54 NB and below	Bronze Globe Valve	BS 5154:1991
67 NB and above	Cast Iron Globe Valve	BS EN 13789:2002

Holes in covers or in gates for screwed portions or spindles shall have full threads of a length not less than the diameter of the spindle over the threads. Glands shall be machined to provide a running fit between the spindle and the stuffing box. Stuffing boxes shall be properly packed, or fitted with 'O' rings which may be located in plastic bushes.

Gate valves shall have split or solid wedge gates.

Regulating valves on circuits shall have characterised plugs and a lockable indicator on the spindle to show the proportional opening. Pressure gauges shall be provided on the up and down streams of the regulator.

Fullway gate valves shall have metal wheel handles. Wedge gates and all seatings, including the top of the wedge and the associated back seat on the bonnet facing, shall be accurately machined, or alternatively designed, to provide a back seating.

The flaps of non-return valves shall be of light construction and shall pivot on a spindle secured by two phosphor bronze hangers. Each valve shall be fitted with a stop to prevent undue movement of the flap and shall be as silent as possible in operation. The valve shall be constructed so that minimum resistance is offered to gravity flow.

Automatic air vent shall be of the mechanical type and works at a maximum operating pressure of 14 bar and maximum operating temperature of 260 ^{o}C. The body and cap of the automatic air vent shall be made of brass to BS EN 12165:1998 with stainless steel capsule.

C7.4.5 Safety and Pressure Relief Valves

Safety and pressure relief valves shall comply with ISO 4126-1:2004 and the relevant International Standards for calorifiers or pressure vessel to which they are connected.

The PR valves shall be sized to match the plant operating pressure and relief capacity so as to give the appropriate degree of protection.

Valves shall be of the totally enclosed spring loaded type with padlock.

Relief pipes from valves to discharge shall be run in full bore tubing of the same quality as the service vessel or pipeline with which the valve is associated. Where any low point occurs in the discharge run, it shall be fitted with a 15 mm size waste pipe carried clear of the insulation for drainage. The discharge and waste pipes shall be run to visible safe positions to be approved by the Architect.

C7.4.6 Strainers

Unless otherwise specified, strainers shall be of Y-type with stainless steel screen Grade 304-S16 to BS1449:1991 with cast iron body suitable for operating temperature up to 250^{o}C with designed operating pressure not less than 16 bar.

C7.4.7 Hot Water Circulating Pumps

The Circulating Pump shall be of the centrifugal type with direct drive and mounted on a common bed-plate or flange mounted. Circulating Pumps of small flow rate shall be of the vertical in-line type of mounting which shall be either floor mounted or pipe mounted.

The pump shall have cast iron casing, gun metal impeller and stainless steel shaft and shall be suitable for an operating temperature of up to 100 ^{o}C. Bearings shall be of the seal-for-life ball or roller type.

Pump motors shall be suitable to operate on 380V/3/50 ±2% Hz, of totally enclosed fan-cooled type, type of protection IP54 to IEC 60529:2001 "Specification for Degrees of Protection provided by Enclosures", with insulation class F to IEC 60085:2007, and provided with motor starters with adjustable overload protection relay and

under-voltage release.

The continuous rating of all motors shall cover the full specified range of duty plus a further 10% margin for the pumps.

C7.5 ERECTION AND INSTALLATION

C7.5.1 Pipework and Fittings

(a) Throughout the pipe runs long sweep bends shall be used in preference to round elbows wherever practicable. Square elbows shall not be used;

(b) All made and set bends shall have as large a radius as possible and shall be free from buckling. No fire bends on galvanised pipe shall be permitted without re-galvanising after making;

(c) Pipes shall not be built solidly into walls and joints, and shall not be positioned within the thickness of walls, floor or in any other inaccessible position;

(d) Screwed joints shall be clean threaded pulled up tightly. No caulking shall be allowed in any circumstance. All pipes and fittings shall be carefully reamed to ensure that the full bore of the pipe is maintained and absolutely free from internal obstructions before erection. Plugs shall be inserted in all open ends during the progress of the works to prevent the ingress of dirt & moisture. Plugs of wood, paper, etc. shall not be used;

(e) Any stoppage which is found to impede passage through the pipework after the system have been put into commission shall be located and removed, and the concerned pipework shall be made good, including the cost of necessary building work and redecoration;

(f) In all positions which will facilitate erection and dismantling, all pipework shall have joints in accordance with those specified for the particular service;

(g) All fittings shall be of the same size as the tubes and pipes connected to them. Bushed outlets shall only be accepted if the required outlet size of a fitting is not of standard manufacture. Eccentric bushings and square tees shall be used at locations where concentric bushings and pitcher tees might cause air to be trapped in the system;

(h) Pipework shall follow the contours of walls and shall be graded to ensure venting and draining. Suitable automatic air vent and key-operated drain cocks shall be installed at suitable locations for complete venting and draining. The clearance between pipework (or the lagging) and the wall and any other fixtures shall be not less than 25 mm;

(i) Purpose-made sets or springs may be used at odd locations and subject to the approval of the Architect to deviate from a straight run in ungalvanised pipework. Sets or springs in tubes of 50 mm size and above shall be fire-made and the tubes shall remain circular after setting. In galvanised pipework deviations shall be formed from standard fittings;

(k) Eccentric reducing sockets shall be used where changes of bore are made in runs of nominally horizontal pipework to facilitate air venting and draining;

(l) For hot water pipework, when brazing or bronze welding is undertaken, such welding shall be carried out in accordance with the testing procedures described in BS EN 14324:2004 and BS 1724:1990;

(m) Galvanised pipework shall not be welded unless the pipe is re-galvanised after welding; and

(n) Buried part of the pipework carrying hot fluids such as blow-drain pipe or hot drain shall be protected by wrapping with "Denso" tape or approved equivalent to make a total thickness of 3 mm.

C7.5.2 Pipe Support

All pipework shall be adequately supported in such a manner as to permit free movement due to expansion and contraction. Pipe supports shall be arranged as near as possible to joints and changes in direction. The spacing of the supports shall not exceed the centres given in the Table C7.5.1. Where there are two or more sizes of pipes the common support spacings shall be based on the centres required by the smallest bore pipework.

Table C7.5.1 - Supports for Copper Pipework

	Intervals for Horizontal Runs / m		Intervals for Vertical Runs, Bare or Lagged / m
	Bare	Lagged	
15	1.2	1.2	1.8
22	1.2	1.2	1.8
28	1.8	1.5	2.4
35	2.4	1.8	3.0
42	2.4	1.8	3.0
54	2.7	1.8	3.0
65	3.0	2.4	3.7
76	3.0	2.4	3.7
108	3.0	2.4	3.7
113	3.7	3.0	3.7
159	4.5	3.7	3.7

Vertically rising pipes shall be adequately supported at the base of riser to withstand its total weight. Branches shall not be used to support the riser.

Pipes shall be arranged so as to provide subsequent access to any pipe for maintenance or removal purposes.

The anchors and supports shall be constructed of mild steel with sections of appropriate strength and stiffness.

On mild steel pipework, mild steel anchors capable of resisting the maximum stresses shall be provided which shall preferably be welded to the pipework. Where it is impracticable to weld the anchors to the pipework, cast-iron chairs with at least two wrought-iron stirrup bolts shall be used, the bolts being provided with sufficient thread to ensure an effective grip on the pipe.

All cleats, brackets and steelwork required for anchor points shall be supplied and fixed in position, ready for building in. Anchor steelwork secured to the bottoms of ducts or trenches shall be coated with hot-poured bitumen.

C7.5.3 Thermal Expansion Bellow

The proposed locations of expansion joints and loops shall be submitted for the Architect's approval prior to any installation work.

Expansion bellows shall be installed so that they are not subject to stresses other than those for which they are designed. They shall be installed so that they are in their free position at a temperature midway between the high and low limits of normal service.

Expansion bellow joints shall be provided with guides to ensure that all movements are taken up in the designed manner. The manufacturer's recommendations shall be closely followed. Guides shall be secured rigidly and shall provide free movement for expansion without undue tolerance. Means for lubrication shall be provided where necessary.

Each expansion device shall be fitted with a clearly inscribed plate giving the following details:

(a) Manufacturer's Name;

(b) Date of Manufacture;

(c) Reference Number;

(d) Maximum Working Pressure;

(e) Direction of Flow; and

(f) Maximum and Minimum Working Lengths.

At building expansion joints, and wherever else necessary, allowance shall be made by the provision of stainless steel axial or articulated bellows type expansion compensators complete with all necessary guides, etc. as recommended by the manufacturer to give a working life of not less than 20 years.

Guides shall be adjustable in both directions in the lateral plane so that the pipework can be accurately aligned with the expansion device or loop. Each guide shall not be less than a pipe diameter long and have a minimum manufacturing clearance. The distance from the expansion joint to the first guide shall not be more than 4 pipe diameters and the distance between the first guide and the second guide shall not be more than 14 pipe diameters.

Anchor points shall be installed, where applicable, to provide immovable fixing. All cleats, brackets and steelwork required for anchor points shall be supplied and fixed in position, ready for building in. Care shall be taken to ensure that no anchor point is within 60 mm of any welded joints. Anchors shall be of an adequate strength to resist the maximum load, and their designs and positions shall be approved by the Architect before installation commences.

On steel pipework, the pipe shall be welded to the anchors via heavy steel straps.

Guides and anchors shall meet with the written approval of the expansion joint manufacturer and shall be submitted to the Architect for approval before manufacture commences.

C7.5.4 Sleeves Through Walls and Floors

Holes shall be made through walls and floors based on the relevant Drawings. All sleeves necessary to accommodate piping with insulation through walls and floors shall be provided and the openings in the walls or floors after sleeves fixing shall be made good. The positions of such sleeves shall take into account of the structural stability of walls or floors and shall be approved by the Architect prior to the commencement of Works.

The sleeves shall be of mild steel pipe of sufficient diameter to permit freedom of movement of the pipes but the clearance all round shall not exceed 5 mm. For walls, the sleeve shall be of a length so that it is flush with both sides of the finished wall. For floors, the sleeve shall be of a length so that it is flush with the finished ceiling below and shall project 25 mm above the finished floor surface or as the Architect may direct.

C7.5.5 Thermal Insulation

No insulation shall be applied before the relevant service has been satisfactorily tested, cleaned and painted.

Each pipe or duct shall be separately insulated with a minimum space of 50 mm between finished services.

Each section of preformed insulation shall be secured to the pipe by one of the following means:

(a) Circumferential tie-wires, each formed from three turns of wire not less than 1 mm thick, spaced not more than 450 mm apart;

(b) Staples along longitudinal joints spaced not more than 100 mm apart; and

(c) Circumferential bands of non-ferrous metal, plastics fabric or adhesive sheet.

Rigid insulation applied to cylinders and flat surfaces shall be secured with non-ferrous metal or plastic fixings.

All insulation shall be applied so as to give a smooth, homogeneous and lineable surface. All rigid sections shall be concentric, and accurately matched for thickness. Steps and undulations in the surfaces shall not be acceptable. Any sections or slabs having damaged ends or edges shall be rejected.

All insulation shall fit tight to surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary. Any minor interstices left in insulation shall be filled and sealed.

Insulation shall be applied to clean and dry surfaces, free of foreign material such as oil, grease, rust, scale or dirt. Any surface to be insulated, which shows any signs or rusting or damage shall, prior to insulation, be thoroughly scraped and wire brushed as necessary to remove all rust, scale, etc. Surfaces shall then be solvent cleaned to remove all oil, grease, salts and dirt prior to the application of a coat of primer. Application of primer shall be as specified in Clause B3.4 of this Specification.

Only clean and dry insulation shall be used. Insulation shall be applied in accordance with the manufacturer's recommendations.

Continuous insulation shall be provided through all sleeves and insulation joints shall be staggered with respect to joints on the associated pipework or ductwork systems.

Thermal insulation on the pipes immediately adjacent to flanges, etc., shall be neatly swaged off to allow for easy removal of bolts. An insertion shall be provided to allow the insulated boxes to be removed without damage to the pipe insulation.

Unless otherwise stated, finish on all thermal insulation shall be fabricated hammered aluminium casings. Each casing shall be not less than 0.8 mm thick on all pipework. For valves, flanges, strainers, expansion joints and fittings, they shall be insulated in conformity with the pipework in which they are incorporated, and to the same thickness. All such items shall be provided with fibreglass filled 0.8 mm thick hammered aluminium split casings and fixed with quick release clips arranged for easy removal. The insulation on the pipes immediately adjacent to such flanges, etc., shall be neatly swaged off to allow for easy removal of bolts. A canvas insertion shall be provided to allow the insulated boxes to be removed without damage to the pipe insulation. Heat bridges between the hot surfaces and the metal casings shall not be permitted.

On external pipework, the outer covering shall be weatherproof and applied to all the pipework. The outer covering shall be perforated on the underside of all horizontal runs with 6 mm diameter holes at approximately 150 mm centres, so that the insulation is open to atmosphere at these points.

At pipe supports, both insulation and outer covering shall be continuous and shall not be punctured by the supports. The insulation at supports shall be of material of sufficient density to take the loads transmitted to the supports. The load-bearing insulation shall be extended on each side of the supports. At entries into buildings, the weatherproof insulation shall extend not less than 100 mm beyond the inner face of the wall and be sealed to the satisfaction of the Architect.

At flanges, expansion joints and anchor points, particularly attention shall be paid to sealing the insulation against water vapour ingress.

All types of finished pipework shall be colour coded to comply with BS 1710:1984 and BS 4800:1989 with the instructions of the Architect.

C7.5.6 Safety and Pressure Relief Valves

Valve shall be mounted with the centre line of the valve spindle in vertical position to ensure that the valve reseals properly after operation.

Relief pipe connections shall be of equal bore to the vessel connection.

C7.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

Before installations are handed over or subjected to inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fluid-related installations shall be flushed with clean water. This shall be preceded by chemical cleaning where indicated. During the flushing or scavenging process, provision shall be made to exclude filters, pumps, meters and any other items of plant which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Architect.

Factory tests shall be carried out for the boiler plant, calorifiers, tanks, cylinders and pumps in accordance with Clauses D1.1 and D1.4.

Installations or sections which will be embedded in the structure or concealed in permanently sealed ducts, trenches, roof spaces, etc. shall in addition to the above specified tests be individually tested as they are laid and before being embedded or concealed.

All pressure tests for pipework and fittings shall be carried out before the application of thermal insulation.

C7.6.1 Inspection by Surveyors

After finishing the installation work, the complete hot water system installation including calorifiers, pressure reducing valve sets, water pipeworks, fittings and associated accessories shall be subject to the inspection and approval by the Commissioner for Labour, Director of

Water Supplies and other relevant statutory authorities. The examination of the plant by approved independent Surveyors is required if deemed necessary by the said authorities. The Contractor is required to obtain the respective Certificate of Approval or Fitness, at the Contractor's expense, on behalf of the Employer for those equipment or systems which fall within the Boilers and Pressure Vessels Ordinance Chapter 56, Fire Services Regulations Chapter 95, requirements from Water Supplies Department and other relevant statutory regulations. Original (and in triplicate) certificates of approval shall be submitted to the Architect before the relevant equipment is put into operation.

Each safety valve shall be surveyor tested to its designed pressure on completion. Test Certificates in triplicate, including the original copy, shall be submitted to the Architect.

C7.6.2 Submission of Form WWO 46

The Contractor shall submit Form WWO 46 to Water Supplies Department for the installation of the hot water system.

SECTION C8

INDUSTRIAL COMPRESSED AIR SYSTEM

C8.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of industrial compressed air system complete with the associated electrical power and control system.

C8.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with all relevant statutory regulations, in particular

(a) Boilers and Pressure Vessels Ordinance, Chapter 56, and other subsidiary legislation made under the Ordinance

(b) ISO 5388:1981 Code of Practice for Stationary Air Compressors

(c) BS 5169:1992 Fusion Welded Steel Air Receivers

(d) ISO 4126:2006 Specification for Safety Valves for Compressed Air or Inert Gases

(e) ISO 1217:2009 Methods for Acceptance Testing of Positive Displacement Compressors and Exhausters.

C8.3 DESIGN

C8.3.1 System Description

The compressor system shall consist of air compressors compressing naturally aspirated air into air receivers. The air receiver outlet shall be connected to a distribution main. Compressed air shall be distributed to consumption points via compressed air pipe works for industrial type applications.

All the system components shall be designed to the working pressure as specified in the Particular Specification and the relevant design codes.

The type of compressor shall be specified in the Particular Specification.

The compressor shall be controlled by automatic regulation system which shall be capable of performing one of the following functions as required:

(a) Constant Running - with the compressor running continuously at constant speed, to load and unload the compressor automatically so as to maintain the pre-selected pressure;

(b) Automatic Stop/Start - when the demand for air is more intermittent, the electric motor shall be automatically stopped and started so as to maintain the pre-selected air pressure;

(c) Manual Dual Control - a combination of constant running and automatic stop/start control. A manually operated changeover switch shall be incorporated so as to permit selection of one or other of the functions;

(d) Automatic Dual Control - a combination of constant running and automatic stop/start control. The compressor shall be stopped after a pre-determined period of unload running. The stop time delay shall be adjustable up to a period of 20 minutes.

For compressors working in parallel, check valves for preventing rotation reversal shall be installed on the discharge side of compressors which do not have built-in non-return valves.

An air governor shall be provided to regulate the compressor output automatically in accordance with air demand. Demand shall be based on receiver pressure and the governor shall be adjustable both for pressure and differential range; the pressure differential shall not exceed 15% at its closest setting.

Air line filters, lubricators, pressure regulators and drain traps shall be provided at appropriate location throughout the distribution network to maintain cleanliness of the compressed air and for protection of the pneumatic equipment.

Relief or safety valves shall be fitted to the compressed air system in places where pressure is likely to be accumulated so that such pressure can be released automatically once it exceeds the maximum allowable working pressure by more than 10%.

Venting pipes from relief or safety valves shall be of the full bore tubing and the same quality as the pipework with which the valves are associated. The discharge point of vent pipes shall be terminated at a safe position subject to approval by the Architect.

Unless otherwise specified, the noise level of the compressor shall not exceed 80 dB(A) measured at a distance of one metre from the compressor during operations.

C8.4 EQUIPMENT AND MATERIAL

C8.4.1 Air Compressors - Screw Compressor

The compressor shall be of single stage, air-cooled, rotary "screw" type with oil injection.

The male and female rotors of the compressor shall be carried on heavy duty double ball/roller bearing of long design life. The rotors shall be precision-ground with no relative sliding movement and the moving elements shall be well balanced to reduce the bearing load. The rotors shall be housed in a high quality cast iron casing.

The compressor unit shall incorporate a replaceable high efficiency paper cartridge filter at the suction end.

An air valve, of air-tight design, shall seal the intake of the compressor at 'no load' or 'stop' condition to prevent the air/oil mixture in the compressor from discharge through the air intake.

An efficient oil separator with easily removable filter shall be fitted at the compressor outlet to limit the coolant carryover to less than 5 ppm. A finned tube type after-cooler with forced draught cooling shall be provided. The cooling fan shall be used to cool the oil cooler as well. A full-flow oil filter with replaceable elements of 10 micron size shall be fitted in the oil return line to the compressor.

A combined check and minimum pressure valve shall be fitted at the oil separator outlet to ensure that the high pressure air cannot back flow from the system and a rapid rise in air pressure in the oil separator to supply oil for lubrication and cooling.

Oil shall be maintained at an optimum operating temperature of around $55^{o}C$ to prevent condensation of atmospheric moisture in the system. A thermostatically controlled three-way valve shall be provided for by-passing the oil cooler.

The compressor and motor unit shall be resiliently mounted onto a steel section baseframe through anti-vibration pads.

The complete assembly including the cooling fan etc. shall be housed in a steel enclosure with fully removable steel panels. The panels shall be fabricated from galvanized steel sheets of not less than 1.2 mm thick, infilled with sound absorbent, flame proof glass fibre acoustic lining. Sufficient air intake opening area shall be allowed for in the enclosure. The noise level, measured at 1 m from the enclosure shall not exceed 75 dB(A) while the machinery is in full load operation.

The instrumentation and control panel shall be fabricated from galvanized sheet steel and ergonomically designed to give the operator a clear and comprehensive monitoring of the whole system. Push button or touch-sensitive control switches with indication lamps or L.E.D.'s showing the status of the machine shall be provided. Control voltage shall not exceed 50V.

The instrumentation and control panel shall incorporate the following items:

(a) Start button.

(b) Stop button.

(c) Reset button.

(d) Hours run meter.

(e) Large clear dial indicating the delivery air pressure.

The plant shall be automatically shut down under the following fault conditions with light indication.

(a) High compressed air temperature.

(b) Motor overloaded.

The contactors, fuses, relays and all other items of equipment necessary for the proper control and operation of the compressor shall be housed in the panel with front access for maintenance. It shall be lockable to prevent unauthorised access and malicious damage to the equipment inside.

The electric or electronic component shall be labelled appropriately to indicate its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

C8.4.2 Air Compressors - Reciprocating Compressor

The compressor shall be of the single acting, two stage air-cooled design.

The air compressor shall be complete with:

(a) Air receiver of appropriate type and capacity;

(b) Electric motor complete with star-delta starter & support frame;

(c) Automatic start/stop control devices;

(d) Air inlet filters & silencer;

(e) Valves including safety valves;

(f) Intercooler;

(g) Aftercooler;

(h) Air pressure gauge; and

(i) Oil pressure gauge.

and other standard accessories for the complete and satisfactory operation of the air compressor.

The air compressor shall deliver the compressed air into the air receiver through suitable non-return valves. The air receiver shall be equipped with fusible plugs, safety valves, a drain valve, pressure gauge calibrated in kilo-pascals and an air inlet connection.

The air compressor, once started, shall be fully automatic in operation and provision shall be provided for pressure controlled automatic starting or stopping of the compressor depending on the demand for compressed air.

To avoid starting under load, the compressor shall be equipped with automatic unloading devices to bleed off the compressed air from the cylinders whenever the compressor is started or stopped. Bleeding of the trapped air into the crankcase will not be accepted.

Should the trapped compressed air be released every time the compressor is started, manual operation of the unloading device shall be provided for maintenance purpose and sufficient warning sign shall be provided in the Compressor Room and in the O&M manual to draw the attention of the maintenance personnel.

C8.4.3 Compressor Drive

The compressor shall be driven by electrical motor directly or through belt drive.

Belt drive shall be in the form of multi-vee endless belts complying with BS 3790:2006. The belt loading shall be such that should one belt fail, the remaining belts can transmit the full load.

Direct drive for non flange-mounted motors shall be by means of a flexible coupling.

The compressor and motor shall be mounted on a common bedplate. Means shall be provided for adjusting belt tension for belt drive or for aligning the motor and compressor for direct drive.

Flange mounted motors will be acceptable when the motors are attached to and supported and aligned from compressor frames.

C8.4.4 Compressor Lubrication

Lubrication shall be automatic throughout and so designed that frequent start-up and long running of the compressor shall require only minimum attendance and inspection.

For pressure feed systems, lubrication shall be independent of the direction of compressor rotation and an oil pressure gauge shall be fitted.

Effective and accessible means shall be provided for checking the oil level, topping up and draining the sump.

C8.4.5 Compressor Valves

The compressor valves shall be manufactured from stainless steel or other durable material to ensure trouble free service and long life.

The valves shall be of automatic, unequal pressure operation type. Access to valves for maintenance shall be possible without disturbing pipework and ancillary equipment.

Reciprocating compressor valve and valve port design shall be such that no inlet valve can be fitted instead of a discharge valve and that no discharge valve can be wrongly fitted in such a way as to prevent the improper discharge of air.

C8.4.6 Intercoolers and Aftercoolers

All compressors of two or more stages shall be fitted with intercoolers, relief valves and pressure gauges between each stage and shall be provided with drainage arrangement.

All compressors of discharge pressure over 700 kPa shall, unless otherwise indicated, be fitted with aftercoolers, relief valves and pressure gauges and shall be provided with drainage arrangement.

Both the intercooler and aftercooler shall employ the same medium for cooling as used on the cylinders.

C8.4.7 Air Receivers

The receiver shall be an all steel welded fabrication complying with BS 5169:1992 Class III Grade E for a storage capacity up to 500 litres and Class II Grade C for storage capacity above 500 litres.

The receiver shall be either vertically or horizontally mounted to suit the requirements. It shall have welded bosses fitted with properly sized supply, delivery, drain, and safety valves; pressure gauge, handholes or manholes, fusible plug where called for, identification plate and supporting feet.

The receiver shall bear legible and permanent indication of the following:

(a) Manufacturer's identification mark and serial number;

(b) Hydraulic test pressure;

(c) Date of hydraulic test;

(d) The reference of standard to which it complies;

(e) Class number and grade letter;

(f) Design pressure;

(g) Maximum design temperature; and

(h) Minimum design temperature.

The above indication shall be engraved on an attachment welded to the vessel solely for this purpose. Name plates riveted to such an attachment is also acceptable.

A copy of the manufacturer's certificate of construction and a copy of a certificate issued by a recognised inspection body in the country in which it was constructed, certifying that the receiver complies in all respects with the requirements of this standard shall be submitted. In addition, the certificate shall include particulars of the marking on the receiver.

For those air receivers not constructed to BS 5169:1992 but up to an equivalent or superior international standard, details of such standard in English and the relevant design/construction drawings for the receivers shall be submitted during the submission of tender. The drawings shall be certified by a recognised inspection body in the country in which it was constructed.

C8.4.8 Pipework

Compressed air pipework including vent pipes shall comply with the following current standards:

(a) BS EN 10255:2004 for steel tube sizes up to 80 mm nominal bore, 'Medium' grade tube for pressure up to and including 1000 kPa, and 'Heavy' grade tube for pressure above 1000 kPa; and

(b) BS EN 13480:2002 and BS EN 10217-2:2002 steel tube for sizes greater than 100 mm nominal bore.

All steel tube used for compressed air pipework shall be galvanised both internally and externally. Screwed fittings shall be of galvanised malleable iron conforming to BS EN 10242:1995.

Screw joints, excluding screwed on flanges, shall be used for steel pipes up to and including 80 mm nominal bore, provided that the maximum permissible pressure does not exceed those specified BS EN 13480:2002. Taper pipe threads shall be used with taper threaded fittings and shall comply with BS 21:1985.

Welded flange joints shall be used for steel pipe with maximum permissible pressure in excess of those specified in BS EN 13480:2002 and for steel pipe above 80 mm nominal bore irrespective of pressure.

Flanges and bolting of flanges shall be in accordance with the recommendations made in BS EN 1515:2000: Sections 3.1 & 3.2 and BS EN 1092-2:1997.

Gasket materials for use with flanges complying to BS EN 1092 shall comply with the dimensions given in BS EN 1514-1:1997.

C8.4.9 Valves

Stop and isolating valves up to and including 80 mm nominal diameter shall be of the copper alloy screw down type, and shall comply with, and be used within the limits laid down in BS 5154:1991. For sizes greater than this the valves shall be of the cast steel gate type and shall comply with, and be used within the limits laid down in ISO 10434:2004.

Steel ball valves which comply with, and are used within the limits laid down in ISO 17292:2004 may be used as an alternative to both of the aforementioned types of valves.

Pressure reducing valves for main distribution pipe lines shall be of the fullway type for use with compressed air at the highest working pressure of the system. Valves shall be capable of an adjustment of ±20% of the rated reduced pressure and lockable in any position within the range. A relief valve shall be fitted on the low pressure side of the valve and a pressure gauge shall be fitted on each side of the reducing valve.

Relief or safety valves shall be made of bronze or gunmetal and shall be of the enclosed adjustable spring loaded type. It shall comply with and be used within the limits laid down in ISO 4126:2006. Valves and seats shall be accessible and capable of being reground and reseated. The discharge shall be arranged to avoid injury to personnel.

The relief valves shall be so designed that the moving parts are efficiently guided and have adequate clearance under all conditions of service. In addition, the breakage of any part or failure of any device shall not obstruct free and full discharge through the valve.

Each relief valve shall incorporate permanent markings as follows:

(a) Manufacturer's identification;

(b) Direction of flow;

(c) Set pressure; and

(d) Flow capacity of valve.

C8.4.10 Air Line Filters

The air line filters shall be designed for the working pressure of the system with aluminium die casting body, bronze filter element and a float type auto drain.

Filters of the 5 micrometer grade shall be used. The bowl assembly shall be of the transparent plastic type with bowl guard. For applications involving thinner solvents or other hydrocarbons which may attack the plastic bowls, metal bowls with level gauge shall be used.

C8.4.11 Air Line Lubricators

Air line lubricators shall be of the oil fog type with adjustable drip.

Lubricators shall be suitable for the working pressure and air flow rate of the system with aluminium die casting body, transparent plastic type bowl and bowl guard. For applications involving thinner solvents or other hydrocarbons which may attack the plastic bowls, metal bowls with level gauge shall be used.

C8.4.12 Pressure Regulators

Pressure regulators shall be of the balanced diaphragm type and incorporate a built-in pressure relief feature.

The regulator shall be designed for the working pressure of the system and fitted with pressure gauge and limit indicator. The adjustment knob shall be of the locking type.

C8.4.13 Drain Traps

The drain traps shall be float-operated and automatic in operation.

C8.4.14 Pressure Gauges

Pressure gauges shall have their scale marked in kPa and comply with ISO 4126:2006 and BS EN 837-1:1998. A gauge cock fitted with anti-syphon pipe shall be provided at the points which require pressure readings.

The operating pressure of the gauge shall be within the middle of the full scale reading and provided with a red field on the scale to indicate the maximum allowable working pressure.

The dial of the pressure gauge at a level above 1.8 metre shall be 150mm whilst that at a level below 1.8 metre shall be 75mm.

C8.4.15 Quick Release Couplings

The couplings shall be so designed that they automatically seal the air pressure on the upstream side and vent the air pressure on the downstream side, so as to prevent a hazard when the adaptor is removed. Other connectors for flexible hose shall be of the fullway screwed union type with seating rings.

C8.5 ERECTION AND INSTALLATION

C8.5.1 General

A schematic flow diagram of the compressed air system, properly framed, shall be provided in the Compressor Room.

For emergency shut-down of electric motor, a self-latch red stop button shall be provided at a readily accessible location within one meter from the compressor to interrupt power to the motor.

C8.5.2 Installation of Air Compressors

The air compressor shall be bolted onto the plinth through anti-vibration mounting to prevent vibration generated by the set from being transmitted to the building structure.

Sufficient space shall be allowed around each compressor unit for inspection, necessary attention, and dismantling when required.

Independent isolators shall be provided for each compressor.

The compressor shall be installed with an efficient air intake filter designed and constructed in such a manner that it shall be easily accessible for inspection & cleaning and shall be as close as possible to the compressor.

The compressor shall also be fitted with a suction silencer to reduce the intake noise to a level in compliance with the Noise Control Ordinance. The silencer shall be located at the downstream of the air filter so that the filter is subjected to minimum pulsation effects.

All piping connected to the compressor shall be arranged with flanged fittings or unions to permit easy removal of the compressor or components at any time, without disturbing the piping.

The discharge pipe from the compressor to the aftercooler or receiver shall be free to expand under heat and shall not be in contact with wood or any flammable material.

In multiple-unit compressor systems, valves shall be provided for isolating each compressor. Check valves alone shall not be relied upon for isolating compressors.

Where an isolating valve or non-return valve is installed between the air compressor and the receiver, the pipe line on the compressor side of the valve shall be protected by a suitable safety valve so adjusted as to permit the air to escape as soon as the design pressure of the piping or compressor is exceeded. The safety valve shall be of sufficient size to relieve the full output of the compressor without the pressure rising 10% above the set blow-off pressure.

For air compressors over 5.5 kW, an ammeter with phase selector shall be provided.

C8.5.3 Guards and Insulation

All moving parts of the machine shall be guarded so as to comply with the requirements of Factories and Industrial Undertaking Ordinance, Chapter 59, Occupational Safety and Health Ordinance, Chapter 509, and other subsidiary legislation made under the Ordinances.

The guards shall be easy to remove and re-install, and shall have sufficient rigidity to withstand deflection and prevent rubbing as a result of bodily contact.

Pipework or other parts with an external surface temperature in excess of $60^{o}C$ and which may be accidentally contacted by personnel in normal operation shall be guarded or insulated. Other high-temperature pipework shall be clearly marked in accordance with BS 5378:1980 and BS 1710:1984.

C8.5.4 Air Distribution Pipeworks

All compressed air distribution pipeworks shall be adequately supported.

Service connections shall branch from the top of the main using long sweep bends and outlet points shall be provided at a height of approximately 1.5m from the floor level unless otherwise specified.

Each take off pipe shall be provided with one outlet point with a self-sealing, quick release coupling for connecting pneumatic tools or instruments.

The distribution system shall be self-draining by arranging the pipework sections to slope down in the direction of air flow, to convenient drainage points. Each drainage point shall be fitted with an automatic drain trap and the drainage points shall be installed at intervals not exceeding 30 metres of pipe run.

The main shall fall approximately 1 in 100 in the direction of flow. At suitable intervals, the main shall be brought back to its original height by using two 90^{o} long sweep bends and with the provision of a drain leg at all the low points.

When pipe mains are subject to variations of temperature, e.g. the main runs outside from one building to another, a separator and drain leg shall be fitted at the point where the air flow enters the building so that the moisture condensed is collected and removed.

If a pipeline is laid direct in the ground or embedded in concrete, the pipes shall be either flange jointed or continuously welded and shall be protected by a wrapping of two layers of 'Denso' tape or products having equivalent function and performance. In addition, the line shall be sloped and a drain fitted at the lowest point with an access hand hole and cover. The size and position of the hand hole shall be as indicated in the drawings.

For pipes on straight runs of more than 10 metres, slightly oversized brackets shall be used to allow axial movement and accommodate expansion, but provide lateral restraint. Under no circumstance shall the supporting interval exceed those recommended in the Code of Practice for the Selection and Installation of Compressed Air Services by British Compressed Air Society.

Unless otherwise indicated in the drawings, brackets shall be used to support the pipe runs.

The pipelines through which the discharge air passes to the aftercoolers or air receiver shall always be kept clean internally to avoid combustion of the oily carbon deposits. The piping shall drain toward the aftercooler and receiver so that gravity assists the flow of oil through the hot zone.

C8.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The complete installation shall be subject to a hydraulic pressure test at 1.5 times the maximum working pressure of the system for a minimum period of one hour without any deformation or leakage.

Following the hydraulic pressure test, air leakage tests shall be carried out. Pipework shall be isolated into convenient sections and the air pressure in each section raised to the maximum working pressure of the system. This pressure shall be held, with the supply disconnected, without sign of leakage for a minimum period of one hour.

The air receiver and all relief or safety valves shall be subject to survey in accordance with the Boilers and Pressure Vessels Ordinance by an approved surveyor. Three copies of the survey report including the original copy issued by an authorized surveyor shall be submitted to the Architect for retention after the survey.

SECTION C9

SEWAGE PUMPING SYSTEM

C9.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of sewage pumping system complete with the associated electrical power and control system.

C9.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with the relevant regulatory requirements as stipulated in Section A2.1.

C9.3 DESIGN

C9.3.1 System Requirements

The pumps shall be designed for handling sewage containing solid particles up to 60 mm diameter. The pumps shall be designed for operation in completely or partially submerged conditions.

The motor shall be capable of tolerating a maximum continuous starting frequency of 12 times per hour without overheating.

The power developed by the motor shall not be less than 110% of the power required by the pump.

C9.3.2 Pump Control

There shall be two modes of operation, the 'Automatic Mode' and the 'Manual Mode'.

Normally the system will be put under automatic mode of operation. In this mode, one of the 2 pumps shall be on duty while the other pump shall be in "standby". The standby/duty operation shall be interchanged after each pumping operation, and the 2 pumps shall alternate in turn to operate as standby/duty. The main purpose of this arrangement is to ensure even tear and wear of the pumps. However, provision shall be made to ensure that if one pump is taken out of service or fails, the other pump shall be able to operate to take over all necessary duties of the former pump.

The operation of the pump shall be completely automatic as set by the appropriate level regulators as indicated in the Drawings. When the sewage level rises to a certain predetermined level, the duty pump shall automatically start under the control of the regulator at that level. The duty pump stops when the sewage level falls to the lowest level regulator. If there is an upsurge of sewage, and the duty pump fails to cope, the standby pump will be started if the level rises to the higher level regulator. Under this circumstance, both pumps shall then be operating until the sewage reaches the lowest level regulator.

There shall be another extra high level regulator to provide high level alarm when both pumps are incapable of discharging the incoming sewage flow.

The level of the level regulators shall be adjustable and determined on site.

No-flow protection device shall be provided for each pump. The running pump shall be locked out on detection of no-flow condition. An adjustable timer shall also be provided to inhibit the no-flow detection system during starting of pumps.

Manual operation for these pumps shall be provided for individual control of the pump operation for maintenance purpose. However, the pump shall be stopped automatically by the lowest level regulator.

An emergency stop button shall be provided adjacent to the pumpset at a location approved by the Architect.

C9.3.3 Control Panel

The control panel shall consist of a lockable isolator for each pump, suitably rated HRC fuse for each pump and control circuit.

An alarm system shall be installed within the control panel for indication of high sewage level in the pump chamber, no-flow condition, motor overload, single phasing and power supply under-volt. A button shall be provided to mute off the above audible alarm but the appropriate indication red light shall remain energized until the fault is cleared.

C9.4 EQUIPMENT AND MATERIAL

C9.4.1 Pump

Pumps shall be manufactured to meet the following requirements:

Pump casing	Cast Iron to EN 1564:1997 Grade 220
Impeller	Austenitic Cast Iron to BSEN 13835:2002 Grade L – Ni Cu Cr 1563
Shaft	High Tensile Stainless Steel to EN 10084:2008, EN 10087:1999, EN 10088, EN 10095:1999 and EN 10250-1 & 4:2000 Grade 431S29
Bearing	Ball/Ball, no regreasing shall be required until after 3 years of continuous operation
Seals	Carbon/Tungsten Carbide
Bolts, nuts, screw & washer	Stainless Steel to EN 10084:2008, EN 10087:1999, EN 10088, EN 10095:1999 and EN 10250-1 & 4:2000 Grade 316
Hold-down bolts	Stainless Steel to EN 10084:2008, EN 10087:1999, EN 10088, EN 10095:1999 and EN 10250-1 & 4:2000 Grade 316

The sewage pump shall meet the designed capacity on normal operation.

The sewage pump shall be arranged with flanged connection to the discharge pipe. Each pump shall be closely coupled to the totally enclosed built-in submersible electric motor suitably rated for the pump.

Two mechanical seals, made of the material specified in above, shall be provided to seal off the leakage of sewage from the pump to motor.

The hydraulic efficiency of the pump shall be within the highest efficiency range at the specified operating point.

C9.4.2 Pump Motor

The motor shall comply generally with BS 4999 and shall operate on a 3 phase, 380 volt, 50 Hz supply.

The motor shall be of the squirrel cage, totally enclosed type with insulation of Class "F" to IEC60085:2004. Enclosure type of IP 68 to IEC 60529:2001 shall be used.

The motor shall be capable of supplying its rated output at rated speed at any voltage in the range 94% to 106% of the nominal voltage and shall satisfactorily operate continuously at its rated duty without excess temperature rise within this range.

The motor shall have its own built-in cooling system which shall enable the motor to operate continuously at its rated current regardless of whether the electric motor is above or below the surface of the liquid.

C9.4.3 Control Panel

The cubicle of the control panel shall be vermin proof and lockable to prevent vandalism. The thickness of sheet steel shall not be less than 2 mm and shall be properly reinforced with angle iron. The cubicle shall be constructed to conform to IP 44 to IEC 60529:2001 for indoor use and IP 65 for outdoor use.

All indicators, relays, control switches, push-buttons, fuses and other auxiliary apparatus shall be provided with labels clearly stating their function. The labels supplied shall be inscribed in English and Chinese characters.

C9.4.4 Level Regulator

Level regulators of PVC sheathed stainless steel Grade 316 electrodes shall be used.

C9.4.5 Pipework

Pipes and fittings shall be of ductile iron.

Ductile iron pipes and fittings shall be to EN 598:2007. Pipes shall be to Class I. Flanges shall be PN16 to EN 1092-2:1997 but made of ductile iron. The first and last flanges shall match the building contractor’s provision.

Flanges shall be machined smooth, drilled to EN 1092-2:1997: PN16 and jointed with a 3 mm thick full face rubber gasket to EN 1514-1:1997. All fixing and holding down bolts, nuts and anchors etc. shall be of stainless steel to EN 10084:1998, EN 10087:1999, EN 10088, EN 10095:1999 and EN 10250-4:2000 Grade 316.

C9.4.6 Valves

Gate valves shall be made of cast iron of full bore clearway pattern to EN 1171:2002 with solid wedge gates and outside screws and shall have a minimum normal pressure rating of PN10. Ductile iron flanges shall be PN16 to EN 1092-2:1997.

Reflux/non-return valves shall be to EN 12334:2001 and of single door swing check pattern having cast iron housing and gunmetal seat. Door shall have shock absorbent facing of suitable material.

Both gate and non-return valves shall have stainless steel stem of Grade 316.

C9.5 ERECTION AND INSTALLATION

Discharge connection and stainless steel Grade 316 guide bar and chain shall be supplied and installed for automatic connection of the pump to the discharge end and for the lifting up of the pump for inspection without entering into the sump. The lifting chain shall have intermediate hooking rings for easy lifting.

The guide bars shall be properly installed and the alignment shall not exceed the tolerance as required by the manufacturer or obstruct lifting up of the pump.

Adequate supporting arrangements for all pipes shall be provided.

Pipes with puddle flanges shall be provided where they pass through the walls of concrete substructures.

C9.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

Pressure tests shall be carried out to the pipework with the pump removed and the testing procedures to be agreed by the Architect.

The pumping system including sewage pipes and foul sewerage system shall be visually inspected after installation.

The whole system shall be functional tested by using supply water or sewage, if available.

SECTION C10

PNEUMATIC TUBE TRANSPORT SYSTEM

C10.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of pneumatic tube system complete with the associated electrical power and control system.

C10.2 COMPLIANCE WITH SPECIAL REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with all relevant regulatory and standards' requirements, in particular

(a) ISO 5388:1981 Stationary Air Compressors – Safety Rules and Code of Practice;

(b) Code of Practice for the Electricity (Wiring) Regulations issued by Electrical & Mechanical Services Department;

(c) General Requirements for Electronic Contracts issued by Electrical & Mechanical Services Department; and

(d) General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring and Control System Installation in Government Buildings, the Hong Kong Special Administrative Region.

C10.3 DESIGN

C10.3.1 System Requirements

A pneumatic tube transport system, which may be a single zone or a multi-zone system, is a distribution network of tube system, in which carriers of various sizes containing small items are driven by air. The prime mover is a blower that can alter the direction of the air in the tube as required to move the carrier through the system. The destination of the carrier may be controlled by diverters that switch the carrier from one branch to another. A central controller ensures that carriers are transported through the network.

The system shall be comprised of sending and receiving stations, a central control and supervisory unit, a transfer tubing network, transfer switching devices, or transfer units, blower units, carriers, and all other ancillary facilities for the completion of the System.

The system shall allow for future extension up to 25 zones and 500 stations.

The System shall be able to be extended by adding inter-linkages or connections among the zones. The inter-linkages shall provide routes to inter-zone transference.

C10.3.2 Operation Requirement

Sending / receiving priorities function shall be provided to ensure that urgent items can be handled with a higher priority.

The dispatching, routing, spacing and storage of carriers shall be directed by the control centre to provide automatic, unattended transmission of carriers between all stations.

The system shall provide shortest route vacuum-pressure travel. Transactions between stations on the same zone shall process to the closest turnaround point to the destination.

The System shall provide a smooth, quiet, safe and efficient transaction.

The System shall be modular in design such that it can be easily modified and/or extended. The System shall be suitable for both horizontal and vertical conveyance of the material specified.

The System shall be designed such that each zone in the System can be shut down and isolated from the rest of the System for maintenance or repair without affecting the operation in other branch lines.

Facilities shall be provided to ensure that the materials or specimens being transported by System shall not be damaged or spilled out.

Carriers shall be smoothly accelerated and decelerated. No shock, violent agitation, or excessive vibration is permitted.

C10.3.3 Carrier Velocity

The System shall provide at least 2 transport speeds, standard speed and safety speed. The standard speed and the safety speed shall be 6 m/s and 3 m/s respectively.

C10.3.4 Carrier Distribution

Transaction shall not be accepted at the source station if the carrier cannot be delivered to the destination station.

Carriers in process shall be delivered to dumping station if a failure occurs in the route while they are in transit.

When a power failure occurs at the control centre, all transactions information remaining in process shall be stored in memory and the carriers in-transfer shall be delivered to their destinations when power is restored.

The system shall allow prioritizing the stations on sending or receiving order so that the system can process the urgent carrier on the expressway in the shortest time.

"Automatic Homing" function shall be provided for the system. Each carrier shall be equipped with "transponder" to identify its own "home address". The system shall be fitted with corresponding devices that enable the carriers to return its individual home station automatically.

C10.3.5 System Control

Closed loop control shall verify that commands to the system equipment have been properly executed before the next segment of each transaction is started.

The destination selection capability of any station shall be controlled from the central control and supervisory unit.

Component diagnostics shall be performed at central control and supervising unit and the results shall be displayed for troubleshooting.

Station software feature enhancements shall be capable of being downloaded to the stations from the central control and supervising unit.

The system shall incorporate automatic recovery procedures to find and deliver carriers that do not reach their destination without maintenance personnel intervention as far as possible.

An emergency shutdown special function shall be provided at any designated station. This special function shall be used to immediately shut the system off if a carrier with a leaking specimen is received at a station. Immediate shutdown of the system shall provide for a safer environment by minimising the spread of contamination throughout the system by other carriers.

When the automatic fire alarm system is triggered, the pneumatic tube system shall be able to complete all transactions being in transfer. The fire alarm signal shall be displayed in all sending/receiving stations and the system is required to shut down to prevent the spread of smoke or flame via the system.

C10.3.6 Sending and Receiving Stations (Stations)

Stations shall be of the recessed front-loading type.

The Station shall be electronically activated and motor driven. Loading of the carrier shall be designed for easy and safe operation. The station door shall be automatically closed after the carrier loaded and open after the carrier dispatch.

Stations shall be wall mounted and the mounting height to the top of the Stations shall be 1.6 m above the finished floor level unless otherwise specified.

Stations shall be robust in construction.

Carriers shall be received from either above or below of the Stations.

Stations shall comprise of independent dispatcher and receiver of carrier. Thus outgoing carrier shall be capable of being inserted even when the station is receiving.

All mechanical and electrical components shall be accessible and removable for repair or replacement.

Electronic control units shall be solid state, plug-in units for fast replacement and shall be interchangeable with units in other stations.

All visible metal surfaces shall be factory painted. Bright metal finish parts shall be stainless, brushed aluminium or chrome plated.

The standard station dispatcher shall be capable of dispatching not less than 5 kg payload.

Position of station dispatching and receiving mechanisms shall be detected by no-contact optical sensors.

A full sensor and audible full indicator shall be provided in each station to detect and indicate that a station cannot receive any more carriers. A message shall also indicate the overload and other status information. The condition shall automatically be reset upon carrier removal from receiver.

Each station shall be provided with a storage rack for not less than 5 empty carriers.

An indication or operation algorithm to guide the user entering the destination of the carrier to be sent.

An audible and visual carrier arrival signals shall be provided at each Station to indicate the arrival of carriers.

On receipt of the carriers arrival signal, the signal shall be activated until silenced by the staff.

For Stations which are remote from the manned locations, remote alarm panels shall be provided at such manned locations and wired up to the corresponding Stations, so that appropriate carrier arrival alarm can be relayed to its designated destination. All the fault indications/alarms of the corresponding Stations shall also be repeated in the remote alarm panels.

C10.3.7 Carrier Arrival Baskets

Carrier arrival basket shall be provided and installed for each Station. The basket shall be with sufficient size and capacity so as to accommodate the carriers allocated to the Station.

The baskets shall be fixed under the Stations and positioned to allow the arrival carriers to be stored in them without blocking the exit tubing under the Stations.

The baskets shall be padded with sound-absorbing and soft material so as to provide a soft landing of the carriers.

C10.3.8 Display and Keypad Unit

All Stations shall be provided with an interface for user control. This interface shall include a cleanable keypad and display.

The visual display shall be a liquid crystal display.

All text message used on the display shall be in English.

When performing a shipment, the display shall show, but not be limited to, the following messages to the users:

(a) An indication to show whether the Station/ System is ready to accept a shipment request;

(b) A display echoing the destination of a carrier to the user for his confirmation before dispatching a carrier;

(c) A message to confirm the completion of a shipment; and

(d) Rejection messages shall be provided.

C10.3.9 Station / System Availability

Whenever the Station or the System is out of service for any reason, the screen shall display “system out of use” or “station out of use” as appropriate. In addition, a warning light shall be given out.

The display shall incorporate with station availability lights. The signals shall indicate “the Station is available for use”, “the system is busy” and “the Station / System is out of service”. The colour of the indication shall be subjected to the approval of Architect.

Alarm message shall be displayed for the following conditions:

(a) Incoming carriers at the receiving station;

(b) To empty a station receiver when it is full; and

(c) Receiving station is not available.

A cleanable membrane keypad shall be provided for entering instructions / control. The operation of the interface shall be simple and easy to be understood. The keypad shall provide a control to the following functions:

(a) Send/Enter key - to activate dispatch after destination selection or enter data for special functions;

(b) Cancel/Clear key - to allow for transaction cancellation or clearing of display during special function activation;

(c) Special function key - to request special features;

(d) Directory - listing station addresses;

(e) Instruction compartment - for operating and special function instruction;

(f) Redirecting carries to other Stations;

(g) Giving visual and audible warning when a wrong instruction is input;

(h) Giving visual and audible warning when faults are detected in the System;

(i) Selecting the carrier transferring speed; and

(j) Cancelling wrong inputs.

The display and keypad unit shall provide an activatable station directory. Through browsing the station directory in the help menu, user can have a quick reference to the address of the Stations in the System.

C10.3.10 Central Control and Supervisory Unit

Data stored in the central control and supervisory unit shall not be lost even in case of the mains power supply failure. Once the power supply is restored, the unit shall self-start automatically and complete all outstanding carrier transactions.

2 sets of central controllers, one set as duty and one set as standby shall be provided to perform the function in planning and controlling the transmission of the carriers in the System.

The central controllers shall be capable of being re-programmed so as to cater for the future extension or modification to the System.

The computer or microprocessor in each controller, the interfacing circuits, etc. shall be modular in configuration and shall be built up from solid-state components throughout. Each circuit module shall be easily removable for maintenance. The system shall perform the following functions:

(a) control on sending / receiving transaction among the Stations, and control all movement of carriers;

(b) system self-test;

(c) provision of System status information;

(d) automatic purging cycle;

(e) system software re-configuration;

(f) continuous polling of all Stations;

(g) control, change sending / receiving priorities;

(h) assign any station to priority;

(i) manual control;

(j) PIN or Touch Key Security system;

(k) independently shut down and start up any station, zone or system for isolated diagnostic interrogation or repair; and

(l) interrogate any system component through command/execute/ respond diagnostic programme. Allow for ability to manually process any carrier through the system from the keyboard also.

A key board security mode shall be selected to control access to the displays.

Each central controller shall be multi-tasking which means that several programmes can be operated in the controller simultaneously.

Each central controller shall be able to controlling up to 25 zones and 500 Stations.

Sufficient facilities shall be provided to store and display the following information:

(a) the addresses of the Stations sending or receiving carriers;

(b) the paths of the carriers being transmitted;

(c) the transmission times; and

(d) the System status.

Each central controller shall have a cleanable keypad and display for instruction input.

Each central controller shall provide an interface provision which shall be connected to the automatic fire alarm system, so that in case of fire, the controller shall able to direct the system to complete the transaction in transfer and display the signal in all sending/receiving stations and then shut down the System so as to prevent the spread of smoke or flame via the System.

Each central controller shall also be provided with sufficient interfacing ports for the connection to modem, printer, and the Building Management System.

The workstation shall be located at Pneumatic Tube Plant room and used to monitor and display in real time the progress of all carriers transporting in the System. The display shall include, but not be limited to, the following information:

(a) At sending Station
  (i) carrier loaded
  (ii) carrier accepted
  (iii) carrier despatched

(b) At transfer switching devices
  (i) carrier arrival
  (ii) carrier departure

(c) At receiving station
  (i) carrier approaching
  (ii) carrier arrived
  (iii) carrier ejected to the basket

(d) A display header for all displays shall be provided that show the date, time, daily transactions, total transactions, system status, number of alarms and full stations.

(e) Station List - shows addresses available and their selection codes.

(f) System Traffic Display - shows status, transaction in process and number of pending transactions for each zone.

(g) Alarm Displays - shows failure details and corrective action for any condition that has interrupted normal system operation.

(h) Station Status Display - shows operational data and assignments for a specific station.

(i) Station Maintenance Display - shows accumulated operating cycles for all stations.

(j) Blower Maintenance Display - shows accumulated operating time/cycles for all blowers.

(k) Transaction Summary Display - shows total transactions by zone and by station.

(l) Priority Summary Display - shows transaction priority assignments for all stations.

(m) Diagnostic Display - allows keyboard operation of stations, carrier transfer units and blowers for recovering undelivered carriers, confirming malfunctions, etc.

(n) Configuration Display - allows entry of system layout and operating parameters.

(o) Purge Display - used to automatically purge selected zones or the system of transient carriers.

(p) The workstation shall provide a graphics display to show the System schematics and the working/health status of the major components in the System, and locations of all carriers in traffic etc.

(q) The workstation shall have sufficient memory to store at least the last 1000 carrier transaction records.

(r) A printing facility shall also be provided to record the transaction information.

Based on the transaction records, the workstation shall perform transaction analysis on the System.

A pointer shall be provided for the following functions:

(a) Provide hard copy record of individual alarms and transactions.

(b) Print time and date each alarm is cleared.

(c) Print time of power loss and power restoration for control centre power failures.

(d) Any system event such as transactions and alarms can be recorded on a CD for off-line analysis.

C10.3.11 Diverters

The noise level of diverters shall be less than 50dBA at 1 metre distance.

Diverter design shall be simple and shall require minimum maintenance.

Diverters shall meet all safety and fire resistance requirements.

C10.3.12 Blower Unit

The blowers shall be suitably sized and shall provide sufficient driving force to transport carriers containing the material specified along the transfer tubing network in all tubing, stations, transfer units etc. and any future extension of the system.

The blowers shall provide sufficient vacuum and pressure driving force in the tubing network to transport fully loaded carriers at a speed up to 6 metres/ sec.

All blowers shall be able to operate simultaneously and independently.

Blowers shall be suitable for ceiling, wall, or floor mounting.

Blower packages shall be self-contained units with the blower, motor, shifter, starter and controls factory assembled on a vibration dampened frame.

The vacuum, pressure and atmospheric ports of blower shall have mufflers to minimise noise.

One blower package per zone shall be provided.

The blower assembly shall allow complete and clear access to service mechanical and electrical components.

The blower system shall be provided with automatic shutdown control.

Piping shall be complete with all necessary tees and elbows to suit the system requirements. The locations of the blowers, the transfer units, and the tubing networks etc. shall be properly coordinated and matched to suit the system requirements and component performance/limitations.

A shifter or similar provision shall be used to set the System for vacuum, pressure or idle operational modes.

The shifter shall use dynamic braking instead of physical contact type brakes to eliminate downtime caused by worn or faulty brakes.

Filters shall be provided at the air intake point of the blower units to ensure the cleanliness of air inside the tubing network.

C10.3.13 Drive Motors

Drive motors shall be suitable for operation from an a.c. supply of 380V 3 phase 4 wire 50 Hz. The motors shall have a rating sufficient to start their connected equipment when fully loaded.

Each motor shall be capable of tolerating the starting frequency up to 85 times per hour without overheating.

Each motor shall be able to provide sufficient power for the blower to generate up to 9 m^3/min air flow and vacuum pressure up to 300 mbar.

In addition to other clauses of this part of Specifications, the motors shall comply with IEC 60034:2004 and IEC 60072:1994 whichever is appropriate. Some particulars are as follows:

(a)	Type of Enclosure	IP54
(b)	Rating	Maximum Continuous Rating
(c)	Speed	Not exceeding 3000 rpm
(d)	Method of starting	Automatic
(e)	Method of Earthing	Earthing affixed to motor frame
(f)	Dimensions	The motors shall be of standard dimensions

C10.3.14 Flow Control Valve

Flow control valves shall be provided to alter the airflow direction in the transfer tubing network without changing the rotation direction of the blower units.

The valves shall be able to break the airflow in the network when the carrier almost reach its destination.

The switch-over time shall not be longer than 0.7 second.

C10.3.15 Carriers

The body of the carriers shall be made of clear molded high impact resistant and distortion free polycarbonate plastic.

The carriers shall be fully accessible, equipped with side opening safety swivel self-lock lids on both sides to prevent them from opening during transportation.

Inside both end of the carriers shall be covered with elastic material. A fully loaded carrier shall not be damaged even it is dropped from a height of 1.5 m. New replaceable wear bands and latches shall be provided which shall eliminate gluing process.

Both the interior and exterior of the carriers shall be suitable for steam or chemical sterilisation.

The internal dimension of the carriers shall not be less than 400 mm in length and 110 mm in diameter. It shall be able to carry material up to 5 kg in net weight.

The number of carriers shall be sufficient to enable an efficient operation of the System. In any case, there shall be at least 5 carriers at each Station available for transportation.

'Protective Insertion' shall be provided for holding the handing material such as blood samples, test tube, drugs, small surgical tools, etc as specified in the Particular Specification.

C10.3.16 Carrier Detectors

Beam detectors shall be provided to monitor the progress of the carriers throughout the System.

The detectors shall only operate in the invisible part of the light spectrum and shall not be sensitive to daylight or any form of artificial lighting so as to prevent faults arising from false detection of extraneous light.

The detectors shall be mounted on the transfer tubing securely with precise assembly using injection moulded brackets and shall be removable without damaging the tubing network.

The external of the detectors shall have a LED to indicate its working status.

Whenever a blockage in the System is detected, an automatic purging programme shall be activated to clear the blockage and purge it to the receiving tube. The receiving tube shall be located at the Pneumatic Tube plant room. If the automatic purge is not successful, an alarm signal shall then be given out and kept energized until reset manually by the responsible staff.

C10.3.17 Safety

Access to the System shall be secured to prevent unauthorised entry.

The transfer area room shall permit safe access to all components in the System which require inspection, service or maintenance.

C10.3.18 Station Braking

In order to ensure quiet and smooth operation, carriers shall be received and braked in the Stations by air column or air cushion technique. In this technique, a still column of air shall be formed above the Station. Through controlling the pressure of the air column, the arrival carriers shall be decelerated gradually. Once the carrier come to a complete stop, it shall then be released to a collection basket or a carrier storage below the Station.

Acoustic treatment shall be provided in the Stations to reduce the noise generated. The noise level shall be less than 65dBA at 1 metre distance.

C10.3.19 Station Accessory

A rack for the storage of at least 5 carriers shall be provided at each station.

An encapsulated Stations Directory and Operation Instructions shall be indicated in each station.

C10.3.20 Dumping Station

Dumping station shall be provided in the Pneumatic Tube Plant Room so as to facilitate removal of blockages from the System.

C10.3.21 Empty Carriers Storage Station

In ensuring the availability of empty carriers at each station, empty carriers storage stations or equivalent facilities shall be provided. With these facilities, when there is a demand, users can call empty carriers from the storage stations to their Stations. However, when there is a surplus of empty carrier at the Stations, carriers can be forwarded and deposited in the storage stations.

At least one empty storage station for each zone of the System shall be provided and the storage capacity shall not be less than 4 empty carriers.

Attenuation of the plant noise and/or vibration emanating from equipment shall be provided. The overall pneumatic tube transport system shall be selected which shall not produce a noise level in excess of 65dBA at all times when the plant and equipment are in full operation. Necessary noise attenuators and anti-vibration mountings for all equipment shall be allowed and for and guaranteed to have the deflection necessary giving a total transmissibility of not more than 10%. Mounting sizes shall be determined by the respective equipment manufacturers and the mountings shall be installed in accordance with the manufacturer's instructions. The specified duties or capacities of all systems shall not be degraded when fitted with acoustic or anti-vibration treatments.

C10.4 EQUIPMENT AND MATERIAL

All tubing and bends shall be of appropriate outside diameter, stainless and acid-proof chromium-nickel steel AISI 321 or equivalent performance material. The wall thickness shall not less than 2mm. A smooth internal bore must be retained throughout the tubing network specifically produced for the pneumatic tube transport system.

All bends shall have a centre line radius of not less than 800 mm, with a uniform cross-section free from wrinkles and distortions. No expanded bends shall be allowed in the System.

All pipe-work and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition.

All pipe-work delivered to site shall be new and shall be colour banded at the factory to identify different grades, materials and manufacturers.

All pipe-work and fittings, accessories, joints and joining media used shall be suitable for the substance conveying in the pipes and shall not deteriorate due to atmospheric action.

All pipe-work shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

All pipe-work shall be fabricated as far as practicable to site dimensions such as building dimensions and the sizes and positions of plants on the site.

C10.5 ERECTION & INSTALLATION

C10.5.1 Pipework

All pipework shall be adequately supported in such a manner as to permit free movement due to expansion and contraction. Pipework supports shall be arranged as near as possible to joints, valves and changes in direction. The spacing of the supports shall not exceed 4.5m.

Vertically rising pipes shall be adequately supported at base of riser to withstand its total weight. Branches shall not be used to support the riser.

Pipes shall be arranged so as to provide subsequent access to any pipe for maintenance or removal purposes.

The anchors and supports shall be constructed of galvanized steel sections of appropriate strength and stiffness to an acceptable international / material standards.

Galvanized steel anchors capable of resisting the maximum stresses shall be provided. Cast-iron chairs with at least two wrought-iron stirrup bolts shall be used, the bolts being provided with sufficient thread to ensure an effective grip on the tube.

The system shall be supplied, and fixed in position ready for building in, all cleats, brackets and steelworks required for anchor points. Anchor steelworks secured to the bottoms of tube shall be coated with hot-poured bitumen.

The design of the network shall permit assembly and disassembly so as to accommodate future extension and modification.

Except for the section of tubing immediately connected to the Station, all transfer tubing shall be installed above the suspended ceiling level.

Suitable airtight compound shall be applied for seal joints.

For identification purpose, the tubing network shall be clearly marked / labelled.

As tubing network is prone to build up dust due to an electro-static charge created by the transport of the carriers through the tubing network, action shall be taken to earth the network so as to eliminate the electro-static charge in addition to the electrical bonding as required by BS 7671:2008.

Tubes shall not be built solidly into walls and joints, and must not be positioned within the thickness of walls, floor or in any other inaccessible position.

Joints shall be clean threaded pulled up tightly. No caulking shall be allowed in any circumstance. Particular care shall be taken that all tubes shall be absolutely free from internal obstructions. To ensure this, all tubes and fittings shall be carefully reamed to ensure that the full bore of the tube is maintained, and where necessary shall be cleaned out before erection. Plugs shall be inserted in all open ends during the progress of the works to prevent the ingress of dirt and moisture.

Any stoppage which is found to impede passage through the pipework shall be removed after the system having been put into commission including making good of all pipework concerned.

All pipework shall have joints in positions which will facilitate erection and dismantling.

All fittings shall be of the same size as the tubes connected to them.

C10.5.2 Sleeves Through Walls and Floors

Wherever the pipework passing through the movement or expansion/contraction joints of any building structure, flexible connection joints shall be provided.

Holes shall be made through non-structural walls or floors. All sleeves necessary to accommodate piping with insulation in position and make good the openings in the walls or floors. The positions of such sleeves shall take into account of the structural stability of walls or floors.

The sleeves shall be of sufficient diameter to permit freedom of movement of the tubes but the clearance all round must not exceed 3 mm. For walls, the sleeve shall be of a length so that it is flush with both sides of the finished wall. For floors, the sleeve shall be of a length so that it is flush with the finished ceiling below and shall project 25 mm above the finished floor surface.

Wherever the tubing passing through fire-rated walls, floors, ceilings or other barriers, appropriate and approved fire sleeves or collars with suitable fire rating shall be installed so as to retain the integrity of the Building.

The rating of the fire protection sleeves shall comply with the requirements of Fire Service Department and Building Department.

The fire sleeves shall allow a free passage for the carriers under normal conditions.

C10.5.3 Provision for Thermal Expansion

Provision for movement due to expansion and contraction shall be made by changes in direction of the pipework or by special expansion joints.

Supports, steadies and guides shall be arranged to ensure that all movement is taken up by the change in direction of the pipework loop or joint.

All expansion joints shall be supplied and correctly aligned at the suitable positions. Support at such joints shall be arranged to ensure that all expansion or contraction is taken up to the expansion joint or change in direction of the pipework. Expansion joints shall be pressurised for the purpose of reducing the expansion stress under working conditions. The extent of the cold draw shall be as recommended by the manufacturer.

Expansion joints for angular movements shall be provided with tie rods or hinges to take end thrust.

All expansion joints shall be provided with external protection where exposed to damage.

Expansion joints shall be installed so that they are not subject to stresses other than those for which they are designed. They shall be installed so that they are in their free position at a temperature midway between the high and low limits of normal service.

Expansion joints shall be provided with guides to ensure that all movements are taken up in the designed manner. The manufacturer's recommendations shall be closely followed. Guides shall be secured rigidly and shall provide free movement for expansion without undue tolerance. Means for lubrication shall be provided where necessary.

Guides shall be adjustable in both directions in the lateral plane so that the pipework can be accurately aligned with the expansion device. Each guide shall not be less than a pipe diameter long and have a minimum manufacturing clearance. The distance from the expansion joint to the first guide shall not be more than 4 pipe diameters and the distance between the first guide and the second guide shall not be more than 14 pipe diameters.

Guides and anchors shall meet with the written approval of the expansion joint manufacturer.

C10.5.4 Vibration Control

All equipment, tubing, etc. shall be mounted on or suspended from approved foundations and supports in order to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

Vibration isolators shall be selected in accordance with the weight distribution so as to produce the correct deflection.

All rotating machinery shall be accurately balanced, statically and dynamically. All blowers and other rotating equipment shall be suspended or on vibration isolating assembly.

All connections to rotating machinery or assemblies containing rotating machinery shall be rendered flexible, such as stainless steel flexible tubing connections.

Mounting systems exposed to corrosive environments and in plant rooms shall be protected against corrosion.

Vibration hangers shall contain a steel spring and an 8 mm deflection neoprene element arranged in series. The neoprene element shall be moulded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the hole and neutralising the effect of the spring. Springs shall have a minimum travel to solid, equal to 150% of the rate deflection. Minimum deflection shall be 35 mm.

Where vibration is present in tubing, the tubing shall not contact any part of the building when passing through walls, floors etc. Sleeves containing an approved isolating material shall isolate the tubing and be sealed with heavy non-hardening mastic. Seal shall comply with requirements of Fire Services Department.

C10.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The following tests shall be carried out in accordance with the relevant sections of HTM No. 2009 and EE_GS:

(a) Air leakage test for pipelines and work stations;

(b) Carriers Flow rate and delivery accuracy test;

(c) Electrical tests as specified by EE_GS;

(d) Test of mechanism for operation and control;

(e) All tubing is identified and to the specification; and

(f) All functions of the system shall be fully tested with the use of Central Control and Supervisory Unit to control the system. A full software check and debug of all software errors shall also be done.

All pressure tests for the pneumatic tube and fittings as specified above shall be carried out before the application of the thermal insulation.

The balancing and regulation of the distribution system together with the final adjustment of all automatic control systems.

C10.6.1 Testing of Noise Control System

The method of all sound and vibration measurements shall generally be in accordance with BS 4142:1997 or other technically equivalent natiounal or international standards. Measurement shall be taken by an industrial grades sound level meter.

Sound level readings shall be taken with a simple sound level meter using the 'A' scale weighting network. The spaces in which readings shall be taken in general be the following:

(a) Plant rooms;

(b) Outside plant room doors;

(c) Occupied rooms adjacent to plant rooms; and

(d) Sending / Receiving Stations.

Sound level readings shall be taken using a sound analyser to give an octave band analysis of the sound spectrum and to pinpoint the frequency values of peak sound levels.

Laboratory test shall be carried out for samples transported through the system if required in the Particular specification.

SECTION C11

VEHICLE TURNTABLE

C11.1 SCOPE OF SECTION

This Section shall cover the design, supply and installation of vehicle turntable complete with the associated control and accessories.

C11.2 COMPLIANCE WITH SPECIFIC REGULATORY REQUIREMENTS AND STANDARDS

The installation shall comply with the relevant Regulatory Requirements.

C11.3 DESIGN

C11.3.1 General Requirements

The vehicle turntable shall facilitate better manoeuvring of vehicle of truck or the like in a limited space. The turntable shall be electromechanical driven and capable of handling static, eccentric loads. The maximum handling capacity and turntable diameter shall be as specified in Particular Specification.

The turntable shall consist of a circular structural steel platform supported on maintenance free type centre pivot and castor wheels. The turntable shall be capable of turning 360^{o} continuously in both clockwise and anticlockwise directions and the rotational speed shall be approximately 0.75 revolution per minute unless otherwise specified.

All starting operation shall be by a key-operated on/off switch to prevent unauthorised usage. The operation of the turntable shall be controlled by on/off push buttons of deadman type for forward (clockwise), reverse (anti-clockwise) and reset mode of operation.

A hold-down type emergency stop device shall also be provided to cut off the power to hydraulic power pack in case of emergency.

In the event of power failure, the turntable shall be capable of being disengaged from the drive unit and be capable of manually operated. An easily accessible manual operating device of the approved type shall be provided. An interlocking device shall be installed to prevent the drive unit from being started when the turntable is manually operated, and vice versa.

A float type level sensor shall be provided in the turntable pit for detection of flooding.

C11.3.2 Main Frame

The main frame shall be shop fabricated in segments, bolted and welded properly in good workmanship.

The deck surface of the turntable shall be fabricated from non-slip, solid steel chequer plate of 10 mm in thickness. To allow accessibility for servicing and general cleaning of the turntable, adequately sized access openings with lockable hinged covers shall be provided on the deck surface.

C11.3.3 Drive System

The turntable shall be driven by hydraulic drive unit located in the drive pit of the turntable. The hydraulic fluid shall be supplied by a power pack.

Each drive unit shall consist of a hydraulic motor, speed reduction gear unit, torque limiter, driving sprocket and associated chain drives as necessary.

The system shall be so designed that the turntable shall be locked in position without slip when it is not in use.

The turntable shall be driven continuously 360^{o} in both clockwise and anticlockwise directions by controlling the hydraulic valves unit.

The drive motor shall be of high torque hydraulic motor and designed for intermittent operation.

The motor shall be suitably rated to drive the turntable under all normal conditions of service without overloading and shall not automatically restart on restoration of failed mains or fault.

C11.3.4 Supporting Castors

One set of supporting castor shall be provided underneath the turntable to take up the imposed loading. The castors shall be equally spaced and fixed on appropriate pitch circle diameter(s) to suit the stated builder's work.

Structural calculation shall be provided to support the number of castors required and the number of castors shall normally be in the range of 12 to 24 to suit the site condition.

The structural calculation shall allow spare capacity for driving the turntable in case of one castor is failed.

C11.3.5 Centre Pivot

The bearing for centre pivot arrangement shall be designed with suitably rated dynamic and static capacity to withstand the imposed thrust and moment. The bearing house shall be attached on a mild steel baseplate to be fixed on the turntable pit base by anchor bolts.

C11.3.6 Control Panels

Unless otherwise specified, all electrical equipment shall be suitable for use in ambient temperature up to 40^{o}C and relative humidities up to 100%. All electrical equipment shall be suitable for a rated voltage as specified.

The control panel shall be ergonomically designed to suit the physique of the average Hong Kong operators.

Control cubicles shall be vermin proof and shall also meet the requirements of IP54 enclosures with interior finished to an approved Matt White and exterior opaline green to BS 381C:1996.

All control cubicles shall have labels made from laminated self-coloured materials and engraved with descriptions in both English and Chinese to be approved by the Architect.

The contactors, switch fuses, relays and all other necessary items shall be housed in the appropriate control panel which shall be arranged with front access for maintenance. It shall also be lockable to prevent unauthorised access and malicious damage to the equipment inside.

Each relay shall be labelled appropriately to its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

A wall-mounted lockable control panel shall be installed to include the operation and protection system for the vehicle turntable.

The panel shall be made of galvanised steel sheet of 2 mm minimum thickness and the enclosure shall be protected to IP54 as per IEC 60529:2001. The panel shall be coated with one coat of metallic zinc-rich primer to BS 4652:1995, type 2 or lead primer to BS 7956:2000, two undercoats and one finish coat. Undercoats and finish coat shall be of properly matching type and the finish coat give a hard gloss finish as required. The external paint finish shall be light grey to colour 631 of BS 381C:1996.

All circuits shall be accommodated in accordance with IEC 60439-1:2004. Permanent labels of the approved type shall be provided for the identification of major components.

Each control panel for the vehicle turntable shall include but not limit to the following major items:

(a) Triple pole motor starters to IEC 60947-4-1:2009 for power pack motor. Each starter shall be equipped with triple pole thermal overload protection device complete with manual reset.

(b) Associated power and control circuits with appropriate HRC fuse protection.

(c) One set of outgoing terminals and auxiliary terminals.

(d) Key-operated on/off main switch.

(e) Heavy duty push-buttons for the following purposes:

(i) deadman type push-buttons for the forward and reverse modes of operation;

(ii) lamp test; and

(iii) fault reset.

(f) Heavy-duty, mushroom head, hold-down type emergency stop push button with manual reset.

(g) Indication lamps for the following purposes:

(i) power on;

(ii) modes of peration (forward and reverse);

(iii) motor overload; and

(iv) high water level alarm in the turntable pit.

C11.3.7 Power Pack Motor

The power pack motor shall be totally enclosed, squirrel cage, high torque induction motor to BS 4999 and designed for intermittent operation capable to tolerate a maximum starting frequency of 12 times per hour at rated voltage without overheating. The motor shall have a minimum of Class F insulation and Index of Protection to IP55 in accordance with IEC 60529:2001.

C11.3.8 Cabling

Allowance shall be made to protect all cables from ingress of water, especially in the drive pit, using water tight junction box, flexible conduits, etc.

C11.4 EQUIPMENT AND MATERIALS

The main members of the turntable frame shall be fabricated from beams, channels and angle iron of high grade structural steel to BS 7668:2004, BS EN 10029:1991, Parts 1 to 3 of BS EN 10025:2004, BS EN 10210-1:2006 and shall be so designed to withstand the laden vehicle load.

All steelwork shall be shot blasted to ISO 8501-1:2006 2nd quality (SA 2.5) and painted in accordance with B3.4 of this Specification.

The centre pivot shall consist of bronze bush with suitable vertical thrust bearing arrangement.

C11.4.1 Speed Reduction Gear Unit

The reduction gearbox shall be totally enclosed and shall be capable of transmitting the maximum rated power of the drive motor continuously.

The reduction gears shall be practically submerged in and lubricated by oil bath which can be drained off conveniently at an accessible position on the bottom of the gearbox. The gearbox casing shall be with access for routine inspection and maintenance.

The minimum grade of material of the gearbox components shall be as follows:

Components	Material
Casing & Baseplate	Cast iron
Shaft and Gears	Steel to BS EN 10095:1999, BS EN 10250:2000, BS EN 10084:2008 & BS EN 10087:1999
Drive nut & sleeve	Aluminium bronze

C11.4.2 Chain Drive

Any roller chain incorporated in the drive unit shall be made of high quality non-ageing steel. The chain shall be case hardened for improved wear resistance.

The chainwheel shall be forged and case hardened to provide necessary strength. Roller chains and chainwheels shall conform with ISO 606:2004.

C11.4.3 Motor

The motor shall be suitably rated to drive the hydraulic power pack under all normally conditions of service without overloading.

C11.4.4 Cabling

The power cables shall be steel wire armoured cable to BS 6724:1997 with copper conductor and suitably rated in accordance with BS 7671:2008.

The cables shall be suitable for installation in the piping provided by others between the control panel and the drive unit.

C11.5 ERECTION AND INSTALLATION

C11.5.1 Main Frame Construction

The clearance between the turntable pit and the turntable circular edge shall not be greater than 10 mm during operation.

All steelwork shall be primed before erection and the under coat and finishing coat shall be coal tar epoxy paint. The priming and painting shall be conducted in accordance with the requirements in B3.4 of this Specification.

The foundation of turntable pit provided by the Building Contractor shall be checked to ensure that anchor bolts for castors are correctly located and the pit base is reasonable level for supporting the turntable.

C11.5.2 Supporting Castors

Each castor shall consist of a cast steel wheel running on a stainless steel shaft with self-lubricating bearing, the bearing shall be properly sealed to prevent entry of moisture. The wheels shall be supported on stainless steel wheel brackets to be mounted onto the pit base. Provision shall be made to ensure all castor wheels shall have good contact and match with the running rail as stated below. Grease point shall also be provided for each castor.

Running rail(s) of cold rolled steel shall be installed on the underside of the turntable for each set of supporting castors. The dimensions of each rail track shall conform to the dimensions and location of the respective castor wheels underneath the turntable.

C11.6 PARTICULAR REQUIREMENTS ON INSPECTION AND TESTING

The driving system and supporting castors shall be visually inspected before erection of cover plates.

The system shall be functional tested with the specified loading capacity after completion.

PART D – INSPECTION, TESTING AND COMMISSIONING DURING CONSTRUCTION PERIOD

SECTION D1

GENERAL REQUIREMENTS

D1.1 TESTS AT MANUFACTURER'S WORKS

The original official Birth Certificate for the equipment shall be submitted to the Architect at least 4 calendar weeks before the equipment departs from the manufacturer's factory and prior to shipment.

The complete and fully assembled equipment shall be tested at the manufacturer's works before despatch, including full operational tests as well as tests on control devices, safety devices and protection devices in accordance with the specification. Official certified records of these tests shall be submitted to the Architect at least 4 calendar weeks before shipment.

Before the tests are carried out, the test procedure shall be submitted to the Architect for approval.

D1.2 ADJUSTMENTS, COMMISSIONING, FUNCTIONAL AND PERFORMANCE TESTS AT SITES

The Contractor shall commission the installation and carry out complete functional and performance tests for all equipment and systems installed by him, make all necessary adjustments, including setting all controls and checking the operation of all protective and safety devices in accordance with the manufacturers' instructions, the requirements of the statutory rules and regulations and to the satisfaction of the Architect before the installations will be accepted. Prior to any tests, the Contractor shall submit detailed procedures and a programme for commissioning and testing to the Architect for approval at least 4 weeks before commencement of commissioning and testing or within 6 months after commencement of the Contract whichever is earlier.

The procedures submitted shall be in accordance with the manufacturer's recommendation, relevant standards and statutory regulations and submitted to the Architect for approval before any tests are carried out.

The detailed procedures shall be prepared in two main parts covering the following:

(a) Testing that are required to be carried out during construction period when part of the Works are installed; and

(b) Commissioning and testing required for certifying completion of the Works and before commencement of the Defects Liability Period.

Commissioning and testing shall be carried out in accordance with the Testing and Commissioning Procedures issued by the Architectural Services Department and

shall include, but not be limited to:

(a) Factory tests to be witnessed where required;

(b) Visual inspection and checking;

(c) Safety and quality tests;

(d) Pressure tests;

(e) Load tests;

(f) Commissioning, tuning and adjustment;

(g) Functional tests;

(h) Performance tests;

(i) Final mock-up tests; and

(j) Statutory tests and inspections.

The Contractor shall note that completion of commissioning and testing is one of the considerations for certifying completion of the Works. The Contractor shall make a detailed plan on the programme of the commissioning and testing works at the commencement of the Contract, in order to ensure that all of such works can be completed within the Contract period. The commissioning and testing programme submitted shall detail the types of commissioning and testing works required, the tests that are required during construction and at the time before certifying the completion of the Works, the period of tests with float time allowed, the milestone dates on final test and statutory inspections.

D1.3 UNEXPECTED EVENTS

If by any unexpected events or whatsoever that the commissioning of the plant have to be deferred as deemed necessary by the Architect, the Contractor shall be responsible for the preservation of the plant until after commissioning and handover to the user. The Contractor shall make all necessary arrangement and maintenance effort to safeguard the plant against all risks and deterioration. The costs for such preservative measures, which must have prior approval from the Architect, shall be borne by the Employer. The Contractor shall include this rate in the Schedule of Rate or Bill of Quantity and the rate shall be valid within one year after the original contract completion date.

D1.4 FACTORY TESTS OF INDIVIDUAL EQUIPMENT AT MANUFACTURER'S WORKS

The Contractor shall carry out all necessary testing in the manufacturing factory to ascertain the satisfactory operation and functioning of equipment before assembly and installation etc.

The purpose of the factory test is to ascertain that all major equipment are in proper and safe working conditions, correctly designed to meet with the specified output and free from inherent defects before delivery to site. No equipment shall be shipped until the factory tests have been completed and the certified test reports issued specifically for the installation. Results of these tests shall be submitted for approval by the Architect.

At least four weeks prior to the test, the Contractor shall submit to the Architect for approval of the test forms detailing the tests to be carried out. All test forms shall be written in English.

Prototype tests shall be carried out for some critical items of equipment to ensure correctness of assembly and ease of re-assembly at site. The Contractor shall satisfy the Architect that the assembled item meets with the performance requirements, and are fully compatible not only with respect to the equipment supplied under the individual technical specification but also with respect to other equipment forming the system.

Four copies of test reports shall be prepared by the Contractor and supplied to the Architect within two weeks of the completion of the factory work test. The report shall include a general description of the tests done, test results, curves, all related photographs and test certificates.

On each test certificate, sufficient information including the specification, contract number and equipment details, shall be given for the ready identification of the material or equipment to which the certificate refers.

The Contractor shall allow for repeating any of the testing requirements, including the provision of additional test certificates, curves and etc. until the system is satisfactorily tested to be functioning properly to the acceptance of the Architect.

D1.5 CALIBRATION OF TESTING INSTRUMENT

The calibration and acceptance of the calibration of the equipment shall comply with the requirements as set out in this section.

All inspection, measuring and test equipment shall be properly calibrated.

The maximum calibration period for all apparatus, materials, tools and instruments necessary for testing the installation shall not exceed 6 calendar months.

Calibrated equipment and the associated calibration records etc. shall be made available by the Contractor whenever the relevant test is performed. The equipment together with the relevant documentation shall conform to the requirements specified in this General Specification.

The equipment shall be calibrated by laboratories accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or a scheme with which Hong Kong Accreditation Services (HKAS) has concluded a mutual recognition agreement. The calibration shall be made against certified equipment having a known valid relationship to internationally or nationally recognised standards. Where no-such standards exist, the basis used for calibration shall be documented. In such cases, the laboratories shall provide satisfactory evidence of correlation of results, for example by participation in a suitable programme of inter-laboratory comparisons or proficiency testing.

The Contractor shall define and document the process employed for the calibration of the equipment including details of equipment type, unique identification, location, frequency of checks, check method, acceptance criteria and the action to be taken when results are unsatisfactory.

The Contractor shall maintain and submit calibration records of the equipment to the Architect which shall include:

(a) The description and unique identification of equipment;

(b) The date on which each calibration was completed;

(c) The calibration results obtained after and, where relevant, before any adjustment and repair;

(d) The assigned calibration interval;

(e) Identification of the calibration procedure;

(f) The designed limits of permissible error or accuracy of equipment;

(g) The source of the calibration used to obtain traceability;

(h) The relevant environmental conditions and a statement of any corrections thus necessary;

(i) A statement of the uncertainties involved in calibrating the equipment and of their cumulative effect;

(j) Details of any maintenance such as serving, adjustment, repairs or modifications carried out;

(k) Any limitations in use;

(l) Identification of the person(s) performing the calibration;

(m) Identification of the person(s) responsible for ensuring the correctness of the recorded information; and

(n) Unique identification (such as serial numbers) of any calibration certificates and other relevant documents concerned.

Calibration shall be carried out under suitable environmental conditions considering the conditions under which the equipment is used for inspections, measurements and tests.

The Contractor shall identify the equipment with a label marked “calibrated” and approved identification record to show the calibration status and the next due date.

The Contractor shall re-calibrate the equipment at intervals as shown in the Schedule, or at shorter periods when the Architect has doubt on the accuracy of the equipment.

SECTION D2

ROUTINE INSPECTION

D2.1 VISUAL INSPECTION AND CHECKING

Visual inspection and checking shall include verification of the installed equipment being the approved models and checking of any visible damages such as scratches or dents, or painting problems, found on the equipment surface. The Contractor shall submit relevant documents including delivery orders and payment vouchers to substantiate the equipment installed on site being the approved models if the identification of the manufacturer and model name cannot be seen easily on site.

SECTION D3

HANDOVER INSPECTION

D3.1 TRAINING FOR THE OPERATION AND MAINTENANCE STAFF

Adequate on-site operational training and demonstration of the system or equipment shall be provided to the operation and maintenance staff prior to handover of the system or after completion of the installation. The training shall include but not limit to the following:

(a) Familiarization of equipment and system;

(b) Equipment set-up and adjustment;

(c) On-site training of operation and maintenance procedure; and

(d) Precaution in operating the system or equipment to prevent accidents.

Competent persons from the approval specialist and equipment suppliers shall conduct the on-site training. The exact training arrangement shall be submitted by the contractor to the Architect for endorsement.

D3.2 DOCUMENTS TO BE SUBMITTED BY THE CONTRACTOR

Before the handover inspection, the contractor shall provide the following test/record certificates where applicable.

(a) Copies of manufacturer's certificates/test records on plant items comprising the system installed;

(b) Copies of all noise test/survey records in every noise emitting plant and machineries, individual room/space and a statement of compliance with the statutory requirements under the current Noise Control Ordinance; and

(c) Copies of all performance tests/records such as water balance and air room balancing. These certificates shall be accompanied with appropriate charts and diagrams.

The installation shall not be considered as acceptable for handover to the Architect until the installation is in good working order and all as-built drawings, operation and maintenance manuals, spare parts lists, test certificates, etc. have been submitted to the Architect.

D3.3 RESPONSIBILITIES OF THE CONTRACTOR

The Contractor shall assist the Project Officer to arrange hand-over inspection with the project team and other relevant parties to resolve any administrative and technical problem prior to formal hand-over of works to client.

D3.4 PAINTING WORKS

All painting works shall be completed and left in ventilated environment for at least one week, or the curing period recommended by the paint manufacturer whichever is longer, before occupation or handover of the renovated area to minimize volatile organic compound exposure.

D3.5 RECORD OF FAULT CALLOUT

If applicable, all record of fault callout shall be submitted to the Architect before the handover inspection of installation.

SECTION D4

TESTING AND COMMISSIONING

D4.1 LABOUR AND MATERIALS

The Contractor shall despatch competent and experienced commissioning engineers and technicians to carry out the commissioning and testing of the installation. The Contractor shall provide all labour and materials necessary for carrying out the work, except that the Building Contractor will supply electricity and water as required. The Architect reserves the right to require an independent Commissioning Specialist to be nominated in case of the Contractor's engineers are not competent for the commissioning test. The Contractor will have to bear the cost. The Contractor shall supply any necessary diesel or other fuel oil for engine-driven pumps and generators provided in the Works, etc.

The Contractor shall replenish all the materials expended or used during the test and ensure that the entire installation is in "as new" condition at the conclusion of the tests.

The Contractor shall arrange qualified surveyor(s), who shall act as competent examiners, to carry out load tests, pressure tests required under Statutory Regulation(s) and all certificates shall be submitted to the Architect for record.

The Contractor shall properly drain the water and exhaust the gas during and after the test as required. The Contractor shall provide and adopt measures to avoid damage to the building, installations, decorations and fixtures during the tests for any installation.

D4.2 COMMISSIONING AND TESTING REPORT AND CERTIFICATE OF COMPLETION

All commissioning and testing results shall be properly recorded during commissioning and testing at the witness of the Architect. Immediately after the commissioning and testing, the Contractor shall endorse the data recorded on site, irrespective of whether the tests are successful or not, and submit a copy of the data record sheet to the Architect. A full commissioning and testing report shall be forwarded to the Architect within 14 calendar days after completion of commissioning and testing of the installation. The report shall be in accordance with the requirements approved by the Architect.

SECTION D5

MANDATORY INSPECTION/TEST

D5.1 COMMISSIONING AND TESTING REPORT AND CERTIFICATE OF COMPLETION

For installations where licensing or approval of the statutory Authority is required, the Commissioning and Testing Report shall be approved by the relevant Authority before the Testing and Commissioning of the installation is deemed completed. The Contractor shall repeat the testing and commissioning at his own cost should the test results fail to meet the licensing requirements or did not meet with the approval of the Authority.

PART E – TRAINING, INSPECTION, ATTENDANCE AND OPERATION & MAINTENANCE DURING MAINTENANCE PERIOD

SECTION E1

TRAINING OF USERS AND OPERATION AND MAINTENANCE AGENTS

E1.1 TRAINING TO BE PROVIDED

The Contractor shall conduct in situ training courses for the operation and maintenance staff to operate the mechanical installations after the satisfactory testing & commissioning of the installations. The Training course shall be of sufficient long duration and detail enough to ensure that the operator can manage confidently, safely, efficiently, the complete installation. The details of the training shall be subject to the approval of the Architect.

The training shall generally cover the following aspects:

(a) General description of the installation.;

(b) Operation procedures of the installation, including start-up and shut-down procedures, safety precautions, etc.;

(c) Description of the controls;

(d) Description and operation principles all safety devices;

(e) Emergency procedures; and

(f) Maintenance requirements, adjustment of operating parameters to achieve optimum operating conditions, etc.

Training courses shall be conducted in English and Cantonese and shall be held in Hong Kong.

SECTION E2

EMERGENCY SERVICES AND ATTENDANCE TO FAULT CALLS

E2.1 EMERGENCY CALLED OUT SERVICES IN THE MAINTENANCE PERIOD

Emergency service including overtime work for minor repairs and adjustments shall be included under the Contract.

The Contractor shall be responsible for immediate answering of breakdown calls during the day or night including public holidays, whether true or false, and attention to such calls both inside and outside the normal working hours in the shortest possible time and using the quickest means of transport. In general a response time of less than one hour will be expected unless special arrangement is made and approved for very remote locations.

Any necessary repairs shall be carried out with the most practicably expeditious means to ensure minimum interruption to the operation of the installation.

The Contractor shall keep a clear and legible record of all fault callouts and shall submit this record within 3 calendar days upon request by the Architect for inspection. The record shall indicate the date, time of callout, persons attending, brief description of the fault and subsequent time of clearance for each occasion. The record will be returned to the Contractor after perusal by the Architect but shall subsequently be submitted and kept by the Architect at the end of the Maintenance Period during the handover inspection of the installation.

SECTION E3

INSPECTION, OPERATION AND MAINTENANCE REQUIREMENTS

E3.1 CATEGORIES OF INSTALLATIONS

The mechanical installations shall be divided into three main categories as follows:

Category One:
Installations shall include Steam Boiler Plants, Crane and Hoist Installations, Mild Steel Chimney, Industrial Compressed Air System, Fuel Supply Systems, Garage Equipment, and Hot Water System.

Category Two:
Installations shall include Sewage Pumping System, Vehicle Turntable Installations, and Pneumatic Tube Transport System.

Category Three:
Installations shall include Gondola Installations.

E3.2 GENERAL REQUIREMENTS OF MAINTENANCE SERVICES

The Contractor shall provide free maintenance service for all equipment of the respective mechanical installations from the date of commencement of the Maintenance Period. The free maintenance shall include the followings:

(a) Routine services;

(b) Emergency call out services;

(c) Final Inspections and Handover; and

(d) Training.

E3.2.1 Maintenance for Category One Installations

The maintenance services for Category One Installations shall include periodic inspections, tests and preventive maintenance before the end-user takes over the operations and maintenance. After the installation has been taken over by the end-user, the Contractor shall carry out quarterly visits to the installations to ensure that proper preventive maintenance has been carried out. The Contractor shall advise the end-user of any missed out maintenance work and notify the Architect accordingly.

The Contractor shall also carry out at its own cost periodic inspections, tests and preventive maintenance to any part of the installations in this category or equipment that was not accepted by the end-user for maintenance due to non-performance, improper functioning, or other defects until all defects have been rectified.

E3.2.2 Maintenance for Category Two Installations

The maintenance services for Category Two Installations shall include periodic inspections, tests and preventive maintenance before the equipment or plant is put into operation. After the installation has been put into operation, the Contractor shall carry out monthly inspection to the installation to ensure that proper preventive maintenance has been carried out and all plant and equipment are operating properly. The Contractor shall notify the Architect of any missed out maintenance work or abnormal operation of the installations.

The Contractor shall also carry out at its own cost periodic inspections, tests and preventive maintenance to installations in this category or equipment that was not accepted by the end-user for maintenance due to non-performance, poor performance, improper functioning, or other defects until the defects have been rectified.

E3.2.3 Maintenance for Category Three Installations

The maintenance services for Category Three Installations shall include all periodic inspections, tests, preventive maintenance, and stand-by operations for the whole of the Maintenance Period.

E3.3 PERIODIC INSPECTIONS, TESTS AND PREVENTIVE MAINTENANCE

All inspections, tests, maintenance services and repairs shall be carried out generally in accordance with the manufacturers' recommendations/instructions, this Specification, Particular Specification of the specific installation, and to the satisfaction of the Architect. The maintenance service is to maintain the installation in a good and functional working condition. The maintenance service shall include preventive maintenance and all spare parts required in the Maintenance Period.

The Contractor shall despatch competent and experienced engineers and technicians equipped with the appropriate testing instruments, tools, equipment, etc. to inspect, service, test, adjust and maintain the installation in a satisfactory operating condition. The Contractor shall allow for carrying out such inspection, service, testing, adjustment and maintenance at a time outside normal office hours including general holidays.

All labour and materials necessary including cleaning materials, lubricants, battery electrolyte, tools, instruments, etc., and transportation required for carrying out routine and emergency inspections, tests, repairs, replacements and maintenance services shall be included in the Contract. Any renewals or repairs necessitated by reason of negligence or misuse of the equipment or by reason of any other cause beyond the Contractor's control (with the exception of ordinary wear and tear) shall be carried out at an additional cost with prior notice to the Architect.

The Contractor shall be responsible for all repairs necessary to maintain the installation in a safe, reliable and operative condition at all times. The Contractor must ensure that his/her or their servicing staff shall carry out the necessary repairs by utilizing the manufacturer's original replacement parts. Any component taken down for services shall be reinstated within 2 hours or otherwise replaced by a spare unit at the Contractor's expenses.

The Contractor shall ensure minimum interruption to the functioning of the installation during each inspection, testing, repair or maintenance service. Where any part of the installation is out of service temporarily during the progress of work, the Contractor shall place a suitable notice in a prominent position on the control panel so that the client is aware of the situation. This is, however, not to be construed as an authority to leave any part inoperative for an undue length of time.

The Contractor shall, as and when instructed by the Architect, repair or replace at his/her or their own cost any part of the system proved to be defective by reason of Contractor's negligence, faulty design, inadequate routine maintenance and supervision, workmanship or materials. No claim whatsoever shall be made by the Contractor for such repair or replacement if it is within the scope of the Contractor's responsibility.

After each routine inspection, testing and maintenance service, the Contractor shall furnish to the Architect within 14 calendar days a report complete with the following details:

(a) Date and time of inspection, testing and maintenance service;

(b) Persons carrying out the task;

(c) Details of inspection and maintenance service;

(d) Results of all tests performed;

(e) Any external factors significantly affecting the service and test results; and

(f) Any follow-up actions as required.

The Contractor shall, at his/her or their own expenses, make all suitable arrangements to avoid damage to property or installations provided by others during the course of the Works. The Contractor shall be responsible for all losses and claims for injury or damage to any person or property arises out of or in consequence of the execution of the maintenance work.

SECTION E4

COMPLETION OF OUTSTANDING AND DEFECTIVE WORKS

E4.1 FINAL INSPECTIONS AND HANDOVER OF THE INSTALLATION

The Contractor shall carry the final inspection and testing of the installation at the end of the Defects Liability Period.

At the final inspection, the Contractor shall, in addition to the routine inspection and tests, carry out tests as necessary to demonstrate that the installation is in a good and functional working condition.

The installation shall not be deemed as acceptable for handover to the Architect until the installation is in good working order and all as-built drawings, instruction and maintenance manuals, spare parts lists, test reports, test certificates, etc. have been submitted to the Architect.

ANNEX I

LIST OF TECHNICAL STANDARDS QUOTED IN THIS GENERAL SPECIFICATION

Standard	Description
BS 4-1:2005	Structural Steel Sections - Part 1: Specification for Hot-Rolled Sections
BS 21: 1985	Specification for Pipe Threads for Tubes and Fittings Where Pressure-Tight Joints Are Made on the Threads (Metric Dimensions)
BS 61:1969	Threads for Light Gauge Copper Tubes and Fittings
BS 88:1988	Cartridge Fuses for Voltages up to and Including 1000 V a.c. and 1500 V d.c.
BS 143 and 1256:2000	Threaded Pipe Fittings in Malleable Cast Iron and Cast Copper Alloy
BS 227:1995	Specification for H-Section Steel Arches for Use in Mines
BS 381C:1996	Specification for Colours for Identification, Coding and Special Purposes
BS 417-2:1987	Specification for Galvanized Low Carbon Steel Cisterns, Cistern Lids, Tanks and Cylinders. Metric Units
BS 436	Spur and Helical Gears
BS 466:1984	Specification for Power Driven Overhead Travelling Cranes, Semi-goliath and Gliath cranes for General Use
BS 476	Fire Tests on Building Materials and Structures
BS 545:1982	Specification for Bevel Gears (Machine Cut)
BS 638	Arc Welding Power Sources, Equipment and Accessories
BS 721	Specification for Worm Gearing
BS 799-3:1981	Oil Burning Equipment Part 3: Automatic and Semi-Automatic Atomizing Burners up to 36 Litres per Hour
BS 799-4:1991	Oil Burning Equipment Part 4: Specification for Atomizing Burners (Other Than Monobloc Type) Together with Associated Equipment for Single Burner and Multi Burner Installations

Standard	Description
BS 845-1:1987	Methods for Assessing Thermal Performance of Boilers for Steam, Hot Water and High Temperature Heat Transfer Fluids Part 1: Concise Procedure
BS 845-2:1987	Methods for Assessing Thermal Performance of Boilers for Steam, Hot Water and High Temperature Heat Transfer Fluids Part 2: Comprehensive Procedure
BS 853-1:1996	Specification for Vessels for use in heating systems. Calorifiers and Storage Vessels for Central Heating and Hot Water Supply.
BS 855:1990	Specification for Welded Steel Boilers for Central Heating and Indirect Hot Water Supply (Rated Output 44 kW to 3 MW)
BS 1449:1991	Steel Plate, Sheet and Strip
BS 1486-1:1959	Lubricating nipples, Lubricating nipples and adaptors for use on machinery and vehicles
BS 1552:1995	Open Bottomed Taper Plug Valves for 1st, 2nd and 3rd Family Gases up to 200 mbar
BS 1600:1991	Specification for Dimensions of Steel Pipe for the Petroleum Industry
BS 1710:1984	Specification for Identification of Pipelines and Services
BS 1724:1990	Specification for Bronze Welding by Gas
BS 1821:1982	Specification for Class I Oxyacetylene Welding of Ferritic Steel Pipework for Carrying Fluids
BS 2051-1:1973	Tube and pipe fittings for engineering purposes. Copper and copper alloys capillary and compression tube fittings for engineering purposes
BS 2051-2:1984	Tube and pipe fittings for engineering purposes. Specification for olive type copper alloy compression tube fittings
BS 2633:1987	Specification for Class I Arc Welding of Ferritic Steel Pipework for Carrying Fluids
BS 2640:1982	Specification for Class II Oxyacetylene Welding of Carbon Steel Pipework for Carrying Fluids
BS 2742:2009	Use of the Ringelmann and Miniature Smoke Charts
BS 2790:1992	Specification for design and manufacture of shell boilers of weld construction

Standard	Description
BS 2971:2006	Class II Arc Welding of Carbon Steel Pipework for Carrying Fluids-AMD 9773
BS 3063:1994	Dimensions of Gaskets for Pipe Flanges
BS 3486-1:1996	Wheels for Agricultural Machinery, Implements and Trailers Part 1: Specification for Wheel-to-Hub Fixing Dimensions
BS 3790:2006	Specification for Belts Drives, Endless Wedge Belt, Endless V-Belt,, Banded Wedge Belts, Banded V-belts and their Corresponding Pulleys
BS 4076:1989	Specification for Steel Chimneys
BS 4652:1995	Specification for Zinc-Rich Priming Paint (Organic Media)
BS 4800:1989	Schedule of Paint Colours for Building Purposes
BS 4872-1:1982	Specification for approval testing of welders when welding procedure approval is not required. Fusion welding of steel
BS 4999	General Requirements for Rotating Electrical Machines
BS 5000:1981	Specification for Rotating Electrical Machines of Particular Types or for Particular Applications
BS 5154:1991	Specification for Copper Alloy Globe, Globe Stop and Check, Check and Gate Valves
BS 5169:1992	Specification for Fusion Welded Steel Air Receivers
BS 5378:1980	Safety Signs and Colours
BS 5410-2:1978	Code of Practice for Oil Firing - Part 2: Installations of 45 kW and Above Output Capacity for Space Heating, Hot Water and Steam Supply Services
BS 5410-3:1978	Code of Practice for Oil Firing Part 3: Installations for Furnaces, Kilns, Ovens and Other Industrial Purposes
BS 5422:2001	Method for Specifying Thermal Insulating Materials for Pipes, Tanks, Vessels, Ductwork and Equipment Operating within the Temperature Range -40 Degrees C to +700 Degrees C
BS 5885-1:1988	Automatic Gas Burners Part 1: Specification for Burners with Input Rating 60kW and Above
BS 5970:2001	Code of Practice for Thermal Insulation of Pipework and Equipment in the Temperature Range -100 Degrees C to +870 Degrees C
BS 6037-1:2003	Code of practice for the planning, design, installation and use of permanently installed access equipment. Suspended access equipment.

Standard	Description
BS 6068 SEC 6.7:1994	Water Quality Part 6: Sampling Section 6.7: Guidance on Sampling of Water and Steam in Boiler Plants
BS 6346:1997	Electric Cables. PVC Insulated Armoured Cables for Voltages of 600/1000V and 1900/3300V
BS 6405:1984	Specification for Non-Calibrated Short Link Steel Chain (Grade 30) for General Engineering Purposes: Class 1 and 2
BS 6724:1997	Electric cables Thermosetting insulated, armoured cables for voltages of 600/1 000 V and 1 900/3 300 V, having low emission of smoke and corrosive gases when affected by fire
BS 6956:1988	Jointing Materials and Compounds
BS 7262:1900	Specification for Automatic Safe Load Indicators
BS 7430:1998	Code of practice for earthing
BS 7668:2004	Weldable Structural Steel: Hot Finished Structural Hollow Sections in Weather Resistant Steels
BS 7671:2008	Requirements for Electrical Installations. IEE Wiring Regulations. Seventeenth edition
BS 7786:2006	Specification for Unsintered PTFE Tape for General Use
BS 7956:2000	Specification for primers for woodwork
BS 10255:2004	Non-alloy steel tubes suitable for welding and threading Technical delivery conditions
BS EN 88:2007	Pressure Regulators and Associated Safety Devices for Gas Inlet Pressures up to and including 500 mbar
BS EN 105-1	Part 1 Copper Tubes for Water, Gas and Sanitation.
BS EN 105-2	Part 2 Tubes for General Purposes
BS EN 230:2005	Automatic Burner Control Systems for Oil Burners
BS EN 303-1:1999	Heating Boilers - Part 1: Heating Boilers with Forced Draught Burners - Terminology, General Requirements, Testing and Marking
BS EN 303-4:1999	Heating Boilers - Part 4: Heating Boilers with Forced Draught Burners - Special Requirements for Boilers with Forced Draught Oil Burners with Outputs up to 70 kW and a Maximum Operating Pressure of 3 Bar - Terminology, Special Requirements, Testing and Marking

Standard	Description
BS EN 590:2009	Automotive Fuels - Diesel - Requirements and Test Methods
BS EN 676:2003	Automatic Forced Draught Burners for Gaseous Fuels
BS EN 837-1:1998	Pressure Gauges Part 1: Bourdon Tube Pressure Gauges - Dimensions, Metrology, Requirements and Testing
BS EN 1011:2006	Welding – Recommendations for Welding of Metallic Materials
BS EN 1011-1:2009	Welding - Recommendations for welding of metallic materials. General guidance for arc welding
BS EN 1057:2006	Copper and Copper Alloys - Seamless, Round Copper Tubes for Water and Gas in Sanitary and Heating Applications
BS EN 1092	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated
BS EN 1092-1:2007	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated Part 1: Steel flanges
BS EN 1092-2:1997	Flanges and their joints. Circular Flanges for Pipes, Valves, Fittings and Accessories, PN Designated Part 2: Cast Iron Flanges
BS EN 1092-3:2003	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated Part 3: Copper alloy flanges
BS EN 1171:2002	Industrial valves Cast iron gate valves
BS EN 1172:1997	Copper and Copper Alloys - Sheet and Strip for Building Purposes
BS EN 1254:1998	Copper and Copper Alloys - Plumbing Fittings
BS EN 1254-1:1998	Copper and Copper Alloys - Plumbing Fittings - Part 1: Fittings with Ends for Capillary Soldering or Capillary Brazing to Copper Tubes
BS EN 1254-2:1998	Copper and Copper Alloys - Plumbing Fittings - Part 2: Fittings with Compression Ends for Use with Copper Tubes
BS EN 1514:1998	Flanges and Their Joints - Dimensions of Gaskets for PN-Designated Flanges
BS EN 1514-1:1997	Flanges and their joints - Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS EN 1515-1:2000	Flanges and their joints. Bolting. Selection of bolting
BS EN 1652:1998	Copper and Copper Alloys - Plate, Sheet, Strip and Circles for General Purposes
BS EN 1653:1998	Copper and Copper Alloys Plate, Sheet and Circles for Boilers, Pressure Vessels and Hot Water Storage Units

Standard	Description
BS EN 1654:1998	Copper and Copper Alloys Strip for Springs and Connectors
BS EN 1759-1:2004	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, class-designated. Steel flanges, NPS 1/2 to 24
BS EN 1808:1999	Safety Requirements on Suspended Access Equipment. Design Calculations, Stability criteria, Construction. Tests.
BS EN 1906:2002	Building hardware. Lever handles and knob furniture. Requirements and test methods
BS EN 1984:2000	Industrial valves - Steel gate valves
BS EN 10025:2004	Hot rolled products of non-alloy structural steels
BS EN 10028:2009	Flat Products Made of Steels for Pressure Purposes
BS EN 10029:1991	Specification for Tolerances on Dimensions, Shape and Mass for Hot Rolled Steel Plates 3 mm Thick or Above
BS EN 10048:1997	Hot Rolled Narrow Steel Strip - Tolerances on Dimensions and Shape
BS EN 10051:1992	Specification for Continuously Hot-Rolled Uncoated Plate, Sheet and Strip of Non-Alloy and Alloy Steels - Tolerances on Dimensions and Shape
BS EN 10056-1:1999	Specification for structural steel equal and unequal angles. Dimensions
BS EN 10067:1997	Hot rolled bulb flats. Dimensions and tolerances on shape, dimensions and mass
BS EN 10084:2008	Case Hardening Steels - Technical Delivery Conditions
BS EN 10087:1999	Free Cutting Steels - Technical Delivery Conditions for Semi-Finished Products, Hot-Rolled Bars and Rods
BS EN 10095:1999	Heat resisting steels and nickel alloys
BS EN 10210	Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Structural Steels
BS EN 10210-1:2006	Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Structural Steels Part 1: Technical Delivery Requirements
BS EN 10210-2:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties
BS EN 10216-1:2002	Seamless steel tubes for pressure purposes. Technical delivery conditions
BS EN 10217-1:2002	Welded steel tubes for pressure purposes. Technical delivery conditions. Non-alloy steel tubes with specified room temperature properties

Standard	Description
BS EN 10217-2:2002	Welded steel tubes for pressure purposes. Technical delivery conditions. Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties
BS EN 10241:2000	Steel Thread Pipe Fittings
BS EN 10242:1995	Threaded Pipe Fittings in Malleable Cast Iron
BS EN 10250-4:2000	Open steel die forgings for general engineering purposes. Stainless steels
BS EN 10255:2004	Non-alloy steel tubes suitable for welding or threading. Technical delivery conditions
BS EN 10258:1997	Cold-Rolled Stainless Steel and Narrow Strip and Cut Lengths - Tolerances on Dimensions and Shape
BS EN 10259:1997	Cold-Rolled Stainless and Heat Resisting Steel Wide Strip and Plate/Sheet – Tolerances on Dimensions and Shape
BS EN 10312:2002	Welded stainless steel tubes for the conveyance of aqueous liquids including water for human consumption. Technical delivery conditions
BS EN 12165:1998	Copper and Copper Alloys - Wrought and Unwrought Forging Stock
BS EN 12334:2001	Industrial valves - Cast iron check valves
BS EN 12385	Steel Wire Ropes- Safety
BS EN 12864:2001	Low-pressure, non adjustable regulators having a maximum outlet pressure of less than or equal to 200 mbar, with a capacity of less than or equal to 4kg/h, and their associated safety devices for butane, propane or t heir mixtures
BS EN 13001-1-2004	Crane Safety. General Design. General Principles and Requirements
BS EN 13001-2-2004	Crane Safety. General Design. Load Activity
BS EN 13157:2004	Cranes. Safety. Hand-Powered Lifting Equipment
BS EN 13480:2002	Metallic industrial piping
BS EN 13480-1:2002	Metallic Industrial Piping - Part 1: General
BS EN 13480-2:2002	Metallic Industrial Piping - Part 2: Materials

Standard	Description
BS EN 13480-3:2002	Metallic industrial piping Part 3: Design and Calculation
BS EN 13480-4:2002	Metallic industrial piping Part 4: Fabrication and Installation
BS EN 13785:2005	Regulators with a capacity of up to and including 100 kg/h, having a maximum nominal outlet pressure of up to and including 4 bar, other than those covered by EN 12864 and their associated safety devices for butane, propane or their mixtures
BS EN 13786:2004	Automatic change-over valves having a maximum outlet pressure of up to and including 4 bar with a capacity of up to and including 100 kg/h, and their associated safety devices for butane, propane or their mixtures
BS EN 13789:2002	Industrial valves. Cast iron globe valves
BS EN 13835:2002	Founding. Austenitic cast irons
BS EN 14324:2004	Brazing. Guidance on the application of brazed joints
BS EN ISO9453:2006	Soft Solder Alloys - Chemical Compositions and Forms
BS EN 55014:2001	Electromagnetic Compatibility. Requirements for Household Appliances, Electric Tools and Similar Apparatus.
BS EN 62305:2006	Protection Against Lightning
BS EN 60085:2008	Electrical Insulation. Thermal Classification
EN 545:2002	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Water Pipelines - Requirements and Test Methods
EN 598:2007	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Sewerage Applications - Requirements and Test Methods
EN 837-1:1998	Pressure Gauges Part 1: Bourdon Tube Pressure Gauges - Dimensions, Metrology, Requirements and Testing
EN 969:2009	Specification for Ductile Iron Pipes, Fittings, Accessories and their Joints for Gas Pipelines - Requirements and Test Methods
EN 1011-1:2009	Welding Recommendations for Welding of Metallic Materials Part 1: General Guidance for Arc Welding
EN 1092-2:1997	Flanges and Their Joints - Circular Flanges for Pipes, Valves, Fittings and Accessories, PN Designated Part 2: Cast Iron Flanges
EN 1171:2002	Industrial Valves. Cast Iron Gate Valves
EN 1514-1:1997	Flanges and Their Joints - Dimensions of Gaskets for PN-Designated Flanges Part 1: Non-Metallic Flat Gaskets with or without Inserts
EN 1564:1997	Founding - Austempered Ductile Cast Irons
EN 1677-5:2001	Components for Slings, Safety, Forged Steel Lifting Hooks with Latch. Grade 4

Standard	Description
EN 10084:2008	Case Hardening Steels - Technical Delivery Conditions
EN 10087:1999	Free Cutting Steels - Technical Delivery Conditions for Semi-Finished Products, Hot-Rolled Bars and Rods
EN 10088	Stainless Steels
EN 10095:1999	Heat Resisting Steels and Nickel Alloys
EN 10242:1995	Threaded Pipe Fittings in Malleable Cast Iron
EN 10250-1	Open Steel Die Forgings for General Engineering Purposes - Part 1: General Requirements
EN 10250-4:2000	Open Steel Die Forgings for General Engineering Purposes - Part 4: Stainless Steels
EN 12285-1:2003	Workshop fabricated steel tanks. Horizontal cylindrical single skin and double skin tanks for the underground storage of flammable and non-flammable water polluting liquids
EN 12334:2001	Industrial Valves Cast Iron Check Valves
EN 50060:1989	Specification for Power Sources for Manual Arc Welding with Limited Duty
EU standard 55014	Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Motor-Operated and Thermal Appliances for Household and Similar Purposes, Electric Tools and Similar Electric Apparatus
IEC 60034:2004	Rotating Electrical Machines
IEC 60034-5:2001	Rotating Electrical Machines - Part 5: Degrees of Protection Provided by the Integral Design of Rotating Electrical Machines (IP Code). Classification
IEC 60034-6:1994	Rotating Electrical Machines Part 6: Methods of Cooling (IC Code)
IEC 60072:1994	Dimensions and Output Series for Rotating Electrical Machines
IEC 60079	Electrical Apparatus for Explosive Gas Atmospheres
IEC 60079-0:2007	Explosive Atmospheres Part 0: Equipment General Requirements
IEC 60085:2007	Electrical insulation - Thermal Classification, Evaluation and Designation
IEC 60439	Low-voltage switchgear and controlgear assemblies
IEC 60439-1:1999	Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies
IEC 60529:2001	Degrees of Protection provided by Enclosures (IP Code)

Standard	Description
IEC 60947-1:2007	Low-voltage Switchgear and Controlgear Part 1: General Rules
IEC 60947-2:2009	Low-voltage Switchgear and Controlgear Part 2: Circuit-breakers
IEC 60947-3:2008	Low-Voltage Switchgear and Controlgear - Part 3: Switches, Disconnectors, Switch-Disconnectors and Fuse-Combination Units
IEC 60947-4-1:2009	Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters
IEC 60974:2003	Arc Welding Equipment.
ISO 7-1:1999	Pipe Threads where Pressure-tight Joints are made on the Threads - Part 1: Dimensions, Tolerances and Designation
ISO 65:1988	Carbon Steel Tubes Suitable for Screwing in accordance with ISO 7-1
ISO 606:2004	Short-pitch Transmission Precision Roller and Bush Chains, Attachments and Associated Chain Sprockets
ISO 657:2000	Hot-rolled Steel Sections
ISO 1217:2009	Displacement Compressors - Acceptance Tests
ISO 2560:2009	Welding Consumables - Covered Electrodes for Manual Metal Arc Welding of Non Alloy and Fine Grain Steels - Classification
ISO 4126:2006	Safety Devices for Protection against Excessive Pressure
ISO 4126-1:2004	Safety devices for protection against excessive pressure. Safety valves
ISO 4145:1986	Non-alloy Steel Fittings Threaded to ISO 7-1
ISO 4301-1:1986	Cranes and Lifting Appliances - Classification - Part 1: General
ISO 5388:1981	Stationary Air Compressors -Safety Rules and Code of Practice
ISO 5457:1999	Technical Product Documentation. Sizes and Layout of Drawing Sheets
ISO 5667-7:1993	Guidance on Sampling of Water and Steam in Boiler Plants
ISO 7005:1992	Metallic Flanges
ISO 8501:2006	Preparation of Steel Substrates before Application of Paints and Related Products - Visual Assessment of Surface Cleanliness
ISO 8501-1:2007	Preparation of Steel Substrates Before Application of Paints and Related Products. Visual Assessment of Surface Cleanliness. Part1- Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of Previous Coatings

Standard	Description
ISO 8504:2000	Preparation of Steel Substrates before Application of Paints and Related Products - Surface Preparation Methods
ISO 9453:2006	Soft Solder Alloys - Chemical Compositions and Forms
ISO 10434:2004	Bolted bonnet steel gate valves for the petroleum, petrochemical and allied industries
ISO 10770:1998	Hydraulic Fluid Power - Electrically Modulated Hydraulic Control Valves
ISO 12241:1998	Thermal Insulation for Building Equipment and Industrial Installations - Calculation Rules
ISO 12944:1998	Paints and Varnishes: Corrosion Protection of Steel Structures by Protective Paint Systems.
ISO 17292:2004	Metal ball valves for the petroleum, petrochemical and allied industries