SECTION 15991 - TESTING AND COMMISSIONING

PART 1 - GENERAL

1.1 RELATED WORK

Division 15 - Mechanical

1.2 SYSTEM DESCRIPTION

This Section covers the testing and commissioning requirements for air handling, piping controls and mechanical systems generally.

1.3 QUALITY ASSURANCE

A. The Contractor shall employ the services of a specialist independent international commissioning company for commissioning, testing & balancing. The independent testing and balancing company is to have no vested interest in the project and not belong wholly or partly to a company related to the supply or design of HVAC equipment or systems.

B. The independent company must have been established and carried out commissioning works on at least five projects within the geographical area. The Engineers employed by the independent Commissioning Company shall have at least 5 years proven experience within commissioning. Testing and balancing.

C. All engineering services systems are to be thoroughly commissioned and tested to prove that they are capable of achieving the specified performance, to prove the correct and stable operation of all control systems and are safe to operate and maintain.

1.4 SUBMITTALS

A. Testing and Balancing

1. Certificate

   a. Submit Warning Certificate.
   b. Fully detailed method statements are to be provided in advance for approval for each system to indicate the methods to be employed. Tests are to be carried out in accordance with agreed recognized standards such as those produced by C.I.B.S.E I/ B.S.R.1.A.

2. Data Sheets

   a. Submit type written data sheets on each item of testing equipment to be used.
   b. Include name of device, manufacturer's name, model number, latest data of calibration, calibration due data and correction factors.
   c. All products and instrumentation used shall be subject to approval.
3. Reports form
   a. Submit specimen copies of report forms, for approval for their use on this project.
   b. Forms shall be quarto paper for loose leaf binding, with blanks for listing of the required test ratings and for certification of report.

4. Provision of Test Point and accessories
   a. All required test points, although not mentioned in the BOQ, are deemed to be included in the pipework and ductwork installations and included in the unit rate of these systems. The contractor shall allow sufficient points and where required by the Engineer for the correct and complete regulation, testing and commissioning. All test points shall be indicated on the working and record drawings. Test points shall be fitted with removable plugs, flanges or other approved devices appropriate to the service concerned.
   b. Balancing valves and dampers shall be included on every main branch and subcircuit to facilitate system commissioning. All such devices shall be identified on the working drawings and submitted for approval.
   c. Each volume control damper and fire damper shall be complete with adjacent access panel.
   d. Balancing valves shall be propriety commissioning sets consisting of double regulating valve and close coupled orifice plate.
   e. The Contractor shall prepare system loading diagrams for each system including control dampers, regulating valves and test points and shall indicate their physical location in pipework or ductwork.
   f. Environmental tests are to include, where necessary, the provision of artificial loads to simulate the full range of operating conditions. The correct operation of each system is to be demonstrated on completion of the commissioning and testing.

5. Recording of Test Results
   a. The Contractor shall give 7 days notice, to the Engineer in writing, prior to any regulation, testing and balancing being undertaken to enable the Engineer to witness the work.
   b. The Contractor shall formulate and provide all test sheets to a format agreed by the Engineer. Each sheet shall contain the project title, the logos of the Employer and the Engineer. Each sheet shall have witnessing signatory space specific to the Contractor's Engineer, and the Engineer's designed representative.
   c. The test result sheets shall be fully cross-referenced to the system loading diagrams which shall be updated to include the actual test results.
   d. Duplicate signed test certificates shall be provided after each test, which will be countersigned by the Engineer who witnesses the test. The test certificate shall give the following particulars:
      Apparatus or Section under test
      Makers number (if any)
      Nature, duration and conditions of test
      Result of test
   e. No test shall be valid until the test certificate is provided.
   f. Duplicate copies of test certificates carried out at manufacturer works shall be forwarded to the Engineer for approval prior to dispatch of the article to site.
g. No Section of the works shall be insulated or in any other way concealed prior to testing and inspection and subsequent concealment where applicable shall only take place following written authority from the Engineer.

h. All necessary facilities, measuring and recording instruments including test pumps and gauges for inspection/testing and commissioning requirements shall be provided and shall be checked or calibrated as necessary before use. The Engineer reserves the right to call for a demonstration of the accuracy of any instruments provided.

6. Testing Instruments

a. The Contractor shall submit with his Tender a full list of instruments, together with relevant standards, which he intends to use in the regulation, testing and balancing of the Contract Works. The Contractor shall include the full cost of regular calibration test to be carried out on all instruments used and the cost of any necessary recalibration. Certified documentation confirming current certificate calibration shall be available for examination by the Engineer at all times. Instruments not supported by up-to-date calibration certificates shall not be used.

b. All instruments necessary for conducting the test shall be provided including the following minimum range:

c. Tube type velometer (Range 1.5 to 13 m/sec).

d. Sloping tube manometers.

e. Pitot tubes of various length to suit duct sizes.

f. Mercury in glass thermometers.

g. Weekly recording thermometers.

h. Weekly recording R.H. meters.
i. Specially mounted anemometers fixed in a conical sheet metalwork hood for measuring accurately air flow from diffusers.

A mmeters.

Tachometers.

Surface contact dial indicating pyrometer.

Hot wire digital anemometers.

Sound meters.

Digital touch thermometers.

Multi-channel digital thermometers (where necessary).

“U” tube manometers.

Commissioning set electronic flow meters.

Brass cased certified thermometers.

j. The Contractor shall prepare and submit with his Tender a schedule of recommended test equipment suitable for Technician Grade maintenance staff to assess whether the commissioned standards are being maintained. Whilst the level of equipment need not be comparable to the Specialist Commissioning Contractors own test equipment it should meet the following requirements:

Measurement of air and water temperatures including all test probes.

Air flow measurement, both in duct and at diffuser discharge.

Water flow measurement using commissioning valves sets provided under the Mechanical Services Contract.

7. Final Report

a. Upon completion, all information shall be neatly typed accompanying schematic diagrams of systems tested.

b. All test reports shall be assembled, indexed, and submitted to the Engineer.
PART 3 - EXECUTION

3.1 OPERATIONS OF EQUIPMENT & SYSTEMS

The Contractor shall make the necessary adjustments for each system and piece of apparatus installed, using factory-trained technicians wherever practicable, and shall thoroughly instruct the client appointed representative in the proper operation of the apparatus. Printed instructions written in both Arabic and English, shall be permanently attached to the relevant equipment.

3.2 TESTING GENERALLY

A. Where an individual inspection or test takes place at a sub-contractor’s work a representative of the client will be required to be present.

B. Unless otherwise indicated the Contract shall include the cost of all tests necessary instruments equipment supervision and labor both at the manufacturer’s plant and on site The accuracy of the test instruments shall be demonstrated where so directed.

C. The site test shall be of at least six hours duration On large installations the site test may last several days and shall be long enough to allow the taking of all the measurements required in subsequent clauses of this Section and to demonstrate the performance of the installation Any defects of workmanship materials and performance maladjustments or other irregularities which become apparent during the tests shall be rectified by the Contractor at his expense and the tests shall be repeated at the Contractor’s expense to the satisfaction.

D. The Contractor’s representative present at the site tests shall be fully conversant with the operation of the thermostatic controls the control panel and the refrigeration system representatives of the manufacturers of the equipment shall be present.

3.3 TESTS AT MANUFACTURERS WORKS

A. Unless otherwise indicated tests shall be carried out in accordance with the appropriate Standard or Code or Practice Test certificates for works tests shall be submitted induplicate.

B. Test certificates shall be submitted
   1. For HVAC equipment: Type test certificates showing motors and fans characteristic curves and type test certificates for sound levels.

   2. For Pumps Type test certificates for head discharge speed and power input.

   3. For Electrical Motors Type test certificates for motors of 40 KW output and above routine (individual) test certificate.

   4. For Starters and Control Gear Type test certificates for control panels as a whole routine (individual) high voltage test.

   5. For Other Electrical Equipment Such as air heaters (but excluding thermostatic control equipment) test certificates.

   6. For Hydraulic Equipment: Test certificates for hydraulic and air pressure testing at works.

C. Testing is to include as a minimum.

   1. Pipework Cleanliness, internal and external
      Flow rate/balancing
System component pressure drops  
Pressure reducing valve settings  
Safety relief valve selling and operation  
Operation of all components  
Performance-temperature/noise  
Purity of Fluid  
Earth bonding

2. Ductwork Leakage  
Cleanless, internal and external  
Damper Operation  
Fire & smoke operation  
Flow rate balancing  
System component performances- 
heating/cooling batteries filter  
C.VN.V box operation / calibration  
Performance-temperature/noise air change  
Operation of all components  
Purity  
Earth bonding

3. Plant Equipment Operation-normal abnormal safety devices interlocks  
Performance duty I speed / pressure / efficiency / noise  
Standby  
Component performance- heat / cool / batteries /filter  
Cleanliness, internal and external Vibration  
Electrical safety I security / bonding

4. Room Environmental - temp, humidity, air change, noise  
Air flow direction, distribution, draughts

5. Control Component operation  
Settings  
Control action — limits response time alarms  
interlocks  
Electrical safety/security/bonding

6. BMS Full functional tests

D. The Mechanical Services Contractors shall include for the setting to work of the installation,  
preparation of as fitted drawings and operating and maintenance manuals and the provision of  
labels and charts to be undertaken by a Commissioning Specialist, as identified in section 3 of  
the specification.

E. The Commissioning Specialist must be appointed and identified to the Professional Team  
within 4 weeks of the Contractor receiving an order to proceed or before any working program  
is agreed, whichever is the sooner.

3.4 PRESSURE TESTING OF PIPEWORK SYSTEMS

A. Upon the completion of each length or section of the pipework the Contractor shall subject  
the length or section to a hydraulic test and demonstrate to the satisfaction of the Engineer  
that the length of the section is sound and watertight. The test pressure shall be one and a  
half times the maximum working pressure or 700 KPa, whichever is the greater, for a
period of two consecutive hours. Items of equipment, e.g. safety valves, bursting discs, set to operate at or below this pressure shall be isolated or removed prior to applying this test.

B. All faults discovered during such test shall be remedied by the Contractor at his own expense and the test re-applied until the Engineer is satisfied that the section is sound and watertight.

C. Installations sections thereof which will be embedded in the structure or concealed in permanently sealed ducts, trenches etc., shall be individually tested as they are laid and before being embedded or concealed.

D. All pressure tests shall be carried out before the application of thermal insulation.

E. On completion of the test, the water is to be released and drained completely away as rapidly as possible, the section then being thoroughly sluiced through to ensure the removal of as much dirt and foreign matter as possible before being refilled and put into service.

3.5 AIR LEAK TESTING OF DUCTWORK SYSTEMS

A. General

1. All ductwork and equipment items shall be checked for air leakage. This shall be completed before installation or enclosure of ductwork and before any terminal units are fixed.

2. The air leakage tests shall be based on the measurement of air leakage at constant pressure. The test pressure shall be the design static pressure of the section to be tested plus 250 pa. The aggregate of air leakage shall not exceed 1% of the system design air flow rate, and leaks shall not be audible. The air leakage rate for any section shall not be in excess of the permissible rate, in m3/s per meter, for the whole system.

3. Sufficient time shall be allowed, before testing, for the sealant to cure. The ductwork system, or section to be tested shall be sealed by the incorporation of, blanking plates fitted at flanged joints, for main ducts and for small open ends, polythene bags may be used. The polythene bags may be retained to aid in preventing the ingress of dirt into the system.

4. Care shall be exercised in jointing tested sections of the ductwork system together, as it will generally be impracticable to test such joints.

B. Test Apparatus and Methods

1. Portable test apparatus shall be provided by the Contractor and shall comprise the following equipment: Electrically driven fan capable of delivering not less than 0.03m3/s against a duct pressure of 2.5 Kpa, a static pressure gage suitable for recording the duct static pressure test, an inclined pressure gage, a variable speed type, and a flow measuring device complete with test cocks. The accuracy of the measuring device shall be +/-5% of the permitted air leakage rate.

2. The apparatus shall be connected to the blanking plate inserted in the section of ductwork to be tested. With the bleed valve fully open or the variable speed motor set to minimum speed, start-up fan, and adjust fan speed or close bleed valve until static pressure reading on static pressure gage reaches desired value. If pressure cannot be obtained, the ductwork shall be checked for obvious leaks and rectified. With the duct section maintained at the
test pressure, the ductwork shall be checked for major and audible leaks. The leakage rate, as indicated on the inclined pressure gage, connected across the flow measuring device, shall be recorded and checked that it is within the permitted limits. This leakage rate shall be maintained for at least 15 consecutive minutes without increasing.

3. The fan shall then be turned off and the pressure in the test section of duct returned to zero before starting the fan again and establish that the air leakage rate has not increased from the previous reading.

4. Any results not within the permitted limits shall require that the ductwork be examined and any leaks rectified. Time shall be allowed for the sealant to cure before the test is restarted.

5. Readings of the test for each section of ductwork shall be recorded and presented to the Engineer before any further work is carried out on the section of ductwork tested.

3.6 TESTING OF SOIL, WASTE AND ROOF DRAINAGE PIPING SYSTEMS

A. On completion of the soil and waste pipe works or section of the work as may be required the plumbing contractor shall arrange the testing of the works.

B. The tests shall comprise an air test as set out in the Uniform Plumbing Code, and described in section 1 5405, and a performance discharge test as required. Should the Engineer deem the test unsatisfactory his visit shall at his desecration be considered abortive and all costs incurred in respect of time, travel and expenses shall be recoverable from the contractor who shall then rectify the works and arrange for a further test to be witnessed at his own expense.

C. Where the testing is to be carried out in sections the Contractor shall retain on site a drawing indicating sections tested and recording dates on which the tests took place duly witnessed.

D. The Contractor shall be responsible for providing all skilled and unskilled labor necessary to carry out tests and ensure that all supplies and instruments are available.

3.7 COMMISSIONING GENERALLY

A. General

1. Each installation shall be fully commissioned. Commissioning shall include the balancing and regulation of air and water distribution systems and the final adjustment of control system.

2. Particular attention shall be paid to:
   a. The maintenance of cleanliness of all equipment and distribution and distribution systems during construction and ensuring that distribution systems are cleared through as part of commissioning.
   b. The protection of equipment, particularly sensitive of fragile items, from the activities of other trades during construction and from dirt and maloperation during commissioning.
   c. The protection of Electrical equipment from damp during construction and commissioning.

B. Adjustment

Adjustments shall be made to the following items:
   a. Adjust blowers, fans and ducts to deliver or exhaust design air flow rate.
b. Adjust diffusers, register, and grilles to deliver or exhaust design air flow rate.
c. Adjust relief dampers and vents.
d. Adjust diffusers, registers, and grilles to minimize drafts.
e. Adjust all zones for design supply and return air flow rates.
f. Adjust blowers and fans to design revolutions.
g. Balance cooling water systems to achieve design flow characteristics.
h. Balance domestic hot water return loop.

3.8 COMMISSIONING OF AIR SYSTEMS

A. Preparation

Prior to system testing and balancing.
1. Systems shall be fully operational.
2. All filters shall be clean.
3. Temperature and system controls shall be checked for proper operation.
4. Fan rotation shall be checked.

B. Air blower and FCU System

1. Air flow quantities where required, shall be measured by pitot tube and inclined manometer using multi-point traversing techniques.
2. The following items shall be specifically checked and/or adjusted and recorded on the Site Test Certificate for each air handling unit.
   a. External air dry bulb temperature and relative humidity.
   b. Air dry bulb temperature and relative humidity in each space.
   c. Air dry bulb temperature and relative humidity in each main return duct.
   d. Air dry bulb temperature and relative humidity before and after each air heater.
   e. Air dry bulb temperature and relative humidity before and after each air cooler.
   f. Air dry bulb temperature and relative humidity before and after a humidifying equipment.
   g. Air dry bulb temperature and relative humidity before and after a fresh and return air mixing chamber.
   h. Air dry bulb temperature and relative humidity in each main supply air duct.
   i. Fresh air quantity (m3/s).
   j. Air flow (m3/s) and resistance (Pa or mm of water) across a main fan.
   k. Air flow (m3/s) and resistance (Pa or mm of water) across each heater.
   l. Air flow (m3/s) and resistance (Pa or mm of water) across each cooler.
   m. Air flow (m3/s) and resistance (Pa or mm of water) across each humidifying equipment.

3. Perform the following minimum air system tests balancing.
   a. Air flow (m3 Is) in each main supply, return a grille and diffuser.
   b. Air flow (m3 Is) at each supply grille and diffuser.
   c. Fan and motor speeds, air quantity and dry bulb temperature and relative humidity, both on and off the cooling coil, for at least two of each size fan of the cooler unit.
   d. Main fan and motor speeds.
   e. Current taken under running conditions for each fan above 4 KW and each electric air heater, and maximum current for each electric air heater.
   f. In cooperation with the temperature control system installer, set adjustments of automatically operated dampers to operate as specified, indicated and noted.

C. Record Data

Record the following minimum data:
1. Air flow rate delivery and rpm of blowers and fans.
2. Static pressure at inlet and outlet of blowers and fans.
3. All equipment nameplate data.
4. Actual running current and voltage of fan motors.
5. Air flow rate, delivery or exhaust at each diffuser, register and grille.

COMMISSIONING OF WATER SYSTEMS

Preparation

Prior to system testing and balancing
1. Open all valves to full open position. Close coil bypass stop valves. Set mixing valves to full coil flow.
2. Remove and clean all strainers.
3. Examine water in system and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Clean and set automatic fill valves for required system pressure.
6. Check expansion tanks to determine that they are not air bound after the system is completely full of water.
7. Check air vents at high points of water systems and determine if all are installed and operating freely.
8. Set all temperature controls of all coils calling for full heating. Same procedure when balancing hot water coils: set for full heating.
9. Check operating of automatic bypass valve, if furnished.
10. Check and set operating temperature of boilers to design requirements.
11. A complete air balance must be accomplished before beginning the water system test and balance.

A. Water Handling Systems

1. General
   The satisfactory operation of all make-up, drain and overflow arrangement shall be checked. Where water treatment is included initial commissioning shall be carried out and then rates of flow, dosing quantities etc., shall be calibrated and set for routine operation.

2. Perform the following minimum water system test and balance:
   a. Set water pumps to proper flow rate.
   b. Adjust water flow through equipment.
   c. Check leaving water temperatures and return water temperature. Reset to correct design temperatures.
   d. Check water temperatures at inlet side of coils. Note rise or drop of temperatures from sources.
   e. Proceed to balance each water coil.
   f. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
   g. After adjustments to coils are made, recheck settings at pumps and readjust if required.
   h. Install pressure gages in gage fittings provided on coil, read pressure drop through coil at set flow rate for full heating. Set pressure drop across bypass valve to match coil full flow pressure drop.

B. Record Data

Record the following minimum data at each cooling element:
1. Inlet water temperature.
2. Leaving water temperatures.
3. Pressure drop of each coil.
4. Pressure drop across bypass valve.
5. Pump operating suction and discharge pressures.
6. List all mechanical specifications of pumps. Check and record starter sizes, heater sizes, etc.
7. Rated and actual running amperage of pump motor.
8. Water balance device readings and settings.

COMMISSIONING OF REFRIGERATION SYSTEM
During erection, commissioning and at the end of commissioning particular attention shall be paid to competent workmanship adequate sealing of valves and fittings and comprehensive leak testing, to minimize future leakage of refrigerant.
The following items shall be checked and/or tested and entered on the Site Test Certificate:
a. Refrigerant suction and discharge pressure and temperatures.
b. Compressor and motor speeds.
c. Compressor oil pressure.
d. The satisfactory operation and set operating pressures of high pressure, low pressure and oil pressure failure cut-outs.
e. Current taken by each compressor at full load and at each step of capacity reduction.
f. Inlet and outlet water temperature and pressure in the air cooled chillers circuits.

CONTROL SYSTEMS
Particular attention shall be paid to the following features:
1. Satisfactory operation of any automatic or manually operated sequences to be used in the event of fire.
2. Safety in the event of failure and of sudden resumption of electric supply.
The following items shall be checked and/or tested and recorded on the Site Test Certificate:
1. Set desired value of all control devices.
2. Satisfactory operation of equipment protection devices.
3. Satisfactory operation of all sequencing operations and alternate working selections, and automatic or manual change-over or duplicate equipment.

NOISE AND SOUND CONTROL
A. Sound level readings shall be taken with a simple sound level meter using the ‘A’ scale weighting network. The spaces in which readings shall be taken as agreed but will in general, be the following:
1. Equipment rooms.
2. Occupied rooms adjacent to equipment rooms.
3. Outside equipment rooms facing air intakes and exhausts and condensing discharge, to assess possible nuisance to adjacent accommodation, if the adjacent accommodation is private residential building tests may be required at night.
4. In the space served by the first grille or diffuser after a fan outlet.
5. In at least two of the spaces served by fan coil units.

B. Alternatively, sound level readings shall be taken using a sound analyses to give an octave band analysis of the sound spectrum and to pinpoint the frequency values of peak sound levels.

COMMISSIONING OF BOILER EQUIPMENT
A. Maximum Continuous Rating Test
1. During the commissioning period a maximum continuous rating test shall be carried out on each of the boilers.
2. The test shall be for a period of 4 consecutive hours exclusive of the time required for preparation, attaining test conditions and running down. During this test it shall only be
necessary to measure the evaporation of the boiler, the amount of fuel fired and the exit
flue gas temperature.

B. Acceptance Tests
1. On completion of the installation the Contractor shall carry out thermal efficiency tests on
all the boilers. These tests shall take place during periods of maximum loads and the
Contractor shall allow for adequate visits to satisfactorily test the thermal efficiency of the
boilers and performance of ancillary equipment.
2. Test and record flue gas exit velocity, temperature and CO2 content by volume, fuel
consumption.
3. The following shall be checked and be tested and recorded on the Site Test Certificate:
a. The boiler relief valves and any other relief valves shall be tested and proved to lift at
their required pressure using live steam.

SETTING TO WORK

The work shall be considered to consist of three separate sections of activity, namely Pie-
Commissioning, Commissioning and Post-Commissioning.

A. Pre-Commissioning
The Mechanical Services Contractor and their specialists as specified elsewhere and as follows
shall generally carry out pre-Commissioning:

1. Hydraulic Pipeline Testing The Mechanical Services Contractor shall test all pipework
installations.
2. Flushing All pipework installation, except compressed air systems, shall be flushed by the
mechanical services contractor.
The commissioning specialist shall be in attendance and witness the flushing exercises
and the subsequent cleaning of the strainers.
3. Pre-commissioning Cleaning Low temperature hot water installations shall be pre-
commission cleaned and treated by the mechanical services contractors water treatment
specialist.
The commissioning specialist shall be in attendance and witness the pre-commissioning
cleaning and treatment.
4. Sterilization and chlorination All domestic hot and cold water systems shall be sterilized
and chlorinated by the mechanical services contractor.
The commissioning specialist shall be in attendance and witness the sterilization and
chlorinating exercises.
5. Water Supplies The commissioning specialist shall confirm the presence of water supplies
to all tanks and outlets.

6. Plant and Ductwork cleaning The Mechanical services contractor shall thoroughly clean
all internal and external surfaces of ductwork and plant.
7. Electrical Supplies The mechanical Services contractors controls specialist shall
commission the whole controls installation. The commissioning specialist shall establish
that all electrical connections have been made during pre commissioning and that power is
available to all equipment.
8. Rotating Equipment The commissioning specialist shall check for free rotation of
equipment and correct alignment, security and tension of belt drives and operate fans and
pumps to check direction of rotation.
9. Test certificates The Mechanical Services Contractor shall provide copies of all tests
undertaken at manufacturers work and pre-commissioning tests.

B. Commissioning
1. The commissioning specialist shall commission the whole of the Mechanical Services installations, working in conjunction with the commissioning Engineers of equipment manufactures and systems specialists.

2. Where manufacturers offer a commissioning service this must be used in preference to other methods. All manufacturers reports shall be included in the final documentation.

3. The commissioning specialist shall regulate and adjust valves, apparatus, plant and equipment such that the whole of the works shall be left in a satisfactory working order to the requirements of the professional team.

4. Before commencing final balancing of water circulation systems the mechanical services contractors shall remove, clean and replace all stainers.

5. Where appropriate the systems shall be commissioned in accordance with the latest edition of the C.I.B.S.E./B.I.S.R.A commissioning codes.

6. Upon completion of all tests and balancing of the systems, the whole of the works shall be operated under normal working conditions and fine tuning of controls undertaken to achieve stable operating conditions of the plants and within the building.

7. The commissioning Specialist shall be required to work closely in conjunction with the control specialist to fine-tune the systems.

8. This operation of the installations under normal working conditions and fine tuning shall be undertaken during the commissioning period and shall not be considered as post commission proving.

9. The commissioning Specialist shall maintain a diary on site and record all activities of other specialist and manufactures commissioning engineers. The diary shall be available for inspection by the Professional Team at all times.

10. The commissioning Specialist shall provide all necessary instrumentation and measurement devices along with current calibration certificates for commissioning of the works.

C. Post Commissioning

1. The commissioning Specialist shall demonstrate and prove to the Professional Team that the system operates correctly, with stability and the commissioning Specialist shall undertake tests as directed by the Professional Team.

2. The commissioning Specialist shall be resident on site full time throughout the post-commissioning period.

3. The commissioning Specialist shall, in conjunction with the Mechanical Services Sub-Contractor and his other specialists, instruct the employer in the operation, inspection, inspection and general maintenance of the whole of the Mechanical Services Installations.

4. The commissioning Specialist shall supply and place in position and maintain operation of and calibrate a number of 7 day/24 hr temperature and humidity recorders for a minimum period of seven consecutive days or otherwise as specified. The records shall be positioned and re-located as directed by the professional Team.

D. Commissioning Report

1. The commissioning Specialist shall prepare a Commissioning Report for submission to the Professional Team and ultimately for inclusion in the O&M Manual. The report shall contain the following:

2. Plant run times during tests

3. Air flow volumes for each system, including duct traverse record sheets.

4. Terminal grille and diffuser volume flow records for all systems, including hood factor tests etc.

5. Central plant test data including filter and coil pressure drops, etc.

6. Fan performance including fan curves and plotted performance on high and low volumes where applicable.
7. Pump performance including Pump curves and plotted performance on high and low volumes where applicable.
9. Refrigeration plant commissioning data including water flows for low temperature hot water.
10. Control settings for all plant
11. Control selling programmed into Building Management System
12. Control Panel fuse ratings and overload settings
13. Record of all temperature and pressure point tests
14. Equipment running current for all three phases
15. Noise level recordings including sketch plan of positions where readings were taken.
16. Pressure test certificates
17. Clean water/system certificates for domestic water systems
18. Sketch diagrams of systems indicating all equipment controls and control and regulating valves all referenced.
19. Provision shall be made in the report for recording alterations made to control set points during post-commissioning and the first twelve months of plant operation.
20. Provision shall be made in the report of recording test data during any re-commissioning exercise.

SCOPE OF WORK
A. Pre-Commissioning
   The Independent Commissioning Specialist Company shall provide a part/full time engineer/s to evaluate the systems prior to installations being complete. The engineer shall review the systems being installed and provide a detailed report to the Consultant Engineer
B. Commissioning
   The Independent Commissioning Specialist Company shall provide a full time engineer/s to carry out the commissioning of the installations. The engineer shall provide the Consultant Engineer with a weekly report.
C. Post Commissioning
   The Independent Commissioning Specialist Company shall demonstrate and prove to the Consultant Engineer that the system operates correctly and meet the performance criteria.
D. Duct Work Insulation Testing
   The Independent Commissioning Company shall use a Thermographic techniques to inspect all finished duct work to prove the insulation integrity. The temperature surrounding the duct work shall be recorded on a area by area basis. Any leakage shall be digitally photographed and recorded together with the Thermographic image. This report shall be given to the contractor to rectify and leakages or break down of insulation. The Independent Commissioning Company shall then re-survey these area and confirm that these works have been completed satisfactorily.
E. Electrical Testing
   1. The Independent Commissioning Company shall use a Thermographic techniques to inspect all the electrical systems including the following HV through to LV. Inclusive of switchgear, standby alternators, busbar risers, transformers, cables, MDB, SMDB, final DB’s, fire alarm, audio, PABX, UPS & CVT.
   2. The refrigeration systems shall be inspected including cold stores, refrigerators, air handling units and fan coil units.
   3. The heaters and boilers shall be inspected including ovens, kilns, furnaces and chimneys.
   4. All engines shall be inspected including generators, fire pumps, all domestic pumps, motors, oil sump temperatures, exhaust gas temperatures.

F. Testing & Balancing — Air Systems
   The Independent Commissioning Specialist Company shall provide for Testing of the air systems based upon but not limited to the following information.
a. Number of Air Handling Units  
b. Number of Fans  
c. Number of Fan Coil Units  
d. Number of Smoke Extract  
e. Number of Kitchen Canopies  
f. Number of Volume Control Dampers  
g. Number of Outlet Grilles  
h. Number of Inlet Grilles  

G. Testing & Balancing – Water Systems  
The Independent Commissioning Specialist Company shall provide Testing of the water systems but not limited to the following information:  
a. Number of Water Coils  
b. Number of Boilers  
c. Number of Pumps  
d. Number of Pressure Units  
e. Number of Commissioning Sets  
f. Number of Two Port Valves  
g. Number of Three Port Valves  
h. Number of Pressure Reducing Valves  

H. Electrical Testing  
The Independent Commissioning Specialist Company shall provide Testing of the following systems but not limited to:  
a. Number of Air Handling Units  
b. Number of Fan Coil Units  
c. Number of chillers  
d. Number of Fans  
e. Number of Heaters  
f. Number of Boilers  
g. Number of Fire Pumps  
h. Number of Domestic Pumps  

I. Approved Companies  
The contractor should submit the name of the company for the approval of the Engineer.  

END OF SECTION 15991