SUBSECTION 13: ERECTION, TESTING, TRIAL RUN, COMMISSIONING AND TESTS AFTER COMPLETION

13.0 ERECTION GENERAL

The Contractor's staff shall include adequate and competent erection engineers with proven, suitable, previous experience on similar Contracts to supervise the erection of the Works and sufficient skilled, semi-skilled and unskilled labor to ensure completion of Works in time. The Contractor shall not remove any representative, erector or skilled labor from the Site without prior approval of the Employer's Representative.

The Contractor shall ensure that no installation or erection work shall commence until full and unconditionally approved working drawings, signed and stamped by the Employer's Representative are available at Site.

The Contractor's erection staff shall arrive on the Site on dates to be agreed by the Employer's Representative. Before they proceed to the Site, however, the Contractor shall first satisfy himself, as necessary, that sufficient plant of his (or his sub-contractors) supply has arrived on Site so that there will be no delay on this account.

The Contractor's representative responsible for erection shall be an erection engineer who is conversant with the erection and commissioning of the complete Works. If there are more than one erector, one of them will be in charge and the Contractor shall inform the Employer's Representative in writing which erector is designated as his representative and is in charge. Erection engineer is to report to Project Manager.

The Contractor shall be responsible for setting up and erecting the plant to the line and levels of reference and of the positions, levels dimensions and alignment, appliances and labor in connection therewith. The checking of setting out of any line or level by Employer's Representative shall not in any way relieve the Contractor of his responsibility for the correctness thereof.

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors or operating staff who may be present at the time. Before commencing any erection work, the Contractor shall check the dimension of structures where the various items of Plants are to be installed and shall bring any deviations from the required position, lines or dimensions to the notice of the Employer's Representative. Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the approved drawings. Unless otherwise directed by the Employer's Representative, the Contractor shall adhere strictly to the aforesaid approved drawings. If any damage is caused by the Contractor during the course of erection to new or existing Plant or buildings or any part thereof, the Contractor shall, at no additional cost to the Employer, make good, repair or replace the damage, promptly and effectively as directed by the Employer's Representative and to the Employer's Representative satisfaction.

The Contractor shall align all equipment and holding down bolts and shall inform the Employer's Representative before proceeding with grouting-in the items concerned. The Contractor shall ensure that all equipment is securely held and remains in correct alignment before, during and after grouting-in.

The approval by the Employer's Representative of the Contractor's proposals for rigging and hoisting any items of the Plant into their final positions shall not relieve the Contractor from his responsibility for damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items, whether structural, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Employer's Representative.

No Plant, equipment or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be uniformly transferred to floor beams and girders. If it is required to reduce bending stresses and deflection, the beams and girders shall be provided with temporary supports.

During erection of the Plant the Employer's Representative will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer's Representative.

13.1 LEVELLING AND GROUTING OF MACHINERY

Contractor shall undertake, sufficiently in advance, chipping of any unevenness of concrete on foundations, anchor bolt pockets, cutouts etc., to achieve uniform level of reference for erection. All concrete surfaces receiving grout shall be chipped as required to ensure better bonding with the grouting.

Contractor shall undertake the inspection of all components to be erected sufficiently in advance to check their soundness and conformity to drawings and the inspection records shall be signed by the Employer's Representative as approval for undertaking the installation of the components. Any damage, shortfalls etc. shall be made good to the satisfaction of the Employer's Representative.

All grout for equipment shall be carried out using non-shrinkable continuous grout materials with suitable framework of at least 12mm thickness. Surfaces to receive the grout shall be chipped and roughened and laitance shall be removed by wire brush or blast of air. Concrete surface shall be blown off by compressed air before commencing grouting. Grouting shall be done in one continuous operation from one side such that grout flows in a single wave until grout reaches all confined spaces with no air pockets and air from all confined spaces is expelled. A hydrostatic head of 150 mm shall be maintained during grouting operations. All grouting shall be carried out in the presence of the Employer's Representative. All lines and levels shall be checked after grout is set. Blockouts shall be closed using cement concrete of the same grade as that of the parent structure.

13.2 RECORDS, PROCEDURES AND REPORTS

The Contractor shall maintain records pertaining to the quality of installation / erection work and inspection, testing, compliance with all technical requirements in respect of all his works as described in the previous paragraphs. The reporting formats shall be in the approved formats. The Contractor shall submit such records to the Employer's Representative after the completion of any particular work before submitting the bill of supply / progress of work. Such report shall comprise shop inspection reports, shop testing reports, material test reports, based on which dispatch clearances are provided, and all the quality control reports of welding, erection and alignment records.

All the above mentioned records shall be submitted in the final form duly countersigned by the Employer's Representative attesting conformity to specifications and his approval of installation, and duly incorporating all the additions, alternations, and information as required by the Employer's Representative, on the basis of preliminary reports giving the progress of the work. Such records notwithstanding, any records submitted earlier with bill of supply / progress, etc., shall be duly bound and submitted to the Employer's Representative in six copies by the Contractor on his notification of the mechanical completion of erection.

13.3 GENERAL PREPARATIONS BEFORE COMPLETION OF THE PLANT

The documents listed in Sub-clauses 4.14.3.1, 4.14.3.2, 4.14.3.3 and 4.14.3.4 should be completed in accordance with the Contract schedule before completion of erection. The Employer's Representative and the Contractor shall preserve and control these documents in a safe and appropriate place on Site in order that both parties' personnel can make use of them at any time.

13.3.1 Technical Documents:

- Operation and Maintenance manual
- Design documents including the Contractor's design data, drawings and Specifications.
- Tools and test equipment list
- Spare parts list
- Lubricant list

13.3.2 Procedures:

- Mechanical testing procedure
- Electrical testing procedure
- Instrumentation testing procedure
- Detailed pre-commissioning and commissioning procedures

- Detailed Performance Test procedure

13.3.3 General and Coordination Documents:

- Detailed organization charts for pre-commissioning and commissioning showing lines of authorities and responsibility, and functions of all key personnel
- Job description of the members of the team
- Scheduled dates of assignment of each member to pre-commissioning and commissioning organization.
- Detailed schedule showing the time sequence which the Contractor anticipates to follow for the various steps in completion of erection, pre-commissioning and commissioning of each unit and equipment.
- Regulations for safety, hygiene and discipline
- Practical organization of the relationship (meetings, reports, etc.) between the Contractor and the Employer's Representative at the phases of pre-commissioning and commissioning.
- Emergency communication route.

13.3.4 Manpower:

Required manpower shall be provided as agreed between the Contractor and the Employer's Representative in a Manpower Mobilization Plan, which shall include the number and qualifications of the operator and maintenance personnel to be furnished by the Employer's Representative for the Plant.

13.4 COMPLETION OF ERECTION

The completion of Plant under erection by the Contractor shall be deemed to occur if all the units of the Plant are structurally and mechanically complete and will include, among other such responsibilities, the following:

- Plant in the Scope of the Contract has been erected, installed and grouted as per specifications.
- Installation checks are completed and approved by the Employer's Representative.
- Erected Plants are totally ready for commissioning checks.

At the stage of completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo tests on completion and subsequent pre-commissioning checks.

Upon achieving the completion as described above, the Contractor shall, after having given 21 days advance notice of the expected date for carrying out the inspection, notify the Employer's Representative by a written notice intimating completion of erection and notify the Employer's Representative for inspection. The Employer's Representative shall proceed with the inspection of such units within 24 hours of such a notice.

The Employer's Representative shall certify completion when there are no defaults in the Works or provide the Contractor with a list of deficiencies for rectification, hereinafter referred as the "Punch List". The Contractor shall complete the rectification work within a jointly agreed period before pre-commissioning activities and obtain the Employer's Representative's acceptance or approval before proceeding with the same.

The Employer's Representative may inform the Contractor that the works are accepted with the Punch List (items which do not hamper operability, safety or maintainability) and allow the Contractors to proceed with the pre-commissioning checks when the Contractor under-takes to complete such outstanding works within an agreed time prior to or during the defects liability period. Taking over shall be based on rectification of all deficiencies which are to be completed before acceptance, as advised by the Punch List.

The erection period indicated by the Contractor would be deemed to cover all the activities up to Completion as stipulated in previous paragraphs, notice of completion by the Contractor, inspection by the Employer's Representative for Completion, and Contractor's rectification of all deficiencies as noticed by

the deficiency/Punch List, and acceptance by the Employer's Representative of such rectification's, prior to Tests on Completion.

Minor defects, which in the opinion of Employer's Representative do not hamper operability or maintainability, will not be taken into account for deciding Mechanical Completion. Such defects shall be rectified concurrent to commissioning checks before Tests on Completion. However, the Employer's Representative's decision in this regard is final.

The commissioning period as notified by the Contractor shall include all periods of pre-commissioning, trial runs and tests on completion.

It is in the Contractor's interest to offer the section/units/systems, progressively under Identified milestones within overall erection period, duly completed for rectification of any deficiencies pointed out by the Employer's Representative and to achieve mechanical completion before undertaking the tests on Completion within the specified erection period. The Employer's Representative also reserves the right to withhold the cost as estimated to be equivalent to the rectification of deficiencies pointed out to the Contractor until such a time as the deficiencies are rectified by the Contractor to the satisfaction of the Employer's Representative.

13.5 PRE-COMMISSIONING

After the completion of erection, pre-commissioning activities listed below shall be carried out to make the Plant ready for commissioning. All instruments, materials and provisions necessary for conducting site tests shall be provided by the Contractor at his own cost.

Upon completion of erection of each piece of equipment, facility or discrete part of the plant, mechanical checks and tests shall be carried out according to the Contractor's checklist. The mechanical checks and tests shall be to establish that:

- The Plant is erected in accordance with the Contractor's construction drawings, pipe work drawings, instrument diagrams, etc., issued for the Plant;
- Materials are installed and mechanically function in accordance with the Contract; and
- Applicable codes as listed in the Contract are followed for materials and workmanship.

Items such as painting, thermal insulation and final clean up which do not materially affect the operation or safety of the Plant will be excluded. All these items shall be listed and completed after pre-commissioning or commissioning at the discretion of the Contractor, but before acceptance.

The Contractor shall prepare and maintain at Site test forms and records, which shall include:

- Description of type of test or check;
- Date and times of test or check;
- Identification of equipment and facilities;
- Test pressure, test data and results, including remarks, if any; and
- Signature of the Contractor's personnel attesting to data recorded; if any. The Contractor's construction forces thereof shall carry out checks, tests and records.

Wherever the Employer's Representative's witnessing or attesting of the check or test is required, the Employer's Representative's personnel shall attend such check and test. For this purpose, the Contractor shall keep the Employer's Representative informed of a day-to-day test plan schedule. The test plan schedule may be revised from time to time to reflect the actual progress of the work and test.

Any items found incomplete or requiring repair or adjustment shall be marked as such on the test records and reported by the Contractor to the Employer's Representative and the Contractor's personnel in charge of the relevant construction area.

Checking procedures shall be repeated until all the items on the checklist are cleared.

A complete set of test records shall be handed over to the Employer's Representative on completion.

The tests on the different mechanical and electrical equipment shall include but not be limited to:

13.5.1 Pumps, Piping and Valves

- Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.
- Operating tests shall be conducted on valves.
- The pumps shall be tested for mechanical performance. The vibration and noise levels shall be checked to be within the specified limits.
- Pump performance tests shall be conducted for all raw water and clear water pump sets with initial duty impellers. Each pump shall be tested at a time. For Malpura only one pump is to be tested at a time.
- To check and verify efficiency of each pump and vibration of pump.

13.5.2 Pump Motors

- Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

13.5.3 Instrumentation Testing Requirements

(a) Tests on Cables

i. Check details are in accordance with the specification

ii. Check for physical damage

iii. Megger test between each core and armour / sheath

iv. Continuity check

v. Connections

(b) Continuity of Signal/Control/Power Supply Cables

After laying of the field signal/control/power supply cables and prior to connection up to the control panels/instruments, the following procedures shall be adopted:

i. The signal/control/power supply cables shall be disconnected from each termination point in turn when the wires shall be 'rung-through' for identification and tagged.

ii. The signal/control/power supply cables shall be reconnected to the termination points and again 'rung-through'.

(c) Loop Test

After testing and calibration of individual instruments forming the various loops, simulated functional test of the whole loop shall be performed before pre-commissioning. The procedure for conducting these tests shall be decided by the Employer's Representative and results shall be recorded. During loop test, it is the Contractor's responsibility to ensure that the calibration of instruments is intact and in order and if any instrument is found defective in calibration, he shall recalibrate the same without any extra cost. After the loop test is over, he shall connect back all the terminations and connections removed for loop test.

(d) Tests on Electrical Installation

i. Check all closing, tripping, supervision and interlocking of control devices.

ii. Check operation of all alarm circuits.

(e) Test on Complete Control System

i. On completion, the functioning of the complete control system shall be tested to demonstrate its correct operation in accordance with the Specification.

ii. For control system testing, the Contractor may provide temporary means to simulate operating conditions, but the system will not be finally accepted until correct operation has

been demonstrated to the satisfaction of the Employer's Representative when all the Plant is operating.

iii. The system shall be shown to operate correctly whatever the selection of duty and standby equipments may be.

iv. Conditions to be tested shall include:

- Normal automatic operation
- Normal manual operation
- Emergency manual operation

(f) System Validation

i. The services of factory trained and field experienced instrumentation engineer(s) shall be provided to validate each system and verify that it is operational and performing its intended function within system tolerance. System tolerance is defined as the root-mean square sum of the system component published specified accuracy from input to output.

ii. Each system shall be validated by simulating inputs at the first element in loop (i.e. sensor) of 10 %, 50 % and 90 % of span, or on/off and verifying loop output devices (i.e. indicator, alarm etc. except controllers).

iii. During system validation, provisional settings shall be made on levels, pressure, alarms etc.

iv. Correct operation of controllers shall be verified by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point. All logic sequences shall be verified to operate in accordance with the specifications.

v. All defects and malfunctions disclosed by tests shall be corrected immediately. New parts and materials shall be used as required and approved and tests shall be repeated.

vi. A report certifying completion of validation of each instrument system indicating calculated system tolerances, verification that the system meets these tolerances and any provisional settings made to devices shall be provided. The report shall be made in the format required by the Employer's Representative and shall be certified by the Employer's Representative when he approves it.

(g) Final Operational Testing and Acceptance.

i. Upon completion of instrument calibration and system validation, all systems shall be tested under process conditions.

ii. The testing shall include, but not limited to all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failures, interlocks and operational interlocks between systems and/or mechanical equipment.

iii. Any defects or malfunctions shall be immediately corrected using approved methods and materials and the tests shall then be repeated.

iv. Upon completion of final operational testing, a report shall be submitted, indicating that the total control system provided meets all the functional requirements specified herein. This report shall be made in the format required by the Employer's Representative. The Employer's Representative shall certify this report when he approves it and it shall constitute final acceptance of the control system.

13.6 ELECTRICAL

The commissioning engineer may verify any commissioning tests / completion checks to satisfy himself that the plant is fit and sound.

The commissioning tests / completion checks to be carried out shall include, but not be limited to, those described in subsequent paragraphs, as applicable to the individual equipment / system.

13.6.1 Commissioning Tests / Completion Checks

Preliminary Checks

In general, the following checks shall be carried out on all the equipment/systems, as applicable.

a) Name plate details according to approved drawings / specifications

b) Any physical damage or defect and cleanliness

c) Tightness of all bolts, clamps and connections

d) Oil leakages and oil level

e) Condition of accessories and their completeness

f) Clearances

g) Earthing connections

h) Correctness of installation with respect to approved drawings / specifications

i) Lubrication of moving parts

j) Alignment

k) Correctness and condition of connections

General tests

a) Commissioning Tests of Motor

- Insulation resistance test of motor windings and cables. (PI for MV motors only)
- Continuity check for power and control cables.
- Winding resistance measurement in case of motors rated 55 kW and above.
- Control, interlock and protection schemes.
- Operation and setting of timer, in case of Star Delta starters.
- Phase sequence and rotation.
- No load trial run for observation of vibrations, noise and temperature of bearings etc.
- On load operation, starting and running load current (also observe vibrations, noise and temperature of bearing and winding).
- Relay setting as per relay co-ordination chart
- Simulation check of motor control circuit by local/ remote closing and tripping

b) Commissioning Tests of Transformer:

i) Test oil for dielectric strength, tan delta, acidity, resistivity and dissolved gases, Insulation resistance test of windings.

ii) Capacitance and tan delta test of condenser type bushings, before assembly.

iii) Test the transformer for the following:

- Voltage / turns ratio at all the taps.
- Winding resistance at all the taps.
- Short circuit impedance (at low voltage)
- Magnetic balance.
- Core loss at normal tap at low voltage.
- IR and PI.

iv) Vector group test.

v) Phase sequence test.

vi) Test the current transformers for following:

- Continuity test.
- Polarity test.
- Insulation resistance test.
- Magnetization characteristics.
- Measurement of secondary winding resistance.

vii) Line connection as per phasing diagram.

viii) Winding resistance.

ix) Insulation resistance of control wiring.

x) Buchholz relay operation (for alarm and trip).

xi) OLTC control indicating and alarm circuit.

xii) Operation test of all protective devices (electrical and mechanical) and interlocks.

xiii) Calibration of temperature indicators (oil and winding) and temperature relays.

c) Commissioning Tests of Switchboard:

i) Checks on relays.

ii) Insulation resistance test

iii) High voltage test

iv) Millivolt drop test for busbar joints

v) Checks on motors/ simulation check.

vi) Setting of relays, other alarms, tripping devices and interlocks as per scheme.

vii) Phase angle checks, measurement of magnitude and phase angle of current transformer secondary currents and potential transformer secondary voltage.

viii) Functional checking of all power and control circuits e.g. closing, tripping, control, interlock, supervision and alarm circuits including proper functioning of the component equipment.

d) Commissioning Checks of Relay:

i) Check operating characteristics over the entire range by secondary injection.

ii) Check minimum pick up voltage.

iii) Check operation of electrical / mechanical targets.

iv) Relay settings.

e) Commissioning Checks of Meter:

i) Check calibration.

ii) Megger all insulated portions.

iii) Check CT and VT connection with particular reference to their polarities for relevant meters.

f) Commissioning Test of Circuit Breaker:

i) Check control wiring for correctness of connections, continuity and IR values.

ii) Manual operation of breaker.

iii) Power closing / operating manually and electrically.

iv) Breaker tripping and closing time.

v) Trip free and anti pumping operation.

vi) IR Values, resistance and minimum pick up voltage.

vii) Contact resistance.

viii) Simultaneous closing and mechanical interlocks provided.

ix) Check electrical and mechanical interlocks provided.

x) Checks on spring charging motor, correct operation of limit switch and time of charging,

xi) Checks on CTs.

xii) High voltage test,

xiii) All functional tests.

g) Commissioning Tests of Voltage Transformer:

i) Insulation resistance test.

ii) Polarity test.

iii) Ratio test on all cores.

iv) Line connections as per connection diagram.

v) Open delta test with low voltage, wherever required.

h) Commissioning Tests on Current Transformer:

i) Megger between windings, winding terminals and body.

ii) Polarity test.

iii) Ratio identification checking of all ratios on all cores by primary injection of current.

iv) Magnetization characteristics, secondary winding resistance.

v) Capacitance and tan delta test.

vi) Dielectric test of oil (wherever applicable).

i) Commissioning Checks of Cable:

i) Megger test between each core and armour / sheet.

ii) Continuity check.

iii) Connections.

iv) High voltage test for cables above 3.3kV.

j) Commissioning Checks for Battery:

i) Specific gravity test.

ii) Cell voltage test.

iii) Capacity test.

iv) Initial charging/ discharging cycle.

k) Commissioning Checks of Battery Charger:

i) Functional check of auxiliary devices, such as alarms, indicating lamps etc. and operational checks.

ii) Insulation test of all circuits.

iii) Measurement of voltage regulation and efficiency.

iv) No load current and voltage (AC) and voltage and current (both AC and DC) at different points.

v) Voltage at tap cell (While boost Charging)

l) Commissioning Checks of Capacitor:

i) Measurement of capacitance

ii) Capacitor loss tangent measurement (for above 1000V)

m) Commissioning Checks of Neutral Grounding Resistor:

i) High voltage test

ii) Ohmic value test

n) Lighting System

Commissioning tests stipulated in applicable standards and code of practice covering all lighting system equipment

o) Earthing System

Continuity of all conductors and joints shall be checked. The Employer's Representative may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth grid resistance value should be not greater than one ohm.

p) Tests for Trial run and commissioning of the 33kV Transmission System:

1. General

Before the line is energized, visual inspection of the line shall be carried out to check that all the nuts and bolts are tight and insulators and accessories are in position. The earth connections shall be checked to verify that these are in order.

2. Testing

Before commissioning the line, the following tests shall be carried out:

a) Conductor continuity test – The electrical resistance of the conductor shall be measured with a Wheatstone or other suitable instrument to ensure proper electrical connection of the line.

b) Insulation resistance test – This test may be carried out with the help of a 5kV meggar to ascertain the insulation condition of the line.

3. The line shall be kept charged on no load at the power frequency voltage preferably for 72 hours for the purpose of full scale testing.

13.7 INSTRUMENTATION AND CONTROL

i) The list of tests to be carried for SAT along with test instruments to be used shall be furnished for review by the Employer's Representative.

ii) The testing of all the equipment and accessories shall be carried out as per latest applicable Indian/International standards recommendations.

iii) Prior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employer's Representative who would witness the testing.

iv) After installation and commissioning, the Contractor shall demonstrate, by tests in the field, compliance of the values, functionalities, quality and reliability of the complete system and its components, both hardware and software, as specified and as per guarantees.

v) Contractor shall be fully responsible for interfacing to the equipment of Others as indicated in the scope of works. It shall be Contractor's responsibility to ensure satisfactory functioning of the system in conjunction with related equipment like exchanges, data equipment and other communication equipment of the Employer's Representative. Problems relating to such interconnections shall be mutually resolved.

vi) After tests as above, the complete system shall be on continuous uninterrupted service with all functionalities and interconnections without any failures or manual

interventions for correction, modification, rectification or replacements in the Contractor's system.

vii) Additional specific tests, if required, would be decided mutually.

SAT on local SCADA, UPS systems shall include the all tests covered under FAT documents except tests such heat run test and those tests which can not be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated local SCADA, UPS systems testing at site with all field equipments/instruments

13.7.1 Site Calibration

Standard calibration procedures shall be used for calibrating all field instruments. All reference equipment, used for calibration, shall be certified from an authorized certifying agency, to be arranged by the Contractor at his own cost. At the time of calibration, standard calibration norms shall be adopted and the same will be documented for record purposes.

Calibration shall be performed in the presence of the Employer's Representative. The instrumentation shall be calibrated while being commissioned in order to verify that the high quality calibration carried out during FAT is not being disturbed (No undue adjustments shall be made for minor deviations). The Contractor will monitor and check the instrument calibration throughout the Operation and Maintenance period.

13.7.2 Instrumentation Installation and Pre-Commissioning Checks

a) Check the exact location of the instrument with reference to the pipe and instrumentation diagram and/or the General Arrangement drawing.

b) Check that tag plate with tag no. and description is provided for each instrument.

c) Check the model No. and instrument type with reference to the technical specification requirements.

d) Check all mounting and fixing arrangements and required accessories such as isolation valve, nuts and bolts, siphon etc.

e) Check that the instrument installation is as per the installation drawing.

f) Check the cable type, connections for power supply as well as signal cables.

g) Check that cable shields for the instruments are properly terminated.

h) For the flow meters, check that the flow rate and totalized flow reading on the various displays match.

i) Check that the earthing is as per manufacturer's recommendation.

j) Check that there are no leakages.

k) For the level switches check that the level electrodes are connected to the correct level control units.

l) For the temperature scanners, check that the communication port of temperature scanner is properly configured and interfaced with the PLC system. Also check that the alarm and trip signals for various channels of temperature scanner are properly configured.

m) Check the loop continuity for every circuit. While this is being done, the power supply to the instrument shall be cut-off.

n) Calibration checks of the instruments shall be carried out to ensure integrity with the manufacturer's factory test reports. (No undue adjustments shall be made for minor deviations

o) After switching on the instrument/system, it shall be monitored hourly and the data obtained shall be recorded and compared with the reference norms to ascertain whether any recalibration is required. If recalibration is required it shall be carried out using standard reference equipment/instruments at no extra cost.

13.7.3 Instrumentation Commissioning

a) Each control loop and interlock shall be tested independently, in manual mode first and then in auto mode from the PLC and local SCADA system. The operation shall be checked for conformity with the approved logic in both modes. All pump control ON/OFF shall be checked in manual mode first.

b) Annunciation system shall be checked as performance testing by simulating the condition and by passing in actual mode and then individual loop will be checked for annunciation system.

c) All motorized valves shall be checked in manual mode first, from controls on the control panel, and feed-back from the field for valve on/off shall be checked on the panel.

13.7.4 Programmable Logic Control (PLC)

a) The PLC system and software shall be loaded by the representative of the PLC manufacturer.

b) Testing, commissioning and stabilization of the software shall be carried out by the authorized representative of the PLC manufacturer. The following checks shall be carried out:

- All indicators and indicating controllers will be put in manual mode after independent checking.
- Check that the PLC is properly configured and installed as per the approved drawings.
- Check that the PLC wiring is as per approved drawing.
- Check that the cables terminating in the PLC are properly dressed.
- Check that the PLC is earthed as per manufacturer's recommendations.
- Check that the PLC on-line battery is functioning properly.
- Check that the PLC is correctly time synchronized with the local SCADA system
- Check that the signals and events are getting correctly time stamped.
- Check the PLC response when input signal is out of range.
- Check that the correct ladder program is loaded in the PLC.
- Check the PLC ladder program by simulating various normal and abnormal conditions.
- Check that the data sheets and drawings are updated to reflect the as-built status.
- All analogue inputs shall be connected to the PLC system first. All digital inputs shall be checked at terminals before connecting to the I/O card of PLC system. PLC system shall be installed and checked first, before connecting any control signals/cables. Software shall be loaded in the PLC first, before connecting I/O cards with signal cables. After complete checking of the system in manual mode, system shall be put in Auto mode.

c) The PLC system manufacturer/supplier shall provide assistance/commissioning support at the time of commissioning, to be arranged and coordinated by the Contractor. Details regarding commissioning shall be provided prior to commissioning and any required modifications or changes shall be advised in advance.

13.7.5 Control Panel

a) Check name plate details of every piece of associated equipment for conformity with the specifications.

b) Check the tightness of all bolts, clamps, connecting terminals.

c) Check for physical damage.

d) Check cleanliness

e) Check switch development

f) Each wire shall be traced by continuity tests and it should be confirmed that wiring is as per the relevant drawings. All interconnections between panels/equipment shall be checked

g) Megger test on all wires.

h) Check on meters

i) Check that the primary devices are set as per the system requirements.

j) Checks on the control circuit for the functional requirements

k) Check that the control panel front fascia layout is as per approved drawings.

l) Check that the panel and all the panel equipment (viz. panel indicators, alarm annunciators, etc.) are connected to the proper earth.

m) Check that spare cutouts on the control panel are blanked.

n) Check that the panel indicator tag plates reflect the tag no. and the correct service description.

o) Check whether the panel meters are fixed properly in their cutouts.

p) Check that the instruments are identified inside the panel.

q) Check that the panel meter instrument ranges are as per approved data sheets.

r) Check that panel meters are provided with password protection facility.

s) Check that the alarm inscription details are as per approved drawings.

t) Check that the MCBs are identified by their function.

u) Check that safety guards are provided for power supply terminals.

v) Check the cables terminating in the control panel are properly dressed.

w) Check that proper node addresses are given to the panel meters/ scanners connected on the communication bus.

x) Check that the communication bus is terminated properly.

y) Check working of alarm annunciator by simulating alarm conditions.

z) Check that the panel meter readings match with other displays.

aa) Check that the no. of decimal places and unit of measurement are same for all the displays.

bb) Check that the data sheets and drawings are updated to reflect the as-built status.

13.7.6 Tests for Local SCADA

SAT on local SCADA systems shall include all the tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated local SCADA, communication system and UPS systems testing at site with all field equipment/instruments.

13.7.7 Tests for UPS

SAT on UPS systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated local SCADA, UPS systems testing at site with all field equipments/instruments.

13.7.8 Tests for EPABX System

SAT on EPABX systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated trunks and VHF communication systems testing at site with all telephone instruments

13.7.9 Tests for VHF Communication System

SAT on VHF communication systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative)

in addition to integrated with EPABX system at site with all handheld mobile sets. Site acceptance test shall include check of the antenna in use, and include the following four main characteristics of interest:

i) Type of antenna

ii) Height of the antenna

iii) Direction of main lobe

iv) Gain of the antenna

The radio base stations shall be confirmed as being located at the address as shown on the license. Contractor shall resolve such matters before proceeding with the station inspection. If a radio base station has moved a short distance so that the coverage area is little changed, the licensee should be informed, to regularize the licensing position, rather than closing the station down.

13.8 COMMISSIONING

After the completion of pre-commissioning activities the final checks and preparations necessary for start-up of the plant shall be carried out. The Contractor shall submit to the Employer's Representative a written Notice of Mechanical Completion, which shall include:

1. Identity part of the Plant considered mechanically complete.

2. Copies of all relevant completed test reports.

3. Date on which the completion of the tests was achieved.

4. Check list.

5. Request for issuance of a Mechanical Completion Certificate in respect of that part.

6. Within fourteen (14) days from the date of receipt of the Contractor's written Notice, the Employer's Representative shall:

- In the case of acceptance, issue a Mechanical Completion Certificate.

- In the case of objection, submit a rejection statement setting forth-remaining items to be completed or defects or deficiencies to be corrected before Mechanical Completion status can be accepted. When the Employer's Representative rejects the Contractor's Notice the Contractor shall take any necessary action to complete or correct the items marked and give the Employer's Representative a second Notice of Mechanical Completion.

7. After the issuance by the Employer's Representative of a Mechanical Completion Certificate, commissioning activities listed below shall be carried out to enable the start-up and operation of the Plant. Procedures are described as below:

A) Commissioning procedure shall be carried out in a methodical sequence as follows

- Warming up
- Start-up
- Initial running
- Operability adjustment
- Stable operation
- Final adjustment

8. At all stages of commissioning sequence, the Plant shall be operated at optimum Plant conditions. To ensure this, the Contractor may make minor adjustment to the conditions indicated in the Operation and Maintenance Manual as necessary.

9. The Contractor shall check the operating conditions of the Plant by constantly monitoring operating data.

10. The Contractor shall specify for each discrete part of the Plant the operational data to be recorde the manner in which the data is to be taken.

11. The Employer's Representative on the forms to be mutually agreed shall record all the operating The Employer's Representative shall make a copy of the operating log and analytical data from operation through to the completion of Performance Test available to the Contractor for evaluation.

12. The Contractor shall carry out commissioning tests in the presence of the Employer's Represent The evaluation of test results and decision passed by the Employer's Representative regarding th results will be final and binding on the Contractor. Any additional tests or repetition of tests to est satisfactory operation of any equipment shall be carried out by the Contractor, if so desired b Employer's Representative, at no extra cost.

13. All checks and tests shall be as per the Manufacturer's drawing manuals, relevant codes of installation and as per commissioning checklists.

14. Among other commissioning tests, the following shall be carried out at site after completion of installation. Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards / International Standards. All tests to be carried out in the presence of Employer's Representative.

13.8.1 Commissioning Tests

Following commissioning tests are to be carried out on all the equipment/systems, as applicable.

- Insulation resistance measurement of equipment, accessories, cabling/wiring etc.
- Dielectric tests on equipment, accessories, cabling/ wires etc.
- Phase sequence and polarity
- Voltage and current ratios
- Vector group
- Resistance measurement of winding, contacts etc.
- Continuity tests
- Calibration of indicators, meters, relays, etc.
- Control and interlock checks
- Settings of equipment and accessories
- Checking of accuracy/error
- Checking of operating characteristics, pick-up voltages and currents, etc.
- Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.
- Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.
- Complete commissioning checks of the system

13.9 SAFETY PROCEDURE AND PRACTICE

Following safety procedure and practice should be provided by the Contractor in the switchboard room/ substation as per latest edition of I.S. 5216.

a) Rubber matting in front of HV, MV and LV switchboard and other panels in switchboard room

b) Shock treatment chart in switchboard / electrical equipment room

c) Caution/Danger Board on -

- HV, MV and LV switchboard and other LV panels
- Lighting distribution board

- Transformer yard.

d) Sand bucket in switchboard / electrical equipment room/ transformer yard

e) Fire extinguisher in switchboard/ electrical equipment room

f) One set of hand gloves in switchboard room

g) First aid box in switchboard / electrical equipment room

13.9.1 Fire Safety

The requirement of hand appliance in switchboard room, electrical equipment room shall be as per the latest edition of Fire Protection Manual by Regional Tariff Committee.

13.9.2 Contractor's Licence

- The Contractor shall obtain the necessary Licence/ Authorization from the Licensing Board of the locality/ State for carrying out the installation work. The persons deputed by the Contractor should also hold valid permits issued/ recognized by the Licensing Board of the locality/ State in which the work is to be done.
- The electrical installation work shall be carried out by licensed electricians only and approved by appropriate authorities. It is the responsibility of Contractor to get approval of complete system from the appropriate authority.

13.10 PIPELINE WORKS

13.10.1 Test on Pipe Line

The sectional testing of MS pipeline shall be done as per the provisions set out in the Subsection 3 along with the laying of pipelines. The tested pipeline will be joined by gap pieces to complete the total physical completion of works. The maximum length for sectional testing in case of MS pipeline shall be as specified in Subsection 3 except for cases where, according to the Employer's Representative, the criteria can not be met due to specific Site conditions.

The laid pipeline will be joined with respective manifold through valves. Just before the commissioning the complete transmission main will be checked for:

(i) All the motorized valves in the system will be inspected for proper lubrication, manual and electrical operation.

(ii) All air valves shall be inspected for proper fitting and operation of isolating valves.

(iii) All flange joints/ expansion joints/ couplings will be checked for tightness of all bolts, clamps, etc.

(iv) The entire transmission system shall be checked for proper soil cover/ backfilling/ thrust and anchor blocking, etc.

(v) The structures will be checked for any constructional defects.

(vi) The valve chambers and their surroundings will be checked for its cleanliness.

(vii) The rectifiers, batteries, battery chargers at all CP stations will be checked for their functioning along with pipe to soil potentials (PSP) at every test lead point for proper soil potential. All CP stations, test stations to be monitored regularly during the commissioning and trial run period and data related to PSP, individual anode current, energy consumption, battery performance, etc., to be incorporated in the log-book.

(viii) Surge protection system shall be checked for the proper functioning.

13.10.2 Leakage Test

The entire pipeline shall be subjected to a hydraulic test as follows, to the required test pressure as per IS: 5822.

If a drop in pressure occurs, the quantity of water added in order to reestablish the test pressure should be carefully measured. This should not exceed 0.1 liter/ mm of pipe diameter per

kilometer of pipeline per 24 hours for each 30 m head of pressure applied.

All the joints, valves, fittings which are not tested during sectional testing shall be physically checke leakages and leakages repaired if found.

The Contractor shall provide and maintain all requisite facilities, instruments, for the field testing o material. All pipes, specials, valves and civil works shall be replaced by the Contractor free of cc damaged during testing.

13.10.3 Surge Protection Test

The effectiveness of the surge protection system shall be checked as follows,

- Install pressure gauges at the pressure gauge points such as immediately after pumps, at summit valleys, at critical points, etc.
- Run all the pumps at a time at least for one hour and then shut off all the pumps at a time.
- Record the pressure gauge readings before and after shut off.
- Inspect working of the various equipment of the surge protection system.

The pressure gauge readings at any point should show the pressure increase less than as specified for design of surge protection system given in Subsection 6. Vacuum pressure of -3.0 m (minus three meters) is allowed in the system. No leakages should occur other than the places observed above in the leakage test. The surge protection system shall work smoothly without any visual distress, failing which the Contractor shall take necessary measures to improve/correct /replace the surge protection system.

13.10.4 Cathodic Protection System Test

The effectiveness of the cathodic protection system shall be checked by monitoring the current requirements at all the Cathodic Protection (CP) Stations, If the current requirement is more than that stipulated in the Subsection 4, then the corrective steps shall be taken to bring the current requirement within specified limit.

13.10.5 Hydraulic Tests

All equipment subject to water pressure including castings, pressure vessels, pumps, pipes, fittings, and valves, shall be hydraulically tested to the pressure specified or in accordance with the applicable standard. Hydraulic test facility shall be made available at the manufacturer's works.

Any of the hydraulically tested items shall be subject to the Employer's Representative inspector's random item proof re-test and notice of testing dates shall be submitted to the Employer's Representative.

13.10.6 Site Testing

The Contractor shall arrange for the full site testing of all items of equipment and shall include provision of:

a) All skilled and qualified operating and test staff for the testing of all equipment;

b) Provision and disposal of all services, lubricants, and fuels other than electricity;

c) All measuring and testing instruments to demonstrate equipment operates to the fulfillment of the works test;

13.10.7 All Loading Weights for the Load Testing of all Lifting Equipment

The Contractor shall carry out all the tests to the satisfaction of the Employer's Representative.

The Contractor shall be responsible for coordinating the programme of site testing of all items and to ensure that all parties concerned are present during any tests to obligate their responsibilities.

13.10.8 Documentation

Set of documents shall be prepared and maintained by the Contractor and one set of the latest revised documents shall always be kept at site. The following documents shall be prepared by the Contractor:

- All latest approved L-sections and alignment drawings.

- All up-to-date as built drawings.
- Data sheets for instrument specification and selection
- List of electrical equipment along with data sheet/ literature
- Erection/ Instruction manual of electrical equipment
- Commissioning manual of electrical equipment
- Instrument Schedule
- Electrical cable schedule and inter-connection diagram
- Instrumentation schedule
- Instrumentation cable schedule
    - Loop drawings for instruments in the field and control panel
    - Instrument test and calibration report
    - Instrument installation drawings
    - As built drawings and G.A. Drawings for equipment and instrument installation

The Contractor shall keep on site two sets of the latest revised Operation, Maintenance and Calibration manuals for all field instruments and sub systems, annunciation system, data loggers, indicating controllers and PLC system etc.

13.11 TESTS FOR WATER TIGHTNESS OF WATER-RETAINING STRUCTURES

Water retaining structures for water supply purposes shall satisfy the following tests for water tightness, before external finishes are applied (if any). The water for testing shall fill the first 1.25 meters and may be filled as quickly as supply permits. Between this and top water level, the rate of filling shall not exceed a steady rate of 300 mm per 24 hours unless otherwise directed. After filling to top water level no further water shall be introduced for 7 days. After expiry of seven days and after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over a period of seven days and the structure shall satisfy the test if at the end of this week no leakage is apparent and or the water level does not drop more than 40 mm over the period of 7 days. The Employer's Representative shall decide on the actual permissible nature of this drop in surface level, taking into account whether the tanks are open or closed and the corresponding effect it has on evaporation losses. Foregoing visible leakages and sweating will not be accepted.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing the period of test may be extended for a further seven days and the if specified limit is then reached the structure may be considered as satisfactory.

Following satisfactory completion of the tests the Contractor shall empty the structures and dispose of satisfactorily the contents. He shall clean and disinfect the structures and any equipment therein of all deposits left by the testing.

13.12 SEWAGE TREATMENT PLANT

13.12.1 General

Prior to the commencement of Tests On Completion the Contractor shall submit for approval the following:

- Site Acceptance Test Documents;
- As-Built Drawings;
- Operation and Maintenance Manuals.

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The charges of oil, grease, electrolyte, generator fuel, etc., necessary for Tests on Completion shall be provided by the Contractor. Chemicals required for Tests on Completion will be provided by the Contractor. Electricity shall be provided by the Employer. The Contractor shall

provide adequate raw water to meet his requirements prior to commencement of the Tests on Compl involving its use.

13.12.2 Dry Test Requirements

General

As a minimum requirement the following dry tests shall be carried out as a general requirement:

- A general inspection to check for correct assembly and quality of workmanship;
- A check on the presence of lubricant, cooling medium, electrolyte, etc.:
- A check on adequacy and security of plant fixing arrangements;
- A general check to ensure that all covers, access ladders, water proofing, guard railings, etc, a place;
- A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside;

Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Raw water or treated water (if available) shall be used for hydraulic wet tests. The purpose of the tests is to prove as far as practical the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of raw water to carry out these tests the Contractor shall provide facilities for the disposal off-Site in an approved manner not less one third of the Works rated output.

In order to remove doubt, the following tests, inter alia, shall be carried out:

- Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards;
- Fill all structures and check for leaks;
- Filling of all storage vessels to check for leaks and distortion;
- Running of all pumped systems in order to check for:
  - Correct functionality;
  - Absence of leaks;
  - Correct running temperatures
  - Smoothness of running and the absence of undue vibration or stress;
- Check drive running currents;
- Carry out calibration of instruments where appropriate;
- Hydraulic testing of primary/ impulse tubing.
- Carry out valving, diversions, etc., to full hydraulic load (or where there is a requirement to withstand an over load to overload) for each process element;
- Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops, etc.

During these tests a check on the performance of Plant shall be made, as far as site facilities will allow, to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

13.13 SAFETY AUDIT

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Employer's Representative prior to commencement of Plant sterilization.

13.14 PLANT STERILIZATION

On approval of the safety audit document the Contractor shall carry out sterilization of the wetted parts of the Works. In order to remove doubt this shall also include the wetted surfaces of water treatment chemical storage and dosing systems.

The sterilization process shall be carried out by completely filling the item or items concerned with water containing not less than 30 mg/l of free chlorine and leaving it to stand for not less than 2 hours. On draining down the Contractor shall demonstrate that the chlorine residual has not fallen below 20 mg/l of free chlorine. If this is not true the sterilization process shall be repeated until this condition is met.

The Contractor shall be responsible for the disposal of the sterilization solution. The Contractor shall take the necessary measures to ensure that the free chlorine residual of the solution for disposal is not greater than 1 mg/l before discharge to the environment.

Areas such as the roofs of tanks not easily wetted by filling the vessel with sterilization solution shall be sterilized using a procedure approved by the Employer's Representative.

The Contractor shall give 2 weeks advance notice to the Employer's Representative and the Employer of the proposed date for carrying out sterilization.

The Contractor shall advise the Employer's Representative and the Employer in writing when all wetted parts of Plant and civil structures have been sterilized.

If the Contractor carries out any new work that invades a previously sterilized area the Contractor shall be required to carry out re-sterilization of that area to the approval of the Employer's Representative.

13.14.1 Process Wet Tests

On approval of the sterilization process the Contractor shall carry out process wet tests.

Raw water shall be used as the primary feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less 48 hours.

The Contractor shall provide facilities for the disposal off Site in an approved manner a quantity of treated water equal to not less than one third of the Works rated output.

The following tests, inter alia, shall be carried out:

- Check for leaks on vessels, structures, pumps and pipe work;
- Running of all pumped systems in order to check for:
  - Correct functionality;
  - Absence of leaks;
  - Correct running temperatures
  - Smoothness of running and the absence of undue vibration or stress;
- Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests;
- Carry out calibration of water quality instruments;
- Carry out valving, diversions, etc., to full hydraulic load (or where there is a requirement to withstand an over load) for each process element;
- Demonstrate correct functionality of electrical, control and instrumentation systems

On completion of the tests on the various parts of the works the Contractor shall run the plant as a wh order to demonstrate the full functionality and performance of the Works at various throughput rates continuous period of not less than 5 days.

During the various process tests the Contractor shall take samples and carry out water quality analy not greater than one hourly intervals in order to demonstrate to the Employer's Representative tha Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise liter (minimum) quantities and shall be labeled to identify the contents, where taken and time and date sample shall be used by the Contractor for his analysis; the other shall be handed over to the Empl Representative.

The Employer's Representative reserves the right to take additional samples and to carry out his own or to check the samples taken by the Contractor

The Employer's Representative shall be given reasonable access to the premises where analysis is t place in order to check on working practices and the procedures being adopted.

13.15 WATER QUALITY CRITERIA FOR PASSING THE TESTS ON COMPLETION

The Works shall be considered to have achieved the required water quality standards for passing Tests on Completion if all samples taken during a 5 day continuous operational period comply with the criteria set down for the passing the Tests After Completion, including that criteria relating to the reliability of the plant.

The water quality tests on completion shall not be commenced until all tests associated with the civil/ building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Employer's Representative.

13.16 TESTS AFTER COMPLETION

13.16.1 General

After successful completion of the Tests on Completion the Contractor shall carry out, as soon as reasonably possible but over a period of time not exceeding one year, two separate 20 day operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw water quality. During these tests water produced by the Works will be entering the public supply network. The tests after completion shall be undertaken in accordance with Clause 11 of the General Conditions of Contract.

Each part of the Works shall be considered separately as far as the tests are concerned.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with the General Conditions of Contract. The total time for carrying out the tests shall not be less than six calendar months, of which one of the tests for each part shall be carried out in a period of high raw water turbidity.

On commencement of each 20 day test the Contractor shall allocate a continuous period of not greater than 40 days to complete the test. Any failure to perform during the 40 day period shall restart the '20 day clock'. If the part of the Works fails to pass the test in the 40 day period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Employer's Representative before the Contractor restarts the test again.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals as directed by the Employer's Representative. The tests for performance of the system to meet the tender requirements shall be completed in this period and the penalties if any due on the Contractor as per the Contract shall be finalized. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the water treatment process as a result of power failures (unless as a result of a Plant failure), interruptions in the raw water supply, etc., which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All staff and consumables needed for operation of the Works such as fuels, lubricants etc. and transportation of sludge off site, except raw water, chemicals and power shall be provided by the Contractor under his operation and maintenance responsibilities.

The Contractor shall be required reasonably to co-operate and co-ordinate his activities with those of the Employer and other agencies. The Contractor shall provide all facilities and equipment not supplied under the Contract and which are deemed necessary to carry out and monitor the tests after completion.

13.16.2 Treated Water Quality Criteria

The Works shall be considered to have passed the 20 Day Test for treated water quality if all samples taken during the 20 day period comply with the criteria set out subsection 2.

The Works shall have fulfilled the treated water quantity criteria if the Works have demonstrated that this can provide the quantity of treated water detailed in the Contractors Functional Guarantee over a sustained and continuous period during the tests after Completion.

The treated water quantity criteria are an absolute requirement; i.e., the guaranteed treated water quantity must be achieved.

13.16.3 Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:

- A single item of Plant fails more than twice during the test;
- More than four individual Plant items fail during test.

An item of Plant shall be deemed to have failed if manual intervention is required in order to restore the Plant to its fully operational state, i.e., the failure of a duty drive will be considered as one failure; if the standby drive fails to start that will be considered as a second failure.