Temo Consulting

Technical Specification

For

Mechanical Services

Consultancy for Engineering and Project Management

Prepared For

MFMR AUKI – MALAITA PROVINCE
SOLOMON ISLANDS

OCTOBER 2025

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1 SPECIFICATION REVISION AND QA STATUS

Date	Rev	Issued to	No. of Copies	Approved for Issue	Comments
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2 INTRODUCTION

2.1 OVERVIEW OF THE INSTALLATION

This specification details the requirements for **MECHANICAL SERVICES** for **MFMR Auki – Malaita Province, Solomon Islands**

All works covered by this specification shall be subject to all provisions of the Conditions of Contract and the Preliminary and General Sections of the Architectural Specification.

A qualified and registered Mechanical Services Subcontractor who shall be a Subcontractor to the Main Contractor and shall be subject to the same General and Special Conditions of Contract applying to the main contractor shall carry out the work in this Trade Section.

The Mechanical Services system installation shall be carried out by an approved specialist sub-Subcontractor under the control of this Subcontractor and form part of this contract.

All clauses of the complete specification shall apply to the Mechanical Services Subcontractor and all his specialist sub-Subcontractors.

2.2 SUMMARY DESCRIPTION OF THE MECHANICAL SYSTEMS

The Mechanical Services cover Air Conditioning, Ventilation and all other works necessary to implement this specification.

This section of the work shall be carried out only by Mechanical Services contractors who can show they have had recent and successful experience on work of a similar nature and magnitude, and evidence of this experience shall be submitted if requested

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3 GENERAL CONDITIONS

The following general instructions shall apply in all instances.

3.1 COMMUNICATION

All communication shall be in writing and shall be with the Consulting Engineer or any person appointed by him.

3.2 CONDITIONS OF CONTRACT

Refer to the Main Building Contract for details on the "Form of Contract" for the works specified.

The said document specifies commercial, legal and tendering conditions for these works.

Any queries regarding Conditions of Contract and its interpretations for these works shall be directed to the consulting engineer before tender closing date.

3.3 DEFINITIONS AND ABBREVIATIONS

The term "**Contract**" used herein refers to the work included in this Specification, as does the term "**Subcontract**".

The term **"Mechanical Services Subcontractor"** or **"Contractor"** used herein refers to the Mechanical Services Contractor, regardless of actual contractual relationships, e.g., Mechanical Services, Contractor, Nominated Subcontractor, engaged to complete all works described in this Contract.

"**Approved**" shall mean subject to the inspection and entire approval of the consulting engineer before being worked or fitted into the Contract works.

"**Provide**" and "**Install**" used separately shall be interpreted to mean "Provide and Install" and shall include all testing, commissioning and 12-month maintenance/warranty.

"**Indicated**" or "**shown**" means as indicated or shown on the Contract drawings and specification and by notes, figures, sketches or writing, thereon or by any combination thereof.

The terms "**Employer**", "**Client**", "**Principal**" and "**Owner**" refers to **FMC Pacific**

The terms "**Architect**" refers to **Kearney Architecture**

The term "**Consultant**", "**Engineer**" and "**Engineers**" used herein refers to **Temo Consulting.**

3.4 REVIEW THE SPECIFICATION

The Subcontractor shall read, review, study and familiarise themselves with this specification and bring anything that they do not understand or do not agree with, under the attention of the consulting engineer before or at tender closing stage in their tender letter.

Tenderers are to make use of the tender period to clarify any aspects or inconsistencies of these documents that may influence the pricing or the execution of the contract. Any such inconsistencies found subsequent to the letting of the Contract shall have the interpretation placed upon them by the Engineer. The Subcontractor shall abide by this interpretation.

Requests for alternatives or changes to the specification after tender closing shall not necessarily be accepted.

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3.5 COMPLIANCE

A price for a tender complying with this specification in all respects shall be compulsory.

The intent of this specification is to provide for the work herein set out and as shown on the accompanying drawings to be fully completed in every detail for the purpose designed. The Subcontractor shall allow to supply, construct and install everything reasonably necessary for such construction to comply with the intent of the specification and drawings not withstanding any omissions in the drawings and/or specifications.

The Contract includes all work incidentals to the work shown and specified and as necessitated by the conditions of the site or of the works or of the materials as apparent or as discovered during the progress of the Works.

The Mechanical Services system installation shall be carried out by an approved specialist sub-Subcontractor under the control of this Subcontractor and form part of this contract.

The intent is that all systems supplied under this contract are complete in every respect, and all items and work necessary to this shall be deemed to be included whether specifically indicated or not.

3.6 DESIGN RESPONSIBILITY

The design responsibility for the installation shall be with the engineer.

3.7 SUBCONTRACTOR'S RESPONSIBILITY

The Subcontractor shall be responsible for the installation to perform as designed.

The Subcontractor shall be responsible for all the specified equipment to perform as designed and shall verify the performance compliance with the suppliers before an order is placed.

Performance shall include and not be limited to all aspects of the specified equipment: -

- Cooling/heating and air flow capacities as published/advertised by the manufacturers and suppliers.
- Corrosion resistance and noise levels as published/advertised by the manufacturers and suppliers.
- Life cycle and spare part availability.
- Energy efficiency.

The contractor shall order all equipment subject to the above and obtain the manufacturers and suppliers written approval and agreement before an order is placed.

The Mechanical Services Subcontractor shall be deemed to have carefully examined the Contract Documents, the Specification and Drawings. If the Mechanical Subcontractor has any doubt as to the meaning of any portion of these documents, he shall inform the engineer in writing before tendering on the project. The engineer shall provide clarifications to the query in a notice to tenderers.

The Mechanical Services Subcontractor must carefully consider local conditions, visit the site of the proposed work, and make any field survey necessary for proper planning and execution of the work. Failure to do so shall in no way relieve the Mechanical Services Subcontractor of responsibility for changes or unanticipated costs due to field conditions.

After a tender has been accepted the responsibility for any misunderstanding or error shall rest with the Mechanical Services Subcontractor. The Mechanical Services Subcontractor shall examine

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carefully the Architectural, Structural and other trade's drawings and satisfy himself that the work under his contract can be satisfactorily carried out without changes to the building as shown on drawings. Before commencement of his work, he shall examine the progress of other trades and report at once any defect or interference affecting his own work or the warranty of same. No extras will be allowed subsequently for his omission to make adequate inspection or take adequate precaution.

The Mechanical Services Subcontractor shall arrange his own work in co-operation with other trades so that all work is installed to the best advantage. Where equipment is installed by the Mechanical Services Subcontractor without due regard to other trades, relocation of such equipment shall be performed by the Mechanical Services Subcontractor at his own expense.

3.8 GENERAL RESPONSIBILITY

The Subcontractor shall comply with all proper instructions issued by the Engineer or the Main Contractor in relation to this Contract.

The Subcontractor shall be responsible for the adequacy, stability, and safety of all its site operations and method of construction.

The Subcontractor shall respect the rights of the adjoining areas occupants and shall advise the main contractor when access to areas out of construction areas is requires for the purposes of carrying out the Contract Works.

The Subcontractor warrants that at all times shall be suitably qualified and experienced, and shall exercise due skill, care and diligence in the carrying out and completion of Works under Subcontract (WUS)

The Subcontractor shall carry out and complete WUS in accordance with the design documents so that the Subcontract Works, when completed, shall:

a. be fit for their stated purpose; and

b. comply with all the requirements of the Subcontract

3.9 ERRORS, AMBIGUITIES AND OMISSIONS

Errors, ambiguities and omissions in drawings or specifications shall be reported to the Engineer for correction before any part of the work involved is started. Unless otherwise expressly stipulated, no additional allowance shall be made because of errors, ambiguities or omissions which should reasonably have been discovered during the preparation of the tender or which may become evident later and which should have been directed to the attention of the Engineer in timely manner. The written decision of the Engineer shall be final.

3.10 CONTRACTOR PRICE

A lump sum fixed price excluding taxes is required. The price shall not be subject to variation for the duration of the contract period.

The Contract includes all work shown and specified and as necessitated by the conditions of the site or of the works or of the materials as apparent or as discovered during the progress of the Works.

By submission of a contractor price the Contractor warrants that he is expert in understanding the systems, capable of both design and construction, and that all work will be suitable for its intended function where located, and will comply with all requirements of statutory and other authorities having jurisdiction.

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3.11 PRE-START MEETING

The Subcontractor shall prior to commencing the Subcontract Works on site, attend a pre-start meeting to be held at the address and time mutually agreed with the Main Contractor and at that time, the Subcontractor shall satisfy the Main Contractor and the Subcontract

The meeting may address the following matters:

a. construction and site-specific issues;

b. lines of communication and authority levels;

c. possession of the site;

d. frequency and venue of site meetings;

e. progress payments;

f. working hours;

g. safety requirements;

h. insurance;

i. scope of works;

j. programs; and

k. Resources.

3.12 SITE MEETINGS

A senior and responsible representative of the Electrical Services Subcontractor's staff with powers of making binding decisions on behalf of the Mechanical Services Subcontractor shall attend all site meetings called by the Construction Manager or Project Manager.

3.13 CONTRACTOR'S REPRESENTATIVE

The Subcontractor shall provide all necessary supervision during the Contract. It shall have n site at all working times a competent representative whose name shall be notified to the Main Contractor and Engineer in writing and who shall be authorised to receive on behalf of the Subcontractor any instructions from the Main Contractor, Engineer or Engineer's Representative.

All works shall be carried out under the supervision of the Subcontractor's representative.

3.14 APPROVAL OF DRAWINGS AND SAMPLES

Within ample time to prevent construction delay, the Sub-Contractor shall submit to the Engineer samples of materials and equipment for approval. The Mechanical Subcontractor shall also submit 2 sets of final shop drawings detailing all aspects of proposed work for approval.

The Mechanical Subcontractor shall not enter into any commitment or commence any work without the approval of the shop drawings and materials samples by the Engineer.

Consent shall not relieve the Subcontractor from his obligation to comply with this specification. Supply without delay, any samples, information or drawings requested by the Engineer.

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3.15 ALTERNATIVES

The contractor is encouraged to forward alternatives for both the design and specified equipment and the installation, provided that full details of these alternatives and prices are forwarded with their tender under cover of their tender letter.

Any alternative equipment shall meet or exceed the specified equipment and installation in all respects as follows but not limited to the following: -

- Performance and duty.
- Maintenance and spare parts.
- Durability.
- Energy efficiency.
- Life cycle costs analysis.

All costs associated to prove the above shall be borne out by the contractor.

3.16 APPROVALS

All approvals of documents and site work shall be performed by the consulting engineer or any person appointed by them.

3.17 SHOP DRAWINGS

The Subcontractor shall prepare shop drawings for shop fabrication and working drawings for installation on site. All dimensions and locations shall be verified on site. Shop drawings shall be submitted for review by the Engineer before manufacture. The review of any drawings by the Engineer in no way affects the Subcontractor's responsibility for the satisfactory completion of the work.

The Mechanical Services Subcontractor shall review all relevant drawings, including architectural, structural, other services and co-ordinate and co-operate with the main contractor and the relevant subcontractors to avoid conflict with the building structure and other building services. Any changes required due to this co-ordination shall be provided at no extra cost.

Accurate shop drawings are to be provided for the penetration and cast in requirements for the pre-cast concrete panels for both walls and floor panels.

The Sub-contract shall include the following in the shop drawings: -

a. Schematics and schedules: -
    a. Complete schematic flow and control diagrams of all air, water, refrigerant and any other systems incorporated in the installation
    b. Complete electrical and control wiring diagrams showing all electrical controls, relays, cut-outs, timing devices, interlocks, fuses, over-loads, contactors, solenoids, starters and the like with all items clearly identified as to type and function, with drawings of the switchboard layouts
    c. Complete list of drawings, legends and abbreviations
    d. Complete major equipment schedule
    e. Installation details of all major equipment, ducting, piping, joints, fixings, penetrations, hangers, supports, anchors and the like

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b. Plans: -

   a. Complete ducting layout drawings showing the sizes and locations of all air ducts, dampers, air outlets, test points, measurement instruments, sensors, the air flow rates at all relevant locations, extent of ducting with insulation and protection and the like, with setting outs and installation levels

   b. Complete piping layout drawings, showing the sizes and locations of all refrigerant, water and condensate drain pipes, valves, strainers, flexible joints, water traps, fire collars, test points, measurement instruments, sensors, vents, drains, water flow rates at all relevant locations, extent of piping with insulation and protection, piping connection points for interfacing with installations of other trades, and the like, with setting outs and installation levels

   c. Complete cable containment layout drawings, showing the sizes and locations of exposed and concealed cable containment for electrical wiring and for control wiring, adaptable boxes, outlet boxes, control devices, sensors, dry contacts and power supply points for interfacing with installations of other trades, and the like, with setting outs and installation levels

   d. Detailed builder's work drawings to indicate the exact location, setting out and dimensions of the builder's work; the builder's work items shall include concrete plinths, inertia bases, penetrations, fire rated ceiling and the like

c. Sections of all plant rooms

d. Detail plans of all plant rooms

3.18 AS INSTALLED DRAWINGS

The Mechanical Services Subcontractor shall provide installation and record drawings to be kept on site throughout the construction phase. All deviations to the shop drawings shall be marked clearly in red ink. The marked up set of shop drawings shall form the basis of the production of the as installed drawings.

3.19 PROGRAMME

The Tenderer shall submit a programme of works with their tender in Gantt Chart Form, specifying Tasks, Duration, Resources and dependencies between scheduled tasks. The critical path activities and milestones shall be identified. This programme shall be kept updated at all times for the entire duration of the project

3.20 ACTS, CODES, REGULATIONS AND STANDARDS

The installation shall be performed in accordance with the Solomon Building Code, the Health and Safety in Employment Act, Fire Services Act, the Electricity Act and Code of Practice, OSH regulations and various other acts governing the installation, the relevant Australian/New Zealand standards applicable, Mechanical Code of Practice and all other standard codes of practices and local authority regulations appertaining to this installation.

Where a New Zealand or Australian standard is not available, the relevant British standard shall be used and the standards shall take precedence in the above stated order. Where standards are not available, acceptable engineering standards shall be forwarded for approval.

Equipment suppliers and manufacturers' recommendations shall be closely followed with respect to both the installation and commissioning.

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The latest issue/revision of all the above documents at the time of tender shall apply in each instance.

3.21 PERMITS AND FEES

The Mechanical Services Contractor shall give all necessary notices, obtain all necessary permits and pay all fees in order that the work may be carried out, and shall furnish all certificates as evidence that the works installed comply with laws and regulations. Bring to the attention of and clarify any unusual aspects of the installation with the relevant Authority during the permit application period.

Pay all fees and costs relating to patent rights, trademarks, or other protected rights and fully indemnify the Owner against any claims arising there from.

3.22 SITE WORK

Site work shall be performed in a workman like manner and the site shall be kept neat and tidy.

3.23 WORKING HOURS

For the duration of the contract works, the official working hours shall be coordinated with the main contractor prior to commencement of the contract

3.24 SITE PERSONNEL

The work shall be performed by people with the necessary experience, qualifications and registration to perform the work.

Documentation to this effect shall be submitted to the client's representative before any workmen will be allowed on to the site.

3.25 SITE FACILITIES

All site facilities shall be supplied by the contractor inclusive of communication, storage, office and ablutions.

3.26 OCCUPATIONAL HEALTH & SAFETY

The Contractor shall ensure that all personnel are fully trained in matters relating to work safety. The Contractor shall ensure that their personnel are fully equipped with safety equipment and that a strict regime of safety is followed on site that complies with local OHS (Labour Department) Authority and Westpac OHS requirements. Contractor to liaise with the Westpac OHS representative to get a better understanding of all Westpac OHS requirements.

3.27 COORDINATION

The Mechanical Services Contractor shall at all times liaise with other Subcontractors, the Main Contractors, the Project Managers, and the Engineer to ensure that works are carried out in a timely, orderly faction so as to minimise delays, disturbances and damages to any equipment or property.

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3.28 HOT AND DANGEROUS WORK

All minor and major hot work and work that could cause bodily harm or work that is a fire hazard for example grinding, sawing, cutting, welding, soldering and brazing shall not proceed without the consulting engineer's permission.

3.29 PROGRESS PAYMENTS

Progress payments for sectional completion shall be based on work completed and commissioned less retention moneys.

3.30 VARIATION ORDERS

Variation orders shall be based on the price schedules that shall be completed by the contractor.

3.31 DOCUMENTATION PRECEDENCE

This specification shall take precedence over other documents except in the case where it contravenes a Solomon law or local authority regulation.

In case of document discrepancy or ambiguity, the matter shall be referred to the consulting engineer for a ruling which shall be final and binding to all parties.

3.32 QUALITY ASSURANCE

The contractor shall submit with his tender a draft quality assurance plan indicating his quality control plan with hold points to be signed off by his personnel as well as the consulting engineer to ensure the quality of the installation.

The consulting engineer may add additional hold points or procedures if required.

3.33 MATERIALS FOR CONSTRUCTION AND FINISHES

The materials used in the construction of the equipment are to be of the highest quality of their respective kinds.

All parts liable to rust, including screws, bolts and nuts shall be cadmium plated or hot dipped galvanised. All metalwork in this Contract including switchboards, distribution boards, cable tray, trunking, cable ladder, support brackets etc. shall be protected against corrosion, to the satisfaction of the Engineer.

3.34 PROTECTION OF PEOPLE AND PROPERTY

Insofar as compliance with the Subcontract permits, the Subcontractor shall:

a. Take measures necessary to protect people and property;

b. Avoid unnecessary interference with the passage of people and vehicles; and

c. Prevent nuisance and unreasonable noise and disturbance.

If the Subcontractor damages property, the Subcontractor shall promptly rectify the damage and pay any compensation which the law requires the Subcontractor to pay.

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3.35 PROTECTION OF EQUIPMENT

All equipment delivered to the site for the Contract works shall be adequately protected during transport and adequately protected during storage on site and elsewhere. Damaged equipment shall be totally replaced with new items

3.36 PROTECTION OF WORKS

3.36.1 General

The Contractor shall be responsible for taking all reasonable steps to avoid other trades or environmental conditions from damaging or disfiguring equipment or materials of this Contract by protecting the works adequately at appropriate stages of the Contract programme. The Contractor shall liaise with the Main Contractor and other trades in this regard.

The Contractor shall adequately protect equipment and incomplete works in areas exposed to the weather.

The Subcontractor shall arrange site access with the Construction Manager. The Subcontractor shall comply with all site security provisions set by the Construction Manager.

3.37 WORKMANSHIP

3.37.1 General

Carry out all work in a neat and serviceable manner. Follow best trade practices and comply with any manufacturer's recommendations.

Confirm positioning of all fixtures with the Engineer before installation. Confirm mounting height and location of all fittings before installation.

3.37.2 Finish& cleaning

The completely erected installation shall be handed over in a perfectly clean condition with all rust and dirt removed paintwork in good clean condition with erection scratches and other damage marks made good and bright parts properly cleaned and polished.

Keep the work areas clean and tidy at all times. Remove all rubbish as it accumulates. On completion, remove all debris and waste caused directly or indirectly by the work and leave the installation and surrounding areas completely clean.

3.38 GUARANTEE

The Mechanical Contractor shall provide a written guarantee in respect of all materials supplied under the Contract against defects which may occur or be found in workmanship, materials and design for a period of twelve (12) calendar months in service after the date of Practical Completion Certificate as detailed below.

All defects, fair wear and tear excepted, shall be made good free of all costs to the Owner, whether or not the workmanship and materials have been previously inspected and accepted.

3.39 WARRANTY

The complete installation shall be guaranteed free of defects and faulty workmanship for a period of 12 calendar months after the date of issue of Practical Completion Certificate.

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Any defects during these 12 months shall be repaired/replaced free of charge inclusive of parts and labour.

Any equipment attended to during this period shall have an extended guarantee period of another 12 months from date of repair.

Where equipment supplier's offer extended warrantees in excess of 12 months, they shall be passed unto the client for their benefit.

3.40 AS BUILT DRAWINGS

A draft of the As Built documents shall be provided to the Engineer four weeks prior to Practical Completion for approval. Provision and acceptance of final as-built, commissioning, and maintenance documentation shall be a prerequisite for Practical Completion.

"As Built" drawings, to the approval of the Engineer shall be provided for the Contract Work. These shall be in similar detail to the installation drawings, but shall also include any amendments and any additional detail necessary to show the functioning or installation, or particular items of plant.

The approval of any drawings by the Engineer in no way affects the Mechanical Services Subcontractor's responsibility for the satisfactory completion of the Contract.

3.41 DEMONSTRATION & INSTRUCTION TO CLIENT AND STAFF

The Mechanical sub-contractor shall provide all instructions to members of the Client's organisation as necessary for them to recognise defective conditions in the Contract plant. Formal instruction shall be coordinated with the Client via the Main Contractor and shall take place following provision and acceptance of final as-built, commissioning, and maintenance documentation, and prior to Practical Completion.

The Subcontractor shall also provide such informal instruction as may be required prior to the formal instruction. The hydraulic sub-contractor shall assign a person thoroughly familiar with the Contract plant for the purpose of such instruction for a period of 2 complete days during which period his time shall be completely given over to instruction. Instruction shall be given as follows:

i. Explain the function and operation of all equipment, and indicate where these items are dealt with in the Operating and Maintenance instructions.

ii. Demonstrate all indicating instruments, gauges and settings of equipment and indicate the current readings of such items.

iii. Indicate where and how any item of Contract equipment can be disconnected or isolated.

3.42 COMMISSIONING AND TESTING

Commissioning and testing shall be performed by the tenderer. The tendered shall employ a third party test and balance agency particular for smoke controlled zones.

On completion of the installation, it shall be tested to verify that the installation is performing to the specification in particular that the design intents have been met.

Air flow testing shall be performed to the SMACNA manual – balance all air quantities to +/- 5%.

All test instruments used for air flow, current and noise testing the purpose shall be calibrated to acceptable standards with calibration certificates of no less than 6 months old.

Measure and record: -

i. All motor running currents.

ii. All air flow rates.

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iii. Differential pressure (smoke controlled zones)

iv. Suction/condensing pressures of the air conditioning units.

v. Noise levels.

vi. Perform all the other recordings and test/checks as required by the manufacturers and equipment suppliers.

All commissioning results shall be kept in the maintenance and operating manual

Where brand/manufacturers names are specified in this document, they are specified to set a standard which must be met.

The suppliers and manufacturer's instructions with regards to the installation of their equipment shall be closely followed in all respects and the tenderer shall ensure that they work to the latest edition/version of the supplier's/manufacturer's instructions and data books.

3.43 OPERATION AND MAINTENANCE MANUALS

Provide 3 sets of Operation and Maintenance Manuals bound and indexed in Black A4 ring binders labelled with the project name and purpose on the front cover and spine. The manuals shall include the following information:

i. Brief outline description of systems and principal design details.

ii. Operating instructions for the equipment installed.

iii. Schedule of all equipment showing location, maker's name and details of local agent.

iv. Provide spare parts lists, manufacturers' technical information, with detailed wiring diagrams for all composite equipment.

v. A description of recommended maintenance procedures and the desirable frequency thereof, recommended lubricants, and recommendations for locating faults and isolating equipment.

vi. Commissioning results, copies of works test certificates.

vii. A set of As-built drawings reduced from A1 size to A3 shall be provided for inclusion in each copy of the Manual.

The maintenance and operating manuals shall include all the equipment manufacturers engineering data books and information.

3.44 MAINTENANCE AND DEFECTS LIABILITY

The Maintenance and Defects Liability Period shall extend for a period of twelve (12) calendar months from the date of Practical Completion. During the maintenance and defects liability period the Contract Plant shall be under the control of the Owner but the Subcontractor shall be in attendance and carry out all maintenance works as maybe required at no cost to the Owner.

Repair any defect which does not compromise the effectiveness of any system, excluding fair wear and tear within 7 days during the maintenance period specified.

Defects which do comprise the effectiveness of the system shall be repaired within 24 hours. Failure to do so will result in the work being done by others at the Mechanical Contractors expense.

Tender Issue

3.45 PRACTICAL COMPLETION

After all test adjustments and commissioning have been completed to the satisfaction of the Project Manager and provided all the requirements of the specification have been met to the satisfaction of the Engineer a certificate of Practical Completion will be issued.

3.46 FINAL COMPLETION

Final completion shall be considered achieved when the Maintenance and Defects Liability Period has been satisfactorily completed and all specified requirements have been met to the Engineers satisfaction.

Tender Issue

4 TECHNICAL CLAUSES

4.1 DRAWINGS

The following drawings, including all the architectural drawings and site layout drawings forms part of this specification and shall be read in conjunction with this specification:

Drawing No.	Details
M0000	Drawing Schedule, Legends & Symbols, Abbreviations & General Notes
M0001	Equipment Schedule - Sheet 1 of 2
M0002	Equipment Schedule - Sheet 2 of 2
M0010	Overall Site Plan
M0100	Ground Floor – Air Conditioning and Ventilation Layout
M0200	First Floor – Air Conditioning and Ventilation Layout
M0300	Section A
M0400	Miscellaneous Details

One set of all drawings shall be kept on site by the Mechanical Services Subcontractor.

The attached drawings show the system layouts, general arrangements and requirements. The Mechanical Sub-Contractor shall carry out the detailed installation design and show all required details on the shop drawings.

Tender Issue

4.2 GENERAL SCOPE OF WORK

A. Obtain all regulatory approvals, apply for and obtain building consent and pay all local authority fees.

B. Issue shop drawings for approval.

C. Submit Materials and Equipment Submittals for Approval

D. Perform co-ordination between trades.

E. All tools, etc., necessary to perform the work.

F. Follow the approved Quality Assurance plan.

G. Allow for weekly site meetings.

H. Provide as-built drawings.

I. Provide for a 12-month warranty period and maintenance of all installed equipment after project turn-over.

4.3 DETAILED DESCRIPTION OF WORK TO BE PERFORMED

The tenderer shall allow for the supply, delivery, installation, testing and commissioning of the following equipment as specified below, in this specification and shown on the drawings: -

Mechanical works include but not necessarily limited to the following:

- Supply and installation of split type air conditioning system inclusive of indoor unit and outdoor units as shown and scheduled in the drawings. Note outdoor unit to have factory applied anti-corrosion treatment suitable for a coastal environment.
- Supply and installation of fresh air ventilation fans with associated controls and wiring as shown on the drawings.
- Supply and installation of toilet ventilation fans with associated controls and wiring as shown on the drawings.
- Supply and installation of wall mounted ventilation fans for the kitchenettes with associated controls and wiring as shown on the drawings.
- Provide and install ventilation ductwork with associated supports as per Australian or SMACNA standards. Allow for Unistrut duct supports.
- Provide and install air inlets and outlets, butterfly dampers, oppose blade dampers etc. as scheduled in the plans and drawings.
- Supply and install refrigerant pipes including refnet joints, hanger and support as shown on plans and drawings. Contractor to clad all exposed pipe in proprietary cladding.
- Provide door louvers to be installed by the builder.
- Provide and install required sleeves for duct and pipe penetration including sealants fire rated if required.
- Supply and install insulated condensate drain line as shown on plans and drawing. Contractor to ensure that drain lines have adequate gravity fall, where gravity fall cannot be achieved contractor to install “mini blue or approved equal” drain pumps. All exposed pipe to be in proprietary cladding.
- Interfacing of the air-conditioning & ventilation systems with the fire alarm panel. Mechanical Contractor to allow for interfacing card / module for each unit and fan for interfacing. Mechanical Contractor to coordinate interfacing works with the fire contractor.

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- Provide for electrical works (power and control wirings) for the air conditioning and ventilation systems.
- Conduct Testing, Adjusting & Balancing (TAB) works.

The following work shall be performed by others – the tenderer shall review, verify and confirm all the requirements by others for the mechanical services: -

- Concrete supports structural pedestals or plinths for the outdoor units by the builder.
- Mechanical services switch board, wall mounted mechanical outlet boxes by the electrical contractor.
- Exterior wall, Indoor wall, and ceiling penetrations for diffusers, grilles and ductworks by the builder.
- Outdoor wall penetrations and the flashing, counter flashing and waterproofing there off.
- Access panels shall be by builder. Mechanical contractor to coordinated location of access panel with the builder. Mechanical contractor to also include locations of access panels in their shop drawings.

4.4 DESIGN CRITERIA

The air conditioning systems have been designed to meet the following performance criteria: -

4.4.1 Outdoor Temperatures

The heat load analysis is based on 32.2°C dry bulb and the coincident wet bulb temperature of 25.5° C for Honiara, Solomon Islands.

The capacity of the outdoor condensing units is based on 35°C operating temperature

4.4.2 Indoor Temperatures

The indoor air shall be maintained at 23 °C +/-1 °C.

4.4.3 Humidity

The humidity is not controlled and the resulting humidity level is 65%±5%.

4.4.4 Design Occupancy

The design occupancy is as per furniture layout provided in architectural plans, otherwise values indicated herewith denotes for net floor area

5.0m² per person for office spaces

9.3m² per person for lobbies

4.4.5 Out Door Air Flow Rates

The design outside air is based on ASHRAE 62.1-2013

Airflow control is constant and is initiated when space thermostat controller is turned ‘’on’’.

4.4.6 Heat Load Calculations

The heat load calculations have been performed using Carrier HAP version 5.01

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4.4.7 Equipment Load

Equipment load varies from 20-25watts per m² for liveable area.

4.4.8 Lighting Load

12 Watts per m²

4.4.9 Noise Level

The noise level in each area may depend on other background noise source however the air conditioning system should not exceed the following noise criterion

NC25-35 for bedrooms

NC35-45 for Living areas

4.4.10 Glazing

The design shading coefficient of the glass is ≤0.65 and U value of ≤5.35W/m²-K

4.5 SYSTEM DESCRIPTION

The proposed Air Conditioning System is based on a Split type air conditioning system. The Energy Efficiency Ratio (EER) of the proposed Air Conditioning system is 3.46-4.15.

A combination of high wall and ceiling mounted cassette type fan coil units have been utilized in all areas for cooling the space which is a re-circulating type system. Fresh air system has been designed for the office spaces which is ducted to the fan coil units.

Inline duct mounted fans are used to ventilate spaces as shown on the drawings.

4.6 MATERIALS, EQUIPMENT AND WORK PERFORMED

Where brand/manufacturers names are specified in this document, they are specified to set a standard which must be met.

The suppliers and manufacturer's instructions with regards to the installation of their equipment shall be closely followed in all respects and the tenderer shall ensure that they work to the latest edition/version of the supplier's/manufacturer's instructions and data books.

4.7 DIRECT EXPANSION (DX) TYPE AIR CONDITIONERS

4.7.1 General

- The DX type air conditioners shall be of standard model, direct expansion type, each comprises an outdoor unit (condensing unit), an indoor unit (evaporator), pre-charged refrigerant circuit and accessories.
- The DX type air conditioners shall have capacities as stated in the Equipment Schedule.
- The refrigerant of the DX air conditioners shall be R-410A or R-32.

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4.7.2 Outdoor units

i. The outdoor units shall be of horizontal discharge type, comprises a weatherproof casing suitable for outdoor use.

ii. The outdoor units shall be with ample capacity to dispose the rejected heat from the entire split type air conditioner.

iii. The heat exchangers of the outdoor units shall consist of copper pipes and factory coated anti-corrosion acryl-resin aluminum fins; on-site anti-corrosion application may be considered subjected to proper methodology, however is not recommended.

iv. The compressors of the outdoor units shall be of hermetically sealed and of rotary, swing or scroll type, directly driven by DC motor, and complete with internal motor protection, lubrication and vibration isolation.

v. The outdoor units shall be mounted or supported with approved stainless-steel frame or hanger complete with approved vibration isolation means (double deflection neoprene pads) by the Sub-contractor.

vi. An emergency switch shall be installed next to each outdoor unit to allow cutting the power supply to the outdoor unit in case of emergency.

4.7.3 Indoor units

a. The indoor units shall be of ceiling suspended, cassette or wall mounted type as stated in the Equipment Schedule and/or indicated on the Drawings.

b. Wall mounted type indoor units shall be mounted on wall with the factory-supplied mounting plates; where an indoor unit cannot be mounted directly on the wall, a steel supporting frame shall be constructed for mounting the indoor unit with its mounting plate.

c. The fans of the indoor units shall be statically and dynamically balanced by the manufacturer, and capable of running in three speeds.

d. The fan motors of the indoor units shall be permanently lubricated, and shall be of adequate capacity to prevent overloading at any speed and duty of the fans.

e. Factory-supplied washable air filters shall be installed in all ceiling suspended type and wall mounted type indoor units.

f. Condensate from the indoor units shall be properly drained; no drip shall form on the casings of the indoor units.

4.7.4 Remote controllers

a. For each Fan Coil unit, one wired remote controller shall be supplied and installed at location as shown on the Drawing. Unless otherwise shown on plans, a common space served by multiple indoor units shall be controlled by a group manager or controller.

b. The wired / wireless or group remote controller/s shall allow on-off control, fan speed switching of at least three stages (high/middle/low) or single speed, and room temperature setting of the air-conditioners.

4.7.5 Refrigerant Circuits

I. Refrigerant piping shall be of seamless hard-drawn copper pipes to BS EN 12735-1, and of fittings to ASME B16.22 suitable to use with BS EN 12735-1 copper pipes; the copper pipes and fittings shall be internally degreased and cleaned; the copper pipes and fittings shall be suitable for high pressure refrigerant, such as R-410A.

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II. All field installed piping should be tested for leakage using dry nitrogen to a pressure approved by the Engineer; the Engineer shall be notified before the test.

III. The suction line and liquid line of the refrigerant circuits shall be properly sized to minimize friction loss and to a velocity high enough to carry the lubricant oil back to the compressors.

IV. Schematic diagrams of the refrigerant circuits shall be submitted for approval.

4.7.6 QUALITY ASSURANCE

All wiring shall be in accordance with the Solomon Islands Electricity Authority's Code. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001.

The refrigeration piping system shall be provided, installed, tested, evacuated and charged in accordance with the manufacturer's recommendations and AS Standard Safety Code for Mechanical Refrigeration and local codes.

Perform the following field tests and inspections and prepare test reports:

A. Leak Test - After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Operational Test - After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

4.7.7 REFRIGERANT COMPONENTS

The equipment specified in this section shall operate with refrigerant R410A - no exceptions or substitutions. The system shall utilize fully modulating electronic expansion valves.

4.7.7.1 Refrigerant Piping

The refrigerant piping system shall be provided complete and installed in accordance with the manufacturer's recommendations and as specified herein. The size of the refrigerant pipes shall be obtained from the equipment manufacturer unless otherwise shown on the drawings.

A. Pipe, Fittings, and Accessories - The pipe shall be type ACR 'L' hard drawn copper refrigerant tubing with hard wrought copper fittings. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. A sight glass with moisture indicator shall be provided if not provided with equipment. Use type 'L' copper tubing to pipe the relief valve discharge to the outside.

B. Condensate Drain Piping - Shall be type 'L' copper tubing.

C. Pipe Hangers and Supports - Shall be as required by AS Standards.

D. All refrigerant lines shall be insulated from the outdoor unit to the indoor terminal units.

E. The system shall be capable of operating with refrigerant piping up to 492 equivalent feet, a total combined length of 984 feet of piping between the condensing and fan coil units with 164 feet maximum vertical difference, without any oil traps or additional equipment. The vertical difference shall not exceed a maximum of 131 feet where the outdoor unit is located below the indoor unit.

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4.7.8 Fan

The condensing unit shall consist of a propeller type, direct-drive fan motor that has multiple speed operation via a DC inverter.

The fan motors shall have inherent protection and permanently lubricated bearings and be mounted.

The fan motors shall be provided with a fan guard to prevent contact with moving parts.

4.7.9 Condenser Coil

The condenser coil manufacturing shall be from copper tubes expanded into aluminum fins or microchannel (MCHX) heat exchangers. The condenser coil shall be factory coated with anti-corrosion for protection under humid and marine environment.

4.7.10 Compressor

The compressor shall be variable speed control capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.

The inverter driven compressor in each condensing unit shall be a high efficiency DC, hermetically sealed compressor.

The capacity control range shall be a minimum of 20% to 100% of total capacity.

Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

Oil separators shall be standard with the equipment together with an oil balancing circuit.

The compressor shall be mounted to avoid the transmission of vibration.

4.7.11 Electrical

The power supply to the outdoor unit shall be 380/415 volts, 3 phase, 50 hertz.

The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable shielded communications wire.

4.8 FANS

4.8.1 General

a. The fans shall have capacities as specified in the Equipment schedule.

b. The fans shall be performance tested to BS 848: Part 1:1980 and B.S 848: Part 2:1985 and quality assured to BS 5750: Part 1.

c. The fans shall be statically and dynamically balanced by the manufacturers.

d. The fan static pressure given in the Equipment Schedules are for guidance during tendering only; the Sub-contractor shall be responsible for checking the total final static pressure loss of each system, based on the actual duct run and system components offered, with allowance of an additional 15% safety factor; the fan static pressure calculations shall be submitted to and approved by the Project Manager prior to ordering of the item of equipment.

e. The characteristic curves of the fans shall be submitted along with the fans static pressure calculations.

   The characteristic curves shall be plotted over the entire range from shut-off to free delivery, with static pressure in Pa, total efficiency in percentages and operating kW, against the air flow in m3/s at the specified fan speed, and shall clearly indicate the operating point for each fan

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operating separately and, additionally, in the case of parallel operation fans, the parallel operation characteristics and operating points.

All characteristics curves shall be certified accurate by the manufacturers for the complete fan and drive assemblies.

f. For fans with variable speed drives, the Sub-contractor shall provide sound power rating curves and characteristic curves showing the operating points for the complete range of speeds from the minimum speed to the maximum speeds at intervals of 200 r.p.m. of shaft speed.

g. The fans shall have non-overloading characteristics over their entire operating range, and the characteristic curves must be such that the fan operating point falls below the point of no flow static pressure, to the right of the point corresponding to that of maximum mechanical efficiency, and a 15% increase in static pressure over that specified results in not more than a 15% reduction in air volume and does not affect the stability of fan operation; if necessary, this shall be accomplished by modifying the width of the fan wheel and/or by providing inlet vanes to change the characteristic curve.

h. The Sub-contractor shall make appropriate allowances for the effects on fan performance of all installation conditions including coils, eliminators, attenuators, plenum enclosures and inlet and discharge arrangement so that actual installed fan performance equals that specified

i. The Sub-contractor shall be responsible for any modifications to the ventilation system or any of its component, such as, fans, ductwork, motors, cables, switchgears, and the like, which may be required to meet the air flow rates of the fans as specified in the Specification, the air flow rates of the air outlets as shown in the Drawings, and space limitation, except where the modification is brought about by the written instruction of Engineer.

Notwithstanding the above, no modifications to any system shall be carried out where such modification may result in a reduction in system performance or efficiency, without the prior approval of the Engineer.

j. The fans shall be selected with speeds and outlets velocities (max. 13m/sec.) in order to keep the noise level to minimum.

k. All fans shall be equipped with lifting devices.

l. All fan motors exposed on roof shall be housed in weatherproof stainless steel enclosure.

4.8.2 Ceiling-Mounted Ventilation Fans

a. The impellers shall be of centrifugal type.

b. The fan casing shall be constructed in galvanized steel and complete with a circular outlet for flexible air duct connection and with a louvre face inlet for directly mounted onto suspended ceilings.

c. The circular outlets shall be complete with built-in non-return dampers.

d. The louver face inlets shall be for color and design to the satisfaction of the Engineer. Samples of various colors' and designs shall be submitted for the Engineer's selection and approval prior to ordering.

e. The motors shall be fitted with thermal overload protection.

f. The fans shall be suitable for conveying moisture air, such as exhaust from bathrooms.

4.8.3 Inline Duct Fans

a. In-line acoustic fans shall be of centrifugal / mixed flow type.

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b. The fan cabinets shall be fabricated from heavy gauge steel frame finished with a special coating fitted with galvanized panels.

c. The panels shall be of 1mm thick galvanized steel sheet with 15mm thick fiberglass insulation.

d. The impellers shall be of galvanized steel sheet with integral inlets.

e. The motors shall be of external rotor motors designed to minimum IP54 for indoor fans, and to minimum IP55 for outdoor fans, and to use class B insulation unless otherwise indicated in the Equipment Schedule.

f. The motors shall be capable of being removed from the fan assemblies via a swing-out arrangement.

g. A fan-speed regulator shall be supplied and installed with each fan for flow adjustment.

h. The fans shall be anti-vibration mounted as stipulated in the 'Noise and Vibration' Section of the Specification herein

4.9 MOTORS

4.9.1 General

a. The motors shall be of a type constructed to BS 4999, BS5000 and BS EN 60034.

b. The motors shall be totally enclosed fan ventilated squirrel cage induction motors (IP44) unless noted elsewhere in the specification.

c. The motors shall be of three-phase; motors rated 1.5kW or less may be of single phase.

d. The motors shall be selected to obtain the most suitable drive for the specified equipment, as recommended by the equipment manufacturers.

e. Ratings of the motors shall be based on continuous duty in the prescribed environment or an ambient temperature of 45 degree Celsius whichever is the more demanding.

f. The motors shall be entirely suitable for the duty; a margin of not less than 15% shall be provided between the continuous rating of the motors (without overloading) and the maximum power absorbed by the item of equipment (as installed) under its most arduous operating condition, taking account of the characteristics of the driving machine.

g. The motors shall achieve efficiency equal to or better than those of IE2 class as specified in IEC 60034-30:2008 measured based on test method defined in IEC 60034-2-1:2007.

h. For motors rated between 2.2kW and 30kW, the power factor at full load shall be more than 0.8; for those rated above 30kW, the power factor at full load shall be more than 0.85.

i. Motors rated up to an including 30kW shall be fitted with ball bearings at both ends; larger motors shall be fitted with roller or deep groove ball bearings.

Motors operating with vertical shafts shall be equipped with bearings designed to counter unbalanced end thrust; except where noted, the motors shall have a synchronous speed not exceeding 1500 rpm.

4.9.2 Winding

a. Winding insulation and general construction of the motor casings, terminal blocks and the like shall be to Class F, allowing 80-degree C temperature rise above ambient, unless otherwise specified in this Specification.

b. Each motor shall have locked out type emergency stop switch adjacent to and within sight of the motor; the switches shall be such that all conductors to the motors are isolated in one operation.

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c. Motors rated at 22kW or more shall be fitted with thermistors or other sealed temperature sensitive devices embedded in the windings and suitable for connection to motor protection control circuits.

d. Terminal blocks enclosed in cast iron or aluminum boxes shall be provided for all wiring connections to motors; the blocks shall be arranged to enable easy access for maintenance.

e. Motors rated in excess of 5.5 kW shall be supplied with anti-condensation heaters, controlled such that the heater is only 'ON' when the motor is 'OFF'.

f. For multi-winding motors there shall be no way that the motor isolating switches can be operated whereby any winding may be energized whilst another winding is isolated.

g. Terminal boxes shall be of such dimensions to ensure access to the terminals and allow room for the supply leads.

h. Terminal boxes shall be fitted for normal bottom or top cable entry; with exception of motors with ratings less than 1 kW, all terminal boxes shall be capable of being turned to a further 3 positions, 90 degrees apart without affecting the terminal base or terminals base or terminals.

i. Motors rated in excess of 7.5 kW shall be provided with suitably sized tinned brass cable sockets; sockets shall be in accordance with BS 91; the type of cable terminations shall be as shown on the Drawings.

j. Three-phase motors shall be fitted with separate earthing terminals

4.9.3 Mounting and Drive

a. The motors shall be mounted on a common bed plate with the driven machine wherever possible; the whole assembly shall be supported on vibration isolating material or springs to eliminate the transmission of noise and vibration into the structure; all holding down bolts required shall be supplied and fixed by the Sub-contractor.

b. The drive selected for any machine shall be the type recommended by the manufacturer of the driven machine and subject to approval; all drives shall be fitted with safety guards.

c. For motors over 25kg in weight, lifting eyes or lugs shall be supplied.

4.9.4 Protection by Enclosure

Unless specified otherwise, enclosures for the motors shall be as follows: -

A.	Outdoor, or rooms	IP55
	With water pumps:	
B.	Indoor:	IP44

4.9.5 Identification

The motors shall be provided with name plates.

4.9.6 Noise Level

The motors shall have a maximum sound pressure level of 85 dB(A) at 1 metre; for the motors of AHU, PAU and ventilation fans installed on occupied floors, low noise motor shall be provided with maximum sound pressure level of 77 dB(A) at 1 metre.

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4.10 DUCTWORK & FITTINGS

4.10.1 General

A. This section of the Specification covers the general requirements for ductwork, dampers, fittings, insulation and accessories, unless the general requirements are abrogated by specific requirements elsewhere in the Specification or Drawings.

The Sub-contractor shall supply and install all ductwork, dampers, fittings, insulation and accessories for the correct and satisfactory operation of the air systems covered by this Specification.

B. All ductwork and fittings delivered to site shall be new and shall be clearly and indelibly stamped to identify different grades, materials and manufacturers.

C. All ductwork, dampers, fitting, insulation and accessories shall be suitable for the service and shall not deteriorate due to atmospheric action.

D. All ductwork and accessories, including fire dampers, insulation, acoustic lining, flexible ducts, flexible joints, gaskets, sealants, adhesives, etc., shall fully comply with all requirements of the fire authority, and also with fire performance requirements of AS 4254, and where stated in other sections of this Specification, with Clause 2.2.2 of AS/NZS 1668.1:1998.

Packing for ductwork penetrations through fire resistant walls and floors shall fully comply with all requirements of the fire authority, and also with requirements of AS 4072.1, and where stated in other sections of this Specification, with Clause 3.6.2 of AS/NZS 1668.1:1998.

E. The materials, construction and installation of all sheet metal ductwork and fittings shall be in accordance with the Specification for Sheet Metal Ductwork, DW/144:1998 (HVCA) (‘DW/144’ hereafter).

Where any part of the installation is not covered by the aforesaid HVCA specification, then the recommendations of the HVAC Duct Construction Standards – Metal and Flexible issued by the Sheet Metal and Air conditioning Sub-Contractor’s National Association of U.S.A. (SMACNA) latest edition shall apply.

Where any part of the installation shown on the Drawings is not covered by either the specification or standards of HVCA and SMACNA, then reference shall be made to the Project Manager for approval of materials and methods prior to installation.

F. The ductwork installation shall be leakage tested in accordance with Ductwork Leakage Testing, DW/143:2000 (HVCA) (‘DW/143’ hereafter).

Complete record of the test shall be submitted to the Project Manager on approved forms for approval.

The Sub-contractor shall provide all necessary equipment for the tests.

Should any test indicate leakage rate in excess of that specified by DW/144:1998, the section of ductwork shall be dismantled, joints cleaned down and re-assembled and test repeated.

G. The Drawings indicate the clear internal air passage dimensions of the ductwork and the manner in which the ductwork systems are to be installed.

Due allowance shall be made for the thickness of internal or external linings when dimensioning ductwork and selecting fittings and accessories.

The actual work involved in respect of transitions, offsets, etc., shall be ascertained by the Sub-contractor, who shall co-ordinate the ductwork installation with the work of other trades and services.

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4.10.2 Sheet Metal Duct Materials

A. Generally, all ductwork shall be of hot dipped galvanized steel sheet to BS EN 10142:1991, Grade DX51D+Z, coating type 'Z275' as specified in DW/144, unless otherwise specified in other sections of the Specification or in the Drawings; rectangular ducts shall be fabricated from new, best quality, full sized galvanized flat steel sheets; round ducts and oval ducts shall be of spirally-wound construction.

B. The pressure class and air leakage limit shall be as defined in DW/143 and DW/144.

C. Kitchen Exhaust ducts shall be made of black steel sheet with minimum 1.2mm thickness and shall be welded seam and joint construction. **The ducts shall be thermally insulated with 25mm thick by 48kg/m³ fiberglass board insulation**

4.10.3 Flexible Ducts

A. Flexible ducts shall comply with the requirements of DW/144.

B. Unless otherwise specified, all flexible ducts shall be of flexible fabric ducts.

C. Flexible metal ductwork shall be of spirally wounded type corrugated aluminum tubing.

D. Flexible fabric ductwork shall be of reinforced polyester and aluminum foil laminates encapsulated corrosion resistant steel wire helix.

E. Insulated flexible ductwork shall be factory pre-insulated with 25mm thick fiberglass insulation of 0.037W/mK thermal conductivity at 20 degrees Celsius, and with a reinforced polyester and aluminum vapor barrier.

F. Bends in flexible ducting shall be formed to manufacturer's recommendations and shall have a center-line radius of not less than 1.5 times the diameter of the ducts.

The bends shall remain at full diameter throughout the length of the bend and all bends deformed or damaged in any way during installation shall be replaced with new bends.

G. Fittings such as tee-pieces, Y-pieces and reducers shall be of galvanized sheet metal exactly as specified for circular sheet metal ductwork.

H. Joints between lengths of flexible ductwork shall be made with short spigots of galvanized sheet metal circular duct to form a slip joint.

Similarly, connections to fittings, sheet metal plenums and ducts, and the like shall be of the spigotted slip joint type.

I. All joints shall be sealed with shrink-on type duct bands similar to "Thermofit" or approved equivalent, except that continuous screw type metal bands hose clips or equivalent as approved by the Engineer may be used for low pressure applications only.

Self-tapping metal screws and rivets shall not be used.

J. All flexible ducts shall be adequately supported with hanger straps located, at a minimum of 2000mm centers, to prevent undue sagging and strictly in accordance with the manufacturer's recommendations.

Under no circumstances, should the flexible ductwork rest on the ceiling file or suspension system.

K. The pressure class and air leakage limit shall be as defined in DW/143 and DW/144.

4.10.4 Fittings

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4.10.4.1 Joints and Fittings

A. All cross joints, longitudinal joints, take-offs, bends, transitions and other fittings shall be in accordance with DW/144 for the appropriate class.

B. All flanges and steel works for jointing and supporting members shall be hot-dipped galvanized to BS EN 150 1461:1999, Part 1 or BS EN 10142:1991 Grade DX51D+Z, coating type Z275 whichever is applicable.

C. Details of construction shall be submitted to Project Manager for approval before commencement of fabrication.

4.10.4.2 Ductwork Jointing Sealants

A. Jointing for flanged cross joints shall be formed from a gasket of 'Prestick' lead or other approved material to thickness not less than 4mm.

B. Sealant for longitudinal and slip joints shall be type E/750 sealing compound by Minesota Mining and Manufacturing Ltd or an approved equal compound.

4.10.4.3 Vanes and Deflectors

A. Vanes or deflectors shall be provided inside ducts where required; in particular, such vanes or deflectors shall be provided at all bends having an internal radius less than the width of the duct and also where the included angle exceeds 30° at changes of section.

B. The vanes and deflectors shall be of special profile to ensure complete change of direction of flow at the point, with extended leading and trailing edges, and with radii and spacing selected to achieve uniform velocity at the bend.

4.10.4.4 Flexible Joints

A. Flexible joints shall be provided at the suction and delivery connections of all fans and air handling units and elsewhere as shown on the Drawings or as may be required to eliminate vibration.

B. All flexible joints for use at temperatures up to a maximum of 90°C shall be of neoprene coated glass fabric having a density of not less than 1 kg/m2.

C. All flexible joints for use with temperatures in excess of 90°C and in ‘smoke spill’ applications shall be of non-combustible woven glass fabric capable of withstanding 250°C under continuous operation.

D. All flexible joints exposed to the weather shall be covered with prime quality galvanized sheet steel or fiberglass weather shields arranged to form a complete weatherproof jacket.

E. All flexible joints shall be fixed over mild steel angle flanges at both ends and secured to same with not less than 2.5mm thick x 25mm wide mild steel bands.

For circular ducts flexible joints shall be of the split semi-circular type drawn up tight with bolts at the split points.

Flat bars for rectangular ducts shall be fixed with bolts or screws at not more than 150mm centers.

The flanges to take the connections shall be not less than that specified for the ducts and the "free" space between flanges shall not be less than 50mm.

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The flexible joints shall be installed with not less than 25mm additional slack length between the flanges to prevent transmission of vibration.

F. Flexible joints shall not be used for correcting misalignment of fan and duct.

G. Where the flexible joints are used for connecting fans to insulated ductwork, then flexible fiberglass of equal thickness as for ductwork insulation shall be fitted over the cloth and enclosed in aluminum foil vapor barrier.

H. Where silencers are fitted to fans either on the suction or discharge side, then flexible joints shall be of lead impregnated vinyl or other suitable material providing an acoustic barrier.

4.10.4.5 Fire Dampers

a. Fire dampers shall comply fully with the up-to-date requirements of the fire authority regarding rating, construction, installation and testing; the dampers shall also comply fully with AS 1682.1 and AS 1682.2.

b. The fire dampers shall be constructed generally to the same standards of air-tightness and fire rating of the partition.

c. The fire dampers shall be gravity operated, with fusible links.

d. The fire dampers shall be provided where ducts enter shafts, fire resistant walls and floors, and wherever required by the fire authority or by AS/NZS 1668.1:1998, whatever indicated on the Drawings or not, except for ducts of smoke exhaust systems and kitchen hood exhaust systems; the fire dampers shall be constructed to provide a fire resistance level the same as that of the wall or floor penetrated.

e. In location where the fusible links shall be of the electro-thermal type, the Sub-contractor shall leave the bare wire link connections adjacent to the dampers (unless otherwise indicated) for connection to electrical circuits by others.

f. The fire dampers shall be of multi-leaf type or shutter type, and constructed from corrosion resistant material or otherwise protected to inhibit corrosion.

g. Fire damper assemblies shall incorporate provision to permit free expansion in case of fire, and the integrity of the fire damper shall be maintained by fire resistant packing around the casing and duct through the fire partition.

h. Access openings shall be provided on the duct work adjacent to fire dampers to permit access to and replacement of fusible links.

4.10.4.6 Access Panels

A. Access panels shall be provided at every point in the ductwork systems where access for checking, servicing and cleaning of equipment is required; such equipment shall include all fire dampers, plenums, motorized dampers, fan chambers, air chambers, etc.; where additional access panels are required for checking, servicing and cleaning of equipment not mentioned above, these shall be provided by the Building. Mechanical Subcontractor to liaise with the builder on the requirement of the requirement of the access panels.

B. Access panels in ductwork, casings, or sheet metal partitions shall be of G.I. double construction with insulation of the same general character as adjacent sections of ductwork and retaining safety cable, of not less than 0.8 mm sheet metal and shall have gaskets around their entire perimeter to ensure possible seal conforming to DW/144 leakage class specification as required by the system; minimum size shallbe 450 mm x 450 mm or 50 mm narrower than the duct whichever is smaller.

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C. The Sub-contractor shall submit required locations and sizes of any access panel in finished building surfaces and exposed areas for approval in time to enable them to be incorporated into the construction; access panels in building surfaces will be supplied by others; the exact locations shall be shown on the Sub-contractor's shop drawings.

4.10.4.7 Volume Control Dampers

A. The Sub-contractor shall provide and install hand operated dampers where required for the proper regulation of the ventilating and air conditioning systems. In general, dampers shall be provided as follows: -

B. In all main supply and exhaust air ducts, branches, fresh air or primary air duct connections to fan coil units and all primary air supply outlets.

C. Behind all supply and exhaust air diffusers/grilles or supply connection to grilles.

D. The volume control dampers shall comply with DW/144 and shall be provided in separate purpose-made flanged casings of rigid construction conforming to the same standards of air-tightness.

E. Materials for the dampers in all cases shall be stainless steel or galvanized mild steel.

F. Damper spindles shall be provided with suitable seals when passing through the casing and penetrations shall be limited by the use of internal linkage.

G. Dampers up to width of 300mm in the plane of rotation shall be of butterfly type having blades of double construction fitted round a square mild steel spindle and the edges of blades folded and left smooth; sides of blades shall be folded, left smooth, and in all cases shall be felt to give a good fit against sides of duct; the spindle shall be turned down at each end and carried in substantial bronze bosses fixed to the sides of duct, with substantial cast quadrant piece in an accessible position and with means of clamping after adjustment.

H. Dampers on ducts larger than 300mm shall be of multi-leaf opposite blade type, mounted in built-up frames inserted in the ductwork and bolted thereto; individual blades shall be as specified for butterfly dampers, each shall be carried on solid spindle with ends housed in bronze or nylon bushes; the group of blades forming the damper shall be linked to a hand-operated mechanism, which shall be controlled by a quadrant in cases where the damper is accessible from ordinary working level and in all other cases, shall be provided with screw-operate remote-control gear with the winder at an accessible point.

I. After final testing and adjustment, all dampers shall be clamped in their correct positions which shall be marked on the quadrant in a permanent manner and stops fitted; the damper quadrants shall be covered with wooden boxes with hinge lid for access.

4.10.4.8 Non-Return Dampers

1. Non-return dampers shall present a minimum resistance to air flow under running conditions and take up a stable position in operation; maximum resistance shall be presented under reverse air flow conditions such that they will be forced to close and remain so.

2. Resilient strips or other purpose made devices shall be provided to prevent the damper rattling and as an aid to air sealing under reverse flow conditions.

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4.10.4.9 Motorized Dampers

1. Modulating dampers construction shall be the same as the volume control dampers except multi leaf dampers shall be of parallel blade type.
2. Dampers required fully closed at any time shall be fitted with blade edge and blade end seals; the seals shall be of a standard such that total air leakage does not exceed 30, 40 and 52 L/s per m2 of damper area when closed against static pressures of 250, 500 and 1000 Pa respectively.
3. Blade seals shall be mechanically fastened in position; the seals which are glued on shall not be accepted.
4. Shafts shall be securely fixed to the centre of each blade; driven shafts shall run the full length of the blade and extend to provide suitable attachment to the drive motor.
5. Blade shaft bearings shall provide free rotation of shafts and shall be of brass or 'oilite' construction; bearings in fire smoke control dampers shall be sintered bronze, ball or roller type.
6. Dampers shall be interconnected to give the required parallel or contra rotating action.
7. Motors shall be rigidly mounted to prevent flexing and shall be linked to the driven blade shaft extension using suitable linkages; maximum damper area per drive motor is 1.6m2.
8. Where the dampers are required to response upon the receipt of a fire alarm, the dampers shall operate to their required position within a time not exceeding 60 seconds from the receipt of such alarm.
9. Smoke dampers shall be of HOLYOAKE model HCD-150/75-ET model or approved equal.

4.10.5 Duct Supports, Hangers and Bracing

1. The Sub-contractor shall be responsible for building in all supports and the like, and shall allow for using expansion anchors on masonry construction; where expansion anchors to be used on masonry construction other than concrete, the expansion anchors shall be of the type suitable for such usage.
2. No vibration whatsoever shall be transmitted from the ductwork of plant to the structure, and the Sub-contractor shall provide where necessary resilient mounting to achieve this.
3. The construction of hangers shall be in accordance with DW/144; the hangers shall be provided with screw lengths or turnbuckles for adjustment of ducting runs to level; welding of hanger to bearers shall not be permitted; nuts shall be provided with washers and lock-nuts; projecting ends of bolts shall be cut-off.
4. On no account shall supports be riveted or bolted to the air ducts.
5. Vertical ductwork shall be supported by angle iron bearers under flange joints.
6. Ductwork hangers shall be as follows: -

Locations	Brackets, Supports and Hangers
External locations	Hot-dipped galvanized steel to BS EN ISO 1461:2009 with epoxy protective painting

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Internal locations exposed to sight, including public areas and plant rooms	Hot-dipped galvanized steel to BS EN ISO 1461:2009
Internal concealed locations including building ducts and false ceiling voids	Hot-dipped galvanized steel to BS EN ISO 1461:2009

Painting shall be executed as stipulated in "Painting, Labelling and Finishing" Section of this Specification herein.

All brackets shall be fixed by means of bolts and nuts or screws electroplated with zinc or cadmium to BS 7371-12:2008 with minimum plating thickness of 25 microns.

7. The ducts shall be tightened to underside of slabs or beams, and after the projecting ends of bolts are cut off, no other part of the support shall project below the bottom bearers, thus maintaining maximum height throughout.
8. Lengths of steel angles and the like used in fabrication of the brackets, flanges and bracing shall be cut from full length sections; short lengths of sections butt welded together to form a longer length shall not be used.
9. All hanger supports shall be placed as close as possible to transverse joints or bracings.
10. All ducts shall be carefully designed and provided with all necessary anchoring and flexible connections to prevent damage to either the ducts or the building structure due to expansion and/or contraction of the ducts or building.
11. All anchor points and flexible connections shall be shown on the shop drawings and specific approval shall be obtained from the Project Manager before proceeding with the installation of any anchors or fixings to the building structure.

4.10.6 Louvres

A. All internal and external louvres shown on the Drawings will be supplied and installed by the Main Contractor; the Sub-contractor shall be responsible to provide the dimensions of all louvres to be used for outdoor air inlets and outlets for the MVAC installation and submit for Project Managers approval.

B. Louvres to be used for outdoor air inlets as indicated in the Drawings shall be complete with galvanized steel wire meshes of 12mm grid fitted on the rear face of the louvres; the wire meshes shall be supplied and installed by the Sub-contractor.

C. Inactive louvres, i.e. louvres other than those used as outdoor air inlets and outlets indicated in the Drawings, shall be blanked off by plates of 0.6mm galvanized sheet metal painted matt black.

4.10.7 Thermal Insulation

A. All thermal insulation shall comply with the fire performance requirements of AS 4254, and the requirements of the fire authority.

B. All external thermal insulation shall comply with the following requirements: -

   a. The insulation shall be of duct wrap type fibreglass with density of 48 kg/m3 and with thermal conductivity of not greater than 0.035 W/mK at a mean temperature of 24°C.

   b. The insulation shall be complete with fibre reinforced one-sided aluminium foil vapour barrier; the vapour barrier shall be of at least five-layer construction: aluminium foil,

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polyethylene film, craft paper, 3-way fibreglass reinforcement and aluminium foil; the fibre reinforcing grids shall not be greater than 10mm x 10mm.

c. The insulation shall be adhered to duct with fire resistant adhesive; the adhesive shall be applied so that insulation conforms to duct surfaces uniformly and firmly.

d. For ducts up to 450mm wide, the insulation shall be wrapped around the duct with lapping of all joints by 50mm minimum.

e. For horizontal ducts over 450mm, metal or nylon pins shall be located on the bottom side of the ducts at 400mm maximum centres; the insulation shall be wrapped around the ducts with lapping of all joints by 50mm minimum; the insulation shall be impaled over the pins and secured by using 25mm minimum speed clips or nylon washers.

f. For vertical ducts over 450mm, metal or nylon pins shall be located on all sides of the ducts at approximately 300mm centres; the insulation shall be wrapped around the ducts with lapping of all joints by 50mm minimum; the insulation shall be impaled over the pins and secured by using 25mm minimum speed clips or nylon washers.

g. Protruding ends of pins shall be cut off flush after clips have been applied; the vapour barrier facing shall be thoroughly sealed with a vapour-barrier mastic or tape where the pins have pierced through.

h. All joints of the insulation shall be overlapped by at least 50mm and sealed with at least 75mm wide vapour barrier tape to provide a continuous external vapour seal; prior to the application of tape, all contact surfaces of vapour barrier foil shall be wiped clean of dust and grease using cloth and suitable solvent all in accordance with the manufacturer's recommendation.

i. The insulation shall be applied so as to form a continuous heat barrier without gaps, cavities and openings; care shall be exercised to ensure that the minimum thickness specified is maintained at corners, protrusions, etc.

j. The insulation shall extend over external flanges and stiffening of the ductwork.

Duty	**Location**	**Insulation Thickness**
Cold supply, return and exhaust air ducts **(Treated) fresh air ducts**	In all areas internal to building and shafts	R=1.2 minimum
	External to building, exposed to ambient	R=2.4 minimum
(Untreated) fresh air ducts	In air conditioned space or ceiling	25mm fibreglass insulation
	In non-air conditioned spaces or ceiling	Nil
Toilet exhaust air ducts (from non-air-conditioned space	In all areas	Nil
Toilet exhaust ducts	In all areas	25mm fibreglass insulation

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k. Ductwork shall be insulated from hangers and supports generally as indicated in DW/144:1998 (HVCA).

l. At the points of support, specially prepared blocks of hardwood or styrofoam material shall be positioned to ensure integrity of vapour barrier by bonding the supports to the insulation.

m. All externally insulated ductwork installed outdoor, susceptible to rain or exposed to sight, including those in plant rooms and service corridors, but excluding those concealed in false ceiling voids and building ducts, shall be sheathed externally by means of 0.5mm hammered aluminium cladding with all joints lapped and secured by self-tapping screws at 100 mm centres.

n. Insulated flexible ductwork shall be factory pre-insulated; refer to section on flexible duct.

4.10.8 Duct Insulation Application

A. All air ducts shall be supplied and installed external thermal insulation as follow, unless otherwise specified: -

B. In the previous two tables, ‘air conditioned spaces’ shall include false ceiling voids of air conditioned spaces, and ‘non-air conditioned spaces’ shall include building ducts and all outdoor areas.

C. Internal thermal insulation shall be applied to air ducts where specified on the Drawings; where internal thermal insulation is applied to an air duct, external thermal insulation shall be not required for the air duct.

1. No insulation shall be applied until duct and plant have been tested as specified.
2. The 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.
3. The insulation shall fit tight to surfaces to be covered, and all slabs and sections shall be built up close, with butting edges being mitred, chamfered or shaped as necessary; any minor interstices left in the insulation shall be filled and sealed.
4. The insulation shall be applied to clean and dry surfaces, free of foreign material, such as, oil, grease, rust, scale or dirt.

   When a surface where the insulation to be applied shows any signs of rusting or damage on its galvanized coating, the surface shall, prior to insulating, be thoroughly scraped and wire brushed as necessary to remove all rust, scale, etc., and then be solvent cleaned to remove all oil, grease and dirt, and then a coat of zinc-rich primer shall be applied.
5. Only clean and dry insulation shall be used; the insulation shall generally be applied in accordance with the manufacturers' recommendations.
6. Any projection through the insulation shall be sealed by vapour barrier.
7. Joints of the insulation shall be staggered with respect to the joints of the associated ductwork system.
8. Continuous insulation shall be provided through all sleeves.
9. Where air ducts pass through fire resistant walls and floors, a metal fire stop shall be provided around the air ducts including the fire dampers; the continuity of the insulation shall be maintained throughout the penetrations through the walls and floors.

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4.10.9 Internal Acoustic/Thermal Insulation

A. The finished duct system shall meet the requirements of AS 4254 and local fire authority.

B. All air duct system operating at internal air velocities not exceeding rated duct liner limitations as listed in manufacturer's recommendation, and an internal air temperature not exceeding 121°C

C. Dimensions shown on the plans are finished inside dimensions

D. Fabrication and installation shall conform to manufacturer's recommendation and to the requirements of AS 4254 and SMACNA standards.

E. Provide all supply / return ducts and related fittings as indicated on plans with highly efficient acoustic material produced from strong resilient glass fiber firmly bonded together with a thermosetting resin for zero fiber migration. The air stream side shall have strong black pigmented coating and is dimensionally stable.

F. Insulation R value should not be less than 1.2m²-W/K for ducts inside conditioned space or false ceiling and 2.4m²-W/K for ducts exposed to ambient or outdoors

G. Duct liners shall be adhered to the sheet metal with 90% coverage of adhesive complying with requirements of ASTM C916. All exposed leading edges and transverse joints shall be factory coated or coated with adhesive during fabrication

H. Duct liner shall be additionally secured with mechanical fasteners, either weld-secured or impact driven, which shall compress the duct liner sufficiently to hold it firmly in place

4.10.10 Sealing and Flashing

1. Where air ducts pass through walls, floor, and the like the Sub-contractor shall provide sleeves of 18-gauge steel; where the sleeve are fitted through floors, they shall extend to at least 12 mm clear of finished floor.
2. The sleeves shall be of sufficient size to allow free movement of the air ducts; and furthermore, where air ducts are insulated, the sleeves shall be oversized to allow the insulation to be carried through the sleeves.
3. Penetrations through roofs shall also be provided with a weatherproof apron and up stand curb.
4. Where air ducts pass through fire resistant walls and floors, a metal fire stop shall be provided around the air ducts.
5. Where air ducts penetrate the building fabric, the penetrations shall be detailed as follows: -
   i. An oversize sleeve shall be built into the construction leaving a consistent clearance of 12-15mm all-round the ducts when installed. This gap shall be packed carefully with 80 kg/m3 mineral wool and the ends of this packing shall be caulked using a non-setting waterproof mastic compound giving an air tight and water tight seal.
   ii. Where the air ducts shall be thermally insulated, the insulation shall terminate at both ends of the sleeve; a seal between the surface of the insulation and the end of the sleeve shall be provided by the use of a single bellows arrangement using a flexible material having a minimum surface weight of 5 kg/m2.

4.10.11 Test Points

Test points for measuring air flow shall be provided at the following locations: -

A. At all fans (in the straightest section of duct near to the outlet)

B. At main branches after regulating dampers

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C. At cooling coils before and after the coil.

D. At any other positions as shown on the Drawings

E. The exact locations of the test points shall be subject to the Engineer's approval.

On insulated air ducts, the test points shall be boxed out for the thickness of the insulation.

The test points shall be 25mm diameter and fitted with an effective removable seal plugs.

4.10.12 Leak Testing

Leak testing shall be carried out by the Sub-contractor in accordance with the requirements stipulated in the 'Commissioning, Testing, Maintenance and Services' section of this Specification.

4.10.13 Plenum Boxes

All plenum boxes shall generally be designed as specified in 'Noise & Vibration Control' section of this Specification.

The plenum boxes shall be so designed as to provide an efficient, quiet and maintenance free air distribution system.

4.10.14 Air Boots

1. All air boots shall be robustly constructed in 0.8mm galvanised sheet metal and internally lined with min. 25mm thick, 24Kg/m³ fibreglass complete with black mat-liner facing to prevent erosion.
2. The air boots for supply air outlets shall be internally lined with minimum 25mm thick 24kg/m³ fibreglass insulation complete with black mat liner facing to prevent erosion.
3. The spigot diameter of the air boots shall suit the size of the flexible ducts connected to the air boots as indicated on the Drawings.
4. The air boots shall be provided with suitable support points independent of the suspended ceilings.
5. The air flow and acoustics performance of the air boots shall be tested in accordance to ACD Standard or other approved international standard.
6. The Sub-contractor shall co-ordinate with the contractor responsible for the works of the suspended ceilings for the installation of the air boots.

4.11 PIPEWORK AND FITTINGS

4.11.1 General

i. This section of the Specification covers the general requirements for pipework, valves, fittings, insulation and accessories, unless the general requirements are abrogated by specific requirements elsewhere in the Specification or Drawings.

ii. The Sub-contractor shall supply and install all pipework, valves, fittings, insulation and accessories for the correct and satisfactory operation of the air systems covered by this Specification.

iii. All pipework materials delivered to site shall be new and shall be clearly and indelibly stamped to identify different grades, materials and manufacturers.

iv. Prior to any ordering or installation, the Sub-contractor shall furnish the following information for approval:

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v. Manufacturer of all pipes and fittings.

vi. Specification and standard for all pipes and fittings.

vii. Shop drawings for all pipework system, including plans, sections, elevations, schematics, schedules and details of all systems.

viii. Manufacturers' data for all valves, strainers, pipe hangers, mechanical couplings, flexible or expansion couplings, gauges and for any other equipment as may be requested by the Engineer; this shall include printed installation, operation and maintenance instructions, performance data, complete parts lists, materials specifications, recommended spare parts lists and any other information as may be requested by the Engineer.

ix. Details of all pipe supports, thrust blocks and anchors.

x. The Drawings indicate the nominal size of pipes and the manner in which the various piping systems are to be installed; the actual work involved shall be ascertained by the Sub-contractor, who shall co-ordinate the pipework installation with the work of other trades and services.

xi. Exposed pipework will not be permitted in occupied areas without prior approval.

xii. Sizes indicated for copper and plastic pipe are nominal outside diameter, and for all other pipes are nominal inside diameter.

xiii. All pipework delivered to site shall be new and shall be colour banded to identify different grades.

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

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

xvi. All open ends shall be plunged or capped to prevent ingress of dirt; on completion each system shall be flushed out with clean water.

xvii. Where two or more pipe runs follow the same route all shall be parallel to each other and to the building structure, except for the required allowance for draining and venting; pipework which is to be insulated shall be spaced to allow an individual finish to each.

xviii. The Sub-contractor shall be entirely responsible for ensuring compliance with any Government requirements for the stamping of valves and for the payment of any fees levied.

xix. The Sub-contractor shall include for all valves necessary for the proper completion, working, isolation and regulation of the installation.

xx. All pipework shall be provided with hangers, supports, guides, anchors and the like in accordance with BS 3974.

4.11.2 Operating and Test Pressure

4.11.2.1 Refrigerant Systems

i. Refrigerant piping circuit shall be pressure tested to 3000 kPa for 24 hours, using dry nitrogen or anhydrous carbon dioxide.

ii. Pressure test shall be carried out with compressor discharge and suction services valves closed; the pressure test shall be immediately followed by evacuation simultaneously from both sides of the systems to an absolute pressure of 3-mm of mercury (i.e. the boiling point of water in the system is below 0 deg C) with compressor service valves open and vacuum

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pump running; the compressor service valves shall then be closed, and the vacuum pump isolated from the system.

iii. The evacuation test shall be deemed satisfactory if the absolute pressure rise over twelve hours does not exceed 4-mm of mercury measured on an approved mercury manometer or electronic vacuum indicator.

iv. On completion of the vacuum test, the vacuum shall be broken and the system charged with refrigerant, and the whole system shall be halide tested to suit the manufacturer's recommendations.

4.11.3 Piping Materials

Pipework Class	Nominal Bore (mm)	Specification
I	10 ~ 200	uPVC pipe to BS 3505, minimum Class D
II	10 ~ 150	Copper pipe to BS EN 12735-1

Pipework for the various shall be according to the tables as follow: -

Services	Pipework Class as Referred in the Next Table
Condensate drain pipework	I
Refrigerant pipework	II

4.11.4 Pipe Joints Unions and Flanges

1. The following methods of joining pipework shall be employed: -

Pipework Class	Joint
I	Solvent welded joints to BS 5392:1976 Part 1; using solvent cement to BS 4346 Part 3
II	Flanged, flared (up to 20mm outer diameter only) or blazed with or without capillary fittings; blazing material shall be 15% silver solder

2. All screwed joints shall be made in accordance with BS 21 using jointing compound carefully selected to suit the type of service.

3. Sufficient joints shall be provided to ensure that access to equipment for maintenance, removal and replacement can be effected without dismantling large sections of pipework or adjacent plant.

4. Where pipework is connected to items of equipment having flanges of dissimilar metal to the pipework, and then isolating flanges of a proprietary brand shall be used with plastic bolt inserts.

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5. No pipe joint shall be permitted within the thickness of walls or floors, etc.

6. No welded joint is allowed for galvanized pipework.

7. Pipe unions shall be installed to facilitate the future removal of pipework in sections and where pipework connects to fixed items of plant; the unions shall be of the following types: -

Pipework Class	Joint
I	Mechanical joints to BS 4346:1970 Part 1

4.11.5 Pipe Fittings

1. Pipe fittings shall be as specified hereunder for the various tube materials.
2. Change in direction of pipes shall be made with long sweep elbows; under no circumstances shall pipes be sent without the use of fittings.

   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.
3. Bushes shall not be used and where a reduction in pipe size is required reducing sockets shall be used; eccentric reducing sockets shall be used wherever necessary to ensure proper drainage or elimination of air pockets.
4. The following fittings shall be employed: -

Pipework Class	Joint
I	Injection mouldeduPVC fittings to BS 4346:1969 Part 1; solvents to BS 4346:1974 Part 3
II	Copper fitting to ASME B16.22 and suitable to use with BS EN 12735-1 copper pipes

4.11.6 Welding Joints on UPVC Pipework

1. Un-plasticized P.V.C. pipework shall be solvent or hot air welded as recommended by the manufacturers and as detailed elsewhere in this Specification.
2. Where solvent welding is used, particular attention must be paid to preparation; abrasive paper and spirit cleaner must be used; when applying solvent, heat shall be avoided in order to prevent the cement drying before the chemical bond between the two surfaces is completed; mating surfaces shall be turned for even spread of the solvent. Excessive cement shall be wiped off quickly.
3. On uPVC pipework, hot air welded joints shall be made where standard fittings are unavailable and were approved by the Project Manager; the welding using a jet of hot air and PVC filler rod shall only be carried out by a welder qualified in plastic fabrication; complete fusion shall be ensured by applying from 3 to 6 runs of weld; welds shall not be cleaned off; the Sub-contractor must guarantee that any fabrication is similar in strength to a manufacturers items.

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4.11.7 Welding Joints on Copper Pipework

1. Brazed joints shall be to BS 1723:1963.
2. Welding rods shall be suitable for the piping materials and atmospheric conditions to BS 1845:1977.

4.11.8 Pipe Supports

1. Pipe supports shall be provided as required for the stable and sufficient support of the pipe work; these supports shall allow free movement for expansion and contraction and shall be graded to required levels for air elimination and drainage.
2. Spacing of the supports for both vertical and horizontal pipes shall not exceed the centres given in the following table: -

Pipework Class	Nominal Bore (mm)	Centres for Horizontal Supports (m)		Centres for Vertical Supports (m)	
II	15 ~ 22	1.4		2.0	
	28 ~ 35	1.7		2.4	
	42 ~ 67	2.0		3.0	
	76	2.4		3.6	
	108 & over	2.7		3.6	
		At 20°C	At 70°C	At 20°C	At 70°C
I	15 ~ 20	0.9	0.5	2.0	2.0
	25 ~ 32	1.1	0.7	2.0	2.0
	40 ~ 80	1.4	0.9	2.1	2.1
	100	1.9	1.0	2.4	2.4
	150	2.1	1.1	2.4	2.4

Where there are two or more sizes of pipes the common support spacing shall be based on the centres required by the smallest size of pipework.

Vertically rising pipes shall be adequately protected at the base of riser to withstand its total weight. Branches shall not be used to support the riser.

3. All piping supports shall be designed to take the combined loads of pipes, valves, fittings, insulation (if applicable) and fluid in the pipes and all re-actions due to thermal expansion or contraction of the piping.

   All valves shall be located as close as possible to points of support and all valves in line sizes 200mm and larger shall be separately supported.

4. All supports shall be capable of keeping the piping in proper alignment and shall conform with all appropriate statutory and code requirements.
5. All individually hung pipes shall be provided with bolted, two-piece type clamps with clevis or welded yokes; however, for pipe sizes 65 dia. or less, bolted, one-piece type clamps with clevis may be used in approved locations.
6. All pipes to be rigidly attached to fabricated steel or masonry supports shall be clamped with full pipe clamps.

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7. All clamps shall be rated for the full load of the pipe plus its fluid contents, insulation, flanges, valves and fittings; where necessary, particularly in respect of hung pipes of 200mm and larger the spacing of supports shall be reduced in order to reduce the loads to within the rated carrying capacities of the clamps.

8. All insulated lines on services operating at or below 100□C shall have hardwood saddles located between the clamps and the pipes; the saddles shall consist of wedge shaped hardwood blocks arranged to form complete circular collars of the same thickness as the insulation and having lengths sized to project approximately 10mm on either side of the clamps; high temperature sectional heavy density fibreglass or mineral wool saddles shall be used for heating water and similar services operating over 100°C.

   In the case of an insulated pipe where condensation may occur on the hanger an insulating material as approved by the Project Manager shall be inserted between the clamps and pipes.

9. All clamps and collars described above shall be firmly attached to pipework and/or insulating saddles without applying undue pressure to the pipe walls and in this connection particular care shall be taken in respect of copper piping.

10. Allowance for movement due to thermal expansion and contraction shall be in the method of support (e.g. hanger rods or rollers) and not between the pipe and the saddle or clamp. Vibration shall be absorbed by the use of anti-vibration hangers.

11. All hanger rods and associated fittings shall be hot dip galvanized steel bar of not less than the following diameters: -

Pipework Size (mm)	**Rod Diameter (mm)**
Up to 50 (inclusive)	10
65 & 80	12
100 & 125	16
150 & over	20

12. Where no allowance is required for expansion, contraction or vibration, hanger rods may be fixed direct to floor slabs, structural members or to support brackets fixed to floor slabs, walls or structural members; alternatively, the pipes may be clamped directly on to support brackets fixed to floor slabs, walls or structural members.

    Where two or more pipes are to be run in parallel and adjacent to each other, they shall be supported from common channel section rigid brackets or trapeze type supports fixed to floor slabs, structural members or walls as appropriate; for pipe sizes larger than 100mm the supports shall be of standard rolled steel channel sections.

    For fixings to the underside of floor slabs, channel sections with foam filled inserts or approved alternative cast into the floor slabs may be used.

    All proprietary type channel sections shall be installed and used strictly in accordance with the manufacturer's recommendations particularly in respect of maximum allowable loadings and within permissible stress limitations.

13. Moving supports shall be provided in all cases where the pipes are subject to movement due to expansion or contraction and the supports shall be designed to allow for the maximum possible movement involved.

    Where hanger rods are used to take up this movement, they shall be selected such that the ratio of the effective rod length between pivots, to the maximum movement of the pipe is not less than 6:1.

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All hanger rods used for moving type supports shall be provided with "u" type brackets having over-sized holes for the rods; similarly, the clevis or welded yokes on the pipe clamps shall have oversized holes for the rods; the rods shall be secured at both ends with spherical washers and lock-nuts; nuts shall not be used on any part of the rod between the bracket and the clevis or welded yoke.

Where the ratio of the effective rod length between pivots, to the maximum movement of the pipe exceeds 12:1, flat washers may be used instead of spherical washers.

Where sufficient rod length cannot be provided to take the maximum movement of the pipe and the movement is less than 250 from the vertical swing, spring and double deflection hangers shall be used.

Where pipe movement is extensive due to high operating temperatures, rigid channel section brackets or trapeze type supports shall be used complete with rollers or proprietary P.T.F.E. sliding pads to accommodate pipe movement.

14. Where roller or sliding supports are required for use with insulated pipes, the insulation shall be rigid for at least four pipe diameters and sheathing shall be of heavy gauge galvanized sheet steel forming a sleeve adequate to fully support internal pipework and to protect insulation during movements.

15. All pipework located in plant room and adjacent areas to occupied spaces, where vibration from equipment may be transmitted via the pipework, shall be supported from anti-vibration hangers as stipulated in the ‘Noise and Vibration Control’ section of this Specification.

16. Ferrous pipes shall have ferrous brackets and copper pipes shall have brass or gun metal brackets.

17. Additional supports shall be provided adjacent to mixing valves and the like, mounted items to prevent undue strain on adjoining pipework. Additional supports shall also be provided adjacent to pump connections and the like, to prevent undue strain on plants.

18. The Sub-contractor shall be responsible for the building in of all supports, brackets and the like, shall allow for using expansion anchors on masonry construction; where expansion anchors to be used on masonry construction other than concrete, the expansion anchors shall be of the type suitable for such usage;

It may not be possible to fix bolts directly above the pipes to be supported and cantilever angles above the pipes channels shall be used where required.

19. All supports for pipes shall be as follows:

Locations	**Brackets, Supports and Hangers**
External locations	Hot-dipped galvanized steel to BS EN ISO 1461:2009 with epoxy protective painting
Internal locations exposed to sight, including public areas and plant rooms	Hot-dipped galvanized steel to BS EN ISO 1461:2009

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Internal concealed locations including building ducts and false ceiling voids	Hot-dipped galvanized steel to BS EN ISO 1461:2009

Painting shall be executed as stipulated in 'Painting, Labelling and Finishing' Section of this Specification herein.

All brackets shall be fixed by means of bolts and nuts or screws electroplated with zinc or cadmium to BS 7371-12:2008 with minimum plating thickness of 25 microns.

20. Vertical copper pipes shall be fixed with copper or copper alloy holders or pipe brackets of pattern approved by the Project Manager; horizontal pipes shall be fixed with heavy duty copper or copper alloy pipes brackets or hangers; the supports for horizontal pipes shall be split type pipe rings and details shall be submitted to the Project Manager for approval.

21. Underground piping shall be supported on concrete bedding provided by the Contractor and the Sub-contractor shall provide pipe guides to the details approved by the Project Manager.

22. All uPVC pipes support shall be stainless steel with plastic coating.

23. All pipework shall be installed plumb or level unless otherwise indicated elsewhere in the Specification and Drawings, and shall be clear of all adjacent surfaces.

24. All pipes shall be properly and substantially supported by approved hangers, brackets, clips or supports designed to suit the requirements at each support point.

25. Piping shall be neatly grouped on steel framed racks arranged so that the minimum numbers of cross-overs are necessary, with adequate provision for all movement, expansion and contraction.

26. All non-ferrous piping and fittings shall have approved non-conductive isolation at all ferrous supports.

27. Capillary tubing shall be clipped to large pipes or steel battens at 450mm centres.

4.11.9 Valves

Valves for refrigeration piping shall be suitable for the refrigerant used at the required working pressure.

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4.11.10 Pipe Sleeves

A. Where pipes pass through walls, floor, etc. (including floors in ducts) the Sub-contractor shall provide pipe sleeves.

B. Pipe sleeves for cast iron and steel pipes shall be steel (where the pipe is galvanized the sleeve shall also be galvanized); for plastic pipes, the sleeves shall be steel.

C. Where the pipe sleeves are fitted through floors, they shall extend to at least 12 mm clear of finished floor.

D. The Sub-contractor shall supply the detailed information to the Main Contractor before concrete is poured and in compliance with the Main Contractor's programme.

Where holes have to be cut through structure after concrete has been poured as a result of the Sub-contractor's failure to provide timely information to the Contractor, then all costs for this shall be to the Sub-contractor's account.

E. Were pipes pass through walls, floors or ceilings rendered liquid-tight puddle flanges shall be supplied by the Sub-contractor.

F. The pipe sleeves shall also be provided where piping penetrates external walls and roofs; space between pipe sleeves and the pipe or insulation shall then be completely caulked by the Sub-contractor with a soft, non-setting waterproof mastic compound giving an airtight seal.

Penetrations through roofs shall also be provided with a weatherproof apron and up stand curb.

G. The pipe sleeves shall be of sufficient size to allow free movement of pipes and furthermore where pipes are insulated the sleeves are to be oversized to allow the insulation to be carried through the sleeves

H. Details of pipes through walls and floors to be approval by the Project Manager before installation.

I. All pipe sleeves in walls, floors, etc. and in shuttering shall be installed by the Builder.

J. The holes which are formed in beams will be provided by the Main Contractor.

K. Where pipes pass through fire walls and floor slabs, a metal fire stop shall be welded for bolted around the pipe; this is to be in the form of a 6 mm (min) thick flange located so as to occur in the centers of the slab/wall thickness and welded/screwed to the pipe, the flange being of the same diameter as the internal bore of the pipe sleeve.

4.11.11 Intumescent Fire Sleeves (Fire Collars)

A. The Sub-contractor shall provide intumescent fire sleeves (fire collars) for PVC pipes penetrate fire rated structures.

B. The fire sleeves shall be consisted of a specially designed metal container or collar into which has been placed a liner of intumescent material; As soon as the temperature resulting from the fire reaches about 150°C, the intumescent material expands closing off the uPVC pipe and effectively sealing the hole and stopping the passenger of smoke and flame.

C. Once the sleeve has closed the pipe, it shall be imperative that the seal maintains its integrity in a fire for a period of time at least equal to the fire rating of the barrier which is penetrated.

D. The swelling action of the intumescent material shall not be triggered by hot water of up to 80°C passing down the pipe.

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E. The intumescent material in the fire sleeves shall be water resistant and unaffected by moisture and damp which might be present either during storage/construction on site or after installation.

F. The fire sleeves including the installation method shall be tested and approved to AS 1530.4 and accepted by the fire authority; the Sub-contractor shall strictly follow the instruction and recommendation of the manufacturer for the provision and installation of the fire sleeves.

4.11.12 Pipe Cleaning

A. All pipes shall be stored with closed ends, which shall not be opened until erection.

B. Every precaution shall be taken to clean out all piping before, during and after erection, and to prevent foreign material being left in the pipe; the Sub-Contractor shall be responsible for any damage caused by debris in pipes.

C. On satisfactory completion of all pipe testing, drain, the Sub-contractor shall clean and fill all piping systems to Engineer's approval.

4.11.13 Pipework Insulation

A. All materials used for pipework insulation shall be fire resistance, and shall comply with the requirements of the National fire authority of Solomon Islands.

B. Pipework insulation shall generally comply with BS 5970:2001 or equivalent.

C. All condensate drain pipes and refrigerant pipes shall be insulated with 19mm thick CFC and HCFC free flexible closed-cell elastomeric insulation with the following properties: -

(i) Thermal conductivity: not greater than 0.036 W/mK at mean Temperature at 20°C

(ii) Water vapour permeability: not greater than 0.28 ugm/Nh

(iii) Ozone depletion potential: 0

(iv) Spread-of-frame index: 0
Tested according to AS1530.3

(v) smoke-developed index, 3
Tested according to AS1530.3

D. The elastomeric insulation shall be factory-applied with talc coating on the inner face.

E. In outdoor application or where susceptible to rain, the elastomeric insulation shall be painted with two coats of manufacturer’s recommended paints; the paints shall be a highly flexible polymeric coating which provides outdoor weather protection, resistance to ultraviolet radiation; the fire hazard properties of the elastomeric insulation shall be maintained after application of the paint.

F. The insulation shall be secured to the pipework by means of approved adhesive and according to the recommendations of the insulation material manufacturer

The adhesive shall be so applied to provide 100% coverage on the internal face of the insulation.

Corrosion resistant metal bands not less than 20mm wide shall be placed around the insulation spaced at 450mm centre, with additional bands at all points where the material has been shaped.

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All joints of the insulation shall be sealed with a 75mm wide pressure aluminium tape to provide a continuous external vapour seal.

G. At points of support, the insulation shall be of heavy load bearing phenolic foam insulation, of density not less than 80kg/m3 for pipe sizes up to 125mm diameter, and not less than 120kg/m3 for pipe sizes 150mm diameter and above, and complete with double-sided reinforced aluminium.

The heavy load bearing phenolic foam insulation shall have the following properties: -

(i)	Thermal conductivity:	not greater than 0.022 W/mK at mean Temperature at 20°C
(ii)	Water vapour permeability:	not greater than 10 ugm/Nh
(iii)	Spread-of-frame index, Tested according to AS1530.3	0
(iv)	Smoke-developed index, Tested according to AS1530.3	3

H. Pipework insulation details shall be submitted by the Sub-contractor for the Project Manager's approval prior to installation.

I. No insulation shall be applied until pipes and plant have been pressure tested as specified.

J. The insulation shall be applied so as to give a smooth, homogeneous and line-able 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.

K. The insulation shall fit tight to surfaces to be covered, and all slabs and sections shall be built up close, with butting edges being metered, chamfered or shaped as necessary; any minor interstices left in the insulation shall be filled and sealed.

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

When a surface where the insulation to be applied shows any signs of rusting or damage on its galvanized coating, the surface shall, prior to insulating, be thoroughly scraped and wire brushed as necessary to remove all rust, scale, etc., and then be solvent cleaned to remove all oil, grease and dirt, and then a coat of zinc-rich primer shall be applied.

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

N. Any projection through the insulation shall be sealed by vapour barrier.

O. Joints of the insulation shall be staggered with respect to the joints of the associated ductwork system.

P. Continuous insulation shall be provided through all sleeves.

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Q. Where air ducts pass through fire resistant walls and floors, a metal fire stop shall be provided around the air ducts including the fire dampers; the continuity of the insulation shall be maintained throughout the penetrations through the walls and floors.

4.12 SYSTEM CONTROL

4.12.1 General

A. The control systems of the HVAC installation shall be basically electrical and shall be of the same manufacturer.

B. All control equipment and their associated wiring and cable containment shall be supplied and installed by the Sub-contractor; the Sub-contractor shall be responsible for the selection and provisions of all necessary control components, including control valves and dampers where applicable, to achieve the automatic operation of the installation as specified herein and to maintain the desired levels of temperature and humidity with the limits specified; the Sub-contractor shall be responsible for ensuring that the control equipment shall comply with the details of this Specification.

All control equipment shall be constructed with materials suitable for the operating temperatures, humidity and pressures.

C. The design of control systems is diagrammatically shown on the Drawings; however, the Sub-contractor is to, prior to installation of any work, submit to the Project Manager for approval complete diagrams and drawings to show the arrangement and sequencing of all controls and details of equipment actually offered; wiring diagrams shall be included.

D. All automatic control equipment shall be of the highest commercial standard and shall be rated and tested in accordance with an approved testing authority.

E. All control equipment shall be so located as to be readily accessible for maintenance.

4.12.2 System Control for DX Type Air Conditioners

A. One emergency stop button shall be supplied and installed adjacent to each outdoor unit of DX type air conditioner to allow for stopping the air conditioner upon accident or during maintenance purpose.

4.12.3 Shut Down of Air Systems upon Fire Alarm

All air conditioning and ventilation system shall automatically shut down upon fire alarm sequence. Contractor to allow wiring provisions to and from fire alarm control panel for all HVAC equipment.

Mechanical contractor to coordinate with fire alarm contractor for requirements.

4.12.4 Thermostats

A. All thermostats shall provide on-off switching within an adjustable temperature range of approximately 18°C to 26°C.

B. Thermostat covers shall have a finish which is to the approval of the Engineer and concealed adjustment.

C. The thermostats shall have contacts rated sufficiently high for the switched load; for loads above the contact rating, relays must be utilized.

D. The thermostats shall be covered with temporary covers before handover to the Employer.

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E. Location for the thermostats shall be agreed with the Engineer prior to the installation of the associated concealed conduit system.

4.13 NOISE & VIBRATION CONTROL

4.13.1 Vibration Control

4.13.1.1 General

1. The Sub-contractor shall furnish and install vibration and noise control devices, materials, and related items; they are expected to perform work as shown on the Drawings and described in the Specifications for the job.
2. The Sub-contractor shall co-ordinate with other trades to avoid through their related activities any rigid contact with the building that will degrade the noise and vibration with 'following-work', such as plastering or electrical, to avoid any contact which would adversely affect the vibration isolation.
3. The Sub-contractor shall bring to the Project Manager's attention prior to installation any conflicts with other trades works which will result in unavoidable transmission contact with their equipment due to inadequate provision of space or other unforeseen conditions.
4. Prior to installation, the Sub-contractor shall bring to the Project Manager's attention any discrepancies between the Specifications and the actual site conditions or changes required due to specific equipment selection; corrective work necessitated by discrepancies discovered after installation shall be at the Sub-contractor's expense.
5. The Sub-contractor shall be responsible for providing vibration isolators of the appropriate size and capacity to meet the specified deflection requirements and are required to follow the instructions from the manufacturer or vendor of these products.
6. The Sub-contractor shall submit to the Engineer for approval product data, including manufacturer's specifications and installation instructions.
7. The Sub-contractor shall submit samples of vibration isolators (each type) to the Engineer for approval.
8. The Sub-contractor shall submit the vibration isolator types, manufacturer, location, equipment to be isolated and specifications for approval; the specifications shall include isolator free standing heights, static deflection at chosen load, spring diameter and material.
9. The Sub-contractor shall submit calculations indicating that the deflection of proposed framework for any frame mounted equipment does not exceed one-tenth of the deflection of the vibration isolator.
10. A single, approved manufacturer shall supply all vibration isolators.
11. Within a stated reasonable time period after being awarded the Sub-contract and before ordering any materials, the Sub-contractor shall submit to the Engineer a complete list of all products proposed for use, including the manufacturer's name and all related product data.
12. The resonant frequency of the isolation system shall be lower than any operating speed and in no circumstances shall coincide with the natural frequency of any component of the equipment.

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13. Vibration systems shall be selected to suit the environment in which the equipment is to be located. For example: weatherproof, re-rusting, etc.
14. The Sub-contractor shall be responsible to bring to the Engineer's attention if in his opinion there are constraints in the design or architecturally that will forbid his attainment of the required criteria.
15. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection load can be verified.
16. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.
17. Overloading of any isolators during installation or servicing shall require isolators to be fitted with overloading restraints.
18. Overloading of equipment due to service connections shall not occur.

4.13.1.2 Spring Isolators

A. Spring type vibration isolators shall preferably be constructed from suitably treated and finished steel or steel alloys. They shall be manufactured with rubber, neoprene or glass fibre 'acoustic pads' to prevent transmission of high frequencies.

B. Spring type vibration isolator shall be freestanding and laterally stable; all mounts shall have levelling bolts; the spring diameter shall not be less than eight-tenths of the compressed height of the spring at rated load and springs shall be capable of 'additional travel to solid' for another 50%, as a minimum before becoming fully compressed.

C. Springs shall be selected so that the ratio of horizontal stiffness to vertical stiffness ranges between 0.9 and 1.1.

D. Restrained spring isolators shall have vertical travel limit stops to control extension of the spring when the weight is removed or to provide wind resistance in outdoor locations and to prevent excessive movement as the machine speed passes through the resonant frequency of the mounting system.

E. Where restrained spring isolators are to be used, minimum clearance of 13mm shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action; limit stop shall be out of contact during normal operations; mounting used out of doors shall be painted, hot dipped galvanised or neoprene coated.

4.13.1.3 Rubber 'In-shear' Isolators

A. The active element of the isolator shall be bonded to mild steel or steel alloy plates, sleeves, pressings or forgings; both element and bonding agent shall be resistant to lubricating oil and water and suited to the operating temperature.

B. The location of the fixing bolts shall not be in such a way that creates unnecessary stress in the elements.

C. The dynamic deflection and damping coefficients of the active material, at the operating speed of the supported equipment, shall be used in calculation of isolation efficiencies; alternatively, certified isolation efficiency charts may be used.

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D. Mountings whose stiffness varies with direction of deflection shall be mounted with orientation marks for use during maintenance and installation.

4.13.1.4 Vibration Isolation Pads

A. Waffle-pattern or ribbed neoprene pads shall be made of 40 to 50 durometer neoprene where required these shall be adhesively cemented to 1.6mm steel plates of similar area so as to form a sandwich.

B. The pads may be bolted through (where necessary) with bolts isolated from the machine by neoprene grommets. Alternatively, 'waffled' neoprene pads can be used without holding down bolts where the vibration is minimal and the weight of machine is such that the resultant friction is adequate and the machine unlikely ever to move.

C. The area of the pads to be used and number of layers shall be determined for each application in accordance with the manufacturer's recommendations.

D. Where multiple-layer pads are selected to increase the static deflection the layers are to be separated by steel shims as recommended by manufacturers.

4.13.1.5 Double Deflection Pads

A. Double deflection pads shall be of 40 to 50 durometer neoprene and sized so that deflections do not exceed 15 percent of the pad's thickness.

B. All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom.

C. Bolting down holes shall be provided for applications where bolting down is required.

4.13.1.6 Pipe Hangers and Supports

A. Piping connected to vibration-isolated equipment shall be installed so that it does not strain or force vibration isolators supporting the basic equipment out of alignment; the pipes shall not restrict such equipment from floating freely on its vibration-isolation system.

B. Spring in series with neoprene pad hanger shall contain a steel spring that is set in a neoprene cup manufactured with a projecting brushing that passes through the hole in the hanger box or is otherwise isolated from the hanger housing to prevent short-circuiting of the hanger rod against the hanger box.

The neoprene cup shall have a steel washer designed to distribute the load properly on the neoprene and prevent its extrusion.

The spring diameters and the lower holes of the hanger boxes shall be large enough to permit the hanger rod to swing through a 30□ arc before touching the edge of the hole.

The springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection and diameters equal to no less than eight-tenths of the compressed height of the spring.

C. All pipe supports shall incorporate a neoprene or felt gasket.

4.13.1.7 Pipework in General

A. Vertical pipe chases through a building should not be located beside acoustically critical areas with NR40 or better; if they are located beside critical areas, the pipes shall be resiliently mounted from the wall of the pipe chase.

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B. When a pipe passes through the plant room wall, a minimum 25mm clearance shall be provided between the pipe and the penetration in the wall; the pipe shall be supported on either side of the hole, so that the pipe does not rest on the wall; the clearance space shall be stuffed with fibrous fill or material and sealed both sides with non-setting or non-hardening caulking compound.

4.13.1.8 Duct Hangers and Supports

A. Unless otherwise specified all discharges duct runs through NR40 areas for a distance of 10 meters from the connected vibrating equipment shall be isolated from the structure.

B. Hangers used for vibration control shall consist of a mild steel welded cage containing a helical spring, or neoprene/rubber/glass fibre isolator, (or both) and be suitable for suspension from drop rods.

C. Isolators shall be protected from overloading by external containment or metal to metal restraints; no permanent deformation to the spring shall be resulted under 150 percent of the rated maximum loading.

D. The hanger cages shall be capable of carrying five times the maximum rated normal service load without permanent distortion; the drop rods arrangements shall allow 30° movements without metal to metal contact.

4.13.1.9 Flexible Connectors and Expansion Joints

1. Flexible neoprene connections shall be used on all equipment; the connections shall be manufactured of multiple ply of nylon type cord fabric and neoprene both bonded and cured in hydraulic rubber presses; where flexible pipe connections are required, they shall have a length that is approximately 6 to 10 times its diameter; twin sphere connectors are preferred.
2. The axis of the connectors shall be perpendicular to the direction of vibration. Alternatively, where the design allows, the connectors may be formed into 90° bends.
3. Where expansion joints are required to achieve vibration isolation, the tie rod fixings shall be constructed in such a way to prevent metal to metal contact throughout the normal range of movement of the joint.
4. Where service pipes are joined to equipment incorporating flexible connections, the first 3 service supports after the flex connection shall have vibration isolation mounting with minimum 25mm static deflection or one-half the static deflection of the mounting system used for the equipment whichever is greater.

4.13.1.10 Equipment Mounting

- The Sub-contractor shall submit catalogue of proposed equipment complete with manufacturer's specification to the Engineer.
- Mechanical equipment with operating weight substantially different from installed weight (such as pumps) and equipment subject to wind loads (such as roof top equipment e.g. ACCU's) shall be mounted on spring isolators with travel limit stops.
- The installed and operating heights of the vibration-isolation equipment shall be identical; the Sub-contractor shall maintain a minimum clearance of 1/4 inch around restraining bolts and between the housing and the spring to prevent interference with the spring action; the Sub-

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contractor shall keep travel limited stops out of contact with isolator top plate and bolts during normal operation.

- Unless otherwise specified, all floor-mounted equipment shall be set on 100mm high concrete plinth.
- For air cooled condensing units, primary air handling units and ventilation fans: -

1. All fans motors shall be isolated with spring isolators complete with double-layer neoprene pads separated with 1.6mm steel shims.
2. The units shall rest on spring isolators of minimum 50mm static deflection; there shall be no significant casing radiation due to such installation.
3. All pipes connected to the units shall have flexible union pipe connectors.

4.13.1.11 Other Associated Equipment and Non-Vibration Equipment

1. All other mechanically and electrically associated equipment that is capable of causing undue vibration and noise shall be vibration isolated with 25mm static deflection spring and neoprene isolators.
2. To short-circuit noise and vibration transmitting paths, all non-vibrating equipment shall be isolated with neoprene friction pad.
3. It is the responsibility of the Sub-contractor to include the cost of such work in his tender price.

4.13.1.12 Execution

1. Locations of all vibration-isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation; vibration-isolation hangers shall be placed so that hanger housing may rotate a full 360° without touching any object.
2. Under no conditions should piping, ductwork, or conduit be suspended from one another or touch one another; vibrating systems shall be kept separate from non-vibrating systems.
3. Vibration isolators shall be fixed without unnecessary stressing of the elements.
4. Vibration isolator selection guide is given in the following table: -

Equipment	Isolation Type	Minimum Static Defection	Remark
Pumps	A or B	50mm	Inertia bases; Flexible connectors; Inlet and discharge piping isolators; Concrete Plinth
Chillers	B	50mm	

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Ventilation fans	A or C	50mm

Isolator Types:

A - Spring isolators complete with double layer of 6mm thick neoprene friction pads. Pads to be separated with 1.6mm steel shims.

B - Restraint spring isolators complete with double layer of 6mm thick neoprene friction pads. Pads to be separated with 1.6mm steel shims.

C - Spring and neoprene in series hanger as per specification details.

The selection shall vary and follow the criticality of adjacent spaces, and the running speed of the equipment.

5. The Sub-contractor shall submit the schedule of mechanical vibration isolation systems and noise control products selected and to be used in this project.

4.13.2 Acoustic Requirements

4.13.2.1 General

1. This section covers general requirements of materials, constructions and applications required to achieve a comfortable acoustic environment within the building and the criteria set out below.
2. The total noise level arising from all simultaneously operating mechanical and electrical plant as well as regenerated aerodynamic noise, whether it be duct borne, structurally transmitted, or airborne, shall be limited to the following levels, unless indicated otherwise in specific parts of the Specification.
3. The Noise Criteria (NC) levels for spaces shall be as follows: -

Types of Occupancy/Activity	NC Level
Kitchen,	NC45
Office Space	NC40
Meeting Rooms	NC35

These specified criteria shall apply to all areas as measured at a level 1.5m above the floor level, except next to the air conditioning unit room or other plant rooms where the measuring points shall be 1.5m from the room walls.

4. To prevent hearing damage to operator's unprotected ear, the noise level inside plant room shall not exceed 75 dBA.

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5. The noise transmitted to external shall comply with the statutory requirements and the requirements of the relevant authorities.
6. The Sub-contractor shall be responsible for providing acoustic products of the appropriate size and capacity to meet the dynamic insertion loss and self-noise requirements and are required to follow the instructions from the manufacturer or vendor of these products.
7. The Sub-contractor shall submit product data including manufacturer's specifications and installation instructions to the Engineer for approval.
8. The Sub-contractor shall submit the attenuators type, manufacturer, location references, system references and specifications for approval; the specifications shall include the dynamic insertion loss, self-noise and equipment sound power level selected.
9. The Sub-contractor shall submit certified test data on dynamic insertion loss, self-noise power levels and aerodynamic performance for reverse and forward flow test conditions as in accordance with ASTM E77-80 or equivalent.
10. A single, approved manufacturer shall supply all sound attenuators; within a stated, reasonable time period after being awarded a contract and before ordering any materials, the Sub-contractor shall submit to the Engineer a complete list of all products proposed for use, including the manufacturer's name and all related product data.
11. The Sub-contractor/supplier must report to the Engineer in advance and in writing any limiting effect of the intended attenuator locations and system conditions on performance.
12. All self-noise and dynamic insertion loss data shall be in accordance with the applicable portions of ASTM E477-80 to the latest revision.
13. It is the responsibility of the Sub-contractor to bring to the Engineer's attention if in his opinion there are constraints in the design that will forbid his attainment of the required criteria.
14. Unless otherwise specified, perforated galvanized steel sheet shall have 2.4mm diameter holes at 4.8mm staggered centres.

4.13.2.2 Sound Attenuators

1. All sound attenuators shall consist of an outer casing of 1.0mm thick galvanised sheet steel, sound absorbing materials and internal baffles, splitters and supports.

   The casings of the sound attenuators shall be tested to 2 kPa and shall show no more than 2% leakage or distortion in this condition.

   Seams shall be lock formed and mastic filled.

   End flanges shall be made from galvanized mild steel or rolled steel angle, as determined by the Engineer.

   The attenuators shall be fitted to ductwork using neoprene gaskets between bolted flanges.

   The geometry of selected attenuators shall not result in requirements for sharp transformation in adjacent ductwork, shall not interfere with adjacent services or with the aerodynamic performance of the system or encourage regeneration of noise local to the attenuator, all to the satisfaction of the Engineer.

   A schedule of attenuator types and sizes shall be included with the tender return.

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2. Sound absorbing materials shall be fibreglass or mineral wool held in place with at least 5% compression to prevent voids due to settling; the density of the sound absorbing materials shall be minimum 48 kg/cu.m; the sound absorbing material shall be faced with minimum 0.5mm (26g) perforated galvanized steel sheets.
3. Acoustic infill and sound absorbent materials shall be tested to with stand air velocities of 20m/s without evidence of material breakdown, migration or dusting.
4. Where fan noise attenuators are located at a position not immediately adjacent to the noise source ductwork between fan and attenuator must be constructed from sheet metal of minimum thickness 1.2mm and internally lined with 25mm thick acoustic lining; where the sound attenuators are to be located close to a turning elbow, the minimum separated distance shall be 3D, where D is the duct diameter or equivalent diameter.
5. The sound attenuators or silencer selected shall meet the specified fan static requirements of pressure drop and air quantities and submit pressure drop calculation for approval; the Sub-contractor shall be responsible for upgrading of fan static in order to achieve the stipulated noise criteria without cost implication.
6. The sound attenuators for kitchen exhaust shall be of packless type

4.13.2.3 Acoustic Panels

1. Acoustic panels shall be 100mm thick and constructed of 0.8mm perforated and 1.2mm solid galvanized steel sheet for the interior and exterior facings.
2. Acoustic infill shall be 48 kg/cu.mfibre glass or mineral wool.
3. Internal panel reinforcement shall be a minimum of 1.2mm galvanized steel and spaced so that span does not exceed 600mm; perimeter and internal reinforcement and panel sheet shall be welded and riveted to form a rugged metal-sheathed acoustical panel; spot welds shall not exceed 75mm on centers.
4. The sound transmission loss (STL) and sound absorption coefficients of the panel when tested in accordance with ASTM E90-61T and ASTM C423-65T respectively, shall be as follows: -

Octave Band Centre Frequency(Hz)	63	125	250	500	1k	2k	4k	8k
STL (dB)	20	21	27	38	48	58	58	58
Sound Absorption Coefficient	-	0.89	1.20	1.16	1.09	1.01	1.03	-

4.13.2.4 Equipment

i. All air handling units, primary air handling units and ventilation fans shall be constructed of minimum 1.2mm thick galvanized steel external casing.

Mixing chambers of the air handling units, primary air handling units and ventilation fans shall be lined internally with 100mm thick, or 48 kg/cu.mfibreglass faced with 0.8mm perforated sheet of 2.4mm diameter holes at 4.8mm staggered centres.

Where plenum chambers are not fitted for the air handling units, primary air handling units and ventilation fans, all ductwork connecting the casings of those equipment and

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duct silencers shall be constructed of minimum thickness 1.2mm galvanized steel and internally lined with 25mm thick lining as above.

ii. All flexible connections between the air handling units, primary air handling units or ventilation fans and ductwork shall be made of approved materials such as lead vinyl or similar of minimum surface density of 5kg/m2 installed such that airflow is not obstructed.

iii. The Sub-contractor shall be responsible to submit proposed silencer selection, and the sound power level spectra of all selected air handling units, primary air handling units and ventilation fans, for endorsement.

iv. Access doors for the air handling units, primary air handling units and ventilation fans shall seat with neoprene gaskets to provide an airtight seal the access doors or openings shall be provided for maintenance and servicing.

v. For the external casings of the air handling units, primary air handling units and ventilation fans: -

   i. Roof channels, aprons and corner joiners shall be made of 1.5mm galvanized steel formed to prevent a direct path for sound and/or air leakage; floor channels shall be made of 1.2mm galvanised steel; panel joiners shall be made of 1.0mm galvanized steel and shall be roll formed.

   ii. Duct penetrations shall be located and cut in the field and sealed in accordance with the Manufacturer's instructions.

   iii. The acoustic infill to the same specifications of those used for the panel shall fill the gap between the joiners and the panels to avoid flanking path transmissions.

   iv. All joiners/channels shall be mastic filled continuously along the inner edges prior to assembly with the panels.

   v. Where self-tapping screws are used for assembly, they shall not be spaced more than 300mm on centre.

vi. Due consideration shall be given to minimizing system pressure drops, with particular attention to silencer locations in areas of poor airflow; silencer pressure drops, at normal system duty, exceeding 70 Pa may be included only with the prior approval of the Engineer and shall be identified and reported at the time of tender.

4.13.2.5 Noise Break-in/break-out

i. Where duct attenuators are positioned outside air conditioning unit rooms, the duct shall be externally insulated, secured by 20mm chicken wire mesh and plastered to 12mm thick.

ii. External insulation shall comprise 50mm thick rock wool or fibreglass minimum of 60kg/m3 density.

iii. Where ductwork, piping and services pass through walls, floors or ceilings the penetration shall be acoustically sealed in the following manner.

iv. A 12~20mm clearance all around the duct shall be filled with acoustic infill either rockwool or fibreglass of high density. Acoustic infill to be tightly compressed and mastic caulking applied to provide airtight seal over all exposed infill.

v. The Sub-contractor shall be responsible to ensure that all pipes and duct penetrations are well sealed acoustically and that there is no noise leakage through the penetrations and no vibration or vibration-induced noise due to the mechanical installation is noticeable in any part of the building.

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4.13.3 Noise and Vibration Compliance Test

1. Compliance test shall be carried out to ensure the installation will fulfil the stipulated requirements and criteria.
2. Test shall be carried out when the mechanical equipment is at normal operating condition. At time of the tests, the areas to be tested shall be unoccupied and not suffering from any other noise intrusion.
3. All equipment used for the tests shall be calibrated. The sound level meter and octave filter set used shall meet the ISO/IEC 651 Precision and general purpose sound level meters requirements.
4. All dBA and octave band sound pressure levels shall be read direct from the sound level meter or plotted on a chart level recorder; real time analyzers may be used to check the effectiveness of vibration isolators installed if there is reason to suspect inadequate vibration isolation as determined by the Engineer.
5. The Sub-contractor shall be responsible at his own cost for all corrective work should the vibration and noise levels due to the installation exceed the specification; the Sub-contractor shall also be responsible for the cost of all tests after his remedial work.
6. Vibration measurements shall be made using calibrated accelerometer, charge amplifiers and narrow band analyzer; hard copy printout is necessary for documentation.

4.14 ELECTRICAL EQUIPMENT AND INSTALLATION

4.14.1 General

1. This section covers the general requirements for electrical work to be installed under this Specification.

   The Sub-contractor shall supply and install all electric wiring, switchgear, etc., necessary for the complete, safe and satisfactory operation of the installation covered by the Specification.
2. In case the permanent supply is not available, the Sub-Contractor shall be responsible for the supply and installation of all temporary power required for the operation of all ventilation fans during any test and inspection by the authorities or utilities.
3. All equipment provided shall be selected of 'tropicalized' designed for use in conditions up to 40°C ambient air temperature and 100% relative humidity.
4. The electricity supply will be either 415V/3-phase/50Hz, or 240V/1-phase/50Hz; all equipment shall be designed to operate with a ±5% voltage tolerance without a loss of rated output.
5. The entire electrical installation shall be in accordance with the laws and the statutory regulations, and the requirements of all relevant authorities having jurisdiction over the installation, and the requirements of the power company.

   The latest Edition of the Regulations for Electrical Installation, and the subsequent amendments published by the Institution of Electrical Engineers, United Kingdom, shall also be compiled with whenever there is no contradiction to those statutory regulations and requirements.

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4.14.2 Switchboards and Switchboards Equipment

4.14.3 MCB Distribution Boards

1. Miniature circuit breaker distribution boards are to be provided to serve circuits as indicated in the Drawings.

2. All wiring terminations and busbars within distribution boards shall be shrouded and an insulating front shield of a flame retardant type, minimum 1.6mm thickness, shall be provided to completely screen distribution unit interior. Only the MCB operating dolly and insulated surround shall project through the shield.
3. Neutral bars are to be of approved cross sectional area, mounted on insulators and drilled to receive circuit wiring. Clamping screws are to be provided for each circuit way. Screws are to be brass with round heads.
4. A link of approved cross section shall be provided in the neutral bar between the incoming neutral and the final sub-circuit neutral conductors.
5. Distribution board enclosures are to be galvanised sheet metal constructed and finished in enamel of a colour to approval. The sheet metal for the enclosure and the door shall be not less than 1.2mm thick. Hinged enclosure doors are to be fitted with ball catch locks.
6. Space shall be provided for the future accommodation for 20% additional circuit breakers in all distribution boards. All necessary busbars, studs and neutral bar ways shall be allowed.
7. Wiring schedules shall be provided and installed inside a clear plastic envelope on the inside of distribution board doors, giving the following information: -
    1. Distribution board designation
    2. Rating of all circuit breakers
    3. Size of all cables
    4. Type and location of circuit load

4.14.4 PVC Insulated Copper Cables

PVC insulated copper cables shall comply with BS 6004. Cables are to be 600/1000 or 250-volt grade depending on size.

4.14.5 Wiring

1. The current carrying capacity shall be in accordance with IEE Wiring Regulations and shall be limited by the allowable voltage drop. Minimum conductor size shall be as follows: -
    1. Control 1.5mm2
    2. Power 2.5mm2
2. All wiring shall be carried out on the loop-in system. For conduit wiring systems, wiring shall be drawn into the conduits after the whole of the conduit installation has been completed. No joints or connectors will be allowed in any such cables, except that connectors may be used in accessible positions within lighting fittings or device outlet boxes.
3. All cables shall be colour coded consistently over their entire length. Red, yellow and blue shall be used for phase conductor and black and green for neutral and earth respectively.
4. The maximum number of cables that may be accommodated in a given size of conduit or trunking is not to exceed the number given in the IEE Regulations.

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4.14.6 Conduit System

4.14.6.1 PVC Conduit

i. PVC conduits shall be embedded inside construction.

ii. The minimum size of conduit used in the electrical installation shall be 25mm diameter.

iii. Before any work on the installation is started, the Sub-contractor shall prepare drawings of proposed conduit runs showing the number, size and circuit reference of all conductors to the satisfaction of Engineer prior to the commencement of works. The Project Manager's endorsement shall not relieve the Sub-contractor from liability in respect to the provision of an adequate number and/or sizes of conduits for the installation.

iv. Rigid plain PVC conduits and conduit fittings shall comply with B.S. 46087: Part 1, B.S 6099: Section 2-2 and BS EN 50086-2-1. Conduits shall be type 'A', i.e. they shall be suitable for installation, storage or transport at temperatures not normally below minus 5°C. (Couplers shall be of the slip-type).

v. Pliable conduits shall be formed of self-extinguishing plastic material and shall comply with BS EN 50086-2-, classification type A. Conduits may be corrugated plain, or re-inforced. Pliable conduits shall not be used in situations where they would be subject to continuous flexing.

vi. Adaptable boxes and boxes for the enclosure of electrical accessories shall be made from insulation materials and shall comply with BS 4662. The dimensions of the plastic boxes shall be such that they can be interchangeable with steel boxes. The minimum wall thickness of boxes shall be 2mm.

vii. Boxes for the suspension of luminaries or other equipment, where considerable heat will be produced, shall be fitted with steel insert clips. Plastic boxes shall not be used in situations where the temperature of the box is likely to exceed 60°C or where the mass suspended from the box exceeds 3-kg.

viii. Conduit bends shall have an internal radius of at least 4 times the outside diameter of the conduit.

ix. The method of carrying out the conduit bends, conduit joints, fixing conduits to boxes without spouts, and the tools and materials to be used shall be as recommended by the manufacturer of the conduits.

x. A PVC insulated cable shall be drawn into the conduit system to serve as the circuit protective conductor (CPC), the cross-sectional area of which shall comply with the latest edition of the IEE Wiring Regulations for the size of the largest live conductors enclosed.

xi. Due allowances shall be made for the expansion of the PVC tubing at high temperatures. Expansion coupling or other fittings shall be included in a straight run of 8m or more. Saddles or clips shall be of sliding fit.

xii. A separate earth wire will be enclose in every length of flexible conduit.

xiii. Wiring for power supply and signalling shall be use separate conduit systems.

xiv. All empty conduits shall be provided with draw wire.

xv. The minimum size of conduit for signal wiring shall be 25mm diameter.

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4.14.6.2 G.I Conduit

1. All surface run conduits shall be G.I conduits. Conduit runs inside false ceiling voids, building ducts and plant rooms shall be considered surface runs.
2. All conduits and fitting used in the installation, expect flexible conduits, shall be heavy gauge, screwed, steel, longitudinally welded, solid drawn, galvanized on both internal and external surfaces, in accordance with BS 4568 Part 1 and 2, Class 4.
3. Flexible conduit and fittings shall comply with BS EN 50086-1 and in addition shall be of metallic watertight pattern, PVC over sheathed and with a separate earth wire enclosed within the conduit.
4. The minimum size of conduit used in the installation shall be 20mm diameter.
5. Wiring for power supply and signalling shall be use separate conduit systems.
6. Conduits shall be installed to enable “loop-in” wiring to be carried out.
7. -type and non-inspection type conduit bends, elbows and tees shall not be permitted.
8. Conduit systems shall be electrically and mechanically continuous and watertight after installation. They shall be arranged, wherever possible, to be self-draining to conduit outlet points for equipment. The system when installed, and before wiring, shall be kept plugged with wooden plugs.
9. The Sub-contractor shall make good any damage to the finish of all conduits (including threads cut as site) by painting two coats of cold galvanized paint to match the non-damaged galvanized surface.
10. All conduit and conduit fittings shall be erected complete and swabbed through with approved draw tapes and absorbent cloths before any cables are installed. The swabbing operation shall be carried out to the satisfaction of Engineer.
11. All surface conduits shall be run in a vertical or horizontal direction. Diagonal runs shall not be permitted. The conduits shall be secured to the surface by means of heavy spacing saddles fixed with brass or rust screws.
12. On straight runs, 20mm and 25mm dia. conduits shall be supported by not less than one saddle every 900mm and conduit above 25mm dia. shall be supported by not less than one saddle every 1200mm in addition to any support provided by structures, boxes, or fittings etc. In all cases bends shall be supported by two saddles fitted as near to either side of the bend as practicable.
13. All bends in conduits shall be formed on site by bending machines.
14. Runs between draw-in boxes shall not have more than two right angle bends or their equivalent and the length of such runs shall be limited to 10m to permit easy draw-in of cables.
15. In concealed conduit systems all adaptable boxes for accessories and draw-in boxes shall be installed such that the outer rim of the box is flush with the finished surface of the wall.
16. In concealed conduit systems where flush type distribution boards are installed, a separate 20mm conduit for each spare way, shall be installed from the distribution board to a convenient point in the wall near the ceiling and shall be terminated in a common BS 4662 adaptable flush type box.
17. All conduits shall be entirely separated from other piping services and no circuit connections shall be permitted between the conduits and such pipes. Conduits and

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outlets fixed in area where there is waterproofing to building shall be installed with no damage to the waterproofing.

18. All conduit systems shall be efficiently earthed. Before any cable is drawn into the conduit, a test for continuity of the system shall be carried out and the result of the test shall be notified by the Sub-contractor to Engineer for approval.
19. Where a conduit crosses an expansion joint, special arrangement shall be made to allow relative movement to occur on either side of the expansion joint. A separate circuit protective conductor shall be installed to maintain an effective electrical continuity across the expansion joint. The circuit protective conductor shall have a cross-sectional area rated to suit the largest live conductors drawn into the conduits in accordance with the IEE Wiring Regulation.
20. The maximum number of cables permitted in one conduit shall be in accordance with the IEE Wiring Regulations.
21. All cables used in conduit installations shall have copper conductors and shall be PVC-insulated. All cables shall be of 450V/750V grade unless otherwise specified.
22. Each conductor inside the conduit run shall be of one continuous length. Joints in a conductor in any part of a run shall not be permitted unless directed by Project Manager.
23. Where flexible metallic conduits are fixed to the rigid conduit this shall be achieved by means of either male or female adaptors terminating at a BS 4662 adaptable box. The adaptors shall be of brass, sweated or screwed onto the flexible conduit.
24. Where conduit systems are installed exposed in weather, all fittings used shall be installed in such manner that each is water-tight.
25. Circular boxes, dome covers shall be malleable cast iron, galvanised in accordance with BS EN 50086-1. Ceiling mounted circular boxes shall have an internal depth of not less than 60mm
26. Adaptor boxes complete with covers shall be of cast iron, galvanised or sheet steel having Class 4 protection against corrosion in accordance with BS EN 50086-1. Boxes shall be not less than 50mm deep and of such dimensions to enable the largest size cable to be drawn in the conduits without excessive bending of the cables.
27. Metal boxes for the enclosure of electrical accessories shall be in accordance with BS 4662. 35mm deep and 47mm deep boxes shall be used to house accessories such as domestic switches, socket outlets, etc. Boxes shall have heavy duty protection against corrosion in accordance with BS 4662.
28. BS 4662 box shall be used in concealed or cast-in purpose. For surface mounting, hot-dipped galvanized adaptor box shall be used.
29. All conduit boxes shall be provided with gaskets and lids with brass fixing screws. Holes shall be drilled in boxes according to the conduit entries requirements.
30. All conduit entries to adaptor boxes, outlet boxes and switchgear shall be made with couplings and hexagonal male bushes.
31. Samples of the conduit boxes shall be submitted for approval prior to the installation.

Surface runs of conduits shall be allowed in the following areas only: -

i. inside plant rooms
ii. inside the MEP areas on the roof below the top edge of the slanted roofs, for conduits with wiring serving equipment installed inside the MEP areas only.

No conduit runs through the roofs shall be allowed, so as to avoid protrusion of water proofing of the roofs and seepage of rain water along surface of the conduits; the conduits run from below to

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roof shall have roof-side conduit boxes on the parapet walls, which shall be above the top edge of the water proofing of the parapet, where applicable, and shall be at least 300mm above the finished roof level.

4.14.7 Cable Tray

A. Cable trays shall be of perforated pattern 1.6mm minimum mild steel with returned edges complying with BS 1449: Part 1 and hot-dipped galvanized overall.

B. Trays shall be supported from the soffit of structural slabs and beams by rods not less than 8mm dia. and/or angle iron brackets fixed on wall. The rods and brackets shall have two layers of primer and enamel paint finish, the bolts and nuts for fixing shall be electroplated with zinc or cadmium to BS 7371 with minimum plating thickness of 25um. The colour of the paint shall be agreed by the Engineer.

C. Tray supports shall be spaced according to the number and size of cables being carried on the tray, but nowhere shall they be at greater than 1.2m intervals.

D. Cables mounted on the trays shall be laid after installation of the tray and spaced in accordance with the latest edition of the I.E.E. Regulations to avoid derating of the cables. Cables shall be grouped in circuits and individually clipped, cleated or tied at intervals of not less than 2m lengths on horizontal runs and 1m lengths on vertical runs, using insuloid type or equal and approved fixing.

E. Notwithstanding the minimum gauge of metalwork specified, gauges shall be of sufficient strength to prevent sagging between supports.

F. Cables leaving cable trays shall be installed properly without damage to cables by cutting edges of trays and rubber pads shall be inserted to underside of cables.

G. Trays shall not be bent for change in direction of run. Proper bends or straight trays meeting at angle shall be employed at change of direction. Cable trays shall be supported at either sides of junction.

H. Where trays are exposed to the weather, they shall be coated with epoxy resin before painting. PVC coating is not acceptable.

4.14.8 Cable Trunkings

A. Cable trucking's and fitting shall be compatible to the requirements laid down in BS EN 50085-1 and 50085-2 and shall be fabricated with metal enclosure by electro galvanized steel sheet or epoxy powder coated to BS 4800 to provide resistance to corrosion having a nominal thickness indicated hereunder: -

Nominal Size (mm)		Nominal Thickness (mm)	
From	Up to	Body	Cover
-	50 x 37.5	1.0	1.0
50 x 50	100 x 75	1.2	1.2
100 x 100	150 x 100	1.4	1.2
150 x 150 and above		1.6	1.4

Steel trunking shall be of square or rectangular cross section and no projection from screw or other sharp object will be allowed inside.

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B. Manufacturer's standard fittings such as tee or angle pieces, connectors etc. shall be used throughout unless prior endorsement has been obtained from the Engineer.

C. Trunking and fittings shall have at least Class 2 protection against corrosion in accordance with BS EN 50085-1 i.e. medium protection (e.g. electroplated zinc having a minimum thickness of zinc coating of 0.0025mm plus stove enamel or air drying paint).

D. Connection between adjacent lengths of trunking, tee or angle pieces, accessories, etc. shall be made by means of butt joints. The two adjacent ends of trunking shall be fixed so that no relative movement can occur between them.

E. Electrical continuity shall be achieved by means of connecting a tinned copper tape of adequate size across the two adjacent ends of the trunking.

F. Trunking and fittings shall have removable covers extending over the entire length. The covers shall be of the same material and finish as those of the trunking body.

Removable covers shall be held in position on the trunking either by the quick-fix pattern with centre captive screw or spring-on type.

Bends, tee junctions, etc. shall also be fitted with removable covers.

G. Connection between trunking and apparatus shall be by a screwed coupler and brass male bush, or a standard flange coupling or an adaptor neck, fabricated or casted. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the lid of the trunking is left intact.

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

I. Trunking shall be adequately supported through its length. Trunking support shall be fixed at regular intervals with maximum spacing's as follows:

Trunking Size	Maximum Distance Between Fixings
Up to 50mm x 50mm	900mm
Up to 75mm x 75mm	1200mm
Up to 150mm x 150mm	1500mm
Up to 225mm x 150mm and above	1800mm

J. Overhead trunking shall be suitably supported by means of hangers, brackets or other approved devices, so that no visible sag is observed when loaded with cables. All hangers, brackets or other approved devices shall apply two layers of primer and enamel paint with bolt and nuts electroplated with zinc or cadmium. The painting and electroplated standards shall be as described in Clause E7 (b).

K. Cables penetrating through trunking shall be protected by conduits except for PVC insulated and sheathed cables if such cables form part of a surface wiring system. In such case, the holes in the trunking, through which such cables penetrate, shall be fitted with suitable rubber grommets to BS 1767 or insulated bushes.

L. Whenever trunking passes through a fire resistant structural element, such as floor and wall, designated as fire barrier, the opening thus formed shall be sealed with approved type of fire resisting material according to the appropriate degree of fire protection required. In addition, suitable internal fire barriers shall also be provided to prevent the spread of fire or smoke through the trunking.

In vertical trunking installations, internal fire barriers shall be provided between floors or at intervals of 5m apart, whichever is the less.

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M. Every entry to the trunking shall be so placed as to prevent and/or to be protected against the ingress of water.

N. Holes in trunking shall be drilled, punched or cut by ring saw. After cutting, burrs and sharp edges on the trunking shall be removed and painted by galvanised paint to prevent abrasion of cables and rusting.

O. Trunking, which is installed in such a position that the cables would fall out when the cover is removed, shall be fitted with cable retaining bars or other suitable devices to prevent the cables from falling out.

Trunking installed in a vertical plane shall contain sufficient supporting devices within the trunking to prevent strain on the cables due to the weight of the cables, and to prevent vertical movement of the cables.

P. The number of cables put into a trunking shall be such that no damage is caused to the cables or the trunking. In determining the size of the trunking required for a particular installation, the "unit system" method as recommended by the latest edition of the IEE Wiring Regulations shall be adopted.

For cables and trunking not included in 'unit system' method, the number or cables to be enclosed in the trunking shall be such that the resulting space factor shall not exceed 45%.

Q. Where a common trunking is used to accommodate cables for different circuit categories, they shall be effectually segregated by means of partitions or dividers. The partitions or dividers shall be adequately secured to the body of the trunking.

4.14.9 Starters

i. Contactors used in starters shall be of Class A3 type provided with silver alloy contacts. Auxiliary contacts shall be provided to facilitate the connection of interlocks, status indication and auxiliary controls. Unless explicitly described, a minimum of one normally open and one normally closed contact shall be provided.

ii. Each starter shall be completed with protection incorporating the following features: -

A. overload protection in each supply phase adjustable from 80 to l20% of full rated load

B. manual reset

C. phase failure protection

D. ambient temperature compensation

E. an auxiliary contact to signal an overload condition.

iii. Contactors or complete starters not mounted in switchboard shall be contained in metal or approved plastic enclosures with conduit entries, shrouded ‘stop’ and ‘start’ push buttons and a manual ‘reset’ button, which may be combined with the ‘stop’ button.

iv. Unless otherwise specified reduced voltage starters of the following type shall be selected: -

i.	Motors less than 5kW	Direct on line
ii.	Motors from 5kW to 55kW	Star delta
iii.	Motors in excess of 55kW	Auto transformer

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v. Each starter of the open transition ''Star-Delta'' type (for motor rating from 5kW to 15kW) shall include the following:

1. One (1) main line contactor suitably rated for the motor.
2. Star and Delta configuration contactors suitably rated for the motor, mechanically and electrically interlocked to prevent simultaneous operation.
3. One (1) triple pole overload relay meeting the requirements as specified previously in this clause under 'Generally'.
4. One (1) approved time delay relay, with at least 0-30 second adjustable time delay period, to control the star to delta switching contactors.

vi. Closed transition reduced voltage starters shall be approved type and manufacture and shall be capable of starting the motor from stopped to full load speed without interruption and in such a manner that the torque developed by the motor increases as uniformly as practicable during the whole starting sequence: -

1. Closed Transition "Star Delta" Starters (CT.SD) (for motor rating from 18.5kW up to 55kW)

   Each starter of this type shall include the following equipment:

a. The equipment as specified in Clause ‘Open Transition Star-Delta Starters (OT.SD)’.
b. A suitably rated transition resistance bank such as to allow approximately full load supply current when in circuit prior to opening of the star point. The short time rating of the resistors shall also be considered in relation to the length of their "in circuit" requirements.
c. A transition contactor suitably rated to facilitate connection of the resistance bank during the transition period.
d. Any additional auxiliary contacts, timers, etc. required for the transition sequencing operation.

2. Auto-Transformer Starters

   Auto-transformer starters shall be of the type having standard tappings and Korndorfer connections, and shall include the following equipment: -

a. One (1) contactor operated auto transformer type starter tapped 50 per cent, 65 per cent and 80 per cent and comprising main line contactor, run contactor and auto-transformer star point contactor, all complete with the necessary auxiliary relays suitably rated for the motor.
b. One (1) triple pole overload relay meeting the requirements specified previously in this clause under "Generally".
c. One (1) set of thermostats for auto-transformer protection with relay and reset push button. Alternatively, thermistors embedded in the transformer windings and a thermistor relay may be provided.
d. One (1) approved time delay relay, with at least 0 to 30 second adjustable time delay period, to control the start and run contactors.

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4.14.10 Earthing

A. All metalwork associated with the electrical installation but not forming part of a phase or neutral circuit shall be bonded together and solidly and effectively earthed.

B. Metal conduits, ducts and cable armours shall be earthed at the switch board at which they originate by means of locknuts, screwed connection or cable gland.

C. The electrical resistance of metallic enclosures or framework to earth shall be low enough to permit the passage of current necessary to operate the device protecting the associated circuit.

D. The size of all earth continuity and bonding conductors shall be in accordance with the PLN Regulations.

E. All earth conductors fixed or run outside the building shall be protected against corrosion and mechanical damage.

4.14.11 Spares

The Sub-contractor shall supply the following items as spares: -

(a) 3 fuse cartridges for TP fuse switch or switch fuse for each rating.

(b) 20% indicating lamps of all colours and sizes

4.15 PAINTING, LABELLING AND FINISHING

4.15.1 General

A. All parts of the work installed under this Specification shall be painted, except those items specified as being painted by others or otherwise exempted from painting in this section of the Specification.

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

C. The paints shall be selected to withstand the temperature on the surfaces that the paints are applied, and shall be suitable in all respects for the environmental conditions in which it shall be located.

D. The paints shall be suitable for the materials of the surfaces that the paints are applied.

E. Finishing paints shall be full gloss unless otherwise specified.

F. Metalwork to be painted shall be wire-brushed and cleaned from rust, scale, dirt and grease before the paints are applied.

G. All paints shall be of one brand approved by the Project Architect.

H. Before ordering any primer, undercoat and finishing paint, the Sub-contractor shall submit the colour scheme to the Project Architect for approval.

4.15.2 Plant, Machinery & Equipment

A. All items of plant, machinery and equipment supplied painted ex-factory shall be given one finishing coat of full gloss enamel, except where the manufacturer's standard finish is approved.

B. All surfaces of plant, machinery and equipment shall be cleaned and polished to the satisfactory of the Project Manager.

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4.15.3 Outdoor Metalwork

i. Metalwork installed outdoors or susceptible to rain shall be painted with one priming epoxy coat and one finishing coat of full gloss epoxy.

ii. Stainless steel surfaces shall not be painted.

iii. Hammered aluminium cladding shall not be painted.

4.15.4 Exposed Metalwork

i. Metalwork exposed to sight, including those inside plant rooms, shall be painted with one priming coat, one undercoat and one finishing coat of full gloss enamel, unless otherwise specified.

ii. Stainless steel and anodized aluminium surfaces shall not be painted.

iii. Hammered aluminium cladding shall not be painted.

4.15.5 Concealed Metalwork

i. Black iron and steel surfaces of metalwork concealed in building ducts and false ceilings shall be painted with one coat of zinc chromate or red oxide primer.

ii. Galvanized iron, stainless steel and anodized aluminium surfaces shall not be painted.

iii. Metal ducts and pipes enclosed by thermal insulation shall not be painted.

iv. Aluminium vapour barrier surface of insulated ducts and pipes shall not be painted.

4.15.6 Plastered Finish Insulation

Plastered finish insulation surfaces shall be given one coat of size, one undercoat consisting of two parts of ordinary undercoat to one part of sealer, and one finishing coat of full gloss enamel.

4.15.7 Pipework Identification

i. All pipes etc. shall be identified in accordance with BS 1710:1984.

ii. Circumferential bands of standard ground colours shall be not less than 100mm wide on pipes up to 50mm nominal diameter, and not less than 150mm wide on pipes greater than 50mm nominal diameter.

iii. Supplementary colours shall be displayed as bands not less than 25mm wide in the centre of the ground colour bands.

iv. Where lettering is required it shall be painted in contrasting colours in accordance with the standard, in block letters not less than 15mm high for pipes up to 50mm nominal diameter, and in block letter not less than 40mm high for larger pipes.

v. Identification bands shall be located where they are clearly visible in each room or compartment through which the pipe runs, and shall be placed at centres not exceeding 6m.

vi. Direction of flow shall be indicated by an arrow painted on the pipe adjacent to each colour band; the arrows shall be 75mm long on pipes up to 50mm nominal diameter, and 150mm long on larger pipes.

Tender Issue

4.15.8 Colour Schemes

A. The pipework of the installation shall conform to the colour schemes as shown in the following schedule:

Identification	BS 1710:1984
Colour coding	BS 4800:2011

B. Equipment shall be painted and colour coded to BS 381C:1996 as follows:

Equipment	Colour	No.
Switchboards & Control Panels	Grey	-
Electrical Motors	Primrose	310
Electrical Conduits	Light Orange	557
Pumps and Tanks	As for respective piping	-
All other equipment	As directed by the Engineer	-

4.15.9 Labelling

A. All plant and equipment provided under this Specification shall be labelled in English as to duty or services, all such labelling to correspond to schedules, diagrams, etc. to be provided as part of the as-fitted drawings; labels shall be of white Trifoliate with black engraved lettering of not less than 20mm high or as otherwise required and approved.

B. Manufacturers' nameplate shall generally be provided for all plant and equipment and shall show serial and model numbers and date of manufacture.

C. The following refers to specific items (but not be limited to) requiring labelling: -

A. Valves,
B. Motor starters,
C. Fans,
D. Distribution boards,
E. Gauges,
F. Contactors,
G. Cable terminals in switchboards,
H. Circuit breakers.

Labels shall be attached to valves (or pipe adjacent thereto) with a light gauge metal band or alternatively to be screwed to the insulated valve box where provided; these labels shall state the valve number.

Distribution boards, starters etc. shall be labelled to indicate the circuit number, phase and item controlled.

Tender Issue

D. Label shall be screwed or riveted to sheet metal. Adhesive fixing is not acceptable.

E. Details of exact lettering shall be agreed with the Engineer prior to manufacture.

F. A complete valve schedule shall be incorporated in the as-fitted drawings and this schedule shall clearly indicate the valve numbers, duty, function, size, flow rate and any other relevant information necessary to allow the Employer's plant operators to safely operate each valve and to subsequently maintain or replace the valve as required.

The valve schedule shall clearly relate to the various system schematics to enable the entire operating sequence and circuitry to be followed.

4.15.10 Application of Painting

A. Paints shall be prepared and applied in accordance with the manufacturer's recommendations.

B. Galvanized metal surfaces shall be properly etch-primed to ensure correct adhesion of the paint to the surface; materials for etch-priming shall be as recommended by the paint manufacturers; Subsequent painting of galvanized surfaces shall comply with this Specification.

C. Prior to painting, all metallic surfaces except galvanized surfaces shall be thoroughly scraped and wire brushed as necessary to remove scale, rust and swarf; surfaces shall then be solvent cleaned to remove all oil, grease and dirt.

D. When the surfaces to be painted are clean and dry, one coat of an approved primer shall be evenly applied over the entire area; after surfaces have been primed, the Sub-contractor shall notify the Engineer so that an inspection of the primed surfaces can be made prior to the application of the undercoat and the finishing coats.

E. When the priming coat has been approved, one coat of an approved paint flat undercoat shall be applied; before applying the finishing coats, the Sub-contractor shall ensure that the undercoated surface is rubbed flat and smooth; finally, an approved high gloss finishing paint shall be applied when all dust has been removed.

F. Each successive coating shall be completely dry prior to the application of the next coat; the minimum thickness of each layer of paint shall be 50 µm.

4.16 SAMPLES

Within one month following the award of the Contract, the Sub-Contractor shall submit for approval three sets of labelled samples, where applicable, as follows: -

- Pipes and fittings
- Valves, strainers, vents and drains
- Pipe supports
- Sheet metal for ductwork
- Flexible ducts materials
- Duct supports
- Pipe supports
- Cables and wiring
- Cable supports
- Air grilles and diffusers
- Thermal and acoustic insulation materials

Tender Issue

- Vibration isolators
- Trunking, conduits and cable trays
- Earthing copper tapes
- Conduit boxes
- MCB boards
- Emergency stop push button
- Indicating lamps
- Push buttons
- MCCB
- Isolating switches
- Air filters

The Engineer reserves the right to require samples which show the fabrication techniques and workmanship of component parts, and the design of accessories and other auxiliary items, before any installation work proceeds.

The Sub-Contractor shall submit to the Engineer for endorsement manufacturer's specification and installation instruction for trade products.

4.17 CLIMATIC CONDITIONS

The Sub-contractor is deemed to be familiar with climatic conditions prevailing in Solomon Islands, and to be aware of the high temperature (up to 32° C), the high relative humidity (RH 99% max.), and the strong wind of cyclone (up to 280km/h).

The Sub-Contractor in proposing equipment for the installation shall warrant that all materials and items of equipment are suitable for continuous use and/or operation in the various climatic conditions encountered.

All the electrical, electronic and mechanical equipment of the installation shall be at least suitable for use in service conditions as stated below: -

- Climate Tropical
- Temperature 10°C to 40°C
- Relative humidity 99%
- Cyclone 280km/h

All installation installed outdoors or exposed to rain shall be of weatherproof / waterproof type.

Tender Issue

5 DOCUMENTATION AND DRAWINGS

Documentation and drawings shall be provided for as follows: -

5.1 GENERAL

Drawings and documents for approval by the client's representative and the local authority, shall be provided for at the stages as indicated and work shall not proceed with the next stage until the drawings, documents and samples have been approved and the various actions have been taken as required.

5.2 TENDER STAGE

Submit at the time of tender the completed price, rate prices and deviations schedules, draft quality control plan as well as a tender letter with any deviations.

5.3 TENDER AWARD STAGE

Within three weeks of tender award, issue the following documents: -

Issue building consent documentation to the local authority.

Issue 5 sets of paper copies of the shop drawings detailing the extent of the installation.

The shop drawings shall be drawn with AutoCAD ver. 2006 minimum or later versions to a 1:100 scale in general and 1:50 scale for plant and equipment layouts.

The shop drawings shall contain all the technical information, all air flow rates and equipment model numbers shall be shown on the drawings. It is preferable that technical information is shown on drawings rather than in the owner's manuals.

5.4 CONSTRUCTION STAGE

The Q/A plan shall be updated and signed off as and when required.

5.5 HAND OVER STAGE

5.5.1 As-Built Drawings

Issue 3 sets of 1:100 paper copies and a CD with the electronic version of the as built drawings.

The as built drawings shall show the actual commissioned flow rates and equipment details and capacities.

A draft of the As Built documents shall be provided to the Engineer four weeks prior to Practical Completion for approval. Provision and acceptance of final as-built, commissioning, and maintenance documentation shall be a prerequisite for Practical Completion.

`As Built' drawings, to the approval of the Engineer shall be provided for the Contract Work. These shall be in similar detail to the installation drawings, but shall also include any amendments and any additional detail necessary to show the functioning or installation, or particular items of plant.

The approval of any drawings by the Engineer in no way affects the Mechanical Services Subcontractor's responsibility for the satisfactory completion of the Contract.

Acceptance of these drawings shall be required as a pre-requisite for Contract Completion.

Tender Issue

All costs incurred for correction or alteration work due to failure of the Contractor to seek approval, or error in late submission of information supplied by the Contractor shall be to the Contractor's account.

5.5.2 Operation and Maintenance Manuals

Provide Operation and Maintenance Manuals as specified in General Conditions clause 3.42

Tender Issue

6 MAINTENANCE (DEFECTS LIABILITY PERIOD)

6.1.1 GENERAL

Maintain the work for a period terminating 12 months from the date of Practical Completion of the whole of the Contract Works, replacing or repairing any faulty equipment or materials, or the results of incompetent workmanship, free of charge.

6.1.2 SCOPE OF WORKS

a) Routine maintenance and servicing are to be carried out on a monthly basis for a period of 12 months from the date of Practical Completion to the end of the Maintenance and Defects Liability Period without cost to the Owner.

b) Monthly maintenance and servicing in accordance with maintenance schedules recommended by equipment manufacturers.

c) Maintenance, testing and inspections in accordance with regulatory requirements and relevant Solomon Islands and New Zealand standards.

d) Rectification of defects at Providers cost.

e) Replacement of consumables at Providers cost.

f) Provision and filling out log book which must on site detailing all visits.

g) Service personnel to be available for call out on a 24-hour per day, 7-day per week basis. Response time for emergency and corrective maintenance must not exceed 2 hours.

6.1.3 SCHEDULE OF MAINTENANCE CONTRACT

The contractor shall provide a price to carry out preventative maintenance of all systems installed on the expiry of the Defects & Liability Period. A brief summary of the minimum maintenance scope follows;

GENERAL

a. The provision of skilled personnel fully conversant with the plant and equipment and competent to attend the same shall be included.
b. Attendance upon the plant and equipment for the purpose of routine cleaning and inspection at specified intervals shall be included.
c. All periodic maintenance services requiring system shutdown shall only be carried out after the normal operating hours and with authorization from the Employer's representative. The frequency of maintenance shall be as per Schedule of Maintenance Works of this Specification.
d. All replacement of parts and components shall be included in the comprehensive Maintenance Contract.

VENTILATION FANS			
Sr#	**Description**	**Monthly**	**Quarterly**
1	Check bearing noise of fans and motors	•	
2	Check fan blade for proper work as required	•	
3	Check air flow for any obstructions	•	
4	Check air inlet for any damage	•	
5	Check wiring, terminal lags for loose connections and tighten as required	•	

Tender Issue

SPLIT TYPE AIR CONDITIONER			
Sr#	**Description**	**Monthly**	**Quarterly**
1	Check/clean filters	•	
2	Check state of insulation on pipe work and repair if required	•	
3	Check all electrical connections for loose or dry joints	•	
4	Clean indoor and outdoor coils with pressurized water spray		•
5	Clean, dust and wipe all grilles and indoor surfaces	•	
6	Check for undue noise and vibration – rectify as required	•	
7	Check compressor mount fixing	•	
8	Prove operation of all fans	•	
9	Test for all bearings on motors where appropriate		•
10	Prove satisfactory operation on thermostatic controllers	•	
11	Check and clean drain pans	•	
12	Check refrigerant pressure	•	
13	Note any further maintenance requirement on the unit	•	

Tender Issue

7 EQUIPMENT SCHEDULES

The equipment schedules give the type, manufacture and required performance of the equipment as shown on the drawings and specification.

Tender Issue

8 PRICE SCHEDULES

The tenderer shall complete the pages of the section and forward a completed copy to the client's representative together with their tender letter.

8.1 TENDER PRICE

…… (Tenderer's company name)

…… (Street address)

…… (City)

…… (Tel.)

…… (Fax.)

…… (Email)

We, as per above, tender for the installation as per this specification inclusive of the provisional sums above for the total sum of

$……..…... (VIP)

And in words ……

……Dollars

Responsible person's first and last names ……

Signature……

Tender Issue

8.2 RATE PRICES, MARGINS AND SUBCONTRACTORS

The rate prices below are for the purpose of calculating variation to the contract in addition to the work in this specification: The prices shown and the percentages shall include all the margins, P & G's as a selling price to the client and shall also be applicable to all sub-contractors.

Hourly charges: -

Installation technician weekdays	…… $/hour excl. VAT normal time from 7h00 to 17h00
Commissioning weekdays	…… $/hour excl. VAT normal time from 7h00 to 17h00
Electrician weekdays	…… $/hour excl. VAT normal time from 7h00 to 17h00
Engineer weekdays	…… $/hour excl. VAT normal time from 7h00 to 17h00
Overtime	…… % additional to normal time.
Travelling charges	…… $/per round trip excl. VAT to site

8.2.1 Margins' percentages

The margins below are for the purpose of calculating variations to this contract in addition to the work in this specification: The prices shown and the percentages shall include all the margins, P & G's as a selling price to the client and shall also be applicable to sub-contractors.

Margin on bought out equipment and materials …… % on invoice value excl. VAT.

8.2.2 Subcontractors

No work shall be performed by staff other than the tenderer's own staff except as nominated below – written permission shall be obtained from the client's representative prior to using any other sub-contractors than nominated below.

The tenderer shall complete the following table and name either their own company staff or a sub contracted company they intend to use for any work not performed by their own staff:

Sub contractor's company name	Work description
……..	…….
……..	…….
……..	…….

8.3 DEVIATIONS AND ALTERNATIVES

The tenderer shall complete this page and forward a completed copy to the client's representative together with his/her tender letter.

Tenderers are welcome to offer valid savings with alternative equipment satisfying the same standard to those scheduled, subject to approval by the client's representative.

Tender Issue

9 TENDER PRICE BREAKDOWN:

9.1 MFMR AUKI – MALAITA PROVINCE, SOLOMON ISLANDS - PRICE SUMMARY

Item No.	Description	Price ($)
1.	Supply and installation of split type air conditioning system inclusive of indoor unit and outdoor units as shown and scheduled in the drawings. Note outdoor unit to have factory applied anti-corrosion treatment suitable for a coastal environment	$
2.	Supply and installation of fresh air ventilation fans with associated controls and wiring as shown on the drawings.	$
3.	Supply and installation of toilet ventilation fans with associated controls and wiring as shown on the drawings.	$
4.	Supply and installation of wall mounted ventilation fans for the kitchenettes with associated controls and wiring as shown on the drawings.	$
5.	Provide and install ventilation ductwork with associated supports as per Australian or SMACNA standards. Allow for Unistrut Duct Supports.	$
6.	Provide and install air inlets and outlets (grilles, louvers) butterfly dampers, oppose blade dampers etc. as scheduled in the plans and drawings	$
7.	Supply and install refrigerant pipes including refnet joints, hanger and support as shown on plans and drawings. Contractor to clad all exposed pipe in proprietary cladding	$
8.	Provide door louvers to be installed by the builder.	$
9.	Provide and install required sleeves for duct and pipe penetration including sealants fire rated if required	$
10.	Supply and install insulated condensate drain line as shown on plans and drawing. Contractor to ensure that drain lines have adequate gravity fall, where gravity fall cannot be achieved contractor to install “mini blue or approved equal” drain pumps. All exposed pipe to be in proprietary cladding	$
11.	Provide for electrical works (power and control wirings) for the air conditioning and ventilation systems;	$
12.	Interfacing of the air-conditioning & ventilation systems with the fire alarm panel. Mechanical Contractor to allow for interfacing card / module for each unit and fan for interfacing. Mechanical Contractor to coordinate interfacing works with the fire contractor.	$
13.	Commissioning, Testing, Adjusting and Balancing (TAB) works.	$
14.	Provision of shop drawings.	$

Tender Issue

15.	Instruction of the Principal (Client Training).	$
16.	Maintenance (defects liability) for 12 months.	$
17.	As-built drawings & O&M manuals	$
18.	Any other items not covered in above but required in the installation of mechanical works. Contractor to describe items below:	$
	Add:	
	Value Added Tax	$
	TOTAL MECHANICAL SERVICES (VIP)	**$**

The prices to be set out in this schedule are to provide a breakdown of the tender sum and shall be inclusive of all incidentals in accordance with the specifications. This is a comprehensive supply and installation contract and the tenderer shall take all responsibility for all items required to complete the Contract Works in accordance with the Contract Documents.

Tender Issue

10 SCHEDULE OF UNIT RATES - MECHANICAL

Item No.	Description	Unit	Unit Cost
	1 TR = 12,000BTUH = 3024kCal/hr = 3.517kW Cooling)		
1.0	**Split Type Air Conditioning Units**		
1.1	FCU 2.2kW	Ea.	$
1.2	FCU 2.8kW	Ea.	$
1.3	FCU 3.5kW	Ea.	$
1.4	FCU 6.0kW	Ea.	$
1.5	FCU 8.5kW	Ea.	$
1.6	FCU 10.5kW	Ea.	$
2.0	**Refrigerant Piping - Copper Type L**		
2.1	Ø6.4 mm	m	$
2.2	Ø9.5 mm	m	$
2.3	Ø12.7 mm	m	$
2.4	Ø15.9 mm	m	$
2.5	Ø19.1 mm	m	$
2.6	Ø22.2 mm	m	$
2.7	Ø28.6 mm	m	$
3.0	**Refrigerant Pipe Elbow Fittings - Copper Type L**		
3.1	Ø6.4 mm	Ea.	$
3.2	Ø9.5 mm	Ea.	$
3.3	Ø12.7 mm	Ea.	$
3.4	Ø15.9 mm	Ea.	$
3.5	Ø19.1 mm	Ea.	$
3.6	Ø22.2 mm	Ea.	$
3.7	Ø28.6 mm	Ea.	$
4.0	**Flexible Pipe Connectors**	Ea.	$
4.1	Ø 25 mm	m	$
4.2	Ø 32 mm	m	$
4.3	Ø 40 mm	m	$
4.4	Ø 50 mm	m	$
5.0	**Condensate Drain Piping - uPVC (Straight Pipes)**		
5.1	Ø 25 mm	m	$
5.2	Ø 32 mm	m	$
5.3	Ø 40 mm	m	$
5.4	Ø 50 mm	m	$

Tender Issue

6.0	**Condensate Drain Pipe Fittings - uPVC (90 deg. Elbows)**		
6.1	Ø 25 mm	Ea.	$
6.2	Ø 32 mm	Ea.	$
6.3	Ø 40 mm	Ea.	$
6.4	Ø 50 mm	Ea.	$
7.0	**Pipe Insulation - Rubber Closed Cell, 25mm thick**		
7.1	Ø6.4 mm OD	m	$
7.2	Ø9.5 mm OD	m	$
7.3	Ø12.7 mm OD	m	$
7.4	Ø15.9 mm OD	m	$
7.5	Ø19.1 mm OD	m	$
7.6	Ø22.2 mm OD	m	$
7.7	Ø28.6 mm OD	m	$
8.0	**Pipe / Duct Hangers and Supports**		
8.1	3/8” threaded rods, galvanized	m.	$
8.2	25mm x 25mm x 4mm thick angle bars, galvanized	m.	$
9.0	**Vibration Isolators**		
9.1	10.5 mm thick Pad, 50mm x 50mm, Neoprene	Ea.	$
9.2	Spring type, hanging and floor mounting, 25mm deflection	Ea.	$
10.0	**Flexible Duct Connectors**		
10.1	100mm wide canvass or Vinylflex with double offset metal seam	m.	$
11.0	**Electricals**		
11.1	Power wiring and thermostat wiring	m.	$
11.2	Wall mounted Thermostat, digital type, programmable, 3 speed control	Ea.	$
11.3	Cables and conduits	m.	$
12.0	**Ductworks**		
12.1	Supply/Return/Fresh air ducts	Kg.	$
12.2	Exhaust Ducts	Kg.	$
12.3	Flexible Ducts	m	$
13.0	**Fans and blowers**		
13.1	In-line centrifugal - up to 100 L/s	Ea.	$
13.2	In-line centrifugal - 100 to above L/s	Ea.	$

Tender Issue

13.3	Wall mounted exhaust fans – up to 100 l/s	Ea.	$
14.0	**Grilles and Diffusers**		
14.1	Exhaust Air Grille - Eggcrate type/ECO Manual	Ea.	$
14.2	Door Louver	Ea.	$
14.3	Exhaust disk valve	Ea.	$
14.4	Linear diffusers	Ea.	$
14.4	Side Wall Mounted Grilles	Ea.	$
15.0	**Filters**		
15.1	Washable type media, G3	Pc	$
15.2	Carbon Filters	Pc	$
16.0	**Ductwork Insulations**		
16.1	Blanket type, fibreglass insulation for ductworks	m^2	$
16.2	Fibreboard duct insulation	m^2	$
17.0	**Balancing Dampers**		
17.1	Leaf Type balancing dampers	m^2	$
17.2	Opposed Blade dampers	m^2	$

Tender Issue