BAHAGIAN MEKANIKAL DAN ELEKTRIKAL

SENARAI SEMAKAN DAN GARISPANDUAN SAINS UNTUK KELULUSAN AWAL SISTEM PENGEPAMAN (BOOSTER PUMP)

Tiga (3) set rekabentuk sistem pam dan elektrikal hendaklah dikemukakan kepada Unit Mekanikal & Elektrikal SAINS setelah mendapat kelulusan rekabentuk terperinci keperluan air, sistem retikulasi, *civil & structure works.* Setiap cadangan rekabentuk dan instalasi hendaklah mengandungi:-*Schematic Layout Drawing* (saiz A3) antara tangki sedutan, rumah pam dan tangki agihan dengan menyatakan GL, TWL, BWL, saiz, jarak dan jenis paip serta kapasiti tangki mengikut yang **telah diluluskan oleh Bahagian Perancangan Dan Pembangunan SAINS**

i. 3 Set *Layout Drawing* (saiz A3) bagi pemasangan lengkap dengan alatan berikut:-

- Pumpset
- Valves
- Gauges
- Strainer
- Instrumentas
- Panel Boards (MSB, MCC, etc.)
- Overhead Hoist- Lighting & S/S/O
- Air Compressor minimum 2 nos.
- Water Surge system (surge valve or surge vessel)
- Dan lain-lain alatan Mekanikal & Elektrikal.

ii. Pengiraan-pengiraan rekabentuk sistem pam termasuk *Pump BKw, Motor Kw*.

iii. Pengiraan-pengiraan rekabentuk sistem perpaipan pengepaman termasuk *fitting, friction head, velocity*

iv Pengiraan-pengiraan rekabentuk tangki penyerap tekanan (*surge vessel*) atau *surge valve*.

v Naskah set rekabentuk dan semua perkiraan alatan mekanikal hendaklah disediakan oleh Perunding Mekanikal dan disahkan Jurutera Mekanikal Bertauliah yang berdaftar.

vi. Dua (2) set lukisan rekabentuk sistem elektrikal lengkap dengan *component material list* hendaklah dikemukakan ke **Unit M & E, SAINS.**

vii. Naskah set rekabentuk sistem elektrikal hendaklah disediakan oleh Perunding Elektrikal dan disahkan oleh Jurutera Elektrikal Bertauliah dan berdaftar dengan SPAN.

viii. Spesifikasi rekabentuk dan peperalatan sistem pengepaman Mekanikal & Elektrikal hendaklah merujuk kepada **LAMPIRAN A (M&E).**

LAMPIRAN A

MECHANICAL DESIGNS FOR PUMP STATIONS

D.1 MECHANICAL SYSTEM

D.1.1 General

The design of pumping stations, and the selection of mechanical equipment, shall meet the following requirements:-

a. Pumping stations and associated equipment shall conform with Jabatan Keselamatan dan Kesihatan Pekerjaan's (JKKP) specific requirements concerning Occupational Safety and Health matters.

b. There shall be no objectionable noise and vibration emissions within the pumping station. Conformance with Occupational Safety and Health Act's (OSHA) work place noise and vibration limits shall be factored into the design of the pump station and selection of specific equipment.

c. The additional pump stations shall comply with Jabatan Alam Sekitar's (DOE) conditions pertaining to noise (65 dB at the building) and air pollution (conformance with).

d. The design and the selection of equipment types shall take into consideration the life cycle cost of constructing, and operating and maintaining pump sets, piping and fittings.

e. Adequate headroom and horizontal clearances (minimum of 1 meter) shall be provided around all equipment (e.g. pump sets, compressors, etc.) and pipework for ease of maintenance, and for future replacement of any equipment and pipework.

f. Pumps and motors selected shall be of EFF1 type, i.e. high efficiency types, and shall comply with the current regulations with respect to energy efficiency.

g. Protection and safety devices shall be interlocked such that in times of failure of one part of the system, the system shall stop to operate thus preventing further damage to the rest of the system.

h. The degree of sophistication of a control system for the pumping station shall take into consideration the availability of persons with the required skills and competency level to operate and maintain the facilities.

i. Direct boosting, or boosting tapped from the main pipe, is generally not allowed. If this is unavoidable, detailed designs by a competent person shall be included in the design submission to the Certifying Agency.

j. The pumping system shall be designed to operate under positive suction heads; if this is not possible, self priming pumps or submersible pumps shall be used.

k. This chapter is applicable for pumping stations forming part of the external reticulation system or supply mains; and in general does not pertain to pumping systems installed within individual buildings. The requirements for pumping system serving a building are described in **Part C Planning and Design of Plumbing Systems**.

D.2 DETAILED DESIGN SUBMISSIONS

a. Detailed designs of mechanical and electrical works shall be carried out and endorsed by a competent person as specified in Second Schedule of the Water Supply Rules and submitted to a Certifying Agency for approval in two (2) specific stages (i.e. before and after tender award) as described in **Sections D.2.1 and D.2.2**.

b. All plans / drawings submitted shall be of A1 size.

c. All drawings shall be endorsed with the word "SUBMISSION DRAWING FOR APPROVAL".

d. All drawings shall be approved before any construction is permitted to commence.

e. All fire fighting systems for pumping stations shall be as per Jabatan Bomba dan Penyelamat, Malaysia (BOMBA) requirement, and be separately submitted to BOMBA for approval.

D.2.1 First Stage (Design Stage Before Tender Award)

Detailed designs submitted to the Certifying Agency, during the first stage process, shall incorporate the following specific information:

a. Submission of Mechanical & Electrical (M&E) designs shall be accompanied by a letter from the Certifying Agency formally approving the detailed design of associated civil works.

b. General arrangement drawings of pumping installation; including the arrangement of suction and discharge piping.

c. Design calculation for pumping system which shall include the pump curves; system curves; available Net Positive Suction Head (NPSH) calculation; pumping head calculation; sizing of suction pipe; headers and pumping mains; and sizing of prime movers.

d. Pump and prime mover (electrical motor or diesel engine) specifications and other relevant details.

e. Design calculation and layout of mechanical ventilation systems.

f. General layout of all mechanical handling systems.

g. General layout of generator set installation (as the case may be).

h. General layout drawings of a Surge Suppression System, if warranted, incorporating details on surge vessels or surge anticipator valves. The sizing of components of a surge suppression system shall be determined after a hydraulic surge analysis has been carried out.

i. Layout of fire fighting systems.

D.2.2 Second Stage (During Approval Stage of Equipment)

Upon confirming the specific details of equipment to be installed, the competent person shall submit to the WDL / CA the following information:-

a. Full details of equipment offered or proposed, together with copies of manufacturer's specifications to enable the nature, workmanship and functional characteristics of the equipment offered to be assessed.

b. The pump type, brand and manufacturing details for a minimum of three (3) brands of pumps for final selection by the Water Distribution Licensee.

c. Characteristic curves of the pump offered when operating singularly; describing the relationship between total dynamic head and rate of discharge; and superimposing on the system curve details on horsepower ratings, efficiency and Net Positive Suction Head (NPSH) requirements.

d. Duty point and efficiency of single pumps.

e. The scope and details of pump accessories to be provided.

f. Detailed specifications pertaining to the motor.

g. All pipework and valves; providing details on material specifications and sizes.

h. Surge suppression system complete with surge analysis calculation (including sizing of surge vessel) or sizing of surge anticipator valves.

i. Details of all components of mechanical handling equipment together with specifications.

j. Details on fire fighting system and equipment together with relevant specifications.

k. Details on proposed spare parts and tools to be provided.

l. All relevant shop drawings.

D.3 PLANNED PUMPING RATES AND NUMBER OF PUMP UNITS

333Generally, the rates of water to be pumped, and the number of pump units required, shall be determined according to the following basic criteria:-

a. Flow of water to be pumped directly into an external reticulation system shall take into consideration the estimated average and peak water supply rates, and fire flow rates, to be conveyed within the reticulation system. Pumping water to a service reservoir shall be based on a rate of flow which is equivalent to 1.2 times of the average daily flow to be distributed to consumers within its service area over a period of 16 hours.

b. The number of pumps required shall be determined by the estimated rate of water to be pumped, as well as other criteria such as installation cost, operation and maintenance requirements, power consumption and level of redundancy required.

c. Standby pumps shall be provided in accordance with the design criteria for pump sets given in **Table D.1**. The number of standby pumps depends on the size of duty pumps, the locality of the pump station and the required factor of the redundency desired.

Pumping Rate Per Pump (m^3 / hr)	Number of Pump sets	Total	Pumping Hours	Minimum Pump Efficiency (%)	Maximum Pumping Head (m)	Maximum Speed (rpm)	
						Horizontal Split Casing Pumps	End Suction Pumps
>30 ≤100	On Duty = 1 Standby = 1	2	12	60	75	-	2900
>100 ≤ 300	On Duty = 1 Standby = 1	2	12	70	75	1500	2,900
>300 ≤1000	On Duty = 2 Standby = 2	4	12	75	75	1,500	-
>1000	On Duty = 4 Standby = 2	6	12	80	75	1,500	-

Table D.1 : Design Criteria for Pump sets

Notes:

i. Duty pump is the primary pump used for continuous operation in accordance with the WDL's operational programme to achieve their optimum operational objective.
ii. Standby pump is an additional pump used to alternate or serve as duty pump in case of any duty pump failure.
iii. All pumps shall be installed to operate under positive suction heads.

d. In the case where water demand fluctuates widely, such as for an in-line booster system, it is advisable to have a combination of different size pumps; or resort to the use of variable speed pumps.

e. The capacity and the number of pumps in a pumping station shall take into consideration the specified maximum number of starts / stops the pump motor can withstand.

D.4 PUMPSETS

D.4.1 Duties and Selection

a. Electric motor driven pumps shall operate below 2900 rpm.

b. The pump shall have a stable characteristic curve such that the pressure falls steeply and continuously from a closed valve position.

c. For economic operation, it is advisable to employ a single duty pump which operates constantly near the point of maximum efficiency. Larger pumps normally have better performance efficiencies.

d. The duty point of the pump supplied shall lie within a range of 20% below and not more than 20% above the best efficiency point of the characteristic curves associated with specific impellers which are selected to pump the required quantity of water.

e. The performance of the pumps shall be verified by tests conducted under controlled factory conditions, and subsequently at site, in accordance with BS EN ISO 9906 : 2000.

f. **The material for pump shaft shall be of Stainless Steel of Grade 420 or better.**

g. In the design of a pumping system, pumps should not operate more than twelve (12) hours continuously in a day. This requirement is distinct from the criteria for determining the rating of the duty pump to deliver the estimated daily quantity of water over a specific time period and each pump is rotated based on WDL's operating programme.

h. The total pumping head shall not exceed 75m for each pumping stage under normal circumstances. For pumping heads exceeding 75m but below 100m, prior consent from the Certifying Agency shall be obtained. This consent may be granted on case to case basis supported by an economic justification based on an analysis of the total life cycle cost of the pumping system.

i. **All pumps with power ratings of 22.5 kW (or 30.0 water horsepower (HP)) and above shall be of the Horizontal Split Casing Pump type, with pump speeds of not more than 1500 rpm.**

j. **All pumps with power ratings below 22.5 kW (or 30.0 water horsepower (HP)) shall be either of the Horizontal Split Casing Pumps type (with pump speed of not more than 1500 rpm) or the End Suction Pump / Vertical Multi-Stage Pump type (with pump speeds of not more than 2900 rpm).**

k. **The minimum Factor of Safety (FS) in the sizing of motors shall be 1.1 times the motor power.**

l. All pumps, parts and accessories shall comply with relevant Malaysian Standards, or equivalent international standards [such as ISO, British Standard (BS) or European Standard (EN)], and shall be manufactured or supplied from a supplier registered by the Commission.

D.4.2 Horizontal Split Casing Pumps

a. The pump casing shall be of axially split type, made of grey cast iron or ductile iron, and be fitted with high tensile steel shafts running on ball or roller bearings with suitable lubricating arrangements.

b. All impellers, neck rings, sleeves, gland, lantern ring and bushes shall be of zinc-free bronze or stainless steel.

c. Gland seals shall be of the silicon carbide or tungsten carbide mechanical seal type.

d. The pumps shall be supplied with all necessary air release valves, drain valves, and suction and delivery gauge mounting points.

e. The pumps shall be supplied complete with base plates and approved types of flexible couplings.

f. The combined base shall be fabricated according to the manufacturer's instruction.

g. The combined base plate and stool shall be supplied complete with all necessary holding bolts and lifting points.

h. On-line vibration and bearing monitoring system should be installed for pumps of capacity above 1000 m^3 / hr.

D.4.3 **End Suction Pumps**

a. A spacer piece and coupling shall be provided to facilitate removal of impeller without dismantling the connecting pipeworks.

b. Gland seals shall be of the silicon carbide or tungsten carbide mechanical seal type.

c. Pump impellers shall be of zinc-free bronze or stainless steel.

D.4.4 **Vibration Isolation Material**

a. The pump set shall be provided with vibration isolation mechanisms such as a rubber damper between pump set and pump plinth, flexible coupling for the suction pipe and expansion joints for the delivery pipes.

b. For pumps which are supported on ground, neoprene / rubber mount and structural steel base shall be employed for pumps with power ratings less than 4 kW; whereas steel springs and concrete inertia base shall be provided for pumps with power ratings larger than 4 kW.

c. For pumps which are supported on a suspended floor slab, only steel springs and concrete inertia base shall be used.

D.4.5 **Bolt and Nuts**

a. All exposed bolts and nuts in the construction for the pump shall be cadmium treated or hot dipped galvanized.

D.5 **VARIABLE SPEED PUMPING SYSTEM**

a. The objective of adopting a Variable Speed Pumping System is to maintain a near constant discharge pressure while delivering varying rates of water supply to a distribution network whose demand characteristics vary over time.

b. Due to the complexity of designing in-line variable speed booster pumping systems, a detailed engineering study shall be carried out to examine the technology and economic feasibility of selecting a VSD pumping system over other conventional constant speed pumping systems; focusing on the

technical characteristics of individual components. If necessary a pump manufacturer shall be consulted during the selection process.

c. The design submission by the competent person for an in-line variable speed booster pumping system shall include a description of the control system, and a plot of pump performance curves at various operating speeds superimposed on the system curves that describes the range of flows to be pumped and the related total dynamic head requirements to be met. Pump efficiency trends shall also be included in the plot.

d. The type of pumps used, and the pump efficiency ratings at the maximum flow rate, shall comply with the requirements stated in **Table D.1**.

e. The redundancy policy for variable speed pumping systems shall be as follows:-

- Two standby pumps to backup a single duty pump.
- 100% standby pumps to backup two or more duty pumps.

f. Each pump shall be provided with an individual variable speed drive.

g. The power supply to the variable speed pumping system shall be backed up by a generator set capable of supplying the rated power needs.

D.6 PRESSURE GAUGES

a. The construction of pressure gauges shall comply with BS EN 837-1: 1998.

b. The gauge used shall be of the liquid filled type.

c. The entire gauge shall be calibrated, either in a single scale unit expressed in meter (head) or dual scale expressed in head of water.

d. The size of the dial gauge or face of the pressure gauge shall not be less than 100 mm in diameter for pump capacities of below 300 m^3 / hr; and 150 mm in diameter for pumping capacities above 300 m^3 / hr.

e. A pressure gauge shall be installed when measuring suction pressures.

f. The measuring range of a suction pressure gauge shall generally be between - 10m to 10m head of water, or 125% of the maximum pressure.

g. The gauge shall incorporate a micrometer zero adjustment pointer and restrictor screw.

h. The over pressure limit shall not be less than 1.30 x full scale dial. Suitable gauges shall be selected such that the working pressure ranges between 50% and 70% of the full scale dial.

i. The accuracy shall be +/- 1% full scale dial or better according to BS EN 837-1 : 1998.

j. A pressure gauge shall be installed at every suction pipe, every delivery pipe and at the common header pipe.

k. The location of all pressure gauges shall be indicated in the submission drawings.

l. The gauge shall be installed with the following necessary accessories to protect the gauge:-

i. **Snubber** for protection of the gauge against sudden pressure change and fluctuation of pressurized fluid.

ii. **Instrument isolating Valve (Needle Type)** for isolation of the gauge from the fluid in the pipework.

iii. **Overload Protector (For pump discharge side)** for protection of pressure instrument from over pressure, exceeding the specified pressure range by sudden and excessive pressure fluctuation from surges or spikes.

D.7 SUCTION AND DELIVERY PIPES

The criteria to be adopted when designing suction and delivery pipes are as follows:-

a. Suction pipe shall be as short as possible. Push-on-spigot and socket type joints shall not be permitted for suction pipelines.

b. Bends shall be avoided, if possible, along a suction pipeline.

c. The minimum length of straight pipe located before the suction intake of pumps shall be at least 5 times the diameter of the suction pipe.

d. The clearance between the inlet end of the suction pipe, or strains, and the base level of the pumping cistern shall be a minimum of 0.5 to 0.8 times the pipe diameter.

e. The depth between the suction cistern inlet end of a suction pipe, or strainer, and the base level of the pump chamber shall be a minimum of 0.5 to 0.8 times the pipe diameter.

c. The distance between the inlet end of a suction pipe and the wall of the pump chamber shall be more than one and a half (1½) times the pipe diameter.

d. The distance separating adjacent suction pipes of equal diameter shall be more than three (3) times the pipe diameter.

e. For suction pipes of different diameters, the separation distance between pipes shall be more than three (3) times the largest diameter.

f. When sizing suction and delivery pipes within the pumping station, the velocity of flow shall not be greater than 1.5 m/s and 2.5 m/s respectively.

D.8 PIPEWORKS

a. All mild steel pipes shall be cement mortar / concrete lined, or lined by other approved materials internally, in accordance with approved specifications by the Commission.

b. All pipes and specials, and associated materials of construction, shall either be of mild steel or ductile iron conforming to the latest MS standards as imposed by the Commission.

c. All mild steel pipes and specials shall be painted with one (1) layer of zinc chromate and two (2) layers of gloss finish coating, whilst ductile iron pipes and specials shall be painted with two (2) layers of gloss paint externally.

d. All pipes laid above ground and located within a pump station shall be flange jointed, machined and drilled and conforming to BS EN 1092-1 : 2007, BS EN 1092-2 : 2007.

e. Coal tar coating or bitumen coating shall be applied on the external surfaces of all buried pipes.

f. Thrust blocks shall be designed to withstand the magnitude of thrust forces that are induced at bends, tees, wyes, etc.

D.9 VALVES

D.9.1 Sluice Valves

a. Sluice valves shall conform to the requirements of standards recognized by the Commission and the closing direction of the valve should generally be clockwise. Anti-clockwise closing of sluice valves shall be accepted by the Certifying Agency if adequate reasons are submitted to opt for such an alternative mode of operation.

b. The valve should be fitted with hand wheels with the direction of opening and closing cast marked thereon. Exceptions to this norm may be considered and approved by the Certifying Agency.

c. Sluice valves in pumping stations shall only be used for pipe sizes of 300 mm diameter and below.

d. Sluice valves with pressure rating of not less than PN 16 shall only be employed.

e. The sluice valves shall be coated with epoxy paint conforming to standards agreed by the Commission.

D.9.2 **Butterfly Valves**

a. All butterfly valves shall conform to the requirement of Standards approved by the Commission and shall be used for pipe sizes above 300 mm diameter.

b. Butterfly valves with pressure rating not less than PN 16 shall only be employed.

c. For butterfly valves without a motorized gear, a suitable hand wheel on headstock shall be provided for manual operation.

d. Manual gearing actuators may be used for valves of 450 mm nominal diameter and below. For valves of 500 mm nominal diameter and above, only motorized actuators shall be used.

D.9.3 **Non-slam Type Check Valves**

a. Non-slam check valves employed shall conform to BS EN 12334 : 2001, and shall have high operating reliabilities and sustain minimum pressure losses.

b. The valve shall have metal to metal seating and shall be equipped with minimum wearing parts and in general shall require minimum maintenance throughout its operating life.

c. The non-slam type valve shall be designed for shock free closure, and may be installed in any position i.e. horizontal, vertical or inclined.

D.9.4 **Altitude Valves**

a. Float operated valves may be used for incoming pipe of up to 150mm diameter. For incoming pipes of 200mm diameter and above, altitude valves or other level control devices shall be used.

b. Altitude valves control the water level in a reservoir. It remains open when the reservoir is not full and closes when the tank reaches its maximum water line.

c. Strainers shall be installed before any altitude valve.

d. A by-pass pipe and isolation valve shall be installed to facilitate the repair and maintenance of an altitude valve.

e. The selection of altitude valves shall take into consideration the water pressure of the incoming pipe to ensure that the altitude valve shall be able to close without leaking when the high water level is reached. If this is not possible, alternative types of water level control valves which are permitted by the Commission shall be employed instead.

f. Level electrode systems may be used in lieu of altitude valves to control water delivered to a reservoir by pumps.

D.10 SURGE SUPPRESSION SYSTEMS

a. To counter water hammer, the following mitigating systems shall be used in pumping stations:-

i. Adoption of pressurized surge vessel to prevent column separation, taking into consideration the incorporation of check valves as part of the surge vessel system.

ii. Adoption of surge anticipating valves which open or close at specific preset values so as to lower surge pressures in the pipeline.

b. A surge analysis shall be carried out for a particular pumping system to profile the variation of induced pressures along the pipeline, and within a surge vessel.

c. The surge analysis shall elucidate the changes in air volume and pressures within the surge vessel after incorporating check valves as part of the overall suppression system.

d. A surge analysis shall also be carried out if surge suppressionemploying surge anticipator valves is to be adopted.

e. Manufacturers of surge vessels are required to submit complete sets of drawings, calculation and other required information to Jabatan Keselamatan dan Kesihatan Pekerjaan (JKKP) for approval. The Contractor shall be responsible for obtaining Permit Mesin Tekanan (PMT) certificates from JKKP.

f. The competent person shall submit appropriate documentation which describes the concept and functional characteristics of the overall surge suppression system, and provide design calculations supporting the sizing of components including duty and standby air compressors, as well as system drawings and test certificates as part of the O & M manuals.

g. If a surge anticipator valve is used, the water discharged from the surge anticipator valve shall be channeled back to the suction tank or otherwise be recovered without affecting the proper functioning of the surge anticipator valve. If this is not possible, a surge vessel should be used.

h. Other types of surge suppression system sanctioned by the Commission may be employed.

D.11 VIBRATION AND NOISE CONTROL

a. The noise level within a pumping station, and at its boundaries, shall comply with the requirements of JKKP and Jabatan Alam Sekitar (DOE) respectively.

b. Where required, suitable noise barriers or acoustic barriers, shall be installed to reduce the intensity of noise propagated from the noise source so that Jabatan Alam Sekitar's noise limits at the pump station boundaries can be complied with.

c. The design of the pumping system shall avoid intruding into pump operating regimes outside of the stable region of the pump performance curve.

d. The pump manufacturers shall submit a report, or provide evidence that the rotating components in the pumps are balanced in compliance with internationally accepted balancing standards.

e. The alignment of the pump and motor shall be performed by a trained and experienced person and the accuracy of alignment shall meet the specific requirement of the pump manufacturer.

f. The natural frequencies of the supporting floor elements, pump set, and the pipe support system shall be analysed. A structural engineer and the pump manufacturer shall be consulted in

performing this analysis to avoid resonance effects taking place at the pump, pipework and supporting floor.

g. The manufacturer's technical catalogue shall be referred for selecting vibration isolators to be installed. In this respect the performance characteristics of vibration isolators shall be given due consideration in the selection process.

h. Where stipulated by JKKP, hearing protectors shall be provided for use by operating and maintenance personnel.

D.12 MECHANICAL HANDLING EQUIPMENT

a. Gantry crane with electrically operated hoisting equipment shall be installed for lifting loads exceeding 1,000kg.

b. Gantry crane with manually operated hoisting equipment shall be installed for lifting loads between 50kg and 1,000kg.

c. Monorail cranes shall be used for lighter lifting loads, and when the centre line of the equipment is inline with entry or exit provisions.

d. All cranes shall be suitably sized to lift 1.25 times the weight of the heaviest equipment.

e. Electrically operated cranes shall be required in large installations where individual equipment weighs more than 2,000 kg. Wire rope hoisting units shall be used in conjunction with electric operated cranes for lifting capacities more than 2,000 kg of safe working load.

f. Manufacturers shall endorse and submit all design calculations and drawings for cranes to JKKP, and apply for installation approvals.

g. The Contractor shall be responsible for obtaining a Permit Mesin Angkut (PMA) Certificate for the crane or monorail hoist from JKKP.

h. All required drawings, calculations and certificates shall be handed over to WDL during the first handing over inspection process.

D.13 DRAINAGE SYSTEM

a. Scupper drains shall be provided around the pumping equipment to drain any stagnant water which may accumulate to an external drain.

b. Where the pump chamber is located below grade, the scupper drain shall drain to a pit where a duty and a standby drainage submersible pump complete, with float switch for automatic operation, shall be provided to transfer the water accumulated to the external drain.

D.14 MECHANICAL SPARE PARTS

Developers are required to provide the following minimum mechanical spare parts together with any pumping stations:-

a. One (1) set of repair kit for Altitude Control Valves.

b. One (1) set of repair kit for Surge Anticipator Valves.

c. One (1) set of Mechanical Seals.

d. One (1) set of Complete Rotating Assembly for each type of pump

e. One (1) set of Pump and Motor Bearings.

f. One (1) set of impeller wear rings.

PART E : ELECTRICAL DESIGN FOR PUMP STATIONS AND RESERVOIRS

E.1 ELECTRICAL SYSTEM

The electrical design of a typical pumping station and reservoir should address fourteen (14) main topics, namely:-

a. Standards, Codes of Practice, Rules and Regulations
b. Power supply requirements
c. Medium Voltage (MV) installations
d. Low Voltage (LV) installations
e. Essential power supplies
f. Motor starter panel (Motor control centre)
g. Electric motors
h. Internal lighting and small power systems
i. Compound lighting
j. Lightning protection systems
k. Earthing systems
l. Electrical spare parts
m. Electrical As-built drawings
n. Testing and commissioning

E.2 STANDARDS, CODES OF PRACTICE, RULES AND REGULATIONS

a. All designs, materials, construction works and equipment installed shall conform to the relevant standards, regulations and by-laws imposed by authorities having jurisdiction over the installation of an electrical system. These include: -

i. Pihak Berkuasa Tempatan

ii. Suruhanjaya Tenaga (ST)

iii. Tenaga Nasional Berhad (TNB)

iv. Telekom Malaysia Berhad (TM)

v. Jabatan Bomba Dan Penyelamat Malaysia (BOMBA)

vi. Jabatan Alam Sekitar (JAS)

vii. Jabatan Penerbangan Awam (DCA)

viii. Jabatan Keselamatan dan Kesihatan Pekerjaan (DOSH)

ix. All other relevant authorities having jurisdiction on the installations.

b. The following Act, Regulations and standards shall generally be applicable to the design of electrical systems:-

i. Electricity Supply Act 1990
ii. Electricity Regulation 1994
iii. Malaysian Standards (MS), where applicable.
iv. Other International Standards such as IEC, IES, IEEE, where applicable.
v. BS 7671: 2008 IEE Wiring Regulations for Electrical Installation, latest edition.

Where there is a discrepancy between standards, or differences in requirements specified in two or more documents, or between published specifications and the specific requirements of a local authority having jurisdiction, over electrical installations, Malaysian Standard (MS) shall be adopted.

E.3 DETAILED DESIGN SUBMISSIONS

a. The Competent Person shall submit the following information to the certifying agency for approval :-

i. Letter from the Certifying Agency on approving of external water supply system including the pumping station layout works.
ii. Catalogues for all materials/equipments where required by the Certifying Agency.
iii. Control circuit diagrams.
iv. All electrical conceptual drawings including single line diagrams and layout drawings as per items listed in Clause E.1.b. to E.1.k.

b. All electrical drawings shall be of A1 size.

c. All submission drawings shall be endorsed by a Competent Person (PE of electrical discipline as in schedule 2 of Water supply Rules)

E.4 POWER SUPPLY REQUIREMENTS

a. The owner or developer shall apply to TENAGA NASIONAL BERHAD (TNB), through their appointed Competent Person, for electric power supply to the reservoir and/or pumping station.

b. The Competent Person shall liaise with TNB to confirm and obtain approval on the numbers, area of land required and locations of TNB substations as required.

c. for the most appropriate electricity tariff and intake voltage supply level from TNB.

d. The developer shall pay the electricity bill for the reservoir and/or pumping station before handing over of water supply system.

e. The developer shall be responsible for changing the TNB account name to WDL after handing over of water supply system.

E.5 MEDIUM VOLTAGE (MV) INSTALLATIONS

a. All 11 KV switchgears shall incorporate both Potential Transformers (PT) and metering Current Transformers (CT) for TNB to meter electricity usage by consumers.

b. The 11 KV circuit breakers shall be of the vacuum, gas insulation or modular distribution types.

c. A Vacuum Circuit Breaker (VCB) shall have a rated short circuit breaking current of 20 kA for 3 second minimum and rated impulse withstand of 75 kV.

d. Operation of the VCB shall be by a motor-wound spring assisted system. Both over current and earth fault protection via electronic relays shall be provided.

e. Integral earthing on the cable side shall be provided for outgoing feeders.

f. All MV design shall be subjected to the approval of the Certifying Agency.

g. MV cables shall be of cross linked polyethylene (XLPE) copper cables (with steel wire armoured protections). Size of cables shall meet the necessary fault level current associated with the switchgear.

h. Power transformers shall be of the cast resin or oil type, and shall comply with the requirements of BS EN 60076 and BS EN 50216.

i. A separate TNB metering panel shall be provided inside the Consumer MV switch room.

E.6 LOW VOLTAGE (LV) INSTALLATIONS

a. Low Voltage switchboards shall comprise of the following:-

i. A floor standing cubicle shall be provided if the main incoming feeder has a running load of 250A and above.

ii. Either a floor standing or wall mounted cubicle shall be provided if the main incoming feeder has a running load of less than 250A.

b. For Main Incoming of 800 A and above

Air Circuit Breakers (ACB) complete with one (1) element earth fault IDMT relay, three (3) elements over current IDMT relay and all current transformers for protection, shall be provided. IDMT shall be of the numerical or electro-mechanical type. Surge Protection devices complying with Zone 1 Protection as defined in IEC 61643-12 shall be provided.

c. For Main Incoming of less than 800 A

Moulded Case Circuit Breaker (MCCB) complete with one (1) element earth fault IDMT relay, three (3) elements over current IDMT relay and all current transformers for protection, shall be provided. IDMT shall be of the numerical or electro-mechanical type. Surge Protection devices complying with Zone 1 Protection as defined in IEC 61643-12 shall be provided.

d. For Main Incoming of less than 60 A only

A 60 A MCCB complete with shunt trip coil in series with a Zero Current Transformer (CT) and Earth Leakage Relay (ELR), complete with over current used at the incomer side, shall be provided. Electric Surge Protection devices complying with Zone 1 Protection as defined in IEC 61643-12 shall be provided.

e. Outgoing Breakers at Main Switchboards

All outgoing breakers from main switchboards to other parts of the electrical system (such as distribution boards and motor starter panels) shall be of the MCCB type, complete with shunt trip coil of appropriate rating. The rating of MCCB shall be 25% higher than the full load current.

f. Power Factor Correction

The power factor of the loads shall be corrected to not less than 0.90 lagging. The power factor correction capacitance shall be installed either at a central point, for example, at the MSB or in parallel with each individual starter panel.

g. Harmonics

Automatic harmonic current suppressors, capacitors and blocking reactors of appropriate ratings shall be installed in the main switchboards where harmonic generating equipment such as Variable Speed Drives (VSD) is installed.

h. Cable Types

Cable from main switchboard to distribution boards and motor starter panels shall be of XLPE insulated copper cables. For distribution of loads, XLPE or PVC insulated copper cables shall be used. For underground and surface mounted installations, the following cable shall be used:-

Multi-core cable of 25mm^2 and above	-	XLPE/SWA/PVC
Multi-core cable of 16mm^2 and below	-	PVC/SWA/PVC
Single core cable	-	XLPE/AWA/PVC

i. Cables for Fire Fighting Equipment

Dedicated cables to fire fighting equipment shall be of the fire resistance type approved by BOMBA.

j. Circuit Wiring

All sub-circuit and final circuit wiring shall be encapsulated by high impact uPVC conduits when concealed in false ceiling or walls, and by galvanised iron (G.I.) conduits when exposed or supplied to fire protection devices.

k. Cable Supports

All cable trunkings, trays, ladders shall be hot-dipped galvanised. Identification shall be provided for electrical trunkings and cable trays. The number of cables installed in trunking trays, conduits, and ladders shall be such that a space factor of 45% is not exceeded.

l. Materials for Switchboard and Distribution Board

The construction materials for switchboards and distribution boards (DB) shall be as follows: -

i. Main Switchboard

Constructed from electro-galvanised, or galvanised steel iron sheet, with minimum ingress protection conforming to IP42. Form 3B segregation requirement shall be met. Panel thickness shall be at least 2 mm, and painted in beige colour with a paint thickness of at least 75 micron on average.

ii. Sub-switchboard

Constructed from electro-galvanised or galvanised steel iron sheet, with minimum ingress protection conforming to IP42. Panel thickness shall be at least 2mm, and painted in beige colour, with a paint thickness of at least 75 micron on average.

iii. Distribution Board

Constructed from electro-galvanised or galvanised steel iron sheet, with minimum ingress protection conforming to IP42. Panel thickness shall be at least 1.5 mm, and painted in beige colour with paint thickness of at least 75 micron on average.

E.7 **ESSENTIAL POWER SUPPLY**

a. Essential back-up power supply systems, in the form of diesel standby generator sets, shall be provided for pumping stations transmitting a flow of more than 4.5 Mld.

b. For pumping stations transmitting flows less than 4.5 Mld, a manual change over switch shall be provided at the electrical switchboard to enable switching over to back up supply from a mobile generator in the event of failure of power supply from TNB.

c. The essential backup power supply system shall be in compliance with Jabatan Alam Sekitar requirements with respect to limiting noise levels.

d. The fuel tank supplying a diesel generator shall have the required capacity to enable generator sets to continuously run for at for least 24 hours at full load.

e. The sizing of standby generators shall take into consideration the power ratings of all duty pumps running (N-1), and the starting of the last duty pump. (For example: sizing criteria for 3 duty pumps: 2 duty pump running + 1 duty pump starting)

E.8 **MOTOR STARTER PANELS**

a. All motor starter panels shall be of the floor standing cubicle type except for motors having loads of less than 250 A which can be of the floor standing or wall mounted type.

b. The motor starters shall either be integrated with the electrical switchboard, or it shall be a stand alone module with sub-main cables being fed from the main switchboard through circuit protective devices to its starter panel complete with earth fault relay and over current relay IDMT.

c. The motor starter panel shall have the following features:-

i. ACB/MCCB shall be provided for main incoming supply to its starter panel.

ii. The kA rating of the ACB/MCCB shall comply with the fault level of the motor starter panel.

iii. Direct On Line (DOL) starter contactors shall be rated to handle the full load current of the motor.

iv. Miniature circuit breaker (MCB) shall be provided for individual control circuits.

v. Motor heater circuits shall be equipped with motor heater switches and indicator lights.

vi. Panel heater circuits shall be equipped with MCB, heater switches, thermostat controls and indicator lights.

vii. The types of motor protection relays to be provided shall be dependant on power ratings as follows:

0 kW - 37 kW	-	Thermal Overload Relay with ERL
Above 37kW	-	Electronic micro processor or Electro-mechanical type of motor protection relay

viii. All motor starters shall be provided with phasing relays complete with MCB.

ix. The entire autotransformer and rotor resistance bank, complete with thermistors, shall be installed at the top compartment of a switchboard; and within the same vertical module of switchboard housing the motor circuit.

x. The main earth chamber shall be painted in green colour, and the proposed type to be employed shall be subject to the approval of the Certifying Agency.

xi. The motor can be operated by local manual control, automatic control or remote control

mode via a SCADA/ Telemetry system.

xii. The automatic operation of motors shall be controlled by the level of water in the suction and elevated service reservoir tank, by floatless and control relays at the motor control centre, and by a 3-CORE (copper) PVC/SWA/PVC under ground cable laid adjacent to the pumping mains. If the elevated service reservoir tank is located external to the compound of the pumping station, a controller which is coupled with a GSM/GPRS (SMS) system, conforming to WDL requirements, shall be provided. This shall be an independent system from the existing Telemetry system.

xiii. Cables for automatic operation shall be of 2.5 mm2 or above, and insulation shall be above 10M ohm.

xiv. All electrode sets shall be of 13 mm diameter, and of stainless steel make.

xv. The starter shall have a protection timer incorporated in the starting sequence.

xvi. All indicator lights shall be of the LED type.

xvii. Power factor shall be corrected to not less than 0.90 lagging.

xviii. All capacitor banks shall be rated at 440V and shall be protected by fuses.

xix. All outgoing cables to motors shall be of the armoured type, and shall be laid in trenches or concealed in G.I. conduits placed on the floor slab.

E.9 ELECTRIC MOTORS

a. All motors shall be of the induction type as specified below:-

i. All motors shall be of the High Efficiency Motor standard type, i.e. EFF1 CEMEP-EU standard, Class 1 as detailed in **Table E.1**. Motors of capacity greater than 90 kW shall have an efficiency of not less than 95.0%. Compliance to this Clause is mandatory for external pumping stations.

ii. High Efficiency Motors of performance rating equals to or exceeding EFF1 class certified by other internationally recognized organizations may also be used subject to the approval by the Commission.

iii. Motor up to 10 horsepower / 7.5 kW shall be of squirrel cage motor with direct-on line starter.

iv. Motor of more than 10 horsepower / 7.5 kW and less than 150 horsepower / 110 kW shall be squirrel cage motor with autotransformer starter.

v. Motor of 150 horsepower / 110 kW and above shall be squirrel cage motor with soft starter or slip rings motor with rotor resistance starter.

vi. Autotransformer starters may be used for motors of rating higher than 150 horsepower / 110kW on the condition that a detailed calculation to verify that TNB's power supply system is not adversely affected by the starting of the pumps is approved by TNB.

b. In any case, the starting operation of a motor shall not have any undesirable effects on other electrical power consumers.

Table E.1 Class Definition for Electrical Motors

Motor Capacity (kW)	Motor Efficiency (%) for Class EFF1	
	2-Pole Motors	4-Pole Motors
1.1	≥ 82.8	≥ 83.8
1.5	≥ 84.1	≥ 85.0
2.2	≥ 85.6	≥ 86.4
3	≥ 86.7	≥ 87.4
4	≥ 87.6	≥ 88.3
5.5	≥ 88.6	≥ 89.2
7.5	≥ 89.5	≥ 90.1
11	≥ 90.5	≥ 91.0
15	≥ 91.3	≥ 91.8
18.5	≥ 91.8	≥ 92.2
22	≥ 92.2	≥ 92.6
30	≥ 92.9	≥ 93.2
37	≥ 93.3	≥ 93.6
45	≥ 93.7	≥ 93.9
55	≥ 94.0	≥ 94.2
75	≥ 94.6	≥ 94.7
90	≥ 95.0	≥ 95.0

E.10 INTERNAL LIGHTING AND POWER REQUIREMENTS

a. General lighting and power distribution inside the pumping station shall be fed from a distribution board equipped with a current operated Residual Current Device (RCD) and main switch. Separate Residual Current Device (RCD) shall be employed for delivering power to lighting fixtures and power switch socket outlets. The sensitivity of the RCD shall comply with the latest Suruhanjaya Tenaga's specifications for various applications.

b. The light fitting and illumination levels for common areas in pumping stations are stated in **Table E.2**.

Table E.2: Illumination Level

Area	Maintained Average Illumination (lux)
Office/Computer Rooms	400
Store	200
M&E Plant rooms and Pumping Station	250
Internal Corridors	100
Toilets	150

c. Control of lighting for the different areas of a pumping stations and reservoirs shall be achieved by the following methods, depending on type of area and usage:-

i. Partitioned areas : Individual switch

ii. Open areas : Switch centre

d. Lighting circuits shall be arranged as alternating circuits.

e. Lighting and small power circuitry / DB shall be provided with Earth Leakage Circuit Breaker (ELCB) complete with auto reset function for Reservoirs.

f. All light fittings shall be of energy efficient type.

g. The types of light fittings to be employed at different areas are described in **Table E.3**.

Table E.3: Type of Light Fitting

Area	Area Type of Light Fitting
Office/Computer Rooms	Fluorescent light fittings with aluminium reflector (Preferably using 28W T5 lamps)
Store	Bare channel fluorescent light fittings (Preferably using 28W T5 lamps)
M&E Plant rooms and Pumping Station	a. 5 m height and above - low bay metal halide (corrosion resistance type) b. Less than 5 m - wall mounted fluorescent light fittings complete with metal reflector (Preferably using 28W T5 lamps)
Internal Corridors	Fluorescent light fittings with aluminium reflector (Preferably using 28W T5 lamps)
Toilets	Compact fluorescent down light c/w electronic ballast

h. Exit lights ("KELUAR" SIGN) and self-contained emergency lights of fluorescent type, with minimum three hours of battery (rechargeable) reserve, shall be provided for all areas in accordance with BOMBA and UBBL requirements.

i. A "KELUAR" sign complete with arrow sign showing the exit direction shall be provided where appropriate.

j. Sufficient power points of a suitable type and rating shall be provided to serve the intended use of common areas or rooms, and for all equipment and plants to be installed including power points for all mechanical equipment requirements.

k. Each equipment shall have its own power point. No two (2) equipments shall share the same power point. Additional 13A switch socket outlets shall be provided for general use in all areas.

E.11 EXTERNAL LIGHTING INSTALLATIONS

a. External compound street lighting shall be provided for the pump stations and reservoirs. The compound / street lighting shall be mounted on 5 m high galvanized iron poles. Other types of compound / street lighting pole shall be subjected to the approval of the Certifying Agency. Wall mounted light fittings shall be used where pole mounted light fittings are not suitable. Generally, the spacing between the poles shall not exceed three times the mounting height of the pole. The lamps for the light fittings shall be of SON/energy saving type or equivalent. The illumination level on the ground road surface shall not be less than 15 lux.

b. Area floodlighting shall be provided where necessary, and SON type of floodlighting shall be provided with an average of 30 lux.

c. Suitable path lighting with SL or PL lamps shall be provided in the walk paths.

d. All linkways and covered walkways shall be illuminated using tamper proof luminaries with an average illuminating level of 30 lux.

e. Control of these various lighting systems shall be by local relays, time switches and photocells complete with contactors. Override facilities shall also be provided.

E.12 LIGHTNING AND SURGE PROTECTION SYSTEMS

a. Lightning protection system shall be provided for pumping stations, service reservoirs and suction cistern, especially for RC structures.

b. Lightning protection system for the building shall be of the Faraday cage type conforming to MS-IEC 61024-1 requirement. Other lightning protection systems shall be subjected to the approval of the Certifying Agency.

c. For metal roofing, the metal structure shall be exothermically bonded with a copper tape or bare stranded G.I. cable. Otherwise roof conductors shall be installed.

d. The system shall comprise down conductors, non-radioactive air terminals, fixing, bonding, jointing, test clamps, earth clamps, earth electrodes, concrete and precast earth chambers, etc kl;kl;ko.

e. All exposed metallic protrusions on buildings shall be connected to the lightning protection system.

f. Lightning surge protection devices shall be provided for all power and data lines to ensure all equipment inside computer rooms, network equipment rooms and SCADA/ Telemetry control rooms are protected against lightning surges complying with Zone 1 Protection as defined in IEC 61643-12.

g. All down conductors shall be concealed in conduit within building structures to prevent the theft of the copper conductor.

h. Earth resistance value for lightning protection system shall not exceed 10 ohms.

E.13 EARTHING SYSTEMS

a. Earthing systems shall comprise several sets of earth electrodes, earth clamps, lug couplings, copper tape or bare stranded G.I. cable and concrete and precast earth chambers. More elaborate measures shall be proposed if earth resistance values could not be achieved.

b. An equipotential earthing system shall be provided to prevent dangerous voltage rise between different earthing systems. This involves tying together the various roof earthing systems for electrical, lightning protection, telecommunication and the building structure. All service metallic pipes and exposed metallic protrusions on the building shall be earthed together.

c. Earth resistance for electrical earthing, electronic and telecommunication (clean) earthing shall be of 1 ohm or less (separately measured for each system before interconnection).

E.14 ELECTRICAL SPARE PARTS

Developer/Contractor is required to provide the following electrical spare parts:-

a.	RCCB and MCB	-	5 nos. (each type)
b.	MCCB	-	1 no. (each type)
c.	Contactor	-	5 nos. (each type)
d.	Lamps	-	5 nos. (each type)
e.	HRC Fuses	-	5 nos. (each type)
f.	Indicating Lamps	-	5 nos. (each type)

g.	Voltmeter	-	1 no. (each type)
h.	Ammeter	-	1 no. (each type)
i.	Motor Protection Relay	-	1 no.
j.	Current and Voltage Transformer	-	1 no. (each type)

All proposed brands for spare parts shall be as per that installed at site.

E.15 **ELECTRICAL AS-BUILT FITTED DRAWINGS**

a. All electrical drawings shall be of A1 size and endorsed by a Competent Person.

b. Three (3) sets of electrical drawings and electrical load calculations and three (3) sets of key plan shall be provided and endorsed by the Competent Person on behalf of the developers / contractors where:-

i. One (1) set of main single line diagram shall be framed and hung in the pumping station.

ii. One (1) set shall be submitted to WDL Headquarters.

iii. One (1) set shall be submitted to the District Office of WDL.

c. Three (3) sets of Operation and Maintenance Manual shall be provided by the Competent Person on behalf of the developers / contractors where:-

i. One (1) set shall be kept in the pumping station and located at a wall mounted rack.

ii. One (1) set shall be submitted to WDL Headquarters.

iii. One (1) set shall be submitted to WDL District Office.

d. Two (2) electronic copies (in AutoCad Format) of the As-Built drawings and O&M Manual shall be handed over to the WDL.

E.16 **TESTING AND COMMISSIONING**

a. Two (2) sets of a testing and commissioning reports incorporating results that are endorsed by a Competent Person, shall be forwarded to the Water Distribution Licensee (WDL).

b. The developer's contractor shall carry out all testing and commissioning to verify the safe, reliable and satisfactory operation of the electrical supply and distribution system and equipment installed.

c. At least two months prior to testing or commissioning of any system, the developer's contractor shall furnish the following information for each system or process to the WDL for review.

i. Testing procedure and details as well as the relevant report forms that will be submitted to the WDL for approval.

ii. Type of testing instruments to be used

iii. Valid calibration certificate by approved Authority

iv. Complete schedule and programme of all testing and commissioning

d. The developer's contractor shall employ a team of competent and experienced

personnel to carry out all testing and commissioning works. If it is the opinion of the WDL that the testing and commissioning of parts of a system or the whole system, have not been properly executed by the contractor's own staff, the contractor shall employ a qualified independent Testing and Commissioning Specialist to carry out necessary Works, when directed by the WDL. The cost of employing this Testing and Commissioning Specialist shall be borne by the contractor.

e. The developer's contractor shall provide all instruments, tests and labour necessary for testing and commissioning of the entire installation.

f. All instruments shall have been recalibrated within six months of the start of commissioning or testing. Calibration of all instruments shall be certified by the instrument manufacturers or an approved calibration agency.

g. Should the results of any test show that any plant, system or equipment fails to perform to the efficiencies or duties as given in the Specifications, the developer's contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance may be obtained.

h. Should it be necessary for the developer's contractor to modify or replace any item of plant as described above, he shall be responsible for the cost for making good of any damage or deterioration to the building or other services consequent to such modifications.

i. All equipment testing and commissioning shall be carried out by relevant engineers who has undertaking the similar system.

PART F: TELEMETRY AND SCADA SYSTEMS

F.1 DETAILED DESIGN SUBMISSION

a. The submission requirements shall as per Clause E.3

b. The Competent Person shall submit the following information to the Certifying Agency for approval:-

i. Catalogues for Telemetry and Instrumentation Equipment
ii. All SCADA/ Telemetry system drawings

F.2 GENERAL

a. The purpose of Telemetry or Supervisory Control and Data Acquisition System (SCADA) systems are to enable real time measurements and data acquisition of operating parameters associated with water supply facilities located at remote (outstation) areas. In this context information such as water levels at suction tanks and reservoirs; flow rates and flow volume at outlet pipes of reservoirs; pump operating status (On / Off / Fault); pressure level at pump delivery pipes, and other such important operational parameters are required to be transmitted from an outstation facility to WDL's command centre.

b. SCADA, enables WDL personnel to operate and control the essential functions of water supply facilities at remote areas from their operating centres, in addition to recovering basic information (as in a Telemetry System).

c. Telemetry systems shall be planned, design and installed and paid for by Developers; whereas SCADA systems which build on Telemetry systems shall be installed by the WDL.

d. A Telemetry system shall comprise, inter-alia, transducers (sensors), local display panel / indicator panels, power supply units, Remote Terminal Units (RTU), all necessary cabling work and GPRS / GSM modems for transmission of data to the WDL's command centre. For water supply facilities located at areas where GPRS / GSM services are not available, the wireless communication shall be by radio link.

e. The developer's scope of work for the Telemetry system shall also include installing a termination block at the motor control centre to enable remote manual start / stop of the pumps when the Telemetry system is upgraded by WDL to a full fledged SCADA system.

f. All detailed drawings for RC chambers and covers for flow and pressure transmitters shall be submitted to the Certifying Agency (CA) for approval prior to construction. All chambers shall be design to protect it from becoming water logged.

g. The laying of power and signal cables (inclusive of protective covers, cable route markers and cable joint pillars (for underground cable joint, if any) shall be in accordance with the requirements of the WDL. All underground cables shall be of the Steel Wire Armoured (SWA) type.

h. All earthing points shall be of 1 ohm or less.

i. All equipment and instrumentation requirements and specifications shall comply with the requirements of the WDL.

j. All testing, commissioning and calibration of Telemetry and SCADA system shall be carried out by the supplier as authorized by the WDL.

F.3 HARDWARE REQUIREMENTS

F.3.1 General

a. State-of-the-art Telemetry equipment shall be provided, and shall incorporate the latest available solid-state designs which have successfully been tested in field operations, and are capable of giving satisfactory performance and be compatible with WDL's hardware and software requirements for a SCADA system.

b. The Telemetry system shall be modular in concept, leading to a system that can be easily expanded, modified or reconfigured. The system shall be expandable in order to cope with envisaged future requirements. The addition of outstations or MMIs in future shall be carried out without taking the system out of service and shall not jeopardize the continuous working of the rest of the system.

c. The system shall be designed for continuous fail-safe operation with minimum amount of maintenance. Failure in any part of the system shall be localized to that part only, and shall not cause damage to other parts of the system.

F.3.2 Outstations

a. The outstation equipment shall be provided in dust proof, industrial type fiber reinforced-polyester enclosures rated at IP66 for both indoor and outdoor installations. All outstation equipment including the GSM modem, antennae and back-up power batteries shall be installed within an enclosure, and shall not be directly exposed to the elements.

b. The outstation equipment furnished shall be designed for installation in a dusty, humid and tropical environment and shall operate satisfactorily in temperatures between 5 deg. C and 70 deg. C, and up to 95% relative humidity assuming no condensation will occur. Each outstation shall be a stand alone RTU, unit capable of performing data acquisition and control, independent of the master station. Each outstation shall be provided with the required number of inputs and outputs subject to the approval of the WDL.

c. All inputs shall be time-tagged and transmitted to the master station. The time-tag shall be the actual time of an event, and its accuracy and resolution shall be within 1 second.

d. Reservoirs at outstation locations shall communicate with the master station via a GPRS communication link. In the event of a GPRS connectivity failure, the reservoir outstations shall be able to operate a SMS to the Master Station and/or to respective pumping stations at outstation locations. The outstation RTUs shall incorporate a report-by-exception (RBE) feature, where only data from 110 points that have experienced a change in status shall .be reported back to the master station. For analogue input points, the user shall be able to set the percentage of change in the measured parameter that represents a change in status for reporting to the master station.

F.3.3 Remote Terminal Units

Remote Terminal Units (RTUs) shall be provided at outstation facilities in accordance with the related specification requirements and drawings. Two (2) types of RTU shall be used for different types of function. Both RTU types shall be equipped with a Pulse Counter function which can be assigned to any digital input (DI) point.

a. Type 1 : Designed for installations at remote sites without a permanent AC power supply source. The RTU shall be suitable for operation powered by a single phase supply with auxiliary supplies at 24VDC supply or 12VDC supply from a solar power system. Adequate quantity of solar panels shall be provided to fully restore battery power within 4 hours. Adequate quantity of batteries shall be supplied to provide power supply to the RTU and accessories for operations of up to 5 days without need for charging.

b. Type 2 : Designed for installations at pumping stations and any remote sites that require an expandable feature such as video surveillance features, door access system, and others.

Each type of RTU provided for the scheme shall be from the same manufacturer to provide standardization and interchangeability of equipment; in addition 20% active spares shall be provided for both types of RTU.

The communication protocol provided between RTU and control center (master center) shall be a minimum DNP 3.0; and the minimum standard of communication protocol between RTU and smart sensors shall be by Profibus PA or Profibus DP. The RTU shall be of low-power design. During active mode, the RTU shall consume no more than 1.2 watt. The RTU programming shall be compliant with IEC 61131-3 programming standard, and shall be supported with minimum ladder diagrams and structured texts. The analogue inputs shall have a 16-bit resolution with signal input accuracy of at least 0.05% of full-scale span.

F.3.4 **GPRS/GSM Modem**

a. GPRS / GSM modems shall be provided at each of the remote outstations for data communication. The modems shall come with a dual band feature, and be designed for data, fax, SMS and voice applications. The modems shall be compliant with GSM phase 2/2+ and allow control via AT commands. The modems shall support MS Class Band GPRS Class 8 for data transfer, and be suitable to operate in temperatures up to 55 deg. C. Modems at master stations shall be configured to send SMS to the selected authorized personnel and must be ready to receive SMS from existing metering zone sites. Modems at outstation areas shall be able to communicate with a broadband connection at the master station.

b. The outstations shall have a continuous GPRS link with the master station and upload any status change data to the master station. The master station shall not have to poll the outstations for data.

F.4 **COMMUNICATION SYSTEMS**

a. Outstation RTUs must be configured to use GPRS as a primary link to communicate with a master station, and must be able to switch to SMS mode in the event of GPRS connectivity failure.

b. In the event of GPRS connectivity failure, the data must be recorded, compressed and sent back to the Master Station via SMS at 4 hour intervals. Regardless of the failure of GPRS, all critical alarms shall be sent back in real time via SMS to the respective parties as specified by the WDLs.

C. Data transfer delay from RTU to Master Station and vice versa shall be within seconds.

F.5 **REQUIREMENTS OF TELEMETRY SYSTEM FOR WATER SUPPLY FACILITIES**

F.5.1 **Introduction**

a. Local RTUs shall transmit the relevant data including water levels, pressure, flow and other related information, for monitoring purposes via GPRS/GSM network to the WDL'S Master Station (Command Centre) as required in F.1 and F.2 above.

b. Additional features for the purpose of automatic operation, or SCADA, is beyond the scope of this Uniform Technical Guidelines.

F.5.2 **Suction Tanks**

a. One (1) no. pressure transmitter complete with pressure gauge and lightning surge arrestor shall be provided in a RC chamber located at the inlet pipe. The instrument shall be housed within a floor mounted weatherproof metal cabinet complete with high quality stainless steel padlock. Cable used shall be of 4 Core (C) of 2.5 mm^2 PVC armoured copper cable applicable to both power and signal transmissions. An earthing system of less than 1 ohm shall be provided.

b. One (1) no. level instrument ultrasonic transmitter, complete with lightning surge arrestor, shall be provided at the suction cistern. The instrument shall be housed within a floor mounted weatherproof metal cabinet complete with high quality stainless steel padlock. Cables used shall be of 4C 2.5 mm2 PVC armoured copper cable applicable to both power and signal transmissions. An earthing system of less than 1 ohm shall be provided.

c. An overflow detection system and level instrument accuracy checker, complete with stainless steel electrodes mounted on a stainless steel bracket, and supported by floatless and auxiliary relays, shall be provided at the overflow chamber to detect any overflows. Armoured type copper cable shall be employed for power and signal transmissions. Overflow detection will induce an alarm upon detecting a dangerous high liquid level. An accuracy checker will compare the reading at the level sensor against a fixed level water point in the suction tank. Percentage of error shall not exceed 2%.

d. Copper tape complete with concrete earthing chamber shall be used for an external lightning protection system. All installations shall be concealed inside a slab wall, etc. Earthing systems of less than 10 ohm shall be provided.

e. A 600 mm diameter mechanical dial indicator, incorporating a stainless steel wire type, shall be provided. The range of measurement shall be from 0 -10m.

F.5.3 **Pumping Stations**

a. One (1) no. magnetic flow meter with transmitter complete with two (2) nos. lightning surge arrestor shall be provided within RC chambers along the delivery pipes located within the pumping station compound. The flow meter shall be provided with a 25 mm dia. full bore tapping complete with ball valve. All instruments shall be housed in a floor mounted weatherproof metal cabinet complete with high quality stainless steel padlock. Cables used shall be of 4C 2.5 mm2 PVC armoured copper cable for both power and signal transmission (with 2 pairs of spare cables provided in each case). An earthing system of less than 1 ohm shall be provided.

b. A floor standing Remote Terminal Unit (RTU) instrumentation panel shall be provided complete with mimic diagram, one (1) no. RTU GSM System, time switch with contactor, all lightning surge arrestors, standby power supply system, relays, alarm annunciator, digital indicator, digital clock, indicating lights, siren and high quality stainless steel padlock. An earthing system of less than 1 ohm shall be provided.

c. One (1) no. pressure transmitter complete with pressure gauge and lightning surge arrestor shall be provided in a RC chamber at the pumping main. The instrument shall be housed in floor mounted weatherproof metal cabinet made of high quality stainless steel. Cables used shall be of 4C 2.5 mm2 PVC armoured copper cable (for both power and signal transmissions). An earthing system of less than 1 ohm shall be provided. A display shall be provided at the instrumentation panel for this sensor to indicate the pumping pressure when the pump is running. The signal will be converted to water level in the high reservoir tank when the pump casers to operate.

d. The outstation pumping station shall also perform pump cycling operations. After a particular pump has been on duty for a certain accumulated period of time, the outstation shall stop the pump and designate the next pump as the duty pump. The change in status of the pumps should be detected by the Telemetry system and reported to the master station.

F.5.4 **Reservoirs**

a. One (1) no. magnetic flow meter coupled to a transmitter and with two (2) nos. lightning surge arrestor shall be provided in RC chambers at the outlet pipe. The flow meter shall be provided with a 25 mm dia. full bore tapping complete with ball valve to incorporate the flow sensor. All instruments shall be housed in a floor mounted weatherproof metal cabinet complete with high quality stainless steel padlock. Cable used shall be of 4C 2.5 mm2 PVC armoured copper cables (for both power and signal transmission, with 2 pairs of spare cables provided). An earthing system of less than 1 ohm shall be provided.

b. One (1) no. level instrument ultrasonic transmitter complete with lightning surge arrestor shall be provided at the reservoir cistern. The instrument shall be housed in floor mounted weatherproof metal cabinet complete with high quality stainless steel padlock. Cables used shall be of 4C 2.5 mm2 PVC armoured copper cable (for both power and signal transmission). An earthing system of less than 1 ohm shall be provided.

c. An overflow detection system and level instrument accuracy checker, complete with stainless steel electrodes mounted on a stainless steel bracket, and provided with floatless and auxiliary relays, shall be provided at the overflow chamber to detect any overflows. Armoured type of copper cables (for both power and signal transmission) shall be employed. Overflow detection will induce an alarm upon detecting a dangerous high level. An accuracy checker will compare the reading at the level sensor against a fixed level water point in the reservoir. Percentage of error shall be not more than 2%.

d. Copper tape complete with a concrete earthing chamber shall be used in association with an external lightning protection system. All installations shall be concealed inside a slab wall. Earthing system of less than 1 ohm shall be provided.

e. One additional RTU GSM system shall be provided at the reservoir site if the reservoir location is outside both the pumping station and suction cistern compound. The panel shall be installed together with a high quality stainless steel padlock, time switch with contactor, all lightning surge arrestors, standby power supply system, and relays.

f. A 600 mm diameter mechanical dial indicator with stainless steel wire type shall be provided. The range shall be from 0 -10 m.

g. A pumping line and scouring line shall be connected to the relevant sensors for detection purposes through Telemetry system.

h. The outstation reservoir shall update the master station on the status of the field instruments and equipment on a Report-By-Exception (RBE) basis. This means that the outstation shall only report back to the master station on input / output points that have changed in status. For analogue signals the percentage change that represents a change in status shall be manually or automatically adjustable.

i. The Master Station located in the Command Centre shall be configured with the high and low levels of each ground and elevated reservoir. However, the need for the additional level configuration on alarms can be software generated.

j. Alarms generated shall be able to be viewed by a Crisis Operation Centre located at the office of WDL for appropriate action to be taken.

k. An earthing system of less than 1 ohm shall be provided.

F.5.5 **Testing and Commisioning**

a. The testing and commissioning shall be as per Clause E.16

b. All testing and commissioning works shall be carried out by the developer's SCADA/ Telemetry specialist.

F.5.6 **Spare Parts**

The following spare parts shall be provided with each Telemetry system:-

a.	Ultrasonic level transmitter	-	1 unit
b.	Category 2 Lightning Protection Unit (LPU)	-	1 unit
c.	Category 3 Lightning Protection Unit (LPU)	-	4 units
d.	Lead acid rechargeable battery	-	2 units
e.	Pressure transmitter	-	1 unit
f.	RTU with built in Programme Logic Controller (PLC) + modem	-	1 unit