



Construction of Jericho Well Site (JAIP)

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Particular Specifications

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Design by

مركز الهندسة والتخطيط
center for engineering and planning



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1 GENERAL PRELIMINARIES

1.1 MOBILIZATION/DEMOBILIZATION

1.1.1 Definition and Scope of Mobilization

The project composed of furnishing and equipping a recently-drilled well within Jericho City. The works include all civil and electromechanical works including site grading and fencing, installing a submersible well pump, booster station, water tank, services rooms, and all needed appurtenances and auxiliary works as described in the project Bills of Quantities.

As required for the proper performance and completion of the Work, mobilization shall include, but not limited to, the following principal items:

1. Provide and furnish field office for the Contractor and Engineer as specified in the UNDP Health and Safety Manual.
2. Move onto the site all the Contractor's plant and equipment required for the first month's operation.
3. Install temporary construction power, wiring, and lighting facilities as specified in the UNDP Health and Safety Manual.
4. Establish a fire protection plan and safety program including personnel protective equipment (PPE), first aid kits, etc. as specified in the UNDP Health and Safety Manual.
5. Provide and secure all the requirements in line with the UNDP Health and Safety Manual and maintaining the requirements throughout all the project implementations until the completion of the Works.
6. Provide on-site sanitary facilities and potable water facilities as specified in the UNDP Health and Safety Manual.
7. Arrange for and erect the Contractor's work and storage yard, employee's parking facilities, and temporary fencing as specified in the UNDP Health and Safety Manual.
8. Submit all required insurance certificates and bonds.
9. Obtain all required permits.
10. Mobilize and demobilize all equipment and materials in accordance with all local laws related to transportation and safety.
11. Post all required notices.
12. Have the Contractor's Project Manager and/or superintendent at the job site full time and the other required staff.
13. Submit a detailed construction schedule acceptable to the Engineer.
14. Erect all required Project signboards.
15. Locate and flag the limits of construction and clearing.
16. Satisfy the Engineer that responsive and responsible progress on the Contract Work is under way.

1.1.2 Payment for Mobilization

The Contractor's attention is directed to the condition that no payment for mobilization, or the part thereof, will be approved for payment under the Agreement until all mobilization items listed above have been satisfactorily completed. The full payment of the Lump sum for Mobilization will be paid after satisfactory completion of mobilization components, according to the related item in the Bill of Quantities.

1.1.3 Demobilization

As required for the proper performance and completion of the Work, demobilization shall include, but not limited to, the following principal items:

1. Remove the Contractor's field offices and trailer used for storage.
2. Remove all temporary power and utility lines.
3. Remove all temporary fencing, roadways and parking areas.
4. All areas disturbed during construction are organized turned back as before construction per the Contract Documents.
5. Remove contract signs.
6. Meet with the Engineer or Owner on site and have the site approved and acceptable as is.

1.1.4 Payment for Demobilization

Payment for demobilization will be made in the final application for payment. The full payment of the Lump sum for Demobilization will be paid after satisfactory completion of demobilization components, according to the related item in the Bill of Quantities.

1.2 ENVIRONMENTAL AND SOCIAL PROTECTION

The Contractor shall make every reasonable endeavour both by means of temporary works and by the use of particular plant or silencing devices to ensure that the level of noise or pollution resulting from the execution of the works does not constitute a nuisance.

The Contractor shall take all such precautions as may be necessary in the conduct of the work to avoid water pollution, air pollution, noise pollution harmful to health, spreading of plant diseases and pests or damage to natural resources or the environment, all as is consistent with good practice and as required by applicable laws, ordinances and regulations or lawful orders or authority having jurisdiction, as well as required by the Environmental and Social Management Plan (ESMP) established by the Employer.

End of Section

2 SUBMITTALS

2.1 GENERAL

Inquiries: Direct to Engineer regarding procedure, purpose, or extent of Submittal.

Timeliness: Schedule and make submissions in accordance with requirements of individual Specification sections and in such sequence as to cause no delay in Work.

2.1.1 Identification of Submittals

Complete, sign, and transmit with each Submittal package, one Transmittal of Contractor's Submittal Form (see below). Identify each Submittal with the following numbering and tracking system:

- Sequentially number each Submittal.
- Resubmission of a Submittal will have original number with sequential alphabetic suffix.
 - Format: Orderly, indexed with labelled tab dividers.
 - Show date of submission.
 - Show Project title and owner's contract identification and contract number.
 - Show names of Contractor, Sub Contractor (if any) and manufacturer as appropriate.
 - Identify, as applicable, Contract Document section and paragraph to which Submittal applies.
 - Identify Submittal type; submit only one type in each Submittal package.
 - Identify and indicate each deviation or variation from Contract Documents.
- Resubmissions: Clearly identify each correction or change made.

2.1.2 Incomplete Submittal Submissions

Engineer will return the entire Submittal for Contractor's revision/correction and resubmission. Submittals which do not clearly bear Contractor's specific written indication of Contractor review and approval of Submittal or which are transmitted with an unsigned or uncertified submission form or as may otherwise be required will be returned to Contractor not reviewed.

2.1.3 Engineer's Review

Engineer will act upon Contractor's Submittal and transmit response to Contractor not later than 30 days after receipt, unless otherwise specified. Resubmittals will be subject to the same review time.

2.1.4 Schedule Delays

No adjustment of Contract Times or Price will be allowed due to Engineer's review of Submittals, unless all of the following criteria are met:

Contractor has notified Engineer in writing that timely review of Submittal in question is critical to progress of Work, and has received Engineer's written acceptance to reflect such on current accepted submissions and progress schedule. Written agreement by the Engineer to reduce Submittal review time will be made only for unusual and Contractor -justified reasons. Acceptance of a progress schedule containing Submittal review times less than specified or less than agreed to in writing by Engineer will not constitute Engineer's acceptance of the review times.

Engineer has failed to review and return first submission of a Submittal within agreed time indicated on current accepted schedule of submissions or, if no time is indicated thereon, within 30 days after receipt.

Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return Submittal within time indicated and accepted by Engineer.

No adjustment of Contract Times or Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmission of Submittals, including multiple resubmissions.

2.1.5 Copies

- Shop Drawings and Product Data: Five and one reproducible, except copyrighted documents.
- Samples: Two unless otherwise specified in individual Specification sections.

2.1.6 General

Submit to Engineer as required by individual Specification sections.

2.1.7 Identify and Indicate

- Pertinent Drawing sheet(s) and detail number(s), products, units and assemblies, and system or equipment identification or tag numbers.
- Critical field dimensions and relationships to other critical features of Work.
- Samples: Source, location, date taken, and by whom.
- Each deviation or variation from Contract Documents.
- Design Data: When specified, provide Project-specific information as required and as necessary to clearly show calculations, dimensions, logic and assumptions, and referenced standards and codes upon which design is based.

2.1.8 Preparation

- **Format:** Whenever possible, schedule for and combine Shop Drawings and Samples required for submission in each Specification section or chapter into a single Submittal package. Also combine product data for like items into a single Submittal package.
- **Present in a clear and thorough manner and of sufficient detail to show kind, size, arrangement, and function of components, materials, and devices and compliance with Contract Documents. Identify details by reference to sheet and detail, and schedule or room numbers shown on Drawings.**
- **Reproducible Copy:**
 - Preferred Minimum Sheet Size: A4 and A3, suitable for photocopying.
 - Larger than A3: A1 preferred.
- **Piping Systems:** Drawn to scale.
- **Product Data:** Clearly mark each copy to identify pertinent products or models and show performance characteristics and capacities, dimensions and clearances required, wiring or piping diagrams and controls, and external connections, anchorages, and supports required.
- **Equipment and Component Titles:** Identical to title shown on Drawings.
- **Manufacturer's standard schematic drawings and diagrams as follows:**
 - Modify to delete information that is not applicable to Work.
 - Supplement standard information to provide information specifically applicable to Work.

2.1.9 Shop Drawing Disposition

Engineer will review, mark, and stamp as appropriate and distribute marked-up copies as noted:

- **Approved as Submitted (for incorporation in Work):**
 - One copy furnished Owner.
 - One copy furnished Resident Project Representative.
 - One copy retained in Engineer's file.
 - Remaining copies returned to Contractor appropriately annotated.
 - Contractor may begin to implement activities to incorporate specific product(s) or Work covered by Submittal.
- **Approved as Noted (for incorporation in Work):**
 - One copy furnished Owner.

- One copy furnished Resident Project Representative.
- One copy retained in Engineer's file.
- Remaining copies returned to Contractor appropriately annotated.
- Contractor may begin to implement activities to incorporate product(s) or Work covered by Submittal, in accordance with Engineer's notations.

■ Disapproved:

- One copy furnished Resident Project Representative.
- One copy retained in Engineer's file.
- Remaining copies returned to Contractor appropriately annotated.
- Contractor shall make corrections or develop replacement and resubmit (in same manner and quantity as specified for original submission).
- Submittal is not approved.

■ Incomplete:

- One copy furnished Resident Project Representative.
- One copy retained in Engineer's file.
- Remaining copies returned to Contractor appropriately annotated.
- Contractor shall complete and resubmit or submit missing portions.
- Submittal is not approved.

2.1.10 Sample Disposition

Same as Shop Drawing disposition; samples will not be returned.

2.2 ADMINISTRATIVE SUBMITTALS

2.2.1 Copies

Submit four copies.

2.2.2 Description

Submittals that are not Shop Drawings or Samples, or that do not reflect quality of product or method of construction. May include, but not limited to those Submittals identified below.

2.2.3 Applications for Payment (and Cash Allowance Data and Values)

Meet requirements of General Conditions and MEASUREMENT AND PAYMENT IN GENERAL TECHNICAL SPECIFICATIONS.

2.2.4 Progress Reports and Quantity Charts

As may be required in, Project Control / Procedures.

2.2.5 Schedules

- Progress Schedule(s): Meet the requirements of Project Control / Procedures.
- Schedule of Submittal Submissions:
 - Prepare and submit, preliminary list of submissions grouped by Contract Document article/paragraph number or Specification section number, with identification, numbering and tracking system as specified under Paragraph Identification of Submittals and as approved by Engineer.
- Include only the following required submissions:
 - Shop Drawings and Samples.
 - Training plans (if required by other sections).
 - Test procedures.
 - Operation and maintenance manuals (if required by other sections).
 - Record documents.
 - Specifically required certificates, warranties, and service agreements.
 - Coordinate with progress schedule and prepare submissions to show for each Submittal, at a minimum, the following:
 - ✓ Estimated submission date to Engineer.
 - ✓ Specifically requested and clearly identified Engineer review time if shorter than that set forth herein, with justification for such request and critical dates Submittals will be needed from Engineer.
 - ✓ For first 6-month period from the date the Contract Times commence or following any update or adjustment of the submissions, the estimated submission date shall be week, month, and year; for submissions beyond 6-month time period, show closest month and year.
 - Submit to Engineer monthly (i) updated list if changes have occurred, otherwise submit a written communication confirming existing list, and (ii) adjusted submissions reflecting submission activity planned for forthcoming 6-month time period and beyond. Coordinate with progress schedule updates.

2.2.6 Submittals Required by Laws, Regulations, and Governing Agencies

- Submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, state, or local governing agency or their representative.

- Transmit to Engineer for Owner's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

2.2.7 Disposition

Engineer will review, stamp, and indicate requirements for resubmission or acceptance on Submittal as follows:

- Accepted:
 - Acceptance will indicate that Submittal conforms to intent of Contract Documents as to form and substance.
 - Contractor may proceed to perform Submittal related Work.
 - One copy furnished Owner.
 - One copy furnished Resident Project Representative.
 - One copy retained in Engineer's file.
 - Remaining copies returned to Contractor appropriately annotated.
- Rejected as Noted:
 - One copy retained in Engineer's file.
 - Remaining copies returned to Contractor appropriately annotated.
 - Contractor shall revise/correct or develop replacement and resubmit.

2.3 QUALITY CONTROL SUBMITTALS

2.3.1 Certificates

- Manufacturer's Certificate of Compliance.
- Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in the individual Specification sections.
- Manufacturer's Certificate of Proper Installation.

2.3.2 Statements of Qualification

Evidence of qualification, certification, or registration. As required in these Contract Documents to verify qualifications of professional land surveyors, Engineers, materials testing laboratories, specialty Sub Contractors, trades, specialists, consultants, installers, and other professionals.

2.3.3 Field Samples

Provide as required by individual Specifications and as may be required by Engineer during progress of Work:

- Written Test Reports of Each Test and Inspection: As a minimum, include the following:
- Date of test and date issued, Project title and number, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
- Date and time of sampling or inspection and record of temperature and weather conditions.
- Identification of product, Specification section, location of Sample, test or inspection in the Project, type of inspection or test with referenced standard or code, certified results of test.
- Compliance with Contract Documents, or identifying corrective action necessary to bring materials and equipment into compliance.
- Provide an interpretation of test results, when requested by ENGINEER.

2.3.4 Disposition

Engineer will review, stamp, and indicate requirements for resubmission or acceptance on Submittal as follows:

- Accepted:
 - Acceptance will indicate that Submittal conforms to intent of Contract Documents as to form and substance.
 - Contractor may proceed to perform Submittal related Work.
 - One copy furnished Owner.
 - One copy furnished Resident Project Representative.
 - One copy retained in Engineer's file.
 - Remaining copies returned to Contractor appropriately annotated.
- Rejected as Noted:
 - One copy retained in Engineer's file.
 - Remaining copies returned to Contractor appropriately annotated.
 - Contractor shall revise/correct or develop replacement and resubmit.

2.4 CONTRACT CLOSEOUT SUBMITTAL

2.4.1 Record/As-Built Drawings

Throughout the project, maintain a current complete set of project drawings with all variations plainly marked. Each month, or as otherwise agreed, submit to Engineer a current listing and description of each variation incorporated into the work since the preceding submittal. Contractor will prepare a set of Contract Drawings, with all changes marked in red and including all variations made in materials, locations, and dimensions of the work. The

Contractor shall certify that these drawings represent the actual "as built" condition of the project.

After approval of the Engineer to these drawings, the Contractor will rely upon these drawings in the preparation of Record Drawings of the Work.

The Contractor shall submit to the Engineer three sets of the final record drawings on paper form in addition to one copy of digital form on Auto Cad format at least version 14.

2.4.2 General Guidelines for AutoCAD As-Built Drawings

1. As-built drawings must be prepared and certified by a licensed surveyor.
2. The Palestinian Coordinate System shall be used. The Benchmarks (absolute benchmarks) to be used shall be declared by the surveyor and be documented by photos (to be supplied to the Employer).
3. Surveyor's seal on all sheets signed and dated.
4. As-built drawings shall be drawn to 1/500 scale on A2 sheets.
5. Cover Sheet shall include:
 - a) Project title and number.
 - b) Contractor's name and address.
 - c) Logos as per Engineer's instructions.
6. Key plan.
7. Provide a quantity sheet showing final or As-built quantities.
8. Drawing sheets numbered in sequence.
9. As-built drawings to be submitted in AutoCAD (.dwg) format.
10. Provide a draft copy with an AutoCAD file.
11. After checking the draft one, the Contractor shall provide the Engineer with (3) copies of the final as-built drawings.
12. Draw all the details in each chamber/manhole/cabinet.
13. The Engineer will provide the contractor with an AutoCAD (.dwg) format file which contains the names of all layers.
14. All features depicted in the as-built drawings must be surveyed after construction and before backfilling. The Engineer's surveyor will spot check all coordinates to ensure accuracy.

TRANSMITTAL OF CONTRACOR'S SUBMITTAL FORM**TRANSMITTAL OF CONTRACTOR'S SUBMITTAL**(ATTACH
SUBMITTAL)

TO

EACH

DATE: _____

TO: _____

Submittal No.: _____

☐ New Submittal ☐ Resubmittal

Previous Submittal No.: _____

Project: _____

Contract No.: _____

Specification Section No.: _____

FROM: _____

Contractor

(Cover only one section with each transmittal)

Schedule Date of Submittal: _____

SUBMITTAL☐ Shop Drawing☐ Administrative☐ Sample**TYPE:**☐ Quality Control☐ Contract Closeout☐ Equal"/Substitute

"Or-

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that (i) Contractor has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By: _____
Contractor (Authorized Signature)

End of Section

3 VALVES

3.1 GENERAL

All valves and accessories are recommended to be furnished by a single manufacturer and should be subjected to the Engineers approval before ordering the valves. Valves shall be compatible with pipes and fittings specified in these Specifications. Compatibility should be the Contractor's responsibility at his own expense, and should be approved by a third party accredited by PSI certified Testing Laboratory.

Two copies of manufacturing and installation manuals shall be provided at time of materials delivering.

All valves shall be supplied according to the latest editions of standards and references specified in these Specifications. Valves shall be fabricated according to Standards and References specified in these specifications or shall be equivalent and compatible to these standards and references subjected to third party accredited testing laboratory.

The type and size of valve to be used at any location shall be as indicated on the Contract Documents or specified herein and shall be rated to at least the same pressure as the pipeline in which they are to be installed. All valves shall be designed to avoid cavitation and vibration in all positions, to minimize head loss in the open positions and to seal the water passage when completely shut.

All operating spindles and gears shall be provided with adequate points for lubrication. Unless otherwise specified, all valves shall be closed in a clockwise direction. Head loss curves through the valves for throttled flow conditions shall be provided for all valve sizes.

Bolts, nuts, rubber seals (joint rings), gaskets, and flanges shall be in accordance with standards specified in GTS.

Valves' manufacturers shall have a minimum 5 years' experience in the manufacturing of similar products.

The following brands or equally approved are accepted:

- Vales General: Talis Group, Henry Bratt, VAG, PAM, ARI, DVD.
- Brass/copper alloy valves: Sagiv, NTM, Giacomini, Itap.
- Couplings, dismantling joints, flexible joints and adaptors: Talis-Uni-Joint, BELGICAST, PAM, Viking Johnson, Witzenmann,
- Hydraulic Control Valves: Bermad, Talis-Raphael, Erhard, Bayard and Cla-Val.
- Air Valves: ARI, Bermad, Henry Brat, Val-Matic.
- Water Meters: Siemens, ABB, Euromag, Endress+ Houser
- Pressure Gauges: Ashcroft, Wika, Bourdon, Kobold.

3.2 SUBMITTALS

The contractor shall submit the following:

- Assembly drawings.

- Manufacturer Valid quality certifications ISO or equivalent.
- Certified copies of Manufacturer quality control Test results and reports.
- Assembly shop drawings.
- Instruction manuals.
- Catalogues.
- With every consignment of valves, accessories and specials delivered under this Contract, the Contractor shall furnish a certificate worded as follows:

“This is to certify that the valves, accessories and specials delivered in this consignment comply with the required specifications and Standards”.

3.3 MARKING OF VALVES AND WATER METERS

The valves and water meters shall be clearly labelled and marked with the following information:

■ Valves:

- Class or Pressure rating.
- Nominal Diameter
- Arrow showing the flow directions (for valves designed for one way flow only).
- Name or trade mark of the manufacturer.
- Date of manufacturing.

■ Water Meter:

- Pressure rating.
- Nominal diameter.
- Meter class.
- Arrow showing the flow direction.
- Serial number.
- Name or trade mark of the manufacturer.

3.4 VALVE COATINGS

Unless otherwise indicated in the Tender Documents for an alternative coating system, the internal and external surfaces of valves shall be prepared and coated with epoxy paint. The final coat shall be applied to external surfaces after installing the valves. All coats/materials in contact with water shall be certified for drinking water as per NSF-61 or WRAS or equivalent.

3.5 WORKS TESTS

All valves shall be hydrostatically tested at the place of manufacture. The Contractor shall supply a certificate stating that the valves supplied have satisfactorily passed the specified tests and comply in all respects with these Specifications or BOQ.

All valves shall be subjected to pressure test in accordance with ISO 5208 and shall be drop tight.

3.6 PACKING

All valves shall be securely packed in crates or boxes for protection against damage during transit, and shall be accompanied by the materials necessary to secure all flanges to adjacent pipe work. These materials shall also be suitably packed and shall be stored away from sunlight at all times.

3.7 MATERIAL, PRESSURE RATING AND EQUIPMENT

- All valves and appurtenances shall be of the size shown on the Drawings and as far as possible all equipment of the same type shall be from one manufacturer.
- All valves and appurtenances shall have the name of the maker, flow directional arrows, and the working pressure for which they are designed cast in raised letters upon some appropriate part of the body.
- All buried valves shall open left (counter clockwise). Insofar as possible, all valves shall open counter clockwise.
- All valves installed at the inflow and outflow side of the water reservoir shall be PN 16 bar rating.

3.8 FLANGED JOINTS GASKETS

The joints shall withstand under the same pressures mentioned for the pipes. The dimension of the gaskets shall be such that, when jointed in accordance with manufacturer's instructions, the joint shall provide a positive seal for the range of pressures likely to occur in the pipeline.

The dimensions and tolerances of the flanges of pipes and fittings shall comply with ISO 7005 and/or EN 1092, to insure interconnection between all flanged components like pipes, fittings, valves, ...etc. of the same DN and PN and adequate joint performance.

Gaskets shall be 2-3 mm thick and shall be reinforced compressed fibres or EPDM suitable for drinking water, in one piece, full-cut with holes to pass the bolts. Segmented, straight joint or interlocking gaskets shall not be accepted. Blind flanges shall be casketed covering the entire inside face with the gasket cemented to the blind flange. The dimensional size shall be kept to the full face of the flange to suit the flange bolting.

3.9 NUTS, BOLTS, SCREWS, GLANDS AND WASHERS

Nuts, bolts, screws, washers generally shall be of austenitic stainless steel 316 Grade A4 -70 as per ISO 3506, DIN 267-11 or ISO 4017. Nuts, bolts and screws shall have coarse metric threads.

Bolting for pipes and fittings shall comply with the approved standard.

Bolt lengths shall be sufficient to ensure that nuts are full-threaded when tightened in their final position. At least two washers shall be provided with each nut and bolt set.

bolts and nuts shall be supplied with two washers per bolt, and the bolt length shall be such that after the joints are made up, the bolts shall protrude through the nut by at least 1.30 times bolt size (Not more than 40% of bolt size).

3.10 GATE VALVES AND APPURTENANCES

3.10.1 General

- Ductile Iron Gate valves for water shall meet the requirements of ISO 7259, ISO 5996 or EN 1171. Steel gate valves should comply with ISO 6002 or EN 1984.
- The flanged gate valves shall be face to face doubled flanged, ductile iron, resilient seated for rated pressure up to 25 bar and metal seated for PN 40 valves, wedge gate and non-rising stem suitable for use in drinking water systems and buried/non-buried service.
- Face to-face and centre-to-centre dimensions of flanged valves shall comply with EN 558-1 and EN 558-2, respectively. The required basic series are:
 - Long valve: ISO 5752, EN 558-1 basic series 15.
 - Short valve: ISO 5752, EN 558-1 basic series 14.
- Standard flange drilling and dimension is according to EN 1092-2.
- Stuffing boxes shall be the "O-Ring" type.

3.10.2 Gate Valve Characteristics

■ Gate and stem

- The gate of valve shall be of the Wedge resilient seated type for nominal rated pressure up to 25 bar.
 - The gate sealing in the body shall be ensured by the rubber compression.
 - The gate shall be ductile iron, fully encapsulated in EPDM leaving no exposed metal surface.
 - The resilient material shall have a nominal thickness of minimum 4mm on the seating areas, and minimum 1.5mm on the other non-seating areas.
- The gate of valve shall be of the Wedge metal seated type for nominal rated pressure of 40 bars and above. The body seat shall be of copper alloy; the wedge seat shall be of copper alloy or stainless-steel welded overlay.
- The wedge shall be combined with guide rails and integrated wedge shoes to secure a smooth operation of the valve and low operating torques.
- The valve stem shall be stainless steel BS EN 10088-1: 1.4021 (grade AISI 420) or equal.

■ Stem and bonnet sealing

- Non-rising type shall be used.
- The stem threads shall be rolled in a cold pressing process.

- The stem shall be provided by triple sealing system (EPDM or NBR) as follows:
- Stem 'O' ring seal arrangement shall be suitable for replacement under pressure.
- Bonnet sealing: EPDM O-ring between cap and bonnet, EPDM gasket between bonnet and body.

■ Bolts Sealing

- The Bolts which are used to secure bonnet to valve body are further protected with Plastic Seal/ Wax to provide extra sealing and protection
- The bonnet bolts are encircled by the bonnet gasket, countersunk in the bonnet and finally sealed with Plastic Seal/ Wax to prevent corrosion.

■ Valve Closing:

- The valves shall be closed by turning the stem in a clockwise direction.
- Each valve shall be supplied with a stem cap secured to the valve stem by a stainless-steel headed setscrew or a hand wheel. The stem cap or hand wheel shall be marked with an arrow to indicate the clockwise closing direction of the valve.
- Stem caps shall be designed to be the first component of the valve to break under both of the following situations:
 - Gradually increasing closing torque is applied to the top end of the stem cap when the valve is in a fully open position; and
 - Gradually increasing opening torque is applied to the top end of the stem cap when the valve is in a fully closed position.
- Hand wheel shall be of grey cast iron with epoxy coating according to BS EN 14901 or ductile iron.

3.10.3 Gate Valves and Appurtenances for Buried Service

- Valves shall be steel body, or ductile, bronze- mounted, double disc, parallel seat; non-rising stem type fitted with "O-Ring" seals. The operating nuts shall be 50mm (2in) square.
- Valves shall be equipped either with hand-wheel or the spindle as specified in the Drawings or BOQ.
- Tapping sleeves shall have cadmium-plated low alloy steel nuts and bolts. Sleeves shall be of cast iron, designated for working pressures not less than 30 bars (435 psi). Lead gaskets shall be provided for the full area of the sleeve flanges.
- Tapping valves shall conform to the requirements specified above for gate valves except that one end shall be flanged and one mechanical. Tapping valves shall be provided with an oversized opening to permit the use of full-sized cutters.
- Valve boxes shall be provided for each buried valve. They shall be cast iron, of heavy pattern, adjustable type and provided with cast iron cover. The upper section of each box shall have a bottom flange of sufficient bearing area to prevent settling. The bottom of the lower section shall enclose the stuffing box and operating nut of the valve. Boxes

shall have barrels of not less than 130mm (5in) in diameter and be of length adapted to pipe cover.

- Valve boxes shall be adjustable, with a lap of at least 150mm (6in) when in the most extended position. Covers shall have lettering indicating the type of service.
- Tee handled gate wrenches of suitable length shall be furnished to operate all valves with valve boxes. Valves greater than 300mm in diameter supposed to be actuator operated or fixed in a horizontal position should be fitted with mechanical gear on the wedge working in machined gunmetal channel in the body.

3.10.4 Gate Valves for Non-Buried Service

- Gate valves, shall have flanged, screwed, or solder ends as required; and shall be bronze/ductile iron, solid wedge, rising-stem-type gate valves or non-rising-stem type as specified in the Tender Documents.
- Bronze gate rings shall be fitted into grooves of dovetail or similar shape in the gates. For grooves or other shapes, the rings shall be firmly attached to the gates with bronze rivets.
- Hand wheels shall turn counter clockwise to open the valves. Hand wheels shall be of ample size and shall have an arrow and the word OPEN cast thereon to indicate the direction of opening.
- The design of the valves shall permit packing the valves without undue leakage while they are wide open and in service.

3.11 CHECK VALVES (NON-RETURN VALVES)

3.11.1 General

- Check valves shall be swing type and shall meet the material requirements of AWWA C508 or BS EN 1074-3 or ISO 5781.
- Standard flange drilling and dimension is according to EN 1092-2.
- The valves shall be iron body, bronze mounted, single disc. The Ductile iron check valves should comply with EN 12334.

3.11.2 Characteristics

- Body, disc, cap/cover, lever and weight arm shall be of cast grey or cast ductile iron (Grey cast iron: EN 1561- GJL-250 or ductile cast iron: EN 1563- EN GJS 400-15 or 500-7. The disc shall be of grey/ductile cast iron or carbon steel to EN 10083-1 or ASTM A216-WCB with EPDM or NBR seals. The shaft shall be stainless steel BS EN 10088-1:1.4021 or ASTM 420 – S42010 or equal.
- When there is no flow through the line the disc shall hang lightly against its seat in

practically a vertical position. When open, the disc shall swing clear of the waterway.

- Check valves shall have bronze seat and body rings, extended bronze hinge pins and bronze nuts on the bolts of bolted covers.
- Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing the valve from the line. Valves shall be fitted with an extended hinge arm, outside lever and counter weight. valves shall be also equipped with non-slam dampener (spring or hydraulic dampener).

3.12 QUICK CONNECT COUPLINGS

Couplings shall be of the cam and groove type consisting of a male adapter conforming to Specification ISO 6150, ISO 2861, ISO 7241-1, ISO 16028. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak-proof under working pressures. Each adapter shall be furnished with a dust cap complete with security chain of corrosion resistant material.

3.13 FLEXIBLE COUPLINGS/CONNECTORS

Furnish/Install moulded double arch spherical connector/expansion joints(s). The moulded spherical body must be manufactured using multiple piles of nylon tire cord fabric bonded within the EPDM elastomeric or reinforced rubber bellows. Floating flanges shall be zinc-coated plate steel and must have drilled bolt holes in accordance with pump flanges standard (EN 1092-1). The floating flanges shall be complete with stainless steel AISI 316 tie rods (external restraints) of the same size as of flange bolts to absorb reaction force from internal pressure.

3.14 DOUBLE FLANGED, RESTRAINED DISMANTLING JOINTS

- The adaptor body and end rings shall be constructed of Ductile iron to BS EN 1563-EN-GJS-450-10, Spigot body: Steel to BS 10225:2004, Flange (follower): Steel to BS EN 10025:2004 Grade S275.
- Dismantling joints are to be assembled between two flanges.
- Dismantling joints shall consist of two single flanged sleeves, one loose flange, one gasket and the bolts and nuts required to tighten the coupling and compress the gasket.
- One sleeve shall be able to slide into the other sleeve by at least 50mm.
- Sealing shall be achieved by compression of the gasket by the loose flange.
- Dismantling joints shall be able to restrained axial thrust forces under the nominal working pressures indicated in the design drawings and bill of quantities.
- The metal parts (except bolts and fittings), from internal and external shall have epoxy powder coating.
- The Adaptor and accessories shall be internally and externally coated with a factory applied Epoxy coating.
- Average thickness of Epoxy powder coating is 300 microns with no Spot thickness less than 250 microns.

- The Protective coating comprises chemical treatment of the iron surface followed by electro-deposition of a blue Epoxy resin suitable for Drinking water, resulting in a regular thickness of coating.
- All the bolts, nuts, washers, fixing rods and accessories shall be stainless steel 316 type A4.
- Dismantling Joints of PN 16 shall be 25% restrained, higher ratings shall be fully restrained unless otherwise stated in the Bill of Quantity.

3.15 PRESSURE GAUGES

Pressure gauges shall be manufactured in accordance with ISO 5171 or EN 837-1,2,3 and shall be furnished and installed where indicated in accordance with Tender Documents requirements. The gauges shall be 4" diameter, liquid filled, bottom connected, equipped with while laminated dials and black graduations and shall have shatterproof glass. The measuring element shall be stainless steel bourdon tube with welded stress- relieved joints with stainless steel rotary geared movement. Where gauge taps are not available in the pump's suction or discharge nozzle, the necessary taps in the adjacent piping shall be made for installation of gauge connections.

Provide an accuracy of plus and minus 1/2-percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which the gauge is connected.

3.16 FLAP VALVES

Flap valves to be used in the overflow system discharge lines shall be as specified or as per Contract Drawings and, shall be flanged end.

3.17 AIR RELEASE VALVES

Air release valves shall be of combination 3 function type with ductile cast iron bodies, the inlet flange shall be fitted and drilled in accordance with EN 1074-4.

The valves shall be adequately sized for the release of air from the pipeline (or other container) without restriction of rate of filling or flow due to backpressure. Air shall be allowed to enter at a rate sufficient to prevent excessive reduction of pressure in the pipe during pipeline emptying. The "aero kinetic" type shall be provided; air valves with internal operating linkages shall be avoided.

Valves shall be designed to prevent the operating elements being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float and chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with a separate isolating ball or gate valve and gearing shall be provided, where necessary, to facilitate operation.

In applications where the pipeline characteristics may lead to liquid column separation with consequent possibility of surge conditions, a vented non-return valve shall be provided which allows air to enter freely on separation but controls expulsion of air as the liquid column re-joins (non-slam type).

All air release valves and associated isolating valves shall be works tested and capable of withstanding the same test pressure as the pipeline or vessel on which they operate. All materials used in the manufacture of the valve shall conform to EN 1074-4.

3.18 BALL VALVES

Large full-bore type with BSP threading. Body, bonnet and ball constructed of Chrome/nickel plated brass CW617N and complete with PTFE seals, NBR O- ring, steel PVC coated lever. The valves shall be suitable for drinking water. The threaded valves shall be rated for as per drawings and bill of quantities. The valves shall be marked and tested according to EN 331.

3.19 HYDRAULIC CONTROL VALVES

Hydraulic Control valves should comply with ISO 6263 or EN 1074-5.

The valves shall be hydraulically operated, diaphragm actuated for ratings up to 25 bar and piston actuated for rating of 40 bar and more. The valves may be single or double chamber type according to approved manufacturer recommendations.

The valve body and actuator shall be heavily constructed ductile cast iron as per EN 1563 (EN GJS 400-15, EN JS 1030-GGG 40 grade at least) and shall be of globe or Y or sigma pattern type. Valve internals and trim including stem, springs, seat rings, bolts, nuts, washers of S.S. Valves up to PN 25, shall be hydraulically operated diaphragm actuated, diaphragm and seals shall be constructed of Nylon Reinforced Buna-N or NBR Nylon fabric-reinforced material. PN 40 valves shall be hydraulically operated/ piston actuated, body shall be constructed of Carbon steel EN 10083-1 (ASTM A-216 WCB). The pilots and control loop (tubing and fittings) shall be constructed of S.S 316 or copper alloy. All control valves shall be equipped with indicating rod. The most appropriate type of port/plug shall be selected by the approved manufacturer in order to fit the operating system hydraulic conditions.

Prior to shipment of the valves the manufacturer shall factory test the valves under the pressure and flow conditions specified by tender documents or as directed by the Engineer. The manufacturer shall submit to the Engineer with certified copies of the factory test results.

The valves shall be factory calibrated at the prescribed design control parameters as stated by tender documents or as directed by the Engineer.

Valve sizing calculations shall be carried out by the manufacturer against the system design parameters and enclosed to the valve's submittal.

Control valves shall be installed where indicated on the Drawings. Valves shall be rated as specified in the Contract Tender Documents.

3.19.1 Float Control Valve

The valve shall be double chambered of a float type mentioned on design drawings and BoQ (on/off, bi-level, modulating, etc.). The valve shall allow full open at Pre-set low level and to shut-off at pre-set high level regardless of the valve differential pressure. All necessary repairs shall be possible without removing the valve from the line.

Level float valve shall be installed on the rising main, in concrete chamber or above the ground. The valve shall operate through a remote float control installed in the water storage or balancing tank, and/or as shown on Drawings.

The remote float control shall be connected to the main valve through copper/PE tubes to control the valve opening such that when float rises gradually with water surface the main valve

will close gradually until it is tightly closed when water level reaches the specified high-water level in the two parts of the tank.

3.19.2 Altitude Valves:

Altitude valve shall be the pilot control type, which controls high level in the reservoir, the pilot control system and valve trim shall be bronze. Altitude valve shall stay open as long as the water level of the reservoir is below a pre-set level. As the water level rises the valve gradually closes.

The altitude control valve should be of one-way flow with an automatic control valve designed to control the high-water level in reservoirs and tanks without the need for external control devices such as floats, etc. Control valve should be rated at 16 bars and factory tested at 25 bars unless otherwise indicated. It should be pilot controlled, hydraulically operated, diaphragm actuated globe valve in either the oblique (Y) or angle pattern design. Valve differential pressure powers the diaphragm actuator open or closed.

The lower control chamber shall be connected through a fixed orifice to the downstream pressure, which serves to cushion the closing of the valve. The upper control chamber, which operates on a three-way control principal, has pressure applied from or pressure vented through the three-way altitude pilot.

The altitude pilot senses reservoir or tank pressure head. It closes at a pre-set pressure head and opens on decreasing pressure head.

The closing and opening of the pilot alternatively pressurize or vents the pressure in the upper control chamber causing the main valve to close or open thus maintaining a constant pressure head in the reservoir or tank.

When the head pressure falls below the pilot setting the pilot opens, pressure in the upper control chamber decreases and the main valve opens to refill the reservoir or tank. When the head reaches the set point of the pilot the pilot closes, pressure in the upper chamber increases and the main valve closes to stop flow into the tank or reservoir. The altitude pilot shall have an adjusting screw to pre-set the desired head pressure.

3.19.3 Flow Control Valves

The valve shall be set to maintain a constant rate of flow regardless of fluctuations in upstream pressure. Rate of flow shall be adjustable at any time. Valve shall be installed in concrete chamber as shown on Drawings. Rate of flow shall be set as specified in the Tender Documents. The selected orifice plate shall cover the flow operational range mentioned in design drawings and schedules. Constant down-stream pressure type shall be provided at the inlets of balancing/storage tanks.

All flow control valve chambers shall be provided with bypass loop and water meter of type and sizes indicated unless otherwise indicated on design drawings.

3.19.4 Pressure Relief (Sustaining) Valves and Surge Anticipating Valves

Pressure relief / Surge Anticipating valves shall be in accordance with ISO 6264 and shall be installed on the plant water lines as shown on the Drawings.

The valve body shall be of angle or Y pattern. Valve internals and trim including stem, springs, seat rings, bolts, nuts, washers of S.S. The pilot and control loop (tubing and fittings) shall be constructed of S.S 316. Valves up to PN 25, shall be hydraulically operated diaphragm actuated, diaphragm and seals shall be constructed of Nylon Reinforced Buna-N or NBR Nylon fabric-reinforced material. PN 40 valves shall be hydraulically operated/ piston actuated, body shall be constructed of Carbon steel EN 10083-1 (ASTM A-216 WCB) with S.S 316 actuator assembly. The pilots and control loop (tubing and fittings) shall be constructed of S.S 316.

The pressure sustaining valves shall maintain a minimum pre-set upstream pressure in the pipeline regardless of fluctuating flow or down-stream pressure.

The pressure relief valve shall be equipped with high pressure pilot adjusted at the factory to hold closed against the normal operating system pressure. When the system pressure exceeds this setting, the relief Valve shall open immediately to relieve the pressure rise, but closes slowly at an adjustable rate as the system pressure returns to normal.

The surge anticipating valve shall be equipped with low pressure pilot that senses the initial pressure drop caused at the beginning of surge and opens the valve in order to absorb the inertia caused by returning water column. Should the relief rate be insufficient and the pressure exceeds the setting high pressure, the high-pressure pilot immediately opens and further valve opening is activated in order to release the high pressure until the pressure is maintained to the normal system pressure. When the pressure stabilizes, both pilots close and the main valve starts to close. The valve shall be equipped with flow stem in order to limit the relief flow to prevent column separation and preserve closing pressure.

Prior to shipment of the valves the manufacturer shall factory test the valves under the pressure and flow conditions specified above. The manufacturer shall submit to the Engineer with certified copies of the factory test results.

The valves shall be factory calibrated at the prescribed high pressure (for relief valve) and prescribed low/high pressures for the surge anticipating valves.

Usually, Low pressure anticipating pilot is set @80% of static pressure; high pressure relief pilot is set @ 1-2 bar above maximum system pressure.

Valve sizing calculations shall be carried out by the manufacturer against the system design parameters and enclosed to the valve's submittal.

Control valves shall be installed where indicated on the Drawings. Valves shall be rated as specified in bill of quantity and drawings.

3.19.5 Pressure Reducing Valves

Pressure reducing valves shall comply with ISO 5781 or EN 1567. Pressure reducing valves shall be factory tested. Outlet pressure shall be easily field adjustable over the pressure ranges and meet the criteria noted on the Drawings.

All pressure reducing valves shall have flanged connections, or shall have unions mounted in the pipe on each side of the valve.

Strainers for installation upstream of pressure reducing valves are specified elsewhere. The pressure reducing valve manufacturer shall specify the screen mesh or size of perforations that are required to protect the reducing valve. The valve supplier shall furnish both valve and strainer.

a) Pressure Reducing Valves 50mm and Larger:

- Valves 50mm and larger for pressure reducing shall be flanged diaphragm actuated

cast-iron “Y” pattern body and replaceable bronze valve seat. The valve shall be external pilot operated, diaphragm type single seat with seat base equal to size of valve. The valve shall be supplied with an internal spring to assist in closing the valve and keeping the valve seated when the inlet and outlet pressure differential is near zero. The valve shall also be supplied with a “V” port-throttling plug for effective control of the outlet pressure as recommended by the manufacturer. High pressure reduction valves shall be equipped with anti-cavitation trim.

- The valve shall be packed with material acceptable to the Engineer to ensure tight closure and prevent metal to metal friction and sticking. The valve shall be furnished with indicator rod, to show position of opening of the piston, and pet cocks for attachment to valve body for receiving gauges for testing purposes.
- The pilot valve, controlling operation of the main valve, shall be easily accessible and so arranged to allow for its removal from the main valve, while the main valve is under pressure. The pilot valve shall be easily adjustable without removal of the springs, weights or use of special tools. The control piping on the valves shall have strainers to prevent plugging of control mechanisms.
- The design shall be such that repairs and dismantling internally of main valve may be made without its removal from the line.
- The unit shall be flanged. The valve body shall be constructed of cast iron.
- The valve shall maintain pre-adjusted downstream pressure for varying rates of flow through the positioning of the diaphragm by the pilot without causing water hammer or waste of water and without cavitation.

b) Pressure Reducing Valves Smaller than 50mm:

- Threaded Pressure reducing valves smaller than 50mm shall be constructed of direct acting type and constructed of bronze and brass body; renewable stainless-steel seat and flexible diaphragm of suitable material. Outlet pressure shall be easily field adjustable over the pressure ranges tabulated on the Drawings

3.20 STRAINERS

Strainers will be made of ductile iron or cast iron. Strainer body will be coated with an epoxy powder minimum thickness 120 microns. Screen shall be made of stainless steel.

For maintenance purposes, covers shall be provided to allow ample access to inspection, cleaning and servicing. A drain bend at the bottom of the body, fitted with a stopcock shall be incorporated.

Due to particularly hard conditions of service – high speed, high-pressure, presence of solid elements in the network – bidders are requested to pay particular attention to the quality of the protection provided by the strainers to the regulation valves and meters placed downstream.

Head loss shall not be more than 0.1 bars, when clean, at the nominal flow rate of the control valve or water meter protected by the strainer box.

3.21 ELECTROMAGNETIC FLOW METERS

- Magnetic flow meter systems shall be the low frequency electromagnetic induction type which produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flow meter system. Each magnetic flow metering system shall include the installation and furnishing a metering tube, signal cable, transmitter, flow meter grounding rings, transmitter enclosures, antennas, external batteries and all related items. The meter shall be compatible to the approved control and SCADA systems according to drawings and specifications.
- Flow meters located on transmission pipelines shall be battery powered, the convertor shall have weather proof IP 68 housing. The flow meters at well site shall have IP66 convertors and AC main powered (230VAC or 12/24 VAC-DC).

1. The metering tube shall have:

- a) Pressure ratings as indicated and in accordance with the requirements of piping specifications.
- b) The manufacturer shall provide the recommended size of the water meter based on system flow range.
- c) Polyurethane or Butyl hard Rubber Liner, conforming FDA and/or WRAS.
- d) EN1092-1 Flanges, rating as indicated on drawings and bill of quantities.
- e) Electrodes shall be 316 stainless steel or Higher grade (Hastelloy C)
- f) Metering tube housing rated for IP66 or better. Metering tube housing rated for IP 68, suitable for continuous submergence in up to 3 meters of water, if installed in a below grade vault or any other area with reasonable potential for submergence.
- g) Epoxy protective coating.
- h) Grounding rings shall be 316 stainless steel. Grounding rings shall be designed to protect and shield the liner's edge interface from abrasion at the meter end.

The magnetic meters shall be marked CE and are manufactured according to the following standards:

- a) 2014/35/EU - EN 61010-1:2013 (LVD)
- b) 2014/30/EU - EN 61326-1:2013 (EMC)
- c) OIML R49-1:2013
- d) European directive 2014/32/EU (MID)
- e) 2014/34/UE - IEC 60079 - 0, IEC 60079 - 18 (ATEX - IECEx) Separate version
- f) EN ISO 15609-1 and EN ISO 15614-1
- g) Ebonite conforms to the norms WRAS, FDA

2. The microprocessor-based signal converter/transmitter shall have:

- a) DC pulse technique to drive flux-producing coils.
- b) Six-digit LCD displays for flow rate, percent of span, and tantalization.
- c) An operator interface with keypad which responds to English text entry.
- d) Automatic range change.

- e) Capable of measuring flow in both directions.
- f) Programmable parameters including meter size, full scale Q, magnetic field frequency, primary constant, time constant.
- g) Data retention for a minimum of 5 years without auxiliary power from main source or battery.
- h) Self-diagnostics and automatic data checking.
- i) Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
- j) Ambient temperature operating limits of -20 to 60 degrees C.

■ Calibration and Performance

1. Calibration: Each flow metering system shall be calibrated on a hydraulic bench equipped with a reference weighting system and SIT certified. The flow metering system shall conform to the following:
 - a) Accuracy: $\pm 0.25\%$ Maximum.
 - b) Q3/Q1: 125 at least.
 - c) Repeatability: 0.1%.
 - d) Environmental Limits: - 10 to +60° C.
 - e) Power requirements: external battery with 6 years life.
2. The flow meter shall be furnished with the following accessories:
 - a) Furnish remote mount flow transmitter with a sufficient cable.
 - b) Provide stainless steel stanchions for mounting of remote transmitter no less than 4 feet above grade.
 - c) Provide manufacturer digital calibration verification unit with necessary accessories to interface with the furnished magnetic flow meter.
3. GSM/GPRS Communications:
 - a) Where indicated on the drawings or the Instrument Device Schedule, the magnetic flow meter shall be battery operated with 6 years' useful life at least and main powered operated on 230 or 12/24 volts ac/dc, 50 Hz and capable of GSM/GPRS communications using commercially available cellular data service.
 - b) The meter shall be equipped with EEPROM memory to prevent data loss.
 - c) GSM/GPRS communications hardware shall allow the meter to transmit real-time flow rate, totalized flow, and time-stamped stored process data over a third-party cellular network to the Client's facilities identified on the drawings. The communications hardware shall be integral to either the flow meter or signal converter.
 - d) A high gain remote antenna shall be supplied with the meter that will allow data to be transmitted via GSM/GPRS technology.

- e) Installation of GSM/GPRS-capable magnetic flow meters shall be coordinated with the cellular service provider as specified.

4. GSM/GPRS Coordination.

Where GSM/GPRS communications are employed, the System Supplier shall coordinate with the GSM/GPRS cellular service provider for the following:

- a) Coverage of GSM/GPRS service acceptable to the Engineer at all designated locations.
- b) Antenna, transmitting requirements, and any other requirements.
- c) Setting up the instrument for signal/data transmission over the cellular network.

5. PRODUCTS:

GENERAL, the following paragraphs provide minimum device requirements. The Drawings and Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

- Interconnecting Cable.
 - For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided.
 - The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter.
 - Length of cable shall be a minimum of three meters or as indicated on the Drawings or in the Instrument Device Schedule.
 - The interconnecting cable shall be provided in the length necessary for installation.
 - Splices shall not be allowed in the installed cable.
- Programming Device.
 - For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Client facility (quantity required shall be as indicated in the Instrumentation and Control System section).
 - The programming device shall include appropriate operation manuals and shall be included in the training requirements.
 - For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.
- Configuration Software/Serial Interface.
 - Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link.
 - As a minimum, an appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer.

- One licensed copy of the diagnostic/interface software shall be provided for each Client facility (quantity required shall be as indicated in the Instrumentation and Control System section).
- Software shall be capable of running under the Windows XP operating system.
- If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

6. Field Services:

- a) Manufacturer's field services shall be provided for installation, programming, commissioning, field calibration, start up, and training as specified in the Instrumentation and Control System section.
- b) Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

4 SUBMERSIBLE TURBINE WELL PUMP

4.1 GENERAL

4.1.1 Scope of Work

- A. This section covers the submersible turbine deep well (bore hole) pumping unit for the Jericho Agro-Industrial Park. The Contractor shall provide all pumping unit (pump, protection seal, motor, cable, shroud, check valve, column and well head, level measurement and monitoring devices with all accessories as per these technical specifications), labor, materials, equipment, and incidentals required to provide, test, warranty, supervise installation, training, and make ready for operation the submersible turbine well pumping unit and identified appurtenances as specified herein.
- B. All necessary and desirable equipment and auxiliaries whether specific all mentioned in this specification or not, shall be furnished as required for an installation incorporating the latest version standard for this type services. Also included shall be supervisory during installation and field testing of each unit and instructing the regular operating personnel in the proper care, operation and maintenance of the equipment.
- C. The Contractor shall submit in his bid all the necessary documents, certificate of origin of equipment, characteristic curves, and any other official papers deemed necessary to confirm that the pump, mechanical seal and the driving motor are new and they are complied with the tender's technical specifications.

4.1.2 Main Work Tasks

- A. Supply of submersible pump, protection seal and submersible electrical motor complete.
- B. Supply of pump power cable spliced to the motor leads.
- C. Supply of RTD cable spliced to the motor sensor motor leads, and connecting it with the Motor Control Centre (MCC).
- D. Supply of riser column pipe, DN 150mm * 125 meters including couplings at one end of each pipe as per the technical specifications.
- E. Supply of Suitable Motor Cooling Shroud.
- F. Supply of S.S Check Valve at the top of Submersible Pump with (25 bar.).
- G. Supply of two-line access pipes of uPVC 150 meter each line, total 300 meter.
- H. Supply of cable with electrode and specific dry relay for dry level protection installed at the discharge head.
- I. Supply of all other materials to complete the wiring and cable connection with need panel at the discharge well head.

4.1.3 Related Work

- A. Concrete work and the installation of anchor bolts are included in Division 3 of the General Technical Specifications (GTS).
- B. Field painting is included in Division 4, Section 4.4.2 of the GTS.
- C. Instrumentation is included in “Instrumentation and Control Section” of the Particular Specifications.
- D. Valves, mechanical piping and appurtenances, except as hereinafter specified, are included in Division 5 and 9 of the GTS and Section 3 of these Particular Specifications.
- E. Electrical work, except as hereinafter specified, is included in Division 15 of the GTS and Electrical Specifications included in these Particular Specifications.

4.1.4 Submittals

A. Pump Manufacturers Qualifications

1. The pump unit shall be of submersible turbine bore hole type, protection seal and electrical motor assembly designed for continuous submerged operation. The pump assembly (bowls, strainer, motor, check valve and shroud) shall be provided by one manufacturer who is manufacturing this type of pumps for 10 years at least.
2. The manufacturer service representative shall maintain an adequate stock of spare parts to facilitate timely repairs in the event of equipment failure. The manufacturer or his representative shall provide 7 days/ 24 hours’ service and technical support for the product via worldwide network. A statement of response time and extent of experience of the local service organization shall be included with the submittals.
3. Approved manufacturers: Xylem, Pleuger, National, KSB or equally approved and should have a local agent/distributor in Palestine or Israel.

B. Pump Information

Prior to ordering the fabrication pumping equipment, submit copies of the manufacturer's literature and Shop Drawings, which shall include all the following items, to the Engineer for approval.

Drawings & Documentation	Complete Assembly
	Materials List and part number
	Wiring and schematic diagram
	Foundation details and anchoring
	Shop drawings
	Spare part lists
	Installation, Operation and Maintenance manuals

Submersible Pump	Name of the Manufacturer
	Type, Model, and Serial Number
	Selective materials
	Motor speed
	Number of Stages
	Dimensions and weights
	Complete multi-speed performance Curves including efficiency, BEP, NPSHR, BHP, shut-off head, run out flow, operational range, etc.
	Regulation range speed at VFD
	Tests (hydraulic and performance) including test class
	Installation procedure
	Shop Coatings

Submersible motor Protector Seal	Name of the Manufacturer
	Type, Model, and Serial Number
	Design Rotative Speed
	Number of Seals
	Sensor temperature type
	Weight
	Thrust Bearing (upper thrust ring, down thrust shoe, thrust retainer)
	Speed Range Operation Curves
	Selective Materials
	Installation procedure
	Shop Coatings

Submersible Electrical Motor	Name of Manufacturer
	Type and Model
	Type, Size, and Rating of Bearing & Lubrication
	Base motor type and strainer
	Rated power and IP
	Temperature Rating
	Sensor temperature type
	Service Factor
	Full Load Speed
	Weight
	Current at Full, $\frac{3}{4}$, and $\frac{1}{2}$ Load
	Efficiency at Full, $\frac{3}{4}$, and $\frac{1}{2}$ Load
	Power Factor at Full, $\frac{3}{4}$ m and $\frac{1}{2}$ Load
	Full Load Torque and tongue curves.

		Operation and Maintenance Manuals with Connection Diagrams
		Velocity speed of cooling Water
		Motor Capabilities Curve
		Starting Current Curve
Columns Pipe Check Valve, monitoring pipes, shroud		Manufacturer's Technical Data
		Performance Charts
		Catalogue Cuts
		Thread Pattern
		Wall thickness
		Joint Length data
		Installation Instructions
		Shroud Diameter
		Coating
		Weight
		List of Parts with Price and Source
		List of Supplies with Price and Source

Cable Power and RTD Cable	Manufacturer's Technical Data
	Performance Charts
	Insulation Wall thickness
	Catalogue Cuts
	Installation Instructions
	List of Parts with Price and Source
	List of Supplies with Price and Source

Instrumental and Level electrodes for sensing water level	Manufacturer's Technical Data
	Performance Charts
	catalogue Cuts
	Installation Instructions
	List of Parts with Price and Source
	List of Supplies with Price and Source

C. The following shall be submitted in compliance with this Section:

1. Complete catalogue information, descriptive literature, specifications, and identification of materials of construction. Complete and detailed assembly and installation instructions.
2. The manufacturer of the submersible pump shall have ISO 9001.
3. Any variation from these specifications shall be underlined in the submittal along with the reason and essential documents.

4. The Contractor/ manufacturer shall indicate the allowable and preferred operational range limits on the performance curves recommended for satisfactory operation without surge, cavitation's, heating, and overload, under/over flow or vibration. The operating range shall be with three working curves and as wide as possible based on actual hydraulic and mechanical tests.
5. Predicted pump performance curves for each condition point shown head, temperature, power, efficiency and NPSH required on the ordinate plotted against capacity on the abscissa. Pump inlet, bowel, column and discharge head losses for column pipe shall be shown as separate curves.
6. Control diagrams and process and instrumentation diagrams relating to the submitted equipment, show specific necessary for the equipment proposed in the submittal
7. Multi-speed performance curves shall be provided up to 70% of rated speed of 100 rpm intervals between the minimum and maximum speeds required to achieve the specified operating conditions. Manufacturer's recommended operating range for stable operation and prevention of surge, heating, overload, cavitation's and vibration.
8. Performance data curves showing head, flow, power, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity with a minimum of 5 points. Indicate separately the head, capacity, power demand, bowl efficiency, and minimum submergence required at the guaranteed point.
9. Motor submittal shall include certified calculations for motor rotor and frame reed frequencies.
10. Complete description and sketch of proposed test setup for factory test, at least 2 weeks in advance of the proposed test date. Submittal material shall include sample calculations and proposed test log format. All test reports shall be submitted before the shipment of the pump unit.
11. Drawings show general dimensions and confirming the size of pump, mechanical seal and motor drive, and specified appurtenances; piping connections; construction details of equipment; power and control wiring diagrams. Total weight of pumping unit as well as weight of individual components.
12. Drive unit support calculations and data with analysis should be done at the site during starting and testing the submersible pump.
13. All parts and material used submersible pump should be suitable for drinking potable water.
14. Finish Coating/Lining system.

D. Quality Control Submittals:

1. Factory Functional and Performance Test Reports and Log.
2. Manufacturer's Certification of Compliance that the factory finish system is identical to the requirements specified herein.
3. Special shipping, storage and protection, and handling instructions.

4. Manufacturer's printed installation instructions.
5. Manufacturer's Certificate of Proper Installation.
6. Suggested spare parts. Include a list of recommended spare parts with required special tools for checking, testing, parts replacement, and maintenance with current price information.

E. Instructions

1. Instructions shall be concise, complete, and typewritten.
2. Control & wiring instructions with diagrams shall be comprehensive and include the layout of the entire pump system.
3. Operating instructions with diagrams shall cover preventative maintenance procedures, methods of checking the system for normal operation, and procedures for safely starting and stopping the system.
4. A pump system training course will be provided to the Client by certified personnel.

F. Operation and Maintenance Manuals

1. Complete set of manuals containing the manufacturer's operating and maintenance instructions shall be required for each piece of equipment.
2. The Operation and Maintenance manuals shall be permanently hardcover bound.
3. The manuals shall be inscribed with the following information: "OPERATING AND MAINTENANCE INSTRUCTIONS", name and location of the facility, name of the Contractor/ manufacturer, and contract number.
4. Instructions shall include the following items:
 - a) System layout diagram.
 - b) Wiring and control diagrams.
 - c) Control sequence describing start up, operation, and shutdown.
 - d) Maintenance and troubleshooting.

4.1.5 Delivery, Storage and Handling

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation.
- B. All equipment and parts must be properly protected against any damage during shipment. Store equipment in accordance with manufacturer's recommendations, and suitable for keeping access for predictive maintenance issues during storing if needed.
- C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Client/Engineer.
- D. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted thereto.

- E. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

4.1.6 Accessories

- A. Equipment Identification Plate: Die-stamped equipment tag number securely mounted in a readily visible location on the surface plate with manufacturer name, mode number, serial number, m³/hr. at rated head in meters, rpm, and date of manufacturer.
- B. Lifting Lugs: Required for all equipment weighing over 50 kg.

4.1.7 Factory Finishing

- A. The submersible Pump and all components in contact with water shall be certified for drinking water such NSF-61, WRAS or EA.

4.1.8 Source Quality Control

- A. Pump, protection seal and motor will be factory tested in accordance with ISO 9960 or ANSI/HI 14.6- Grade 1B, IEC 60034-2-1 or IEEE 112.
- B. Types of Tests:
 - Performance test to demonstrate hydraulic and mechanical integrity. It shall include flow, head, power and efficiency.
 - Performance test for mechanical and electrically integrity.
 - Hydrostatic test of pressure-containing components.
 - Vibration test.
 - Motor test.
- C. The motor manufacturer shall perform and submit the additional data for the following tests on each motor actually furnished, and the results shall be within the associated test requirement:
 - No-Load Current at rated Voltage: $\pm 2\%$ Balance between all Phases
 - Oil Dielectric Resistance: $>14\text{kv}$.
 - Winding Resistance to Ground: $>1,000$ Meg. Ohms.
 - Phase - to - Phase Ohms: Manufacturer's Standard
 - Motor Cost Time: Manufacturer's Standard
- D. Records of all tests performed by the manufacturer shall be made in accordance with the applicable standards
- E. The Pump shall have a continuously rising curve. Unless indicated otherwise, the required pump shaft horsepower at any point on the performance curve shall not exceed the rated horsepower of the motor or encroach on the service factor.

- F. All test records shall be bound permanently and provided in a report by the manufacturer. Certified copies of the report shall be provided to the Engineer not less than 10 days prior to the shipment of the equipment from the factory.
- G. The required specific test points on each pump actually furnished are as follows:
 - Head at the rated capacity.
 - Two pump curve points at heads greater than the rated capacity.
 - Two pump curve points at heads less than the rated capacity.
 - Shut-off Head.
- H. The factory test data and test curve shall include Capacity in m³/hr., Head in meters, and Efficiency in percent and Load in kW for each test point. The job pump, protection seal and motor shall be string tested together for the pumping unit. All test data and the test curves shall represent actual test data without correction back to a reference RPM.
- I. Pump Test Tolerances: As defined in the ISO 9906 or Hydraulic Institute 14.6 Standards -Grade 1B.

4.1.9 Extra Materials

- A. Furnish one complete set of any special tools required to dismantle the submersible pumping unit.
- B. All the spare parts, extra materials and provisional material like the pumping unit shall be complete in every aspect, ready to attach to the column pipe and put into use.
- C. Supply 10 splice joints of submerge water type for the power cable.

4.1.10 Reference Standards

- A. ANSI/HI 9.6.3: Rotodynamic (Centrifugal and Vertical) Pumps – Guideline for Allowable Operating Region
- B. ISO 9906 or Hydraulic Institute ANSI/HI 14.6 latest edition.
- C. For Pumps – General Guidelines for Types, Definitions, Application and Sound Measurement Hydraulic Institute ANSI/HI 9.1-9.5-2015 or EUROPUMP Guidelines or equally approved.
- D. Motors: IEC 60034, IEEE or NEMA MG 1 standard.
- E. American Society for Testing and Materials (ASTM), International Organization for Standardization (ISO) or EN or DIN applicable standards
- F. EN 1561 or ASTM A48, Standard Specification for Grey Iron Castings.
- G. EN 10217, EN 10224, or ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- H. Stainless Steels: EN 10088-3 or ANSI/AISI
- I. EN 1982 or ASTM B62, Standard Specification for Composition Bronze or Ounce Metal Castings.

- J. BS EN 1982-2008 GC CC 333G or ASTM B148, Standard Specification for Aluminium-Bronze Sand Castings.
- K. BS EN 1982:2008 GC CC494K or B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
- L. Occupational Safety and Health Administration (OSHA)
- M. Steel Structure Painting Council (SSPC)
- N. ISO 9001 Quality Systems
- O. Vibration Limits: Within the desired limits specified for pump operational ranges provided in BS ISO 10816-7 (Zone A) or ANSI/HI 9.6.4.
- P. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

4.1.11 Warranty

- A. The equipment shall be warranted for a period of 2 year from date of substantial completion to be free from defects in workmanship, design or material. If the equipment should fail during the warranty period due to a defective part(s), it shall be replaced and the unit(s) restored to service at no expense to the Employer. Substantial completion of the well pump incorporates testing and commissioning approved by the Engineer.

4.2 PRODUCTS

4.2.1 General

- A. The pumping unit shall be supplied by one manufacturer and shall be complete including pump, protection seal, motor, and appurtenances such as, but not limited to, couplings, guards and gauges.
- B. The pump, protection seal, elect. Motor and controls shall be designed and built for 24-hour continuous service at any and all points within the required range of operation, without overheating, without capitations, and without excessive vibration or strain. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially constructed to meet the Specifications.
- C. The motor and protection seal should be carried the reverse speed at the reverse flow through the pump in case the check valve out of order.
- D. Pump support and surface discharge is to be as described herein.
- E. Each major piece of equipment shall be furnished with a stainless-steel nameplate, with embossed data, securely mounted to the body of the equipment. As a minimum, the serial number, rated flow capacity, head, speed and all other pertinent data. As a minimum, nameplates for motors shall include the manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles and power and service factors.

- F. Verification of Dimensions: The Contractor shall become familiar with all details of the work, verify all dimensions in the fields and shall advise the Employer of any discrepancy before performing the work.

4.2.2 Conditions of Operation

- A. The pump shall be designed for the conditions of service described herein and shall operate within the system head curves as appended. The pump shall have a rising head system curve for stable pump operation from the minimum head operating point to the shut-off head.
- B. The specific conditions of service for pump as detailed in this Section.

4.2.3 Pump Construction

- A. Contractor to furnish of one complete submersible pumping unit, to be set in the JAIP deep well, suitable for potable water service. The well test and water quality analysis of the well is presented in Appendix A-Well Completion Report-Jericho Argo-industrial Park Well 3.
- B. The pump shall be driven by a protection seal and submersible electric motor, distilled water filled application or as recommended connected to the pump.
- C. The pump, protection seal and the submersible electrical 2- pole motor (≈ 2900 rpm nominal rotational speed) shall be provided by one manufacturer to and meet the duty points and performance specified. The pump shall be designed to provide a long operating life with minimum required maintenance in the deep-set conditions. The motor shall be inverter duty and shall be compatible with approved variable speed drive.
- D. The submersible electrical motor shall be heavy duty and should be carried the reverse speed at the reverse flow through the pump in case the check valve out of order.

4.2.4 Column Pipe

- A. Column Pipe shall be supplied by the Contractor.
- B. Length of column pipes shall position the pump intakes at 125 meters measured from the pump's strainer.
- C. Individual Column lengths shall not exceed 6 meters.
- D. The discharge column pipe shall be a threaded and coupled steel pipe conforming to ASTM A120, ASTM A53 Grade B SCHEDULE 40 or equivalent EN Standard. Threads shall be of the buttress type. The column pipe shall be 150 mm nominal diameter at least or as recommended by the approved manufacturer.
- E. Thread pattern: API 8-10 round long

- F. Couplings: to match column pipe threads, API 8-10 round long or EN 10226/Rp/BSPT.
- G. Torque straps to be welded across the lower 50 meters of couplings shall be steel, 40 mm wide, 7 mm thick, and shall overlap to pipe to allow a 50 mm weld length on the column pipe. Two torque straps shall be welded across each coupling that is set in the lower 50 meters of the column pipe.

4.2.5 Check Valve

- A. The discharge column pipe shall be equipped with a column silent globe check valve located immediately above the bowl assembly.
- B. The material of type check valve shall be **stainless steel 316**.

4.2.6 Pump Characteristics

- A. The pump shall meet the operating conditions stated below.
- B. Guaranteed Performance for JAIP Deep Well
 - 1. Rated Pumping condition
 - a. Pumping Capacity: 140m³/hr.
 - b. Pump Total Head (at the exit bowl): 115m.
 - c. Bowl Assembly Hydraulic Efficiency not less than: %78
 - 2. Other characteristics
 - a. Shutoff head: 25 to 50% of rated head.
 - b. The Submersible Electrical Motor shall be heavy duty type, inverter duty and sized to accommodate for the rated brake power at rated speed on the curve with 115% safety margin at least and shall be designed to work permanently via VFD up to 70% of its rated speed.
 - c. **The design rated point shall be selected within ±7% of the BEP flow.**
 - d. The Preferred Operating Range (POR) is defined by hydraulic institute as 70% to 120% from the Best Efficiency Point (BEP) on each multispeed curve. The operating rated flow of the pump shall be at any speed within 80% to 110% of the BEP flow.
 - e. Maximum Setting Depth: 125m (Strainer).
 - f. Well Casing Size (mm ID) at pump setting: 18” (445mm).
- C. Pump speed shall be 2900 rpm, nominal.
- D. NPSH required shall not exceed 10 meters at any flow rate or as recommended by manufacturer.
- E. Pump head capacity curve shall be continuously rising to shutoff.
- F. Pump horsepower characteristic shall be non-overloading and shall not exceed the motor rated horsepower at any point over the entire pump envelope.

- G. The submersible pumping unit shall be suitable for continuous operation at any condition in the allowable operating range and at specified reduced speed limit without excessive vibration or accelerated wear.
- H. Pump, protection seal and the electrical motor shall be suitable for continuous operation at any condition with multiple stops/starts and starting within the allowable operating range without excessive vibration or accelerated wear.
- I. As the diameter of the well casing is a 445mm. Therefore, and depending on the other available information in this section and the other sections, the Contractor shall coordinate with the pump unit manufacturer to furnish the most appropriate diameter of the pump motor and shroud for this well.
- J. The diameter of the pump (bowls) shall be at least 250mm with suitable electrical submersible motor.
- K. The pump components shall be designed to withstand a sand content of 50 mg per litre at least.

4.2.7 Pump Design and Construction

- A. The pump shall be constructed with enclosed impellers that are dynamically balanced at the full pump speed. Impellers shall be securely fastened to the shaft with taper collets, lock nuts, or keys and constructed such that the impellers do not float down during down thrust.
- B. The pump shaft and coupling strength shall be rated at a minimum of 1.5 times the maximum horsepower requirement of the pump bowl assembly, as well as being capable of transmitting the total torque and thrust of the pump bowl assembly in either direction of rotation.
- C. The impellers and bowls shall be constructed of casted stainless steel (AISI 316-EN 1.4408 or higher grade and should be free from sand holes and other detrimental imperfections. All other pump components shall be of equivalent corrosion resistant materials. The pump assemblies shall be capable of withstanding a hydrostatic pressure equal to twice the pump head at rated capacity or 1.5 times the pump shut-off head, whichever is greater. Shafting shall be stainless steel AISI 316, 410, 420 or equivalent.
- D. The pump discharge threads shall match the column pipe as specified herein, or an adapter of adequate strength shall be provided.
- E. In addition to normal pumping requirements, the pump shall be designed against reversing from total head water at column pipe rise if the main check valve at the top of pumps not holding the column of water.
- F. The complete pumping unit shall operate without overload on any component at any point along the pump entire full-speed operating curve. Pump required by virtue of the specified operating conditions to operate against a closed or throttled valve for any period of time exceeding five seconds.

- G. Pump Selection: Pump shall be selected to place all specified continuous duty operating conditions within the manufacturer's Allowable Operating Range as defined in ANSI/HI 9.6.3. And specified operation range in this document for well pump specifications with rated conditions and all other continuous duty full speed operating conditions specified for this pump.

The detailed pump specifications shall fall within the manufacturer's Preferred Operating Range as defined in ANSI/HI 9.6.3.

The variable speed operation to achieve this objective will not be considered.

Pump selection proposing maximum diameter impellers for the proposed pump model and casing size will not be accepted.

- H. The well pump should be suitable for operation at least fifteen years without pulling pump again.

4.2.8 Seal Sections

- A. The seal sections shall be designed to operate with the provided pump and submersible motor, to the performance specified for these components.
- B. The seal shall be designed to provide a reservoir for the electric motor and equalize the internal pressure of the motor with respect to the well annulus pressure. It shall be designed to have the required construction for expansion and contraction during normal thermal cycling of the unit.
- C. The seal housing shall be manufactured from stainless steel containing 1% molybdenum at least.
- D. The thrust bearing in the seal section shall carry the up and down thrust created by the pump. The thrust bearing shall be rated to carry a load at least 2 times the generated pump thrust at any allowable operating condition or continuous operation at the pump shut-off head, whichever is higher. The thrust bearing must be capable of operating in reverse rotation and under conditions of several pumping unit starts and stops per day.
- E. The seal section design shall include as a minimum three mechanical face seals to prevent water intrusion into the motor. It shall be capable of transmitting the entire motor torque at the service factor and shall contain a heat exchanger section to circulate the motor fluid in the thrust bearing area. Design shall incorporate an elastomeric barrier to isolate well fluids from the motor fluid. A high-capacity mechanical seal (labyrinth chamber) may be substituted for the elastomeric barrier at the manufacturer's discretion.

4.2.9 Electrical Submersible Motor

- A. The motor rated power delivered and as stated on the stamped nameplate shall be greater than the maximum pumping load along the pump curve. And the motor should be one unit.

- B. The complete pumping unit including suction strainer, motor, bowls, check valve and shroud shall be assembled by the pump manufacturer.
- C. The motor shall have a standard nameplate with operating data, and bearing and lubrication data.
- D. The motor shall have motor winding temperature detectors (RTD's) or other approved means to monitor motor temperature. Cable for the RTD's shall be provided suitable for the installation in continuous lengths adequate for the maximum setting depth listed plus 30 meters.
- E. Type F insulation class temperature of the motor less (Max winding temperature of 155°C). Less classes are prohibited. The motor ingress protection shall be IP 68 and shall be suitable for the maximum submergence from static level to pump setting level.
- F. Motor shall be rated for the specified reduced voltage starting application
- G. **Submersible Elect. Motor Performance Specifications:**

1. Motor Rated power:	75 kw (100 hp)
2. Motor Voltage	400
3. Motor Frequency	50 Hz
4. Phase	3
5. Nominal synchronized RPM	2900
6. Minimum Motor Efficiency at full load	84%
7. Minimum Power Factor at full load	82%

4.2.10 Submersible Motor Design and Construction

- A. The submersible motor shall be designed to operate with the provided pump, to the performance specified for these components. The motor shall be constructed using copper winding wire coated with a high dielectric insulation.
- B. The motor windings shall be totally encapsulated in a thermo set epoxy that fills the winding slots and covers the winding end coils in order to prevent winding wire movement due to normal motor vibration. The motor shall be filled with distilled water or as recommended, selected by the manufacturer to provide the lubrication necessary for several starts and stops per day. The motor housing shall be manufactured from stainless steel 316 or similar grade.
- C. The motor thrust bearing shall be designed and built to support the weight of the rotor stack, and the dynamic head generated by the pump while operating continuously at the motor rated speed and full load.
- D. The motor lead connector shall be either the potted, plug-in style, or tape-in style, connecting to the motor with a bolted connector, and of sufficient length to allow the splice to the drop cable above the pump. The motor lead shall be encased in stainless steel cable guards starting from the plug and extending up to the splice

with the drop cable and strapped to the motor, pump end, and drop pipe with 20 mm wide stainless-steel bands spaced a maximum of 1.5 meters apart.

4.2.11 Motor Cooling Shroud

- A. A motor cooling or flow inducer shroud shall be supplied for the motor as part of the well pump installation. The motor shroud shall be designed and utilize pipe material on an outside diameter that will fit inside the well casing without binding and the shroud inside diameter shall provide for a motor cooling velocity to keep the motor temperature at 45°C. The shroud shall be of length to extend at least half meter down the length of the motor.
- B. The shroud shall be fabricated out of stainless-steel material such as or equivalent to AISI 316 or better. It shall be furnished with a bolted adapter that will allow its removal from the pump and motor without welding or cutting. This adapter shall be furnished with the strength required to support the entire string weight of drop pipe, water, check valves, and cable. Fasteners shall be 316 Stainless steels.
- C. The motor cable shall be protected with a rubber seal at the penetration where it passes through the shroud adapter plate at the top of the pump. Submittal drawings shall show sizes and materials for this assembly.

4.2.12 Submersible Cable

A. Materials

- 1. Size, as recommended by the motor manufacturer
- 2. Insulation Rating: 5,000 Volts
- 3. Number of Conductors: 3
- 4. Ground: One
- 5. Conductor Material: Copper
- 6. Stranding Class B
- 7. Fillers non hygroscopic material
- 8. Conductor Insulation: Polypropylene
- 9. Cable Configuration: Flat
- 10. Jacket: Nit rile Rubber with overall armoured stainless steel
- 11. Temperature Rating: 200°C wet
- 12. Tested IEC/EN 60034 or IEEE 1019

- B. The pump cable shall be furnished and supplied in one continuous length from the motor leads to the well head with one splice only allowed at the motor leads. Any cable fillers shall be non-hygroscopic, paper or jute fillers are not allowed. Length of cable shall be adequate for the maximum setting depth listed plus 30 meters.

- C. The down whole cable shall be high-potential tested at the factory, and the applied test voltage shall exceed the nameplate voltage rating of the cable to conform to the applicable IEEE or IEC cable manufacturing standards.

4.2.13 Downhole Sensors

- A. The down hole sensors shall be designed to operate with the provided pump and submersible motor, to the performance specified for these components.
- B. The down hole sensor housing shall be manufactured from stainless steel AISI 316 or better.
- C. Each down hole sensor shall be equipped with an above ground display controller unit with at least 3 programmable digital dry relay outputs, SCADA ready and data logging capability with at least 1-megabyte non-volatile memory.
- D. The following sensors/ transmitters shall be provided
 - Motor winding temperature. The control cable shall be clamped to the power cable.
 - Suction pressure (water level): shall be lowered inside one of the monitoring pipes mentioned below.

4.2.14 Monitoring Pipes

- A. Furnish Two uPVC pipes of 40 mm diameter, PN 20, SDR 11 for level sensors (portable and permanent level sensors) as per EN ISO 1452-2&3 or DIN 8062/DIN 8063 or as per ASTM D 1785- Schedule 40 and shall be thread jointed.
- B. Each pipe shall extend into the well to a depth of 90m and then to be slotted along the remaining depth of the well up to the uppermost bowel of the well pump
- C. The down end of pipes should be plugged and supported the column pipe with stainless steel straps/bands spaced at 1.5m.

4.2.15 Equipment Appurtenances

- A. Pumping equipment shall be provided with all necessary equipment appurtenances for the perfect functioning of the pumping unit.
- B. All Bolts and nuts used for the assembly of the pumping units shall conform to the requirements of DIN EN 4017/DIN 933- Stainless steel A4-70, DIN EN ISO 4032/DIN 934 nut and DIN EN ISO 7091 flat washers or ASTM A307-AISI 316.
- C. Threads shall be clean-cut and shall conform to BSPP or ASME B1.1.
- D. If specified the galvanized bolts, nuts, and washers shall be zinc coated after being threaded by the hot-dipping process conforming to ASTM A123 as appropriate.

4.2.16 Pump Head Assembly

- A. Pump head assembly shall consist of the pump base plate and the discharge head. Head assemblies shall be of low, rigid construction arranged for bolting to concrete foundations and shall be provided with at least two eyebolts, cast lugs or other means of securing slings to facilitate setting and lifting. Pump discharge head and base plate shall be capable of withstanding all end and side thrusts imposed by the pump during operation and have adequate strength to resist vibration at any operating speed.
- B. Pump Base plate: Pump head base plate shall be cast-iron or steel and shall serve as a soleplate for mounting the discharge head assembly.

4.2.17 Control Equipment

- A. Automatically controlled pumps shall have three-position MANUAL-OFF-AUTOMATIC selector switch in cover. Additional controls or protective devices shall be as indicated in the division of boosting pump station. A pump low-water cut off shall be installed in the well on the suction pipe and shall shut the pump off when the water level in the well reaches the low level after giving an audible alarm. Pump shall operate via pressure level transducer located in the balancing tank. This transducer is connected to the PLC unit in the main control panel of the pumping station. A high-pressure transducer is installed on the main pump discharge to cut off the pump in case of high pressure when the above level controller failure or in case of any emergency (closing the valves of tank inflow while the pump is operating). Moreover the pump is equipped with dry flow sensor to shut down the pump in case of dry flow condition as well as to winding RTD protection for submersible motor. Also, the number of pump's starts per hour shall be controlled as per to the manufacturer recommendations.

4.2.18 Shop Tests

- A. The Engineer shall have the right to inspect any equipment to be furnished under this Section prior to their shipment from place of manufacture.
- B. Each pump shall be factory tested as described in ISO 9906/HI 14.6, for submersible turbine pumps and all test data submitted for approval by the Engineer prior to shipment. Certified copies of the calculated pump performance curves shall be submitted including anticipated head, capacity, efficiency, and total brake horsepower. Such testing shall be performed in a manner that will ensure that each assembled pump and motor shall be tested at the specified design operating conditions to make certain that the unit conforms to the specified requirements. Certified copies for hydraulic performance, hydrostatic pressure and vibration tests results shall be submitted to the Engineer for approval.

- C. Each motor shall be factory tested and copies of test results shall be submitted to the Engineer for approval.

4.3 EXECUTION

4.3.1 Preparation

- A. Coordinate with other trades, equipment and systems to the fullest extent possible.
- B. Take all necessary measurements in the field to determine the exact dimensions for all work and the required sizes of all equipment under this Contract. All pertinent data and dimensions shall be verified.

4.3.2 Installation

- A. Provide onsite services during installation of the pumping unit. These services shall be provided by a qualified representative of the Manufacturer during the installation and commissioning in order to witness the perfect installation and operation of the pumping unit. The services are expected to include a minimum of 7 days of onsite inspection and training. It is the intent that the training specified for the operators be done during the actual installation and operation of the pumping unit.
- B. Installation of the pumping unit shall be in accordance with the reference standards and as per to manufacturer instructions.
- C. During installation of the pumping unit, obtain, record, and submit to the Engineer measurements of; line-to-line ohms all phases, line-to-ground Meg ohms, all phases, every 50 meters of setting depth, beginning with the pumping unit hanging above the well.
- D. After the installation is completed, start-up will occur. The Contractor will be given a period of time in which to make adjustments to the pump equipment under the supervision of the pump manufacturer's technical representative.
- E. Once the adjustments are made the pumps will be operated for 7 calendar days of 23 hours per day minimum with a minimum of one start and stop per day to verify successful performance and substantial completion – after which the warranty period of the equipment will commence.
- F. Initial testing of equipment shall be is included in the Contractor's price. The Contractor is responsible for unsatisfactory performance of the equipment and subsequent tests.
- G. After the 7-calendar day period, if the tests are successful, the works of the pumps will be considered substantially completed.

4.3.3 Commissioning and Testing

- A. The pumping unit shall be field tested during the 7-day acceptance period to demonstrate:
 - Satisfactory operation without excessive noise and vibration at any operating head, including shutoff.
 - Indicated head, flow, and efficiency at the design point and at least two points above and below the design point to satisfactorily demonstrate the range of pump performance.
 - No undue attention is required for operation.
- B. The following field testing shall be conducted:
 - Prior to running the pump and motor obtain no load volts, all phases, and static water level.
 - Start up, check, and operate the pumping system.
 - Obtain concurrent readings of motor voltage all phases, amperage all phases, well water level, water temperature, pumping rate in m³/hr, and pump discharge head in meters for at least 5 pumping conditions. Check each power lead to the motor for proper current balance.
 - Electrical and instrumentation tests shall conform to the requirements of the sections under which that equipment is specified.
- C. In the event any pumping unit fails to meet the specified requirements, the pumping unit shall be modified or replaced and re-tested as above until it satisfies the requirements.
- D. After each pumping system has satisfied the requirements, the Contractor and Manufacturer's Representative shall certify in writing that it has been satisfactorily tested and that all final adjustments have been made. Certification shall include the date of the field tests, a listing of all persons present during these tests, and the test data.

4.3.4 Field Painting

- A. Factory painted items requiring touch up work shall be cleaned completely, and shall be primed and top coated as specified.

4.3.5 Well Disinfection

- A. Upon completion of the work, the well shall be chlorinated with a solution of chlorine which when mixed with water equal in volume to that contained within the well will result in 100 mg/L concentration. The solution shall be left undisturbed for at least 12 hours and then pumped to waste. The strength of the solution and manner of introduction shall be further discussed with the Engineer and his approval

obtained prior to performance to ensure compliance with any health requirements. Chlorination of the well, site piping, and the water tank at the site shall be performed simultaneously. Because of this, the chlorination shall be scheduled so that the Engineer may be present during the introduction of the chlorine into the facilities at the site and before the chlorine solution is introduced into the well. The Contractor shall be responsible for sampling and additional disinfecting should sample analysis show the presence of coliform bacteria.

4.3.6 Manufacturer's Services

- A. Manufacturer's qualified representative (Acceptable to the Employer) with experience in the installation, adjustment, and operation of the specified equipment shall supervise the installation, adjustment, and testing of the equipment

4.4 WELL DATA AND PUMP CONTROL MODE

A. Well Data

Name:	Jericho Agro-Industrial Park Well (JAIP)
Coordinates:	192.830.00/142.017.27
Altitude	-240m below sea level
Depth of the well	207 meters below grade level
Casing	28" conductor: 0.0 to -5m 18 5/8" Blank casing: +0.5 to -85 18 5/8" Perforated casing: -85 to -121 Open Hole: -121 to -207. Casing thickness: 1.1mm.
Static Water Level	79m below grade level
Dynamic Water Level	90m below grade level
Proposed Pump Setting	125 m below grade level

B. General Control Scheme and Operation of the Submersible Pump and the MCC

- The submersible pump shall operate on both automatic and manual modes.
- The control scheme shall protect the pump against high pressure or surges, the setting at 1.5 bar, where the setting of hydraulic relief valve at 1.8 bars.
- The pump shall stop working with time delay from 1-60 sec when the flow transmitter indicates that there is a drop flow below the set value (Minimum desired flow- 70% of BEP flow). Also, the pump will stop when the flow exceeds the max set flow (maximum desired flow on the curve-120% of BEP flow).

- The Pump shall stop / start automatically in time delay (0.5 hour) and according to the level water at balancing tank.
- The Pump should not be permitted to operate again without manual **RESET** in the following cases:
 1. The Water Level Sensor in the well indicates that the dynamic water level is below the critical limit (Minimum submergence permitted by the manufacturer).
 2. In the case of motor overheating from RTD.
 3. In case of current overload.
 4. In case of current low load.
 5. In case of over voltage, drop voltage and unbalance voltage.
 6. In case over frequency.
 7. In case sense ground current.
 8. In case over / drop flow pumping flow (Minimum permitted flow, maximum permitted flow on pump curve.
 9. In case of over-flow from balancing tank.
- The control scheme shall utilize an alarm at annunciation at the Operating Room.

Appendix A: Well Completion Report Jericho Argo-Industrial Park Well 3

End of Section

5 BOOSTING PUMP STATION AND MOTOR CONTROL CENTRE

5.1 SCOPE OF WORK

The Contractor shall include in his Bid for the complete supply, installation, testing and commissioning of the pump stations as detailed on the Bid drawings and in this specification. The Contractor shall include for all labor, materials, tools and tackle, complete with all supports and fixings. The Contractor shall include for preparation of all necessary drawings and other required information, checking all dimensions and location of other services, and the correct setting out of the installation.

5.2 DESCRIPTION

The work under this specification shall include the following:

- A. A pump station intended to deliver water from the balancing tank of JAIP well towards the distribution tanks of Jericho Municipality. The station consists of dry installed, vertical centrifugal multi-stage, in ring-section design, close coupled electric pump, with the General Technical Specifications and standard construction as the following:
 - Rated Flow $Q = 70\text{m}^3/\text{hr}$.
 - Rated Total Dynamic Head = 40 m.
 - Shutoff Head 120-135% the rated total dynamic head.
 - Pump hydraulic Efficiency (bowl efficiency) not less than 72% (ISO 9906:2012-Grade 3B).
 - Synchronized Speed (n) r. p.m. = 2900 rpm.
 - Maximum flow shall be $\geq 105\text{ m}^3/\text{hr}$.
 - Rated flow shall be within 80-110% of BEP flow.
- ❑ Motor Control Center-MCC
- ❑ Variable Frequency Drive-VFD
- ❑ Control and Monitoring system for Pumps Station.
- ❑ Instruments and devices required for Measurements and Monitoring's all Process Variables in Booster Station.
- ❑ All pipe work, valves and instruments.
- ❑ All electrical work connected and required for the operation the pumps.
- ❑ Testing and operation of the pumps.

5.3 GENERAL REQUIREMENTS

- ❑ All pumps and their drivers shall be mounted on a reinforced concrete foundation of an adequate construction and dimensions including an anti-vibration floating base.
- ❑ All pumps shall be located in accessible locations for ease of repair and maintenance.
- ❑ All pumps shall be provided from the factory with plugged connections for casing vent, drain and suction and discharge pressure.
- ❑ Each pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with the specification.
- ❑ Each pump shall be hydrostatically tested by the manufacturer for a pressure not less than 25 bars.
- ❑ Each pump shall be hydraulically tested by the factory- The performance test shall be carried out according to ISO 9906:2012-Grade 3B. Certified test reports to be provided with delivered pumps (5 points at least- duty point, 2 points to the right of BEP, 1 point to the left of BEP and shut-off head and shall include flow, head and efficiency).
- ❑ Piping shall be supported independently of pumps nozzles to prevent piping weight or stresses from bearing on or being transmitted to the pump nozzles
- ❑ Drain from base plate, pump, relief valves, etc. shall be piped to the floor drain located in pump shed.
- ❑ All valves, strainers, flexible connections shall be of the same size as the pipe on which they are installed.
- ❑ All pipes, fittings, valves and instrumentation shall have a pressure rating not less than 16 bars.
- ❑ Other requirements of pipe work and valves shall be as called for in these specifications.
- ❑ All conduit for electrical work shall be heavy gauge galvanized steel.

5.4 SHOP DRAWINGS

Shop drawings of the pumping unit shall be submitted to the Project Manager for approval, prior to shipment from the factory.

The shop drawing shall include the following requirements:

- ❑ Certified performance curves showing job number, customer, customer order number, date of manufacture, model number, pump size, impeller diameter, impeller type, rpm, flow-head characteristic curve, consumed horsepower curve and pump efficiency curve.
- ❑ Pump cross-sectional drawing showing major components with parts numbers and parts list.

- ❑ Pumps and controllers outline dimensional drawing showing overall dimensions of all pumps and controller's enclosure, location of foundations bolts holes and size, location and rating of suction and discharge nozzles of pumps.
- ❑ Detailed wiring diagrams of pumps controllers, and any other electrical devices or accessories.
- ❑ Recommended list of spare parts for two years' operation.
- ❑ Installation, operation, and maintenance instruction manuals.

5.5 FOUNDATION AND SETTING

The booster pumps and the electrical motor drivers shall be mounted vertically on a main concrete foundation adequately reinforced against deflection and provided with drip rim and bolt holes.

The pump shall be directly connected to the driver through a suitable flexible coupling easy to be removed and adjusted without disturbing the pump or the electrical motor and shall have a steel protecting cover as required. The pumping units shall be supported on the foundation in such a way that proper pump and driver shaft alignment will be assured.

The foundation of the pumps shall be made of reinforced concrete designed to carry the weight of the pumps. The foundation shall be extended 100 mm at each side of pump base plate, and 250 mm from F.F.L. The foundation shall be provided with anti-vibration floating base pad as shown on the drawings.

5.6 VERTICAL MULTISTAGE BOOSTING PUMPS

5.6.1 Vertical Inline Centrifugal Pump Construction

The pump shall be vertical multistage centrifugal pump with impellers, diffusers, shaft and outer sleeve made entirely of stainless steel, and with pump casing and motor adaptor made of cast iron. Degree of protection shall be not less than IP 55.

The impellers, diffusers and outer sleeve shall be constructed of fabricated stainless steel AISI 316L- EN 10088-1 (1.4404). The impeller shall be dynamically balanced at the factory. The impellers shall be interchangeable. Pump body, support, upper head, seal housing, shall be made of stainless steel AISI 316 –EN 10213-4. The pump adaptor and coupling shall be cast iron to EN 1561-GJL-200 (ASTM class 25). The shaft shall be constructed of stainless steel– EN 10088 (Shaft: AISI 431-1.4057, or higher grade). The fill/drain and air plugs shall be stainless steel AISI 316. The tie rods shall be Stainless Steel AISI 316 or AISI 431 or higher grade.

The shaft shall be sized to carry all axial and radial thrust. Tungsten Carbide shaft sleeves including innovative axial load compensation system to reduce axial thrusts shall protect the shaft.

The pump components shall be designed to withstand a sand content of 50 mg per litre at least.

Standard mechanical shaft seals and elastomers shall be balanced according to EN 12765 and ISO 3069.

The pump shall be provided from the factory with in-line standard flanges (EN 1092) for suction and discharge connections. The pump shall be provided with welded stainless-steel nameplates and all documentation as per CE requirements (catalogues, dimension tables, assembly installation manuals, operating manuals, performance curves). Approved manufacturers: KSB-Germany, Xylem- Lowara, Grundfos or equally approved and should have a local agent/representative in Palestine.

5.7 PUMP INSTRUMENTATION

5.7.1 Pressure Relief/Surge Anticipating Valve

The pump set shall be provided with pressure relief or surge anticipating valve as indicated on drawings. The discharge of the valve shall be re-circulated to the source tank.

Provision shall be made for a discharge to drain.

5.7.2 Automatic Air Release Valve

Each pump shall be provided with combination air release valve of size indicated on drawings.

5.7.3 Pressure Gauges

A pressure gauge shall be connected to the discharge side of the pump casing. Pressure gauges shall be Bourdon tube, oil filled type with 100mm diameter dial with needle pointer, normal operating pointer, brass casing, bronze syphon and bronze gauge cock, all suitable for the working pressure of the system. Each gauge shall be calibrated in bar from Zero to 10. All pressure gauges shall be fully tropicalized and fitted with a red indicating needle set to show the normal operating position.

The Booster Station shall have the following measurement units:

- a. Balancing Tank of booster station:
 - Level transmitter to control start and stop of pumps.
 - Level switch (float) to monitor level of reservoir in case of fail of level transmitter.
- b. Pumps:

Each pump shall be equipped with:

 - Flow switch in suction pipe (for pump safety).
 - Pressure switch in discharge pipe (for pump safety).

- Resistance temperature detectors to monitor the temperature of windings and bearings of each pump (for pump safety).
- Vibrations measurements for each pump (for pump safety).
- c. Common outlet (discharge) pipeline from booster station:
 - Electromagnetic flow meter.
 - Discharge pressure transmitter

5.8 VALVES

- ❑ Pressure Rating: Unless higher pressure ratings are specified elsewhere, valves at pumps discharge and suction shall have a pressure rating of 16 bars.
- ❑ Indicators, hand wheels, caps for key operation, extension spindles, capstan headstocks, locking devices and other detailed requirements shall be provided as specified or shown on the drawings.
- ❑ All valves shall be ‘open end’ tested by an approved method and shall be watertight at the appropriate test pressure.
- ❑ Check valve of the silent, swing type with a counter weight to avoid pressure surges and shall be installed on the pump discharge piping.

5.9 STRAINERS

- ❑ All strainers shall be of 16 bar working pressure rating.
- ❑ Strainers shall be Y-type, with 26-mesh stainless steel screen with 0.8 mm diameter perforations.
- ❑ Strainers shall be cast iron flanged to BS 4504.

5.10 PUMPS’ FLEXIBLE COUPLINGS

Furnish/Install moulded double arch spherical connector/expansion joints(s). The moulded spherical body must be manufactured using multiple piles of nylon tire cord fabric bonded within the EPDM elastomeric or reinforced rubber bellows. Floating flanges shall be zinc-coated plate steel and must have drilled bolt holes in accordance with pump flanges standard (EN 1092-1). The floating flanges shall be complete with stainless steel AISI 316 tie rods (external restraints) of the same size as of flange bolts to absorb reaction force from internal pressure.

5.11 MOTORS

The motors of all electric driven pumps shall be of squirrel cage induction type, 2 pole, 2900 rpm and rated for continuous operation at ambient temperature 45 Deg. C with finned aluminum casing and enclosed construction with external ventilation.

The motors shall be totally enclosed fan cooled type with insulation class F and IP 55 protection. The motor shall be rated for 380-400 volts and 50 cycles. The motor shall be designed for PLC and shall be of inverter duty type.

The locked rotor current of the motor shall not exceed approximately six times the full load current. The motor shall be sized so that the full load ampere rating will not be exceeded.

Motor performance shall be according to EN 60034-1- IE3

All motors shall be provided with nameplates in accordance with above standard.

The power supply feeder of the pump shall be sized at 125 percent of full load current of the pump.

Motor power factor shall not be less than 0.9.

The motor service factor shall be 1.0

The horsepower rating of the motor driving the pump shall be of such magnitude as to ensure non-overloading of the motor throughout the capacity range of the pump for the impeller size selected and shall be at least 110% of maximum shaft power on the pump curve.

The pump and the electrical motor must be as a one unit, connecting together by suitable coupling with a best alignment.

The motor shall be equipped with PT 100 or RTD protection.

5.12 PUMP DATA

The following blanks shall be fully completed by the bidder for every pump. Failure to do so may result in the rejection of the offer.

Pump Size _____
 Pump Type -----Centrifugal Vertical Inline
 Capacity-----m³/hr.
 Total Dynamic Head -----m.
 Efficiency of Motor----- Percent
 Efficiency of Pump ----- Percent
 Overall Efficiency ----- Percent
 Number of Stages ----- Stage
 Pump Power ----- KW
 Motor Power----- KW
 Maximum Pump Diameter ----- mm

Impeller Type: -----
 Type of coupling: -----
 Impeller Diameter ----- mm
 Material of Impellers -----
 Material of shaft-----
 Material of casing-----
 Lubrication Type-----
 Motor Insulation -----
 Motor Protection -----
 Material of Sleeves -----
 Speed ---- -----rpm
 Manufacturer -----
 Country of Origin-----
 Date of Delivery -----
 Pump Size -----

5.13 MOTOR CONTROL CENTRE (MCC)

5.13.1 Description

The starter shall be Variable Frequency Drive as required suitable for a squirrel cage induction motor 380-400 volts, 50/60 HZ, 3-phase, the starting steps shall be such that maximum starting current does not exceed two and half times the rated motor current and tapping of 70% or liquid starter.

The Motor Control Centre-MCC shall be assembled in compliance with standard IEC 61439-1&2. The Standard IEC 61439-1&2 is for Low Voltage Switchgear and ControlGear ASSEMBLY for a voltage not exceeding 1000V in AC with a frequency not exceeding 1000 Hz, or for 1500 V in DC.

Each motor starter shall comprise the following: -

- a. Moulded case circuit breaker of suitable rating.
- b. Variable Frequency Drive-VFD.
- c. All controls for the pump set as specified.
- d. All alarm indication lamps for the pump set as specified.
- e. Re-settable audible and visible alarm system for all faults.

The starter shall be rated to stand a minimum of four starts per hour an ambient temperature of 35-50 C⁰.

The motor starter shall incorporate the following:

- a. Adjustable thermal overload protection.
- b. Dry running protection relay.
- c. One differential protection relay which shall trip the starter in case of: -
 1. Failure of any phase
 2. under voltage in any phase or in all.
 3. Difference of voltage between any two.
- d. An adjustable relay to trip the motor in operation of the motor winding temperature protection.
- e. Level and pressure switches/transducers operation relay.
- f. Earth leakage protection relay as required by the local Electricity Authority Codes.
- g. Alternator each operation for equal operation of each pump.
- h. Volt free terminals for remote indications of common fault.
- i. Automatic changeover to operate the standby pump automatically shall the duty pump fail to operate.

The front of the starter panel shall contain the following control and instruments: -

- a. Local, Off and Remote Selector
- b. A set of “Start” and “Stop” push buttons
- c. Potentiometer to Adjust Pump Speed Locally.
- d. Pump Speed Selector (Locally or remotely)
- e. Pressure control devices.
- f. Level control and measuring devices.
- g. Dry flow devices.
- h. Adjustable Timer
- i. One running hour’s recorder without resting facility to record up to 9999 hours.
- j. Indication lamps to show the following.
 1. Motor “Running” “Shutdown” and “FAULT”
 2. The motor is overloaded
 3. Low water level alarm
 4. Motor winding temperature-High temperature
 5. Pump running
 6. Visible alarms for all faults.
 7. High Pressure
 8. Low Flow
- k. One operating pulses recorder
- l. One stay - put push button for emergency stopping
- m. One audible alarm resettable buzzer
- n. One hand/off /auto selecting switch for each pump
- o. 220 – 24 A.C. transformer to supply low voltage to relay. Timers should be of 24-V type

All fuses rated 30 Amps and below shall be mounted in easily with draw able fuse carrier.

Fuses and links shall be grouped where appropriate according to their functions and shall be clearly marked both on panels and the associated wiring diagrams.

Whenever, possible the starter shall be fully assembled by the manufacturer where modifications such as additions of extra protection devices or indications are required, these modifications shall be performed in a similar, manner by the original equipment manufacturer. In such case full details of modifications and circuit diagrams shall be provided.

Complete circuit diagrams shall be provided together with service instructions, and spare parts list for all components used in the starter panel.

Control System:

Programmable logic controller (PLC) and Human Machine Interface (HMI) based control and monitoring system shall be provided for automatic control and monitor the booster station. The system, in the following known as the Control and Monitoring System (CMS), shall be used for the following:

- Supervisory functions and data acquisition of the booster station.
- Monitoring of alarms and status of the booster station and reservoir.
- Changing of values for timers, for parameters and for set points.
- Calculations.
- Real-time collection and storing of data and alarms.
- Handling of data and alarms.
- "Forced" stop and start of components from the operator station.
- Automatic and Manual control of parts of the booster station.
- Monitoring electricity parameter / consumption.

5.13.2 Mode of Operation

The Pumps of booster Station shall operate in three Different modes:

I. Local Control Mode (From MCC)

The operating push buttons, switches, or handles of all circuit breakers, motor starters, isolators, etc., shall be located on the doors of cubicles, and there shall be visual indications of the “ON” and “OFF” positions.

All operations of fault and alarm circuits shall be clearly and individually indicated on the front of the MCC by lamp operation.

Fault and alarm indication lamps shall remain ON until the cause has been cleared and the system manually reset.

Indication lamps and push buttons shall be colored in accordance with IEC 73.

Each indicating lamp shall incorporate a push-to-test feature.

For the purpose of remote indication, volt free contact shall be provided to duplicate the ON, OFF, Fault and all other alarm indications. The contacts shall be wired to outgoing terminals and shall be rated for 2 amps. At 24 volts d.c.

II. Remote-Automatic Mode

When the Pump Station's Auto/Manual Soft Switch is in the Manual Position (selected by the operator via an Operator Interface Terminal-OIT), Pumps whose LOR switch is in the Remote position shall automatically be controlled in a lead/lag/standby arrangement by the PLC. Pumps shall be automatically controlled in one of two ways:

1. Flow Demand Control mode
2. Speed Control" mode.

The mode shall be selectable from the OIT. In "Flow Demand Control" mode, the PLC shall control the lead pumps to maintain and achieve the demand. The PLC shall start, stop, and control the lag pump' as necessary to achieve the Demand.

In "Speed Control" mode, the PLC shall control the lead and lag pumps to a predetermined, constant speed. The speed setpoint shall be adjustable at the OIT.

III. Remote-Manual Mode

Operation in Remote Manual Mode requires the Pump Station's Manual/Auto soft Switch to be in Manual (selectable from an OIT) while the Pump Station is selected to be in Remote Manual control via a soft switch at an OIT. It also requires that the VFD's LOR selector switch be in the Remote position and the PLC receives a "Ready" status from the VFD controls. Under these conditions, the pump shall be manually started and stopped and its speed adjusted from the OIT.

General Alarm and Interlocks.

The pump shall be called to stop if:

1. High Discharge Pressure when Pressure Exceeds High Limit set points.
2. Low Discharge Pressure when Pressure is less than Low Limit set points.
3. Low Discharge Flow Rate when the Flow is less than Limit set points.
4. High Discharge Flow Rate when the Flow Exceeds Limit set points.
5. Low Demand that shall be a PLC-generated condition signifying a detected combination of low discharge flow rate and high discharge pressure while a pump is in operation.
6. Reservoir Level is Low (LAL)
7. High Motor or Bearing Temperature
8. Motor/VFD Fail condition.
9. High Vibration for Motor

In addition, the PLC shall inhibit pump run command under the following conditions:

- A. Pump Station Fire Alarm active (until system reset).
- B. Reservoir level low alarm from the float switch in the reservoir. (The float switch will stop the pump, via the Low-Water Cutoff Panel, whether the pump is set for local or remote control.) This feature does not depend on the PLC being operational and is a hardwired backup to the PLC-generated break tank low level alarm.
- C. Reservoir Low Level (LAL) condition.
- D. Pump Station discharge pipe break detected as shown on the referenced drawing (shutdown may be disabled at the HMI by an authorized operator)
- E. Operation of more than two pumps at a time when in the Local Automatic, Remote Manual, or Remote Automatic mode.

5.13.3 Starter Construction

The motor starter shall be housed in a suitable factory-built assemblies “FBA” complying with IEC 439. FBA’s shall be multicubicle type the front of which shall have a smooth well finished surface.

The FBA shall be manufactured to a high standard from steel sheet minimum thickness 2 mm. And shall be adequately braced to give a rigid structure. Adequate removable eye bolts for lifting purposes shall be provided.

Access to the cubicles compartment for all normal routine maintenance shall be from the front by hinged and lockable doors secured with can type fastener and cylinder locks with removable key. Hinges shall be of substantial size and stops shall be provided to prevent doors touching adjacent cubicles. Other access shall be by means of bolted panels. The maximum width of any door shall be 700 mm.

Cubicles enclosure shall comply with IEC Publication 144 class shall be not less than IP 68 for medium voltage switchgear. The bus bars and connections shall be completely screened within the switchboards.

All cable and piping shall be made through glands in a plate covering the base of the cubicles. Components shall be so mounted to prevent mechanical shock being transmitted from large components to small components and thereby adversely affected their proper functions. The components shall be so arranged to give adequate accessibility for maintenance and removal of any one component with the minimum disturbance to the wiring. Plug-in connectors shall be used where possible.

All bolts, nuts, screws, hinges, handles, etc. Shall be of stainless steel, cadmium plated steel, or chrome plated steel as appropriate.

The internal wiring of all cubicles shall be completed before delivery.

Interlocks of a substantial mechanical type shall be provided in each cubicle between the door and the circuit breaker or bust switch such that the door cannot be opened unless the circuit breaker or fuse switch is in the “OFF” position and all live parts, which can be accidentally

touched, have been disconnected. When the door is open it shall not be possible to readily turn the circuit breaker or fuse switch to the ON position.

The design of each motor control switchboard shall also comply with the requirements of Class 3 equipment's of BS 5846 (Clause No 2.6.13). The outline of these requirements is as follows:

Class 3. The whole bus bars, including the conductors connecting the bus bars to each outgoing unit shall be arranged to withstand a short circuit at any point.

The FBA shall be designed to withstand any external fault. In the event of any internal arcing fault on a functional unit, the damage should be confirmed to that unit so that the busbars and all other functional units remain fit for further service. However, the conductors connecting the busbars to the outgoing unit might be damaged by the internal arching fault.

5.13.4 Starter Data

The following blanks shall be fully completed by the Bidder: Failure to do so may result in the rejection of the offer:

Type of Starter	_____
Capacity	_____
Protection Devices	_____
Number of Circuit Breakers	_____
Number of Contractors	_____
Number of Timers	_____
Number of Relays	_____
Type Circuit Breakers	_____
Type of Contractors	_____
Type of Timers	_____
Type of Relays	_____
Country of Origin	_____
Manufacture	_____
Time of Delivery	_____

5.14 INSPECTION AND TESTING OF PUMP STATION

5.14.1 General Requirements

The Contractor shall perform all tests including but not necessarily limited to the following:

- ❑ Hydrostatic testing of pipe network.
- ❑ Testing of pumps.
- ❑ Testing Controls and Alarms.
- ❑ Maintenance inspection test.

No part of any piping system shall be painted, covered or enclosed until it has been tested, inspected and accepted.

All tests shall be conducted in the presence of the Project Manager, as directed by him and to his entire satisfaction.

The Contractor shall provide all labor, equipment, material, instruments, power and connections required to execute all testing, balancing and adjusting as directed.

All expense incurred by the testing shall be borne by the Contractor including the cost of repair or replacement of defective work, cost of restoring, repairing or replacing damaged work resulting from the tests and the cost of replacing defective or inadequate equipment and material all as directed by the Project Manager/Engineer.

5.14.2 Hydrostatic Testing of Pipe network

All pumps piping systems except the pumps suction system shall be hydrostatically tested for ensuring complete tightness at not less than 16 bars for 2 hours.

Systems can be tested as a whole or in sections to facilitate the progress of the work.

No part of any piping system shall be tested to a pressure less than the specified test pressure measured at the lowest point of the system.

Care shall be taken not to subject any equipment, apparatus or device to a pressure exceeding its prescribed test pressure as obtained from its name plate data or from manufacturer's published data. Pressure tests shall be applied before connecting piping to equipment. Relief valves, instruments, automatic air vents, and all devices that might be damaged by the test pressure shall be removed, disconnected or blanked off.

No pressure shall be applied against the closed gate of the valves. All valves shall be in the open position but not completely back seated during testing. End valves shall be capped.

In testing flanged piping, temporary blank flanges shall be installed and firmly anchored to accommodate all developed end thrust.

All piping that can be damaged by end thrust developing from hydrostatic testing shall be properly anchored during testing especially at changes of direction.

The piping system to be tested shall be closed by plugging and blanking all openings in the system and filled slowly with water making sure to vent all entrapped air. Plugs shall be released temporarily to ensure that water has reached all parts of the system.

Pressure shall be applied to the system by means of a hand pump drawing from a water container.

The pump discharge shall be connected to the system through a globe valve, check valve and recently calibrated pressure gauge of suitable range to have the test pressure read in the middle of the range.

After the test pressure is reached, the pump shall be blocked off by closing the globe valve and the variations of pressure in the system monitored on the pressure gauge.

While the system is under pressure, a careful inspection shall be made of all pipes and joints and if any leaks in joints or evidence of defective pipe or fitting is disclosed the defective work shall be corrected immediately by replacing defective parts with new joints and materials. No make shift repairs or application of any repair compound will be permitted.

After the correction is made the pressure test shall be repeated until a completely tight system is ensured.

The test pressure shall be released slowly so as not to produce shocks and sudden contraction that might damage the piping.

5.14.3 Testing of Pumps

A. General

The field acceptance test shall be carried out in the presence of the Project Manager/Engineer, the pumps and controllers' manufacturers or their designated representatives, the Employer representative.

A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of results of field acceptance test.

The pumps as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test instruments.

A pump shall be rejected and replaced under the following conditions: -

- ❑ If the pump does not deliver its specified flow requirements under the existing friction loss and static pressure of the system.
- ❑ If the pump motor is overloaded at design flow and head requirements or at higher flow rate.
- ❑ If the pump produces excessive noise or vibration.

Apparent defective pumps or associated equipment shall be repaired and such adjustment made to the pumps or other equipment as may be necessary, all to the satisfaction of the Project Manager.

After pump or equipment is adjusted, repaired, or replaced any or all defective or inoperable parts shall be retested to the entire satisfaction of the Project Manager.

B. Test Instruments

The Contractor shall furnish the following instruments for testing the pumping unit.

- ❑ Clamp on volt ammeter: for voltage and current measurements.
- ❑ Tachometer: for RPM measurement.
- ❑ Any test gauge or devices may be needed.

The test instruments shall be of high quality and accurate and shall be calibrated.

C. Test Procedure

- ❑ The flow test shall be performed by using the installed flow meter
- ❑ Various readings shall be achieved by regulating the discharge valve of the meter
 - The important test points are:
 - Rated flow
 - Shutoff
- ❑ The following data at each test point to be recorded: -
 - Pump RPM
 - Suction Pressure
 - Discharge pressure
 - Ampères
 - Volts
- ❑ Pumps head should be calculated.
- ❑ Corrections of tested flow, head, and horsepower to the rated speed of the pump shall be made for purposes of plotting the performance curve.
- ❑ A head-flow and ampere-flow curves shall be plotted for each pump.
- ❑ A test report shall be submitted to the Project Manager for approval.

D. Controller Acceptance Test

The pumps controllers shall perform not less than 10 automatic and 10 manual operations during the test. A pump driver shall be operated for a period of at least 5 minutes at full speed during each of the above operation.

The automatic operation sequence of the controllers shall start the pump from all provided starting features. This shall include level switches.

E. Alarms

Alarms conditions, both local and remote shall be simulated to demonstrate satisfactory operation.

End of Section

6 MATERIALS

6.1 MANHOLE COVERS

Manhole cover shall be Cast Iron, according to EN124 Standard or equivalent, class D400 (40 tons of resistance minimum).

This compliance will be certified by an Authorized and Independent Third Party, and the cover will be so badge with the logo of the Third Party (such as “NF”, granted by AFAQ/AFNOR Certification).

It will have to be cast by a manufacture complying to the ISO 9001: 2000 Standard

Frame will have to be moulded with wide anchoring holes, at least 16, to allow effective and durable bedding.

Frame will have at least 18 strong ribs, to provide mastered frame profile capable to withstand traffic stresses

The frame height will be of 100 mm minimum, with a good settlement of the manhole and a right behaviour under traffic stresses.

The clear opening of the frame will be of minimum 600 mm

A sound-proofing gasket in composite material (such as PE+PP) will be installed on the frame to support abrasion and crushing when in function. It will be clamped on the frame, with a specific shape to avoid it moves out from the frame.

For an ergonomic opening and lifting once unlocked, the cover will be hinged, with an integrally cast-iron hinge. This hinge will be integral part of the cover, so it resists as well as the cover to corrosion, vandalism and traffic impact.

The cover when opened will have to stay in 130 °position to avoid any accidental self-closure on workers.

The cover will be round shape, unless otherwise mentioned and shall be none ventilated

An elastic spring bar, cast integrally with the cover, will be active that is to say designed to bring a permanent tension between that spring bar, and the cover positioning lugs. It so will provide a remarkable dynamic stability of the cover thanks to 3 points of contact. Furthermore, the spring bar keeps the cover held against the gasket, preventing from rocking.

The elastic spring bar will be such that it will be automatically closed by any load (traffic or pedestrian) when coming over the cover.

This spring bar will nevertheless be flexible enough to open by itself when over pressure in the network, and will so avoid any damage in the network (shaft and pipes).

The unlocking of the cover will be allowed by lever effect in the opening box, located on the side of the frame, and will be permitted with usual tools such as pickaxe or bar. It will be potentially opened via a single operation.

An optional locking mechanism to prevent from any intrusion in the network will be foreseen on the cast cover, thanks to a punch able recessed area.

An anti-theft device of cast iron, will be installed in the frame hinge box, to avoid releasing the cover out of the frame.

6.2 BASE COURSE

Base course sieve analysis, specifications and requirement are as shown in the below tables:

Class	Sieve No.	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#40	#200
A	%	100	100	75-100	60-90	45-80	40-70	30-65	20-40	8-20	5-10
B	passing	100	70-100	55-85	55-80	-	40-70	30-60	20-50	10-30	5-12

Class A: Granular fill Class A to be used as shown in standard details and drawings according to AASHTO T180, T191, or ASTM D 1557, ASTM D1556 or equivalent. Tests shall be carried on the contractor's own expense.

Class B, to be used as shown in standard details and drawings according to AASHTO T180, T191, or ASTM D 1557, ASTM D1556 or equivalent. Plate bearing test, for bearing capacity and settlement evaluation to be done according to AASHTO T 235 or ASTM D 1194 or equivalent. Tests shall be carried on the contractor's own expense.

Base Coarse-Standards and Specification						
No.	Test Type (name)	Unit	Limits	Standards		Remarks
				ASTM	AASHTO	
1	Liquid Limit	%	25 max	D4318	T89	
2	Plastic Limit	%	....	D4318	T90	
3	Plasticity Index	%	2–6	D4318	T90	
4	Maximum Dry Density	g/cm ³	2.1 min	D1557	T180	
5	Optimum Moisture Content	%	....	D1557	T180	
6	Sand Equivalent Value	%	35 min	D2419	T176	
7	Passing Sieve # 200	%	See Specs	C136	T 27	Test Method ASTM C117 or AASHTO T11 also shall be used for material finer than 75- μ m (No. 200) sieve in conjunction with ASTM C136 or AASHTO T27
8	Los Anglos Abrasion (Resistance to Abrasion)	%	45 max	C131	T96	The loss in weight shall not exceed 45% after 500 revolutions
9	Sieve Analysis	....	See Specs	C136	T27	Test Method ASTM C117 or AASHTO T11 also shall be used for material finer than 75- μ m (No. 200) sieve in conjunction with ASTM C136 or AASHTO T27
10	C.B.R (California Bearing Ratio) @ 100% of Max Dry Density)	%	80 min	D1883	T193	
11	Ratio Of Wear Loss	....	0.2 max	C131	T96	The ratio of the loss after 100 revolutions to the loss after 500 revolutions should not greatly exceed 0.20 for material of uniform hardness
12	Elongated And Flaky Particles	%	35 max	D4791		Test if for single size gravel only

6.3 BEDDING MATERIAL (SEMSEM)

SEMSEM Shall be from approved source; sound, from durable stone, free from any foreign materials and structural defects. Also, it shall conform to the ASTM Standards. Sieves openings for SEMSEM are summarized in the below table.

Sieves Openings for SEMSEM

Sieve Size (mm)	9.5	4.75	2.36	1.18
Lower Limit	90	30	5	0
Upper Limit	100	75	25	3

6.4 ROCK FILL

Rock fill shall be composed of materials as follow:

- 75% of rocks with maximum size $\leq 2/3$ of layer thickness, bulk specific gravity of 2.25 minimum and water absorption not exceeding 6%.
- 25% filling material not classified as A-6 or A-7 according to the AASHTO soil classification system.

The specified 60 cm rock fill under the foundation of the water tank shall be applied in two layers (30cm each) and compacted properly by a heavy compactor.

The compaction on top of each rock fill layer shall be tested through the surveying method according to the following steps:

- a) Marking a number of points as directed by the engineer on the top surface layer.
- b) Recording the marks level readings after applying at least 3 cycles of compaction.
- c) Applying additional 3 cycles of compaction and record the readings.
- d) The compaction is considered sufficient if the average settlement (i.e., the difference between readings) is no more than 0.5% of the average thickness layer, which is equivalent to 0.15cm.

7 GENERAL ELECTRICAL REQUIREMENTS

7.1 GENERAL

7.1.1 Scope of Work

- A. It is the intent of this part of the Contract Documents to cover the work and materials necessary for erecting a complete electrical system, tested and ready for continuous use. The system shall be constructed in accordance with the Contract Documents, Drawings and engineer directions.
- B. Specifications related to electrical equipment are based on constructible products and related codes, change or deviate on these specifications will not be acceptable unless for system design upgrade if requested by Engineer.
- C. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete reliable and coordinated project.
- D. Unless specifically named in the Specifications, a manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years per project standards and requirements.

7.1.2 Related Sections

- A. The Contractor shall coordinate the work with other trades such as mechanical equipment, and furnish and install the equipment in accordance with the design requirements.

7.1.3 General Provisions and Design Requirements

- A. Minimum sizes of equipment, and electrical devices are indicated but it is not intended to show every offset and fitting, nor every structural or mechanical difficulty that will be encountered during the installation of the work.
- B. The Year of manufacturing any Electrical Equipment's or devices shall not be less than one year from the awarding date.
- C. Work indicated on the Plans is approximately to scale except for equipment which depends on contractor selection brand, but actual dimensions and detailed Plans should be updated by contractor as closely as field conditions permit and after material selection. Field verification of scale dimensions on Plans is governed by field conditions. Installation of systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination.
- D. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to

the attention of the Engineer for clarification, prior to purchasing and installing equipment.

- E. The electrical equipment identified as being provided by others will be furnished complete for installation by Contractor. Technical specifications under which the equipment will be purchased are available.
- F. The alignment of equipment and conduit shall be adjusted to accommodate architectural changes, or to avoid work of other trades, without extra expense to the Owner.
- G. The Contractor shall furnish and install the parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the Requirements of Contract Documents.
- H. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.
- I. The Contractor shall layout electrical equipment and submit to engineer before starting equipment manufacturing and before starting buildings construction. Furnish and install sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.
- J. The Contractor shall furnish and install inserts and hangers required to support conduits and other electrical equipment. If the inserts, hangers, sleeves, or other mounting hardware are improperly placed, or installed, the Contractor shall do necessary work, at their own expense, to rectify the errors.
- K. Electric Power system:

All equipment and devices shall be designed to be connected to a power system with characteristics as specified below:

Low Voltage: 400/230V as indicated on design drawings.

Frequency: 50 Hz.

All equipment shall be rated and submitted based on above system; equipment technical data based on other systems will not be reviewed.

- L. Unless otherwise mentioned in mechanical equipment specification sections, all driven equipment duty points shall be achieved at 50Hz and at system voltages described above only.
 - M. Electrical equipment shall be capable of operating successfully at full-rated load, without failure or overheating as classified hereunder and specifically rated for the altitude indicated on the Plans. Equipment de-rating shall be required for each Electrical equipment not rated for operation at that temperature or elevations specified below.
1. Equipment located outdoors shall be designed to withstand the following conditions during full load operation.

Temperature:	
Maximum Jobsite Temperature =	+60°C
Minimum Jobsite Temperature =	0°C
Design Temperature -Direct =	+70°C
Design Temperature -Under shed =	+50°C
Relative Humidity:	
Maximum Jobsite Humidity =	100%
Minimum Jobsite Humidity =	5%
Wind Velocity =	120KM/H

2. Equipment located indoors shall be designed to withstand the following conditions:

Temperature:	
Maximum Indoor Temperature =	+50°C
Minimum Indoor Temperature =	0°C
Design Temperature =	+50°C
Relative Humidity:	
Maximum Indoor Humidity =	95%
Minimum Indoor Humidity =	15%

N. The Contractor shall perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. The Contractor shall repair and patch where demolition has taken place in a manner to match existing original structure all these works shall be coordinated and preapproved by engineer.

7.1.4 Regulations, Codes, and Standards

A. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations, codes, and standards, of the following:

1. International Electrotechnical Commission (IEC)
2. National Electrical Code (NEC)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. American National Standards Institute (ANSI)
5. American Society for Testing and Materials (ASTM)
6. Insulated Cable Engineers Association (ICEA)
7. National Electrical Manufacturers Association (NEMA) Standards
8. Ingress Protection Code-IEC Standard 60529
9. Federal Occupational Safety and Health Act (OSHA)
10. National Fire Protection Association (NFPA)

- B. As indicated below all major material used in the performance of the electrical work shall be manufactured per IEC OR UL standards.

7.2 PRODUCTS

7.2.1 General Materials and Methods

- A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged or dirty materials, equipment, and parts, are not considered to be new and unused, and will not be accepted.
- B. Contractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions. All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Except where otherwise specified, structural and miscellaneous fabricated steel used in equipment shall conform to AISC standards. All structural members shall be designed for shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall be at least 6.3 mm thick. When dissimilar metal components are used, consideration shall be given to prevention of galvanic corrosion.
- C. Field verification of scale dimensions on Plans is directed, since actual locations, distances, and levels will be governed by actual field conditions. The Contractor shall also review architectural, structural, yard, mechanical, and other Plans, and the accepted electrical and mechanical shop drawings, and shall adjust their work to conform to the conditions indicated therein.
- D. Programming software shall be provided for any equipment require configuration, programming or troubleshooting such but not limited to as VFD's, PLC's, MCC's, soft starters and controllers, such software shall be licensed from manufacturer for lifetime and shall be freely updated. Software shall be highest professional version and shall be procured in manufacturer stamped packed envelope with related cables and drivers, software with opened envelops will not be accepted. These software's does not compensate any other software's required elsewhere in this or other sections.

- E. Equipment requiring configuration, adjustment or periodic repair by special tools, software or device, such device or tool shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance such as but not limited to hand-held flow meter calibration verification device, Hart Calibrator, network cable and fibre optic cable tester. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices. These tools do not compensate any other tools or devices required elsewhere in this or other sections.
- F. All measuring units shall be set to metric type units and not US type units.

7.2.2 Nameplates and Tag Numbers

- A. The Contractor shall furnish and install nameplates, which shall be white laminate with black letters. The nameplates shall be fastened to the various devices with round head stainless steel screws. Each disconnecting means for service, feeder, branch, or equipment conductors shall have nameplates indicating its purpose.
- B. All Equipment, devices, Junction and Pulling Boxes shall include a Tag Number per P&ID design Drawings and instrumentation schedule, the Tag Number shall be Engraved on 316 stainless steel Plate not less than 250x150 mm, the Plate shall be attached to the equipment or device using pin steady fixing.
- C. All equipment and devices shall be procured with factory installed Name Plate and Tag. Number where applicable. Contractor shall furnish and install nameplates and tag number for other device procured without factory assembled Name Plate or Tag Numbers if approved by engineer.

7.2.3 Equipment Assemblies.

Equipment assemblies, such as Switchgear, Switchboards, VFD's, MCC's, PLC's Control and Distribution Panels, and other custom fabricated electrical enclosures shall bear a IEC or applicable standards label as a complete assembled equipment and not only for internal components.

7.3 EXECUTION

■ Utility Service and Equipment

Contractor will be responsible for coordinating the electrical utility works with the electrical utility company. The Contractor will be responsible for furnishing and installing equipment and material required to bring electrical power service from the nearest connection point to the service location in conformance with the electrical utility requirements, specifications, and design drawings.

■ Installation of Electrical Equipment

- A. Coordinate the installation of electrical equipment with other trades.
 - 1. Arrange and coordinate for the buildings of equipment during structure construction.
 - 2. Verify building size, door height and other dimensions that may affect the installation prior to start construction, any update on buildings or structural dimensions that's necessary to accommodate the contractor selected equipment shall be done without cost or time affect to the original contract. Contractor shall submit new design and calculations for resized structure or building to engineer for approval.
 - 3. Submit building layout reflecting dimensional drawings for building interior including Electrical equipment top view while doors open.
- B. Verify that equipment will fit support layouts indicated.
- C. Contractor shall coordinate all details of the equipment with other related parts of the Work, including verification that all structures, piping, wiring, and equipment components are compatible. Contractor shall be responsible for all structural and other alterations in the Work required to accommodate equipment differing in dimensions or other characteristics from that contemplated in the Drawings or Specifications.
- D. Electrical equipment coordination shall be verified by manufacturer and also through Protective device studies, such as Generators and VFD's, Pumps and motors, VFD's power cables Etc... And any others as required by engineer, a letter from manufacture confirming compliance and reliable operation shall be submitted to engineer along with material submittals.
- E. Equipment Dimensions and Clearances:
 - 1. Do not use equipment that exceeds the indicated dimensions, except as approved in writing by the Engineer.
 - 2. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.
- F. Install equipment in accordance with the manufacturer's instructions, recommendations installation manual and engineer directions.
- G. Equipment Access:
 - 1. Install equipment so it is readily accessible for operation and maintenance.
 - 2. Equipment shall not be blocked or concealed.
 - 3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.
 - 4. Verify clearance and walkways are available for maintenance of equipment's of required sides, for floor mount front access only equipment, maintain minimum 100mm clearance from the walls.
- H. Equipment shall be installed plumb, square and true with the building construction, and shall be securely fastened.

- I. Outdoor wall-mounted equipment, and indoor equipment mounted on earth, or water bearing walls, shall be provided with corrosion-resistant spacers to maintain 1¼ %- inch separation between the equipment and the wall.
- J. Equipment fabricated from aluminium shall not be imbedded in earth or concrete.
- K. Provide all necessary anchoring devices and supports.
 - 1. Use supports as detailed on the Plans, details and as specified.
 - 2. Supports and anchoring devices shall be rated and sized based on dimensions, weights verified and seismic calculations from approved equipment submittals.
 - 3. Do not cut, or weld to, building structural members.
 - 4. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment and approved by engineer.
- L. Contractor shall verify exact rough-in location and dimensions for connection to electrical items furnished by others.
 - 1. Shop drawings shall be obtained from those furnishing the equipment.
 - 2. Proceeding without proper information may require the Contractor to remove and replace work that does not meet the conditions imposed by the equipment supplied.
 - 3. Provide sleeves wherever openings are required through new concrete or masonry members. Place sleeves accurately and coordinate locations with the Engineer.
 - 4. Should any cutting and patching be required on account of failure of the Contractor to coordinate penetrations, such cutting and patching shall be done at the expense of the Contractor.
 - a. The Contractor shall not endanger the stability of any structural member by cutting, digging, chasing, or drilling and shall not, at any time, cut or alter the work without the Engineer's written consent.
 - ✓ Provide additional reinforcing if required.
 - ✓ Cutting shall be done neatly using proper tools and methods.
 - b. Subsequent patching to restore walls, ceilings, or floors to their original condition shall be done by the Contractor.
- M. Provide concrete foundations or pads required for electrical equipment as indicated or specified.
 - a. Floor-mounted equipment shall be mounted on a 4-inch concrete housekeeping pad unless otherwise noted.
Pad shall be poured on top of the finished floor or slab. Contractor shall verify the distance to all equipment from the finished floor meets the current NEC requirements. All modifications shall be made to the electrical equipment as required.
 - b. All conduits penetrating concrete floors shall be grouped as allowed.
- N. Contractor shall utilize Torque wrench for all electrical connections such as bus bar joints and power cable connections recommended by manufacturer.

■ Temporary Power

- A. The Contractor shall furnish, install, and maintain, temporary power and lighting systems needed for construction on his own expense. This temporary system shall include weatherproof panel(s) for the Contractor's. Main breakers, Ground fault interrupting equipment shall be installed and distribution system. Connections shall be watertight, with wiring done with Type SO portable cable. After construction is completed, the Contractor shall remove temporary power equipment and devices.

■ Equipment's Ingress Protection and Area Classifications

A. Outdoor Enclosures

- a. Ingress Protection Rating according to IEC 60529, for Outdoor Enclosure shall be:
 - ✓ IP 55 for Floor Standing Enclosure
 - ✓ IP 66 For Wall Mounting Enclosure
 - b. Outdoor Floor Standing Enclosure shall be Stainless steel 304 double door.
 - c. Outdoor Wall Mounting Enclosure shall be Stainless steel 304 double door for all equipment, enclosures and boxes.
- B. Indoor enclosures and boxes shall be IP52 hot dip Galvanize Steel Powder Coated.
 - C. Chemical Areas enclosures shall be IP66 made of reinforced fiberglass (FRP).
 - D. Outdoor Transformer enclosures shall be NEMA 4 (IP66) hot dip Galvanize Steel Powder Coated.
 - E. Lighting poles, antenna masts and towers shall be made of hot dip Galvanize Steel.
 - F. TEFC Motors confirming IEC shall be rated IP55 minimum or better.
 - G. Enclosures, Boxes or equipment's required to be installed in Electrical and water Manholes or chambers shall be minimum NEMA 6P/ IP68.

■ Coordination of the Electrical System

- A. The Contractor shall verify actual equipment, and full-load demand, and locked-rotor current ratings. The necessary minimum equipment, wire, and conduit sizes requirements are indicated on the Plans and drawings. If the Contractor furnishes equipment of different ratings, the Contractor shall coordinate the actual current rating of equipment furnished with the branch circuit conductor size, the overcurrent protection, the controller size, the motor starter, and the branch circuit overcurrent protection without any additional cost to the original contract. The branch circuit conductors shall have a current carrying capacity of not less than 125 percent of the actual equipment full-load current rating. The size of the branch circuit conductors shall be such that the voltage drops from the overcurrent protection devices up to the equipment, shall not exceed 2 percent, when the equipment is running at full-load and rated voltage.
- B. Specified equipment shall be capable to supply the power to the loads without overloading in normal operation, driven equipment and related drivers shall be fully

coordinated to have reliable operation and protection, any miss coordination with project components and equipment shall be the responsibility of the contractor and shall be replaced by suitable ones.

- C. In case of utilizing generator to supply the power for the station, the generator shall be coordinated with the drivers, Contactor shall submit a calculation verifying that the generator relative short-circuit voltage is within the driver's reliable operation range utilizing generator's Sub-Transient Reactance value, calculations shall be coordinated with the VFD and Generator manufactures. These calculations are important may affect the transformer power rating or internal reactance.

■ One-Line Diagrams

- A. One-line diagrams, as indicated on the Drawings, show circuit voltages, circuit protection rating, and other pertinent data. Where conflicts exist on the Drawings, the one-line diagrams shall take precedence. Grounding conductors are not necessarily indicated. See grounding requirements specified elsewhere herein.

End of Section

8 DIESEL ENGINE-GENERATORS SYSTEM

8.1 STANDARDS

Supply and install a standby diesel-engine driven generator.

The equipment and performance shall be in accordance with ISO and BS for Engine and IEC for the alternator and electric equipment. As CATERPILLAR, POWER LINK or equivalent.

The equipment supplied and installed shall meet the requirements of the NEC and all applicable local codes and regulations. All equipment shall be of new and current production by a MANUFACTURER who has 30 years of experience building this type of equipment. Manufacturer shall be ISO9001 certified.

8.2 GENERAL

The generator set shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment. The engine, alternator, control panel shall be designed, manufactured, assembled and tested by single manufacturer. The manufacturer shall be responsible for a single source warranty for the entire diesel generator set, including the controls.

The diesel generators are to capable of prime operating mode. The generator unit shall be supplied and installed complete with, engine, alternator, control panel, and exhaust silencers. The set shall be designed to give a supply at a voltage of 400 volts 50 Hz 3 phase 4 wire and be of the totally self-contained design incorporating a diesel engine prime mover, self-exciting alternator and electric starter unit.

The sets shall be arranged to start automatically and run up to full speed within 15 seconds. The complete unit shall be maintained on a prefabricated skid base- frame with anti-vibration mountings, the whole unit arranged to bolt on to prepared concrete foundations. All interlocks shall be provided to prevent paralleling of the supplies.

Generator Set Package shall accept 100% block load in one step and meets 110 loading requirements.

Conforms to ISO 8528-5 G3 load acceptance requirements.

8.3 ENGINE

The engine shall be diesel fuelled, four (4) cycle, water-cooled, while operating with nominal speed 1500 RPM. The engine will utilize in-cylinder combustion technology, as required, to meet applicable EPA non-road mobile regulations and/or the EPA NSPS rule for stationary reciprocating compression ignition engines. Additionally, the engine shall comply with the State Emission regulations at the time of installation/commissioning. Actual engine emissions values must be in compliance with applicable EPA emissions standards per ISO 8178 – D2 Emissions Cycle at specified kW / bHP rating. Utilization of the “Transition Program for Equipment Manufacturers” (also known as “Flex Credits”) to achieve EPA certification is not

acceptable. The in-cylinder engine technology must not permit unfiltered exhaust gas to be introduced into the combustion cylinder. Emissions requirements / certifications of this package: LOW BSFC

The engine shall incorporate the following features.

- a. Four stroke Direct injection and Turbo charged
- b. Cooling system (Water system); Thermostats and housing, vertical outlet Jacket water pump, centrifugal Water pump.
- c. Battery charging alternator.
- d. Air to air after-cooled.
- e. Heavy duty lead acid batteries (24V)
- f. Fuel system; mechanically actuated electronic unit injection system.
- g. Primary fuel filter with water separator, secondary fuel filter, flexible fuel lines, and fuel cooler.
- h. Lubrication system; gear type lube oil pump, lubricating oil and filter, and oil drain line with valves.
- i. Heavy duty air cleaner (s) (dry)
- j. Rails – engine / generator / radiator mounting with rubber anti-vibration mounts.
- k. Automatic engine protection system
- l. 24 Volts starting motor.
- m. Dry exhaust manifold with flanged faced outlets, exhaust silencer with flanges, and exhaust system backpressure max of 10 Kpa.

8.4 RADIATOR

High ambient radiator suitable for generator set applications incorporates the following features.

- a. 4-piece fan guard for improved serviceability.
- b. Air to air after cooler line routing.
- c. Fan and belt guards.
- d. Coolant drain line with valve.
- e. Coolant level sight gauge on back side of the tank.
- f. All isolators are in line from front to rear package.

8.5 ENGINE CONTROLLER

Electronic control module with electronic unit injector interface capability incorporating the following features.

- a. Environmentally sealed, aluminum housing isolators from moisture and dirt contamination.
- b. Internal circuits designed to withstand shorts to +battery and –battery.
- c. Temperature accuracy maintained from -40 to 85 C.
- d. Capable of self-diagnostic and fault reporting.
- e. Programmable speed acceleration ramp rate.
- f. Adjustable cool-down duration.
- g. Data link interface.
- h. Capable of calculating the speed and held it within +/- 0.2 Hz for isochronous and droop mode.

- i. Humidity tolerance 0-90% relative humidity over operating temperature.
- j. Input voltage range 18-32 VDC (24 VDC nominal)
- k. Reverse polarity protected.

8.6 CHASSIS

A robust heavy duty fabricated chassis completes with lifting points, anti-vibration mountings, bolt
Down holes.

8.7 ALTERNATOR

High standard alternator that meets the requirements of NEMA, IEC, ISO, IEEE, BS, AS.
Round lamination

Stator design. Stator coil pitch, coil distribution designed to produce optimum waveform and minimum total harmonic distortion. Stator slots are insulated by slot liners and coil separators.

The alternator shall incorporate the following features:

- a. Brushless, revolving field.
- b. One bearing, three phase, series star connected.
- c. Over-speed capability of 150% of synchronous speed at 50Hz.
- d. Waveform deviation, line to line, no load Less than 2%
- e. Paralleling capability; Standard with adjustable voltage droop.
- f. Voltage regulator; 3-phase sensing with variable Volts-Per Hertz response
- g. Voltage regulation, steady state +/- 0.5%
- h. Voltage regulation with 3% speed change +/- 0.5%
- i. Voltage gain; adjustable to compensate for engine speed droop and line loss
- j. TIF Less than 50
- k. Number of leads 6

8.8 GENERATOR CONTROL PANEL

- a. Single location customer connector point
- b. True RMS metering, 3-phase
- c. Controls
 - Run / Auto / Stop control
 - Speed Adjust
 - Voltage Adjust
 - Emergency Stop Pushbutton
 - Engine cycle crank
- d. Digital Indication for:
 - RPM
 - Operating hours
 - Oil Pressure
 - Coolant temperature
 - System DC volts
 - L-L volts, L-N volts, phase amps, Hz

- e. Shutdowns with common indicating light for:
- Low oil pressure
 - High coolant temperature
 - Low coolant level
 - Over speed
 - Emergency Stop
 - Failure to start (over crank)

8.9 ORIGINAL ENERGY CONTAINER

The energy container shall be product of the same generator set manufacturer. And must be comply with following standards:

- Quality Management ISO 9001.
- Recip I.C Engine driven AC generating sets ISO 8528.
- Safety of Machinery. Electrical Equipment of Machines IEC / EN60204.
- Low-voltage Switch-gear and Control Assemblies EN61439.

The sound level must be not more than 85dBA @ 1m and full load power, 78dBA @7m and full load power.

The work includes supplying a complete integrated generator system packaged in the container. The system consists of a diesel generator set with related component accessories.

Enclosure is a robustly constructed walk-in type, designed to provide the necessary weather protection and ventilation for the generator.

Enclosure is a complete custom fabricated structure, and is not modified from a standard type ISO cargo container.

Enclosure is designed to meet ocean shipping standards, and is certified by an independent classification society for CSC freight.

Enclosure is generally constructed from structural steel to EN10025, and galv / electro-zinc coated steel sheet to EN10346 and EN10152.

ISO cargo container fittings are provided on container top and bottom surfaces, providing four point lifting capability for full wet weight via an ISO approved lifting method.

Container complete with suitable number of personnel access doors per side fitted with Kason type locks / handles, internal panic release buttons, door check strap and stainless-steel hinges. Door handles are at a height to suit operation with the container at ground level. All door locks have 1 key number.

2 coat paint system comprising Epoxy Zinc Primer (125 microns) and Urethane topcoat (50 microns) providing a gloss finish at a total nominal dry film thickness of 175 microns

8.10 WARRANTY

The manufacturer's standard warranty shall in no event be for a period of less than two (2) years for standby application or one year for prime application from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs

at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair.

8.11 PARTS AND SERVICE QUALIFICATIONS

1. Service Facility:

The engine-generator supplier shall maintain 24-hour parts and service capability within 100 miles of the project site. The distributor shall stock parts as needed to support the generator set package for this specific project. The supplier must carry sufficient inventory to cover no less than 80% parts service within 24hrs and 95% within 48 hours.

2. Service Personnel

The dealer shall maintain qualified factory trained service personnel.

3. Training

Provide on-site training to instruct the owner's personnel in the proper operation and maintenance of the equipment. Review operation and maintenance manuals, parts manuals, and emergency service procedures.

End of Section

9 INSTRUMENTATION AND CONTROL SYSTEM

9.1 GENERAL

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

9.1.1 General Equipment Stipulations

The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

9.1.1.1 *Drawings*

The Drawings indicate locations and arrangements of equipment and may include installation details and block and one-line diagrams showing connections and interfaces with other equipment. A sample format for the input/output (I/O) list is included in ANNEX attached to this section.

Principal components of the instrumentation systems shall be as indicated on the P&ID drawings and instrument device schedule. A sample format for the instrument device schedule is included in ANNEX attached to this section.

9.1.1.2 *Codes, Permits and Agency Approvals*

All work performed and all materials used shall be in accordance with the National Electrical Code NEC and IEC. Contractor shall, as part of their work, arrange for and obtain all necessary permits, inspections, and approvals by the authorities having local jurisdiction of such work. This shall include any third- party inspections and testing of panels and equipment.

9.1.1.3 *Supplier's Qualifications*

Equipment and software furnished under this section and under other related sections listed in the Scope paragraph above shall be designed, coordinated, and supplied by a single manufacturer or supplier, hereinafter referred to as the System Supplier. The System Supplier shall be regularly engaged in the business of supplying computer-based monitoring, control, and data acquisition systems. The Contractor shall utilize the services of the System Supplier to coordinate all control system related items, to check-out and calibrate instruments, and to perform all testing, training, and startup activities specified to be provided.

The System Supplier shall have the following minimum qualifications:

- The supplier shall maintain a design office staffed with qualified technical design personnel.
- The supplier shall maintain competent and experienced service personnel to service

the hardware and software furnished for this project.

- The supplier shall have as a minimum 5 years of experience in the design, coordination and supply of computer-based monitoring, control, and data acquisition systems.

9.1.1.4 Coordination

Systems supplied under this section shall be designed and coordinated by System Supplier for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications, under other contracts, and, where applicable, with related existing equipment. All equipment shall be designed and installed in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the manufacturer, and the manufacturer of the related equipment.

9.1.1.5 Related Equipment and Materials

Related equipment and materials may include, but will not be limited to, instrumentation, motor controllers, valve actuators, chemical feeders, analytical measuring devices, conduit, cable, and piping as described in other sections or furnished under other contracts.

9.1.1.6 Device Tag Numbering System

All devices shall be provided with manufacturer installed permanent identification tags. The tag numbers shall agree with System Supplier's equipment drawings and shall be as close as practical to the tag numbers used on the Drawings and device schedules. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand- lettered or tape labels will not be acceptable.

9.1.2 General Requirements

The drawings and specifications indicate the extent and general arrangement of the systems. If any departures from the Drawings or Specifications are deemed necessary by System Supplier, details of such departures and the reasons shall be submitted to Engineer for review with or before the first stage submittal. No departures shall be made without prior written acceptance. The specifications describe the minimum requirements for hardware and software. Where System Supplier's standard configuration includes additional items of equipment or software features not specifically described herein, such equipment or features shall be furnished as a part of the system and shall be warranted as specified herein.

9.1.2.1 Governing Standards

Equipment furnished under this section shall be designed, constructed, and tested in accordance with IEEE 519, ANSI C37.90, FCC Part 15 - Class A, and IEC 60529, or equivalent.

9.1.2.2 *Dimensional Restrictions*

Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. The System Supplier shall review the Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications requisite for proper installation subject to acceptance by Engineer. At least 915 mm of clear access space shall be provided in front of all instrumentation and control system components.

9.1.2.3 *Workmanship and Materials*

System Supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except for testing.

9.1.2.4 *Corrosive Fluids*

All parts which are exposed to corrosive conditions shall be made from corrosion resistant materials. System Supplier shall submit certification that the instrument manufacturer approves the selection of materials of primary elements that are in contact with the specified process fluid to be inert to the effects of the process fluid.

9.1.2.5 *Appurtenances*

Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, and isolation devices shall be furnished as needed for proper performance of the equipment.

9.1.2.6 *Programming Devices or Software*

A programming or system configuring device/software shall be provided for each system or instrument that contains any equipment that requires such a device for routine configuration, calibration, maintenance, and troubleshooting. The programming device shall be complete, newly purchased for this project, and shall be in like-new condition when turned over to Owner at completion of startup this device/ software will not compensate any other device or software required elsewhere.

9.1.2.7 *Interconnecting Cable*

For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the

element to the transmitter. Provide required length of cables between element to transmitter. Location of elements and transmitters are indicated on Drawings. Length of cable shall be a minimum of three meters.

9.1.2.8 Configuration Software/Serial Interface

Devices indicated as requiring a serial or Cat5e interface shall be provided with all accessories required to properly communicate over the serial or Ethernet link. An appropriate cable shall be provided to allow the transmitter serial\ethernet interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under the latest version of Microsoft's Windows, 7, 8.1 and 10 operating system compatible with other software. This software will not compensate any other device or software required elsewhere.

9.2 PRODUCTS

9.2.1 General Requirements

All equipment furnished under each section referenced in SCOPE is a part of this section and shall be selected by System Supplier for its superior quality and intended performance. Equipment and materials used shall be subject to review.

9.2.1.1 Standard Products

The systems furnished shall be standard products. Where two or more units of the same type of equipment are supplied, they shall be the products of the same manufacturer; however, all components of the systems furnished hereunder need not be the products of one manufacturer unless specified herein.

To the extent possible, instruments used for similar types of functions and services shall be of the same brand and model line. Similar components of different instruments shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

9.2.1.2 Performance and Design Requirements

The design of the systems furnished hereunder shall utilize concepts, techniques and features that provide maximum reliability and ease of maintenance and repair. The systems shall include board-level devices such as light emitting diodes or other indicators to facilitate quick diagnosis and repair. Diagnostic software shall be furnished to facilitate system-level troubleshooting. Where redundant hardware is provided, the system shall be capable of performing all specified functions, without reconfiguring hardware or software, with only one device of each category in service.

9.2.1.3 *Factory Assembly*

Equipment shall be shipped completely factory assembled, except where its physical size, arrangement, configuration, or shipping and handling limitations make the shipment of completely assembled units impracticable.

9.2.2 *Power Supply and Instrument Signal*

Power supply to all control system equipment will be 230 volts, 50 Hz, single phase; 24 volts ac, 50 Hz; or 24 volts dc as indicated on the drawings or in the specifications.

System Supplier shall be responsible for distribution of power among enclosures, consoles, peripherals, and other components of the system from the power supply receptacles and junction boxes indicated on the Drawings. Power distribution hardware shall include cables and branch circuit overcurrent protection installed in accordance with the electrical section. Unless otherwise indicated, power supply to the instrumentation will be unregulated 230 volts ac. Unless otherwise indicated, all transmitted electronic analog instrument signals shall be 4-20 mA dc and shall be linear with the measured variable.

9.2.2.1 *Facility Distribution System*

Equipment not indicated to be powered from an uninterruptible power source shall be suitable for being supplied from the facility distribution system and shall be capable of withstanding voltage variations of ± 10 percent and harmonics up to the limits of IEEE 519 without affecting operation. System Supplier shall provide voltage conditioning or filtering equipment if necessary to meet the requirements specified.

9.2.2.2 *Power Supplies*

Power supplies for voltages other than those listed above shall be an integral part of the equipment furnished. Internal power supplies shall be regulated, current limiting, and self-protected.

9.2.2.3 *Surge Withstand*

All equipment shall meet all surge withstand capability tests as defined in ANSI C37.90 without damage to the equipment.

9.2.2.4 *Uninterruptible Power Supply*

An uninterruptible power supply (UPS) shall be furnished hereunder to power the equipment indicated on the Drawings or will be furnished under another section. System Supplier shall be responsible for coordinating the size of the UPS unit with the equipment furnished hereunder, and shall advise Engineer if a unit of higher capacity is necessary.

9.2.3 Service Conditions and Environmental Requirements

The equipment provided for the instrumentation and control system shall be suitable for the service conditions specified in the attached equipment sections.

All equipment shall be designed and selected to operate without degradation in performance throughout the environmental extremes specified. Equipment shall be designed to prevent the generation of electromagnetic and radio frequency interference.

9.2.3.1 Ambient Temperature and Elevation

Refer to Section 7 and related instrument section

9.2.3.2 Deleterious Effects

All system equipment will be installed in areas without anti-static floor construction and without any provisions for control of particulates or corrosive gases other than ordinary office-type HVAC filtering. System Supplier shall furnish any additional air cleaning equipment, anti-static chair pads, or other protective measures necessary for proper operation of the system. All input/output hardware shall meet or exceed, without false operation, all requirements of IEC, CE, Electrical Noise Tests.

9.2.3.3 Noise Level

The equivalent "A" weighted sound level for any system equipment located in the control room, except printers, shall not exceed 35 dBA. The sound level for printers shall not exceed 65 dBA. Sound reduction enclosures shall be provided where necessary to comply with these limits.

9.2.3.4 Lightning Protection

In addition to other environmental protection specified herein, the entire system shall be provided with lightning protection. Lightning protection measures shall include the following.

- **Grounding**

All major components of the system shall have a low resistance ground connection including but not limited to flowmeter tubes, temperature, pressure and level transmitters, temperature and pressure switches. Grounding system provisions indicated on the Drawings shall be modified as recommended by System Supplier.

- **Surge Suppressors**

Surge and lightning suppressors shall be no faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds.

9.2.4 Software Documentation

System Supplier shall furnish complete documentation on all software supplied with the systems specified herein. Operating systems, compilers, assemblers, and utility and diagnostic programs that are standard commercial products of third parties need not be included in the optical media backup. Software documentation shall consist of the following principal items.

- a. One backup set of any integrated circuit or solid-state memory- based plug-in firmware used.
- b. Two complete back-up copies of system and application software in executable format on optical media compatible with the system furnished.
- c. Three sets of user reference manuals for all standard system and application software.
- d. One set of user reference manuals for all operating system software.
- e. Three sets of printed as-built reference documentation for any special software provided specifically for this contract.
- f. For each licensed software product, all documentation provided by the product manufacturer shall be provided. This includes all reference manuals and any other documents that were provided by the manufacturer. One set of this documentation shall be supplied for each and every piece of equipment provided. Multiple pieces of similar equipment or software require multiple copies of this documentation.

9.2.5 Software License

All software programs supplied as a standard part of System Supplier's products for this project shall be licensed to Owner for use on the system specified herein. Such license shall not restrict Owner from using the software on the system provided hereunder or its replacement.

Owner shall have the right to make copies of the software for use on the system provided. Specific requirements of System Supplier's software license are subject to review and approval by Owner and Engineer.

9.2.6 Installation Test Equipment

All necessary testing equipment for calibration and checking of system components shall be provided by System Supplier. System Supplier shall also furnish calibration and maintenance records for all testing and calibration equipment used on the site if requested by Engineer.

9.3 EXECUTION

9.3.1 Installation Requirements

The installation of equipment furnished hereunder shall be by the Contractor or their assigned subcontractors.

9.3.1.1 *Field Wiring*

Field wiring materials and installation shall be in accordance with the electrical section.

9.3.1.2 *Instrument Installation*

Instruments shall be mounted so that they can be easily read and serviced and so that all appurtenant devices can be easily operated. Installation details for some instruments are indicated on the Drawings.

All outdoor instrumentation shall be protected from direct sun exposure. Instruments shall be placed in locations to limit south and west sun exposure. Sunshades shall be provided on instruments that are subject to the direct sun exposure. Sunshades shall be located so the opening faces north or east where possible. Sunshades shall be provided as shown on the Drawings.

9.3.1.3 *Salvage of Existing Equipment*

Existing equipment and materials removed or replaced under this contract shall be delivered to Owner at a location designated by Owner, or shall be properly disposed of at Owner's discretion. Care shall be taken to avoid damage to equipment delivered to Owner. Any mounting brackets, enclosures, stilling wells, piping, conduits, wiring, or openings that remain after removal of equipment and support hardware shall be removed or repaired in a manner acceptable to Owner and Engineer. Transmitters or switches containing mercury shall be removed and disposed of by personnel trained in the handling of hazardous materials and using approved procedures.

9.3.2 *System Software Configuration*

System software shall be configured by the System Supplier. Configuration services shall consist of the creation of the system database, report formats, operator interface graphic and tabular display screen formats, password and security implementation, and programming of control units to provide a fully functioning system. The System Supplier shall fully configure the system using data provided herein or supplied by the Engineer and/or the Owner after award of the contract.

The system that is delivered to the field for installation, checkout, and startup shall have all files, or databases, that are configurable in size, sized in a manner in which there will be 50 percent space available for future work after the completion of this project. This sizing should include the addition of memory modules, disk drives, or any other device to insure the 50% spare space availability. All "tuning" of software that is dependent on space requirements shall be done prior to the completion of this project. Tuning of software programs shall be accomplished in such a manner that the program operates at its highest performance level. These programs include, but are not limited to Microsoft SQL Server, all PLC ladder logic, and others.

9.3.3 Control System Database

The control system database shall be developed and configured by the System Supplier. The System Supplier shall enter information obtainable from the Contract Documents into the database prior to soliciting input from the Engineer and the Owner. The System Supplier shall determine the need for any "pseudo" database points and shall ascertain and enter all information needed to define these points. The System Supplier is responsible for entering all information associated with each point. This includes but is not limited to, descriptions, engineering units, associated displays, areas, security, etc. All fields associated with each database point must be completely filled out accurately.

9.3.3.1 Graphic Screen Displays

The System Supplier shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screen. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. These items must be done in accordance to the Configuration Standards and Conventions as described later in this section. Alarm and/or event displays shall also be provided and proven functional prior to acceptance of the system. A means of capturing and printing of all graphic screens shall also be included. The software program provided must be capable of printing the screen in a black and white (using gray scale) or color format. This program must be accessible from all terminals provided under this contract. The black and white printing shall be done in a manner in which the use of the black background is not represented in the printout. This is done to keep the utilization of ink cartridge and toner cartridge to a minimum.

All graphic screens shall be animated to indicate the current state of the piece of equipment. The following graphic screens shall be provided, as a minimum.

- Main Overview of Site
- Alarm Summary
- Event Summary
- Overview of each major process area (with vectoring to sub-areas)
- Summary screen to vector to all video trends

A minimum of 30 custom graphic displays shall be provided by the System Supplier.

9.3.3.2 Report Formats

Report formats shall be developed and programmed by the System Supplier using tag names defined in the database creation. Reports shall be provided as summarized below. All reports will be provided with a header on each page to indicate the contents of each column of information. Each page shall be numbered and indicate the name of the report, the date the report was printed, and the time of the printout. The printout shall also include the time span of the information shown on the report.

- Daily Operating Report. A daily report, listing the major plant variables (up to 20 variables) shall be provided. The report shall include hourly values and

minimum/maximum/average values where appropriate. A minimum of five separate daily reports shall be provided by the System Supplier.

- Monthly Operating Report. A monthly operating report, which averages the values from the above daily reports, shall be provided. The report shall include monthly minimum/maximum/average values where appropriate.

9.3.3.3 *Configuration Standards and Conventions*

A "Software Configuration Standards and Conventions" document shall be prepared and submitted by the System Supplier. The document shall be submitted for review and approval before software configuration commences. The document shall describe and define such items as proposed graphic display process line colors/representations; symbology; color standards for "on", "off", "opened", "closed", and "alarm" conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup.

The following predetermined conventions shall be followed and shall be described in the document:

- Equipment "running" shall be shown in red with "RUN" in text adjacent to the equipment symbol.
- Equipment "alarm" shall be shown with "FAIL" in magenta text with yellow background adjacent to the equipment symbol.
- Equipment "off and ready" shall be shown in green with "READY" in black text adjacent to the equipment symbol.
- High and low water level alarms shall display "HIGH-LEVEL" or "LOW-LEVEL" in red text adjacent to the associated basin.
- High- and low-pressure alarms shall display "HIGH-PRESS" or "LOW-PRESS" in red text at the affect point in the process.
- High and low flow rate alarms shall display "HIGH-FLOW" or "LOW-FLOW" in red text adjacent to the measuring flow meter.
- Graphics showing totalized flow shall include an adjacent reset button and the date of the last totalizer reset.
- Process areas equipped with cameras shall have links on the associated control screen to seamlessly transfer the screen to display the camera image in real time.

All static ("dumb") equipment and graphic objects shall be grey in color

Before submitting the initial draft document, the System Supplier shall meet with the Engineer and/or Owner to review any of the Owner's additional existing standards and conventions. All copies of this submittal shall be provided in color to ensure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system.

In addition to submitting the document for review, an updated version of the document shall be submitted as part of the O&M Manuals. The document shall be revised to document any additional standards that are established throughout the configuration process.

9.3.3.4 *Configuration Review Meetings*

Proposed graphic screens and report formats shall be reviewed with the Owner and Engineer throughout the configuration process. The System Supplier's programming personnel shall attend all meetings. A second review meeting shall be held at approximately 50 percent completion. Both meetings shall be held at the Owner's facilities.

9.3.3.5 *Software Functional Requirements*

General functional requirements for system configuration are indicated on the Drawings and described in the specifications. The information presented herein and indicated on the Drawings illustrates the general functional intent of the system, and may not be sufficient to fully configure the system. The System Supplier shall be responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Engineer or the Owner.

9.3.4 *Systems Check*

System Supplier shall provide the services of a trained and experienced field supervisor to assist the installation contractor during installation, and to calibrate, test, and advise others of the procedures for installation, adjustment, and operation.

9.3.4.1 *Field Manager*

Not used.

9.3.4.2 *Field Inspection at Delivery*

The field supervisor shall inspect major equipment items within five working days of delivery, to assure that the equipment was not damaged during shipment and shall supervise or assist with unpacking, initial placement, and initial wiring of the system.

9.3.4.3 *Field Calibration of Instruments*

After each instrument has been installed, a technical representative of System Supplier shall calibrate each instrument and shall provide a written calibration report for each instrument, indicating the results and final settings. The adjustments of calibrated instruments shall be sealed or marked, insofar as possible, to discourage tampering. Instrument calibration shall be done before checkout of the system operation. A typical instrument calibration report is attached to the end of this section as Appendix C.

9.3.4.4 Training for Installation Personnel

The field supervisor shall train the installation personnel in reading and understanding submittal drawings, and in the correct installation and wiring procedures for the equipment. Three days shall be included as a minimum for this training of six (6) people.

9.3.4.5 Field Inspection Prior to Start Up

After installation and wiring connections are complete, the field supervisor, with additional System Supplier's personnel shall verify that each external connection to the system is correctly wired and field process components and devices are functioning as intended. A minimum of 10 working days shall be included for this task, but System Supplier shall be responsible for completing the following scope of work.

- **Analog Signals**

Analog input signals shall be simulated at the transmitting source, and verified to be received at the proper register address in the control system. Analog outputs shall be generated at the control system, and verified to be received with the correct polarity, at the respective receiving device.

- **Discrete Signals**

Discrete input and output signals shall be simulated and verified that they are received at the respective receiving device, and at the proper voltage.

- **Devices by Other Suppliers.**

If interrelated devices furnished by other suppliers, under other contracts, or by Owner, such as valve actuators, motor controls, chemical feeders, and instruments, do not perform properly at the time of system checkout, the field supervisor shall use suitable test equipment to introduce simulated signals to and/or measure signals from these devices to locate the sources of trouble or malfunction.

End of Section

10 PROGRAMMABLE LOGIC CONTROLLERS

10.1 GENERAL

10.1.1 Scope

This section covers programmable logic controllers (PLCs), including associated input/output hardware to control process equipment and serve as the interface to field devices.

10.1.1.1 Control System

The Instrumentation and Control System section shall apply to all equipment furnished under this section. Additional PLC software requirements are indicated in Software Control Block Descriptions section.

10.1.2 General

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

10.1.2.1 Drawings

Supplementing this section, the Drawings indicate the number and types of PLCs, locations of PLCs, and provide diagrams and schematics regarding connection and interaction with other equipment. All hardware, including power supplies, special cables, and other appurtenant equipment, shall be provided to meet the functional requirements described herein and indicated on the Drawings.

10.1.2.2 I/O List

An input/output (I/O) field device signal listing is included in ANEXX of Instrumentation and Control System.

10.1.3 Submittals

Submittals shall be as specified in the Instrumentation and Control System section.

10.1.4 Delivery, Storage, And Shipping

Delivery, storage and shipping shall be as specified in the Instrumentation and Control System Section.

10.1.5 SPARE PARTS

Spare parts shall be furnished as follows:

Spare Parts

I/O modules: 1 of each type used for every 5 supplied, minimum of one.

10.2 PRODUCTS

10.2.1 General

All equipment furnished under this section shall be expressly selected by System Supplier for its superior quality for the intended purpose and shall comply with the following requirements.

10.2.1.1 Interchangeability

All programmable logic controller systems shall be products of the same manufacturer and of the same series or product line. Processors, local and remote input/output hardware, communications modules, and specialty modules such as coprocessors and ASCII modules shall be interchangeable among all I/O panels and systems. PLC modules and hardware by other manufacturers will be acceptable only if the PLC manufacturer does not offer suitable modules and hardware for the same functions.

10.2.1.2 Initial, Spare, and Future Memory (RAM)

System Supplier shall provide adequate memory for the amount of I/O, control algorithms, and communications in the initial system.

Each programmable logic controller shall include provisions for future expansion and shall have spare memory capacity of 40 percent of the total needed to implement the specified control functions. The spare memory capacity shall be documented by submitting to Engineer, during factory testing, a statement indicating the amounts of memory of all types being utilized and the total amount available in each system. The statement shall include an estimate of the total program and data memory necessary, including spare memory, based on the I/O hardware for the system, and previous programming experience.

10.2.1.3 Spare I/O

The Contractor shall supply Input and Output Modules, shall be installed, wired, and interfaced properly to the terminal strip. Each PLC input/output enclosure shall be provided with at least 20 percent spare inputs and outputs of each type. Spare I/O shall be installed, wired, and interfaced properly to the terminal strip. In addition, each PLC input/output enclosure shall be capable of accommodating 20 percent of additional input/output capacity of each type as originally assembled, without the need for additional expansion racks, communication adapters, cables, or PLC power supplies.

10.2.1.4 Expandability

Each PLC processor and associated I/O shall have a future expandability of at least 50 percent of the provided system.

10.2.1.5 Acceptable Products

The PLCs installed at pumping Station shall be Schneider Modicon M580, ABB AC500 or approved equal processors from Allen Bradley and Siemens, GE.

General Minimum Requirements of PLC:

1. The PLC shall be Modular and centrally expandable up to 10 I/Os Modules.
2. The PLC shall Support Several Communications Possibilities such as Ethernet, Internet, Profinet, Profibus and Modbus ...
3. Terminal Base of PLC processor shall have space for one Communication Modules for Future Expansion.
4. Programmable Logic Controller 1.3GHz, 16MB Program / 16MB Data memory.
5. 24VDC, 1xEthernet Integrated Interface-CPU, 4xEthernet interfaces-communication modules, 2xRS232/485 serial interfaces.
6. Cycle time for 1 instruction, Binary Min. 0.05 μ s, Word Min. 0.05 μ s, Floating point Min. 0.6 μ s.
7. Pumping Station PLCs shall be supplied with the following options and features.
 - Multifunctional 24-volt dc, 40-watt redundant power supplies
 - Ethernet interface modules (SRTP-, EGD-, or Modbus TCP/IP-capable)

10.2.1.6 PLC Power Supplies

PLC power supplies shall be redundant and furnished at each PLC and remote I/O installation, each CPU shall include a hot redundant power supply shall be included in each PLC panel. Both supplies shall be contained in the same enclosure and shall provide operating power to the processor with hot redundant power supply for each remote I/O modules. Switchover from the active supply to the standby supply shall be automatic and shall not interrupt PLC operation. A disconnect switch to shut off power to the processor shall be provided between the power supplies and the PLC.

10.2.1.7 Signal Power Supplies

Separate Regulated dc power supplies shall be provided in each PLC enclosure for analog inputs, digital outputs, digital inputs, Power supplies shall be suitable for an input voltage variation of ± 10 percent, and the supply output shall be fused or protected against short-circuiting. Output voltage regulation shall be as required by the instrumentation equipment supplied (24 VDC). The loop power supply shall be separate from the power supply circuit for the processor and racks. The power source for all digital inputs from field devices shall be separately fused for each digital input module. Unless otherwise noted, all field devices will

be provided with dry contacts that close to provide an input to the PLC. PLC and signal power supplies shall have failure outputs to be connected to PLC inputs.

10.2.1.8 Appurtenances

The PLC processor and I/O hardware shall be provided as complete systems, as shown on the block diagram drawings. The PLCs shall include all necessary hardware and software for a complete working system. All special rack or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished for proper operation of the equipment. Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed for proper operation of the equipment.

10.2.1.9 PLC Arrangement

The PLCs shall be distributed and arranged as indicated on the Drawings.

10.2.1.10 Service Conditions

PLCs will be installed in the locations shown on the drawings. Enclosures for PLCs shall be type tested, furnished with heating strips, ventilation fans, and recirculation fans, as specified Panels, Consoles, and Appurtenances.

10.2.2 PLC Processor

Programmable logic controller processor shall be an industrial-type rack-mounted unit that utilizes battery-backed CMOS type or nonvolatile type memory. Battery backed memory shall include integral batteries with sufficient capacity for at least 1 year's memory retention without power to the processing unit. Standby and shelf life of the batteries shall be at least 5 years. The CPU shall comply Minimum with the requirements Mentioned in PLC section 2.1. 5.

10.2.2.1 Diagnostics

The processor shall utilize self-monitoring diagnostic techniques and shall contain easily visible LED diagnostic indicators for "run" and "halt" conditions as well as memory and input/output error conditions. Diagnostic codes shall also be available through the programming device to facilitate troubleshooting.

10.2.2.2 Programming Port

The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional, and after all communications, human machine interface (HMI), and network connections have been made. Removal or disruption of network communications, remote I/O communications, and HMIs to allow for on-line

programming and monitoring will not be acceptable. A key switch shall be provided on the processor for selection of the operating mode and as a security measure. CPU and its Rack shall have two Programming Port, one of them is Ethernet (TCP/IP) and Other is Serial Port, the Contractor shall supply programming Cables for both Port.

10.2.2.3 Communications

The processor shall be programmed to operate autonomously, regardless of communications status with other units. Each programmable controller shall be furnished complete with communication modules for local and remote input/output hardware communications, communications with other programmable controllers, and communication with host computers as shown on the block diagram. The Processor shall support Remote IO Communication; this feature may be used in Expansion of PLC in future.

10.2.2.4 Environment

The processor shall be suitable for operation in the environments specified in another section.

10.2.2.5 Programming

The processor shall be programmable using the IEC 61131-3 international programming standards and ladder logic programming.

IEC 61131-3 programming shall include the following:

- Functional Block Diagram Sequential Function Chart.
- Instruction List.
- Structured Text.
- Ladder Diagram.

Ladder logic programming shall include a minimum of the following capabilities:

- Contacts, coils, branching.
- Data comparisons.
- On-delay and off-delay timers.
- Counters with comparators.
- Floating point Math and Logical instructions.
- PID loop control.
- Jumps and Subroutine functions.
- Master control relay.
- Transitional or one-shot outputs.
- Standard and user-defined data tables for digital and analog value storage.
- Remote I/O capability.
- Fault-mode subroutine.

10.2.2.6 Programming Capabilities

The processor shall include the following capabilities for programming, debugging of programs, and troubleshooting:

- Off-line programming.
- On-line programming.
- On-line status of coils and registers.
- Input/output forcing.

10.2.2.7 Hardware Configuration

Processors shall be configured for standard rack mounting. Each programmable logic controller processor shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces. The processor shall have at least one integrated Ethernet Port and one integrated serial port, The CPU shall comply with the Minimum Requirements Mentioned in PLC section 2.1.5.

10.2.2.8 Input/output Hardware

Input/output hardware shall be arranged as indicated on the Drawings. Programmable logic controller systems shall support the types of input/output modules identified below.

All digital input/output hardware shall include isolation against surges of at least 1500 volts. All output hardware connected to inductive loads shall be supplied with surge suppression devices and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will be acceptable if they meet the following requirements.

- **Wiring Terminal**

All input/output modules shall utilize easily removable, plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires.

- **I/O Circuit Power Supply**

Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the Drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall operate either interposing relays or relay-type digital output modules in the PLC cabinet.

- **Digital Input Modules**

Digital input modules shall sense voltages of 230 volts ac (50 Hz) or 24 VDC Based on application and shall have LED indicators for each point to display the status of the field contact. Each input module shall be suitable for being connected to a separate voltage source and return. Digital input modules shall have multiple inputs. The PLC system shall also accommodate discrete inputs that operate at 230 volts dc, 24 volts ac (50/60 Hz), 5-to-30 volts dc, 10-to-60 volts dc, isolated 230 volts ac (50 Hz) and isolated 230 volts dc signals.

DI Modules shall be for central and decentralized extension, Power supply over I/O bus connection, galvanic isolation per module, All DI channels protected against reverse polarity / supply, short circuit, Diagnosis LEDs on module Configurable module monitoring, diagnosis by the CPU and configurable substitute values for outputs at communication fault

▪ **Digital Output Modules**

Digital output modules shall control voltages of 230 volts ac (50 Hz) or 24 VDC and shall be rated at least 1 ampere. Outputs shall be individually fused and shall have LED indicators to display output status. Outputs shall withstand a surge of at least 80 amperes for one cycle and shall have an off-state leakage current not to exceed 2.0 mA Digital output modules shall have multiple outputs. The PLC system shall also accommodate discrete outputs that operate at 24 volts ac (50/60 Hz) and 10-to-60 volts DC. DC Digital outputs Modules shall be relays 2 A (24 V DC), the transistor DO is rejected.

▪ **Relay Digital Output Modules**

Relay digital output modules shall have dry contact relay type outputs suitable to control voltages from 24 to 230 volts dc and 24 to 230 volts ac and shall be rated at least 4 amperes at 230 vac. Outputs have LED indicators to display output status. Digital outputs for motor driven equipment shall be powered by the driven equipment. Outputs shall withstand a surge of at least 80 amperes for 15 milliseconds. Relay digital output modules shall have multiple outputs

▪ **Analog Input Modules**

Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Analog to digital conversion accuracy shall be at least 15-bit resolution. Analog input modules shall have multiple inputs. Analog Input modules shall be:

1. For central and decentralized extension.
2. Power supply over I/O bus connection, galvanic isolation per module.
3. Input channels single configurable for current or voltage signals
4. Resolution is 15 bits plus sign.
5. All channels protected against reverse polarity / supply, short circuit and continuous overvoltage up to 30 V DC.
6. Diagnosis LEDs on module (module and channels).
7. Signal value indication by LED brightness.

▪ **Analog Output Modules**

Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure and shall be capable of driving a 0 to 600-ohm load. Digital to analog conversion accuracy shall be at least 12-bit (0-4095 count) resolution. Analog output modules shall have multiple outputs. Analog output modules shall be:

1. Central and decentralized extension.
2. Power supply over I/O bus connection, galvanic isolation per module.
3. Output channels single configurable for current or voltage signals.
4. Resolution is 12 bits plus sign.
5. All channels protected against reverse polarity / supply, short circuit and continuous overvoltage up to 30 V DC.

6. Diagnosis LEDs on module (module and channels).
7. Signal value indication by LED brightness.

- **Panel Terminations**

All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.

- **Interposing Relays**

Interposing relays shall be incorporated on all I/O circuits as shown on the PLC input/output listing, where required by the application of isolated foreign power sources, where the continuous output rating of the PLC relay digital or output module is not sufficient to power the connected device or equipment, where required to meet the requirements for control outputs specified in Section related to “Panels, Consoles and Appurtenances”, or where otherwise required by the System Supplier’s equipment. Interposing relays shall be provided for any digital output module output signal that leaves the PLC enclosure unless that output can be accommodated by a relay digital output module. Interposing relays shall be mounted in the PLC enclosure containing the output module that activates the relays.

10.2.3 Communications

Each programmable controller system shall be furnished complete with communication hardware for communicating with its local I/O and over the network links shown on the Drawings, including Communication hardware shall be compatible with the cable, data highway, fiber optic, or broadband cellular wireless communication media and devices. Ethernet components and cable are specified in other specification sections.

10.2.3.1 Addressability

Each programmable logic controller shall be individually addressable so that only the selected controller responds when queried. IP addressing shall be used for Ethernet links. Designation of a controller's network address may be either a software or a hardware function.

10.2.3.2 Communications Hardware

System Supplier shall provide all necessary communications hardware. For Pumping Station PLCs, the following minimum hardware is required.

- One industrial standard CPU port, IEEE 802.3, 10Base-T Ethernet communication port (RJ45 jack), Four Ethernet in Commination module.
- One EIA-232-C serial programming port
- One EIA-485 Modbus serial dual-port module

The Communication Ports of CPU shall comply with Minimum Requirement Mentioned in PLC section 2.1. 5.

10.2.3.3 Communications Media

System Supplier shall provide all necessary cabling for the PLC communications network and PLC remote I/O communications network. Communications cables shall meet the requirements of the manufacturers of the PLCs and communications modules. PLC communications media shall be as specified under the Network Systems section.

10.2.4 3G Cellular Networks

3G CELLULAR Network shall be used mainly for connecting PLC to SCADA system to monitor and control based to Owner Requirements, the Modem that will be used, covered in Network System Section. The contractor shall prepare communications system as in Drawings.

10.2.4.1 Standard Product

The programming software shall be personal computer based and a standard product of the PLC manufacturer. For global SCADA programming, the standard is Control Maestro 2018 (HTML based).

10.2.4.2 Programming Software Features

The programming software shall allow off-line development of all PLC-related programming, including user annotation of the program, and creation and printing of application programs and I/O cross reference lists. Special programming tasks originally provided by System Supplier shall also be included.

On-line features shall include IEC 61131-1 standards program modification, ladder-logic modification, program language modification, monitoring of real-time ladder-logic execution, monitoring of program execution, monitoring and manipulation of timer and counter preset and present values, monitoring and forcing of physical I/O, and monitoring and manipulation of analog (register) and bit (binary) data table values. PLC and I/O hardware diagnostic and status information shall be accessible using the software in on-line mode.

One licensed copy of the PLC software used to configure and program shall be turned over to the Owner upon successful startup and commissioning of the system.

10.2.5 System Enclosures

Programmable logic controllers and input/output hardware shall be housed in shop-assembled panels as indicated on the Drawings and as described in the Panels, Consoles, and Appurtenances section.

10.2.6 Human Machine Interface-HMI

PLC HMI shall be microprocessor-based, flat panel, touchscreen type. The unit shall have data entry capabilities and shall include a password security function. The unit shall be connected to the PLC and shall display status, alarm, and diagnostic information. The unit shall provide

a nominal diagonal display area dimension of 300 mm, with a minimum resolution of 800x600, 16-bit color, and a luminance of at least 300 cd/m². The HMI shall be furnished with a minimum of 8 MB of flash memory and 8 MB of system memory. The operator interface unit shall be provided with a combination of Ethernet (RJ-45), EIA-232, EIA-485 ports for communicating with the PLC, programming devices, Phones though 3G Modem and additional operator interface terminals or computers as necessary and as shown on the drawings. In addition, the HMI shall have an integrated web server that allows remote access of all display screens and all monitoring and control capabilities from a remote computer running web browsing software or from Tablet and Phones. The HMI shall be rated NEMA Type 4X / IP66, suitable for panel face mounting. Where multiple units are shown on the drawings connected to the same PLC, each HMI shall operate with full functionality and without contention with other units. Any special cables, firmware, software or hardware necessary to support multiple units shall be provided. At the System Supplier's option, a flat-panel, touchscreen-type, industrial computer running suitable web browsing software (or the HMI manufacturer's terminal viewer client software) may be substituted for remotely mounted HMI, provided that the computer is able to provide the same functionality as the HMI without contention with the HMI.

Terminals shall be powered from available 230 volts, 50 Hz, single phase. Dedicated power supplies shall be furnished as necessary to transform the available power to the HMI operating voltage. Terminals shall be suitable for ambient temperatures of 0 to 50°C and a relative humidity of 5 to 95 percent, non-condensing.

One licensed copy of the HMI software used to configure, program, and create the screens shall be turned over to the Owner upon successful startup and commissioning of the system.

The HMI shall be 13 inch Minimum, Siemens Simatic HMI TP 1900 Comfort, Rockwell PanelView Plus 6, ABB CP600 HMI, Schneider Electric "Magelis XBT GT" or equal.

General Requirements of HMI:

1. HMI shall allow users to access HMI projects from a remote web browser running on a computer or on a mobile device such as a tablet or a phone, the HMI shall be based on HTML5 technology which means that no plugins, the Contractor shall create all HMI Pages to access from Remote web browser and tested it.
2. The HMI shall have Alarms system:
 - Numerous alarm conditions like "reach value", "exceed limit", "exceed deviation, "bitwise reach values".
 - Various options for indication like "displaying messages", "blinking of triggered alarms", "change of fore-/background color", "execution of various actions".
 - Several ways for alarm management like "enable/ disable", "acknowledge", "achieving in buffer" "reset of acknowledged alarms".
3. Actions: HMI Actions shall be Interaction functions, executed on triggering of events Versatile types of actions like alarm actions, event actions, keyboard actions, page actions, message/dialogue actions, print actions, recipe actions, system actions, tag actions, trend actions, user management actions and widget actions.
4. Recipes.

5. Trend: the HMI shall Sample and record values of specified tags, Easy analysis and back up of defined data Reliable trend data acquisition
6. Security: the HMI shall support user managements for secure information and operations by organizing permissions and groups the security options of a project can be defined. Restricted access to various widgets and operations by configuring users, users' groups and assigning specific authorizations to each group. Managing of users even during operation for easy adaption to actual requirements
7. Java script -customized function

10.3 EXECUTION

10.3.1 Installation Requirements

PLCs installation requirements are specified in Instrumentation and Control System section except as described herein Field check, testing, and training shall be as specified in the Instrumentation and Control System section.

10.3.2 Configuration

10.3.3 PLC Programming and Configuration

Configuration services are specified in the Instrumentation and Control System section. Use documentation provided in Section of Process Control Narrative for PLC Configuration in each Booster Pump Station.

10.3.4 PLC Operator Interface Programming and Configuration

PLC operator interface programming and configuration shall follow the pertinent requirements for system software configuration as specified in the Instrumentation and Control System. The communications shall be fully configured and installed by System Supplier. Communications shall be configured as shown on the Drawings.

End of Section

11 FLOW INSTRUMENTS

11.1 GENERAL

11.1.1 Scope

The Flow Instrument Section covers the furnishing of flow instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

11.1.2 Design Criteria

Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory wet flow calibrated to the full-scale flow range of the sensors or calibration ranges indicated on the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration and configuration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings or Instrument Device Schedule.

11.1.3 Submittals

Shall be made as specified in the Instrumentation and Control System section.

11.1.4 Shipment, Protection, and Storage

Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as specified in the Instrumentation and Control System section.

11.2 PRODUCTS

11.2.1 General

The following paragraphs provide minimum device requirements. The Drawings and Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

11.2.1.1 Interconnecting Cable

For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of ten meters or as indicated on the Drawings or in the Instrument Device Schedule. The interconnecting cable shall be provided in the length necessary for installation. Splices shall not be allowed in the installed cable.

11.2.1.2 Programming Device or software

For instruments that require a dedicated programming device or software for configuration, calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility. The programming device or software shall include appropriate operation manuals and shall be included in the training requirements. Technical representative that assists with site calibration to provide at least 6 hours training on site in transmitter programming, parameter setting and troubleshooting.

11.2.2 Flow Instrumentation

11.2.2.1 Magnetic Flowmeter Sensor Requirements

Magnetic flowmeter Sensor shall be a completely obstruction less, in-line flowmeter with no constrictions in the flow of fluid through the meter.

The Lining Material of Electromagnetic sensor shall comply with Drinking Portable Water Approval NSF 61 and WARS with carbon Steel Flanges. The Housing Material of Sensor shall be Carbon Steel. In addition, grounding rings or grounding electrodes as required by the application. Flange diameter and bolt drilling pattern shall comply with ANSI/ASME B16.5 for line sizes from 13 to 600 mm or AWWA C207 for line sizes larger than 600 mm. Flange class ratings and meter maximum pressure ratings shall be compatible with the adjoining piping.

Each meter shall be factory 5 point wet flow calibrated to the sensors full flow capacity or as required by engineer at a facility, which is traceable to NIST or other standard acceptable to Engineer, and a copy of the calibration, report shall be submitted as part of the operation and

maintenance manual submittal. Water meters shall be designed and manufactured such that their errors (of indication) do not exceed the maximum permissible errors as defined in OIML R49 Standard- Accuracy class 1 water meters.

The meter shall be capable of standing empty for extended periods without damage to any components and include an empty pipe detection electrode.

Furnish one spool piece for every size magnetic flow meter supplied to allow a meter to be removed for maintenance. The spool piece shall match adjacent piping.

The meter housing shall be of a splash-proof and drip-proof design made to IP 68 (NEMA 6P) unless installed in a below-grade vault, direct buried, or in any location with reasonable potential for submergence, in which case the meter housing shall be submersible. Where required to be submersible, the meter housing shall withstand submergence in 9 m of water for 48 hours without damage.

Acceptable Product:

Flow meters shall normally be provided for 220 V AC, 50 Hz or 24VDC power supply Meters shall be manufactured by ABB, Endress+Hauser, Foxboro, Krohne, Rosemount, Siemens, or approved equal.

11.2.2.2 Magnetic Flowmeter Signal Converters (Transmitter)

Separately Remote mounted, microprocessor-based signal converters shall be provided for the magnetic flowmeters. A cover shall be provided to protect the display. The signal converters shall include output damping, self-testing, built-in calibration capability, and an "empty pipe zero" contact input. The overall accuracy of the magnetic flowmeter transmitter and signal converter shall be ± 0.2 percent of actual flow rate for full-scale settings of 0.91 to 9.14 m/s. The meter manufacturer shall furnish the signal cable between the converter and the magnetic flowmeter. Signal cable shall be continuous and not spliced between the meter and the signal converter. The signal converter shall be housed in a corrosion- resistant, shall be suitable for operation over an ambient temperature range of -10 to +45°C, and relative humidity of 10 to 100 percent. The converter shall have seven-digit totalizer. The converter shall be equipped with a galvanically isolated programmable relays as required below. Scaling factors shall be field adjustable and shall be selected to provide a totalizer multiplier of a power of 10. Transmitters tagged on the Drawings or specified to be of the indicating type shall contain a local indicator with a minimum four-digit LCD type display, scaled to read in engineering units of flow.

Magnetic flowmeter systems shall provide zero flow stability by means of automatic zero adjustment of a DC excited metering circuit. Converters shall be capable of bi-directional flow measurement and leak detection/leak management. Signal converters shall be of the same brand as the magnetic flowmeters.

Magnetic Flowmeter Signal Converters types:

1. Signal Converter (TYPE 1) –Booster Pumping Station

TYPE 1 signal converter shall be IP67 (NEMA 4X), 230VAC or 24VDC power and shall include at least:

- a. One 4-20mA instantaneous flow Hart output.
- b. One Totalizer pulses output.

- c. Two relays for flow limit set-points
 - d. One alarm or failure relay
 - e. Self-cleaning unit integrated with the signal converter, capable to clean the electrodes with enabled by
2. Signal Converter (TYPE 2)-Service Connection Chamber
- TYPE 2 signal converter shall be weatherproof NEMA Type 6P/IP 68 housing, Battery powered with AC Mains Cable for future connection and shall include at least:
- a. 5 years' battery to power the flow meter in case of power fail
 - b. One MODBUS communication port.
 - c. One battery alarm or failure relay

For TYPE 1 and TYPE 2, signal converter calibration shall be periodically verified and restored using a hand-held calibration verification device. One device shall be furnished for all converters provided by a single manufacturer for each facility owner.

11.2.2.3 Data Logger

The Contractor shall supply Data logger with Communication Modem, the two options of Integrated Data logger with Flow Meter Transmitter or External Data logger are acceptable. The Data Logger shall automatically collect the Total, flow values and drinking water network pressure; it shall send these data by SMS, GPRS or 3G once a day, to a centralized SCADA system.

The Data logger shall be IP68 Completely watertight, it conforms to the requirements of the environment in which it is placed: in particular, when fitted underground, or in a wet or flood-prone counting manhole.

The Data logger shall be Battery Powered, external high Gain Antenna, the Remote (Not integrated) data Logger shall be equipped with RS-485 Modbus Link for direct reading of internal Flow Meters Data from SIEMENS MAG 8000, ABB Aquamaster or KROHNE Waterflux or equaled.

The Battery Life of Data Logger for two counts and one pressure measurement or One RS 485 Reading every 15 minutes, processing and daily transmission to the SCADA one time every day shall be same with Battery life of battery power flow meters. The Data logger modem shall initiate communications with the central SCADA System with PWA; it can be used on a GPRS or 3G network with a private (or dedicated) APN or a public (standard) one. On each communication, the Data Logger sends the central system the archived values of its data, the daily reports and diagnostic data.

11.2.3 Target-Type Flow Switches (for Low Flow Pressure Switch at Booster Stations)

Target-type flow switches shall utilize a vane or paddle type target to actuate the switch. For sizes greater than or equal to 2 inch [50 mm], switches shall have a treaded n NPT connection for insertion into the process piping. For pipe sizes less than 2 inches [50 mm], the flow switch shall be factory installed in a spool piece, suitable for flange or thread mounting in the process piping. Switch wetted components shall be Type 316 Stainless Steel compatible with the

process fluid. Switches shall contain at least one non-mercury SPDT contact, rated 2 amp [A] at 230 volts ac. The switch enclosure shall be a minimum NEMA Type 4/IP66 housing. Switches shall be factory calibrated to actuate at the specified flow rates for the given pipe size. All flow switches shall be installed in horizontal piping. Switches shall be Magnetrol Model F10 or approved equal.

11.3 EXECUTION

11.3.1 Field Services

Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor.

End of Section

12 PRESSURE AND LEVEL INSTRUMENTS

12.1 GENERAL

12.1.1 Scope

This section covers the furnishing of pressure and level instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

12.1.2 Design Criteria

Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings and/or Instrument Device Schedule.

12.1.3 Submittals

Submittals shall be made as specified in the Instrumentation and Control System section.

12.1.4 Shipment, Protection, And Storage

Equipment provided under this section shall be shipped, protected, and stored in accordance with the requirements of the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

12.2 PRODUCTS

12.2.1 General

The following paragraphs provide minimum device stipulations. The Drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

12.2.2 Sun Shed

All pressure sensing devices and related components shall be protected from sun using sun shed protector. Sun shed shall be constructed from UV-resistant low flammable hot-pressed; glass fiber reinforced polyester as manufactured by Intertek.

12.2.3 Pressure and Level Instrumentation

12.2.3.1 Pressure and Pressure Sensing Level Transmitters.

12.2.3.2 Three-valve manifold

Each pressure sensing instrument such as pressure transmitters, Diff. Pressure Transmitters, Pressure Switches, Diff. Pressure Switches, Pressure Gauges and Level transmitters shall include a three-valve manifold and a mounting bracket. Manifolds shall have test ports on the instrument side.

12.2.3.3 Premium Accuracy Pressure Transmitters

This transmitter is connected to a process by means of impulse lines and can measure Pressure, Differential pressure or Absolute pressure. The measurement is transmitted to a control system by means of a 4-20 mA signal with a super imposed digital signal (Hart) or by means of a digital transmission, protocols Transmitters shall be an all-solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or cobalt-chromium-nickel alloy diaphragms, and the

transducer may use a silicone oil fluid fill. Transmitters shall have self-diagnostics and electronically adjustable span, zero, and damping. Transmitters shall be enclosed in an IP66 housing and shall be suitable for operation at temperatures from -17° to +82°C, and relative humidity of 5 to 100 percent. All parts shall be cadmium-plated carbon steel, stainless steel, or other corrosion-resistant materials.

Transmitters shall have over-range protection to maximum line pressure.

Accuracy of the transmitter shall be 0.05 percent of span, and transmitter

Output shall be 4-20 mA dc without the need for external load adjustment, or shall have a Foundation fieldbus output signal where so indicated on the

Instrument device schedules. Transmitters shall not be damaged by reverse

Polarity. Transmitters shall have an elevated or suppressed zero. For calibrated spans of less than 55 kPa gage a differential pressure type

Transmitter with side vents shall be utilized. Transmitters shall be provided

With brackets for wall and pipe-stand mounting.

Transmitters shall be factory calibrated to the required range and provided

With the manufacturer's standard hand-held communications/calibration

Device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be indicating type shall be furnished with LCD type digital indicators.

Where indicated on the Drawings or in the Instrument Device Schedule, a

Diaphragm seal shall be provided with the respective transmitter. Diaphragm seals shall be as specified elsewhere in this section.

Transmitters shall have a turndown ratio of 80:1.

Transmitters shall be ABB, Endress+Hauser, Siemens, or approved equal.

12.2.3.4 Pressure Sensing Level Transmitters (Water Tank)

Level transmitters shall be of the differential pressure sensing type that connects to the process to Measure Level. Each transmitter shall have a 1 mm threaded low-pressure connection for the process or atmospheric reference. The transmitter shall be an all-solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or cobalt-chromium-nickel alloy diaphragms, and the transducer may use a silicone oil fluid fill. Transmitters shall have self-diagnostics and electronically adjustable span, zero, and damping. Transmitters shall be enclosed in IP66 housing and shall be suitable for operation at temperatures from -17° to +82°C and a relative humidity of 5 to 100 percent display unit shall be in meter. All wetted parts shall be cadmium-plated carbon steel, stainless steel, or other corrosion-resistant materials. Transmitters shall have over-range protection to a maximum line pressure. Accuracy of the transmitter shall be 0.075 percent of span and the transmitter output shall be 4-20 mA

dc without the need for external load adjustment. Transmitters shall not be damaged by reverse polarity. Transmitters shall have an elevated or suppressed zero.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be the indicating type shall be furnished with LCD type digital indicators.

Each level transmitter shall be equipped with appropriate length capillary tube and diaphragm seal.

Transmitters shall be ABB, Endress+Hauser, Siemens, or approved equal.

12.2.4 Ultrasonic Level Transmitters (Chlorine Tank)

Each ultrasonic level transmitter shall be a microprocessor-based electronic unit consisting of a sensor assembly, a signal converter/transmitter, and an interconnecting cable. The sensor shall be encapsulated in a chemical and corrosion-resistant material such as Kynar or CPVC, and shall be suitable for operation over a temperature range of -28° to +66°C and a relative humidity of 10 to 100 percent. The sensor shall be compatible with the process media being measured. Sensors mounted in areas subject to freezing shall be provided with special transducers or protected against icing by heaters. Sensors mounted in direct sunlight shall be provided with sunshades.

The supplier shall coordinate the sensor mounting requirements and furnish drawings complete with dimensions and elevations.

The ultrasonic level transmitter shall have automatic compensation for changes in air temperature at the sensor location. If separate temperature sensing probes are provided, they shall be mounted with or adjacent to the ultrasonic sensor, as recommended by the manufacturer. The transmitter shall have a four-digit LCD display scaled to read in engineering units. Digit height shall be approximately 12 mm. The transmitter shall be designed to ignore momentary level spikes, false targets, or momentary loss-of-echo. A loss-of-echo condition shall be indicated on the transmitter unit and shall be available as an alarm contact output. The transmitter output shall be an isolated 4-20 mA dc signal linearly proportional to the measured level range, or were indicated on the Drawings or in the Instrument Device Schedule, shall be characterized to be proportional to the tank volume. Calibration parameters shall be entered through a keypad on the unit and shall be stored in nonvolatile EEPROM memory. Accuracy of the transmitted signal shall be ± 0.5 percent of the level range.

A sufficient length of sensor-to-transmitter signal cable shall be furnished with the instrument to locate the sensor 8 to 60 m from the signal converter.

For outdoor installation, the signal converter electronics shall be housed in a weatherproof, corrosion-resistant IP66 enclosure suitable for wall or pipe stand mounting and for operating temperatures of -20° to +50°C and a relative humidity of 10 to 100 percent. A thermostatically controlled strip heater shall be provided in the signal converter enclosure.

The signal converter shall be powered from 24 volts ac, 50 Hz, or 24 volts dc. The ultrasonic level transmitter shall be Siemens, ABB or approved equal.

12.2.5 Submersible Pressure Sensing Level Transmitters

The level transmitter system shall consist of a submersible pressure sensor/transmitter unit that is suitable for direct submersion into the liquid being measured. Sensor size shall not exceed 32 mm diameter by 225 mm length. The sensor shall be a solid-state variable capacitance or diffused silicon semiconductor type that shall provide an output signal directly proportional to the sensed pressure over a factory- calibrated range. The sensor assembly shall have a stainless steel or titanium housing and shall be supported by a polyethylene or urethane jacketed cable with a minimum 90 kg test strength. The cable shall also be constructed with stainless steel mesh or wire for extra support. The sensor cable shall be of sufficient length so that no splice or connector is required in the wet or inaccessible area, and the vent tube termination point is located in an area protected from dirt and moisture. Sensors used for raw water and monitoring wells shall be non-vented and configured as an absolute pressure sensor.

The transmitter shall have a two-wire type 4-20 mA dc current output that is proportional to level. The output shall have surge protection, and shall not be damaged by reverse polarity. The transmitter shall be suitable for an operating temperature range of 0° to +50°C. Accuracy of the level transmitter shall be ± 0.25 percent "best straight line", with an overall combined accuracy of ± 1 percent over the entire operating temperature/pressure range.

Submersible pressure sensing level transmitters shall be Ametek U.S Gauge- PMT Products "Model 575", Endress+Hauser "Waterpilot" or "Deltapilot Series", GE Measurement & Control Solutions "Model PTX1830", or Siemens "SITRANS P MPS". Equivalent, non-vented versions of the above-named products shall be used for raw water and monitoring well applications.

12.2.6 Level Switches

The detecting level switches shall be float actuated and shall be suitable for wall bracket or sump mounting, as indicated on the Drawings or in the Instrument Device Schedule. The switch float mechanism shall actuate when the water level rises to 25 mm above the bottom of the housing. The switch contacts shall be hermetically sealed, rated for 0.1 amp [A] at 230 V ac, and shall be field changeable from normally open to normally close. Switches shall be Siemens "Model 101G" or approved equal.

12.2.7 Pressure Switches

Pressure switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches mounted inside panels shall have IP65 housings. Switches shall be differential type or dual-setpoint type were indicated in the Instrument Device Schedule. Switch wetted parts shall be compatible with the process fluid.

Panel-mounted and surface-mounted switches shall be provided with 6 mm connections. All stem-mounted switches shall be provided with 12 mm connections.

All pressure switches shall be ranged in kPa or bars and all vacuum switches in mm of water. Unless otherwise indicated, switches shall have low fixed dead band and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 5 amps [A] at 230 V ac. Dual-setpoint type switches shall have an independent SPDT contact for each setpoint.

Each switch shall be provided with a threaded end, ball-type shutoff valve. Shutoff valve materials shall be s. AISI Type 316 stainless steel wetted parts and Teflon seals. Multi-port valves shall have all unused ports plugged.

Where indicated on the Drawings, a diaphragm seal shall be provided for the respective switch. Diaphragm seals shall be as specified elsewhere in this section.

Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, S.O.R., or approved equal.

12.3 EXECUTION

12.3.1 Field Services

Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section. Technical representative from manufacturer to assist with site calibration and provide at least 6 hours training on site in transmitter programming, parameter setting and troubleshooting procedures.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

13 MISCELLANEOUS INSTRUMENTS

13.1 GENERAL

13.1.1 Scope

This section covers the furnishing of all miscellaneous instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple miscellaneous instruments of a particular type are indicated, and each requires different selectable features, the required features are described on the Drawings or in Instrument Device Schedule.

13.1.2 Design Criteria

Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by System Supplier.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Instrument Device Schedule.

13.1.3 Submittals

Submittals shall be made as specified in Instrumentation and Control System section.

13.1.4 Shipment, Protection, And Storage

Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

13.2 PRODUCTS

13.2.1 General

The following paragraphs provide minimum device stipulations. The Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

13.2.2 Miscellaneous Instruments

13.2.2.1 Proximity (Door) Switches

Proximity switches shall be magnetic proximity type, consisting of two sensors. One sensor shall be fixed to the door and the other to the door frame. The sensor mounted to the door shall have no electrical connections. Switches shall be provided with DPDT contacts rated 2 amperes at 230 V ac. All necessary mounting hardware shall be provided to allow both the sensors to be installed at the locations indicated on the Drawings.

13.2.2.2 Vibration Transmitters

Solid state vibration detection systems shall be furnished and installed to monitor vibration on each pump and pump bearing where indicated. Vibration detection systems shall include vibration transmitters and mounting equipment for the transmitters. Vibration transmitters shall provide a 4 to 20 mA signal proportional to the vibration in mm per second to the VFD starter and to PLC. Sensitivity of the vibration system shall be unaffected by rotational speed of equipment and shall be coordinated with equipment supplier.

Vibration transducers shall be mounted on the driven equipment as recommended by the manufacturer. Cable between the transducers and the transmitters shall be provided by the equipment manufacturer. Transmitters shall be located in the proximity of equipment in a dedicated local panel.

Alarm conditions shall be generated by the monitoring module located inside VFD or starter on vibration warning, and to shut down equipment on excessive vibration. Alarm and shutdown conditions shall be as recommended by the equipment manufacturer and a

dedicated input shall be installed in PLC cabinet. Alarms and shutdown events shall be monitored by the PLC.

The vibration detection system shall be powered from the PLC control panel (UPS power).

13.2.2.3 Digital Temperature Protection Relay

Digital Temperatures Protection Relay shall be furnished and installed to monitor Temperatures for each Pump Motors as indicated in Drawings, Temperature Protection Relay shall be micro-processor-based relay, designed to protect electric motors and pumps from over temperature.

Temperature Protection Relay shall have 6 temperature inputs-Minimum or as Indicated in drawing that can be programmed to measure Thermistors (PTC or NTC) and RTDs (Pt100).

Temperatures Protection Relay shall be mounted Inside VFD Local Control Panel or as recommended by the manufacturer. Cable between the Temperature Sensor RTD or PTC and the transmitter shall be provided by the equipment manufacturer as specified in Control Cable Schedule.

Alarm conditions shall be generated by the monitoring module located inside VFD or starter on High Temperature Warning, and to shut down equipment. Alarm and shutdown conditions shall be as recommended by the equipment manufacturer and a dedicated input shall be installed in PLC cabinet. Alarms and shutdown events shall be monitored by the PLC.

The Temperature Relay Protection shall be equipped with RS485 Serial Link for Modbus Connection with PLC to display all Temperatures Values of Temperature elements of Pump on the HMI of Site.

13.2.2.4 Chlorine Analyzer

- A. Power Input: Analyzers shall be the fully isolated type with power supply of 220 VAC plus and minus 10 percent, 50 Hz plus and minus 5 percent.
- B. Signal Output: Controller outputs shall include a current regulated 4-20 mA DC capable of driving 500 ohms.
- C. Ambient Conditions: Analyzers shall be suitable for continuous automatic on-line analysis of the indicated parameter under the conditions indicated. Equipment shall operate satisfactorily in ambient temperatures between minus 29 degrees C and plus 49 degrees C or shall be provided with isothermal enclosures so that accuracies will not exceed one percent of span.
Process fluid temperatures will range between 4 and 40 degrees C unless indicated otherwise.
- D. Sample Flow: Samples shall not pass-through housings containing electronics unless indicated otherwise.
- E. Local Indication: Each analyzer shall be provided with means of local indication scaled in process units.

- F. Calibration: Each analyzer shall be furnished with calibration connections at the analyzer.
- G. Single manufacturer: All electrodes, fittings, and transmitters on analyzers measuring the same parameter shall be products of a single manufacturer.

1. FREE CHLORINE RESIDUAL MEASURING SYSTEMS

- A. **Transmitter:** The free residual chlorine analyzer shall be microprocessor based, capable of the accurate determination of free residual chlorine in the range of 0-20 ppm with 0.001 resolution below 3 ppm. Results (chlorine residual and pH) shall be displayed on a high-Resolution LCD or LED display with 18mm high characters. The analyzer shall be capable of automatic pH correction over the range of 6.0 to 9.5 pH without the use of reagents or CO₂ gas (for free chlorine analysis only. diagnostics for operational errors or equipment problems shall be standard. Dual alarms with programmable logic shall be standard along with a third relay with timer functions. A programmable direct or reverse acting isolated 4-20 mADC output for chlorine concentration, expandable over the analyzer's range of measurement shall be standard with optional 4-20mA output for Ph readings also furnished. All functions including zero and calibration, alarm and 4-20mA output, variable input filter and output dampening, and keyboard security shall be accessible from the front panel membrane keyboard. The system shall have a loop accuracy of plus or minus 5% of reading or plus or minus 3 ppb at 25°C (whichever is greater) repeatability of plus or minus 2% of reading at constant temperature, and shall support the HART protocol. Transmitter housing shall be rated IP65 suitable for wall, handrail or panel mounting.

Analyzer Smart Transmitter Manufacturers, or Equal.

1. Rosemount Analytical, Model 54eA
2. Endress and Hauser Liquiline M CM33

- B. **Free Chlorine Sensor:** The residual chlorine sensor shall be of the passive amperometric type with a gold cathode, silver anode isolated from the sample by a chloramine permeable membrane and an electrolyte reservoir of 30 ml. The sensor shall include automatic pressure compensation to prevent any pressure influence when tested to 4.5 bar. The sensor shall also have a 100-ohm RTD for automatic temperature compensation over the range of 0-50°C. Each sensor shall have a replaceable membrane assembly, so constructed that replacement membranes will cause less than a 3% change in readings and be supplied with a minimum of 3 replacement membranes and 120 ml. of electrolyte. The sensor shall have a minimum service period of 4 to 6 months between electrolyte changes. The consumable materials in the sensor shall be sufficient for a minimum of 3 years of sensor life at ambient operating conditions. Sensors shall be designed to be replaced without removal of the sensor cable. Sensors shall include 1 m cable and all components and assemblies necessary for flow-through analysis installation.

Sensors shall be furnished complete with a one-year supply of spare membrane assemblies and sensor electrolyte (as applicable).

Free-chlorine sensor Manufacturers, or Equal

1. Rosemount Analytical Uniloc, Model FCL-O2 with dual sensor flow cell
2. Endress and Hauser Model CCS142D (Free Chlorine) with dual sensor flow cell

- C. **pH Sensor:** A separate pH sensor shall be required to accommodate automatic Ph correction as it is anticipated that pH variation will regularly exceed 0.2. The pH shall be of the combination pH, reference glass electrode type housed in a molded polypropylene or tefzel body with large area reference junction. Reference electrodes shall contain sufficient electrode and buffer solution for 6 months' continuous operation without replenishment. The sensor shall have a 100-ohm RTD for automatic temperature compensation over the range of 0-85 °C up to 6.9 bar. Probes shall be flow-through type as indicated. Sensors shall be designed to be replaced without removal of the senso cable.

pH Sensor Manufacturers, or Equal

1. Rosemount Analytical, Uniloc, Model 399VP
2. Endress and Hauser, Model CPS11D Memosens

13.2.2.5 Conductivity Measuring Systems

- A. **Transmitter:** This device continuously measures water conductivity through a successive measuring voltage applied to measuring cell with a pair of electrodes. The conductivity of environment is calculated from successive flow rate to electrodes and environment. One Pt100 integrated temperature sensor ensures automatic temperature compensation. The sensor is connected to PVC fitting. The suitable measuring transmitter in the field mounted enclosure is controlled by microprocessor.

Conductivity Transmitter Manufacturers, or Equal: Endress and Hauser, Model Liquiline M CM42

- B. **Sensor:** The conductivity sensor shall provide the following:

- Mechanical connection Screw gear R1”
- Maximum allowable temperature 90°C
- Maximum allowable pressure 16 bars
- Measuring range Fit for the required purpose
- Electrical connection to the transmitter by 5 m cable with plug (IP 65)

Conductivity Sensor Manufacturers, or Equal: Endress and Hauser, Model CLS21D MemoSens

13.2.2.6 Turbidity Measuring Systems

The measurement units of turbidity shall be in formazine turbidity units (FTU), however nephelometric turbidity instruments may be used.

Applications and performance requirements:

- Drinking Water
- Total response time, including all sampling lags, shall not exceed 3 minutes
- Range shall be capable of selection by the user and suitable for the application.
- Repeatability shall not exceed +1% of span or + 0.1 FTU, whichever is greater. Self-cleaning integral automatic calibration and manual cleaning facilities shall be included if required to achieve the required time between maintenance. Incorporation of these systems shall not affect the availability of the instrument for a period greater than 1 minute in any one hour for type I instruments and 15 minutes in any one-hour period. The instrument shall incorporate a facility for ensuring that inaccurate readings due to entrained air will be minimized.
- Turbidity Sensor Manufacturers, or Equal: Endress and Hauser, Model Turbimax CUS52D MemoSens.
- Transmitter Manufacturers, or Equal: Endress and Hauser, Model Liquiline M CM44X

13.3 EXECUTION

13.3.1 Field Services

Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

14 PANELS, CONSOLES, AND APPURTENANCES

14.1 GENERAL

14.1.1 Scope

The Panels, Consoles and Appurtenances section covers the furnishing of panels, consoles, and appurtenances as indicated on the Drawings.

This section also describes requirements for panels furnished under other sections whose respective specification refers to this section.

The Instrumentation and Control System section shall apply to all equipment furnished under the Panels, Consoles and Appurtenances section.

14.1.2 General

Equipment furnished and installed under this section shall be fabricated and assembled in full conformity with the Drawings, specifications, equipment schedules, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

14.1.2.1 General Equipment Stipulations

The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

14.1.2.2 Drawings

General dimensions and arrangements are indicated on the Drawings. System Supplier shall be responsible for coordinating the console and enclosure sizes and arrangements to accommodate the equipment provided.

14.1.3 Submittals

Submittals shall be made as specified in the Instrumentation and Control System section. Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

14.1.4 Delivery, Storage, And Shipping

Delivery, storage and shipping shall be as per The Instrumentation and Control System section.

14.2 PRODUCTS

14.2.1 Panel Design and Fabrication Features

All panels furnished shall conform to the stipulations of IEC Standards. Unless indicated otherwise on the Drawings, the following paragraphs describe general fabrication specifications for the PLC cabinets, instrument panels, consoles, enclosures, and subpanels.

Control Panel Assembly shall be based on European directives and international IEC standards. Most of the rules and regulations originate from the following sources:

- Low Voltage Directive 2014/35/EU
- Machinery Directive 2006/42/EC
- EMC Directive 2014/30/EU
- IEC 60364 series (DIN VDE 0100 series)
- IEC 60204-1 (2016, modified)
- IEC 61439 series (DIN EN 61439 series)
- IEC 60947
- EN60529/IP Environmental Ratings

A manufacturer certifies conformity with the applicable directives by a CE marking and an EU Declaration of Conformity. Conformity with directives can be presumed by ensuring compliance with harmonized standards. It is the responsibility of the manufacturer to decide which directive and harmonized standards apply to a particular product.

14.2.1.1 Piping

A. Fittings

Compression type bulkhead fittings shall be provided near the bottom or the top of the panel for all field connections. Compression nuts and sleeves shall be provided for the field connections

14.2.1.2 Power Entrance

Power shall enter the panel at the bottom on the panel and shall connect to terminal box connections. The power entrance to each panel shall be provided with a surge protection device over and under-voltage protection relay. Refer to the Instrumentation and Controls section for surge suppression requirements. Controls within panels shall be 230 volts ac,

single phase. Where the electrical power supply to the panel is 400 volts ac, 3-phase, the control panel shall be provided with a control panel transformer (400 volts-230 volts 1-phase). Control conductors shall be provided as specified herein. The main power feed disconnect shall have a door-mounted handle unless otherwise indicated.

14.2.1.3 Power Wiring

Power distribution wiring on the line side of panel fuses shall be minimum 4 mm². Secondary power distribution wiring shall be minimum 2.5 mm². Wiring for ac power distribution, dc power distribution, intrinsically safe, and control circuits shall have different colors and shall agree with the colorcoding legend on System Supplier's panel wiring diagrams and as specified herein. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 volts, with a moisture resistant and flame retardant covering rated for not less than 90°C

The panel enclosure shall be the source of power for any 230 vac solenoid valves interconnected with the control panel.

Unless otherwise indicated, motor controls shall operate from 24 vac, 50 Hz, circuits. The Contractor shall be responsible for providing 230 vac, 50 Hz; 24 vac, 50 Hz; or 24 vdc circuits as needed for monitoring and alarm circuits.

All instruments shall be powered from panels containing the associated PLC, RTU, or RIO. The Contractor shall be responsible for providing 230 vac, 50 Hz; 24 vac, 50 Hz; or 24 vdc circuits as needed for the supplied equipment. Each instrument's power supply shall be separately fused and have an individual disconnect switch labeled with the instrument's tag number.

14.2.1.4 Instrument and Control Wiring

All internal panel wiring shall be type MTW stranded copper wiring rated not less than 600 volts. Electronic analog circuits shall be twisted and shielded pairs rated not less than 300 volts. Analog circuits shall be separated from ac power circuits. Intrinsically safe circuits shall be physically separated from other circuits in accordance with applicable codes. Wires within the panel shall conform to the minimum size as shown in the table below.

Type	Min. Wire Size	Color
AC Control	2.5 mm ²	Red
DC Control	2.5 mm ²	Blue
Analog Circuits	1.5 mm ² Twisted Pair	Black (+) / White (-)

All wiring shall be grouped or cabled and firmly supported inside the panel. Each individual wire in power, control, and instrumentation circuits shall be provided with identification markers at each point of termination. The wire markers shall be positioned

to be readily visible for inspection and the identification numbers shall match the identification on the supplier's panel wiring drawings. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the depth of the duct remaining available for future use after completion of installation and field wiring. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

Discrete control outputs from the control panel shall be provided by electrically isolated contacts rated 5 amperes at 230 vac. Analog inputs and outputs shall be isolated 4-to-20 mA, two-wire signals with power supply. Power supplies are specified in Section of Panel Mounted Instruments.

14.2.1.5 Terminal Blocks

Terminal blocks for external connections shall be suitable for 4 mm² wire and shall be rated 30 amperes at not less than 300 volts. Incoming power terminals shall be rated 30 amperes at not less than 600 volts when the panel is served by a 400 vac source. Terminal blocks shall be fabricated complete with marking strip, covers, and pressure connectors. Terminals shall be labeled to agree with identification shown on the supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. Not less than 200 mm of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks. Alternatively, a disconnect operable from the control panel front may be used to remove foreign voltage from the panel.

14.2.1.6 Backup Power

Power supply to the panels shall be from electrical sources shown on the Drawings, which may be backed by redundant utility feeds, engine generators, or externally mounted uninterruptible power supplies (UPSs) specified in other sections

14.2.1.7 Device Tag Numbering System

All devices shall be provided with permanent identification tags. The tag numbers shall agree with the Instrument Device Schedule and with the supplier's equipment drawings. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic

identification tags securely fastened to the device. Hand-lettered labels or tape labels will not be permitted.

14.2.1.8 Nameplates

Nameplates shall be provided on the face of the panel or on the individual device. Panel nameplates shall have legends and approximate dimensions as indicated on the Drawings and shall be made of laminated phenolic material having engraved letters approximately 3/16 inch [5 mm] high extending through the black face into the white layer. Nameplates shall be secured firmly to the panel. Panel face nameplates do not replace the requirement for device identification tags as specified under the Device Tag Numbering System paragraph.

14.2.1.9 Indicating Light Color Designations

Indicating lights shall be colored as shown in the following table unless indicated otherwise on the Drawings, in other specification sections, or in the instrument device schedule.

- Green: Associated equipment or device is "running," "open," or is in an "safe" state or position.
- Red: Associated equipment or device is "stopped," closed," or is in an "Unsafe" state or position
- Yellow or Amber: Associated equipment or device has "failed" or a process alarm condition is present or imminent.
- White: All other conditions not defined above.

14.2.1.10 Painting

Interior and exterior surfaces of all carbon-steel panels shall be thoroughly cleaned and sand-blasted per Society of Protective Coatings SP 6 (Commercial Blast), after which surfaces shall be painted with rust inhibitive (universal) primer. The panel interior shall be painted white with the manufacturer's standard coating. All pits and blemishes in the exterior surface shall be filled. Exterior surfaces shall be painted with one or more finish coats of the manufacturer's standard coating. Finish and primer coats shall have a total dry film thickness of at least 0.15 mm. One liter of touch-up paint shall be furnished with the panels.

14.2.1.11 Panel-Mounted Instruments

Instruments, power supplies, pilot devices, and appurtenances mounted within or on the face of the panel shall meet the, Panel Mounted Instruments, for those items unless noted

otherwise herein, on the Drawings or, if applicable, within the referring equipment specification section.

14.2.1.12 Factory Test

Panels shall be factory tested electrically and pneumatically by the panel fabricator before shipment to site. Full test results with quality control certificate to be provided to engineer for review.

14.2.2 Free Standing Vertical Panels

The following paragraphs specify the freestanding vertical panels:

14.2.2.1 Construction

Panel construction shall be an indoor, dust-tight, completely enclosed cubicle formed from steel structural members and steel plates. The base shall be formed of steel channels, with flanges extending upwards. The base shall be provided with 13 mm diameter holes at 300 mm centers so that the base can be bolted to the concrete equipment base. Welds, seams, and edges on all exposed surfaces shall be ground smooth. Suitable lifting facilities shall be provided for handling and shipment.

14.2.2.2 Structure

Panel structure shall be suitably braced and of sufficient strength to support all equipment mounted on or within, to withstand handling and shipment, to remain in proper alignment, and to be rigid and freestanding. Top, sides, and back shall be fabricated from 3.42 mm thick or heavier carbon steel sheets, with stationary back suitable for back to wall installation, or designed for rear access with hinged back doors. Doors shall not be greater than 600 mm wide or spaced not greater than 900 mm center to center. Rear access doors shall be fabricated from 1.9 mm thick or heavier carbon steel.

14.2.2.3 Panel Front

The front shall be a hinged door, or doors, with mounted instruments and control devices, fabricated from 3.42 mm thick carbon steel sheet and suitably braced and supported to maintain alignment. Panels with hinged fronts shall be of sufficient width to permit door opening without interference with rear projection of flush mounted instruments.

14.2.2.4 Doors

Doors shall be essentially full height, having turned back edges and additional bracing to ensure rigidity and prevent sagging. Doors shall be mounted with strong, continuous, piano type hinges. Positive latches, acting from a common door handle, shall hold doors securely compressed at top, side, and bottom against rubber gaskets. Doors shall be lockable with a common key.

14.2.2.5 Mounted Instruments

Instrument Arrangement:

Panel instruments and control devices shall be arranged in a logical configuration for the plant operators. The centerline of recorders shall be within 900 mm and 1.75 m above the base of the panel for convenient reading and chart replacement. Control switches shall be within 1.83 m and 750 mm above the base of the panel. Indicators may be located within 750 mm and 2 m above the base of the panels. Annunciators and clocks may be mounted near the top of the panels.

14.2.2.6 Conduit Entrance

The top shall be provided with nominal 0.1 m³ removable access plates, which may be drilled to accommodate external wiring and conduit to be installed from above.

14.2.2.7 Interior Lighting

Illumination of panel interiors shall be provided by ceiling mounted lamp fixtures spaced at approximately 750 mm and near the door. Fixtures shall be nominal 30-watt LED type, with a common "On-Off" switch near each end door. Duplex-grounded receptacles for 230-vac power shall be provided for service and maintenance tools at spacing not greater than 1.5 m throughout the length of a panel. The lighting and receptacle circuit shall be fused separately from the instrumentation systems.

14.2.3 PLC and Remote I/O Enclosures

Enclosures containing PLCs and remote input/output hardware shall meet the requirements for Wall-Mounted Cabinets or Free-Standing Enclosures specified herein, whichever applies, with the following additional requirements and exceptions. The PLC enclosure shall be Type tested IEC 61439.

Enclosures mounted indoors in areas with controlled environments shall be Type Powder Coated Hot Dip Galvanized Steel, IP 52, with key-locking handle, heating strip, interior lighting kit, thermostat-driven ventilation fans and exhaust vents.

Enclosures mounted outdoors shall be configured the same as process area panels with the addition of a white-powder-coated finish with aluminum sunshields on all sides and doors similarly coated. For all panels, I/O field wiring shall connect on terminal blocks in the lower portion of the enclosure. Sufficient terminal blocks shall be provided to accommodate the full I/O complement of the furnished I/O rack, including spare I/O. A nameplate shall be mounted on the outside of the door and shall be engraved with “PLC-XX” or “RIO-XX” where “X” is the identifier shown on the drawings. The Contract Drawings show approximate enclosure dimensions; however, the Contractor shall supply enclosures of suitable size to accommodate all equipment contained within the panel. The Contractor is responsible for providing sufficient cooling fans to maintain all enclosed equipment with its manufacturer-recommended operating temperature range. Enclosures shall be sized and mounted so that no indicating light, switch, push button, or display is less than 1220 mm above finished grade. Enclosures shall meet the requirements of NEC Article 409 (Industrial Control Panels).

14.2.4 Wall-Mounted Cabinets

Cabinets, which contain the system components indicated on the Drawings, shall be suitable for wall mounting and shall meet the IP enclosure rating as indicated on the Drawings or, if applicable, in the referring equipment specification section. The enclosures shall be fabricated from 1.9 mm thick, or heavier, carbon steel, stainless steel, or fiberglass. Cabinets shall be equipped with full size gasketed doors with hinges and a chromium-plated or stainless steel three-point latch. The door shall be lockable with a key. A screened vent shall be provided in the bottom of enclosures that contain pneumatic devices.

Illumination of panel interiors shall be provided by a ceiling mounted lamp fixture. The fixtures shall be nominal 10-watt LED type, and shall operate automatically when the door is open. A grounded receptacle for 230-vac power shall be provided for service and maintenance tools. The lighting and receptacle circuit shall be fused separately from the instrumentation systems.

Floor stands shall be provided to support cabinets not fastened to a wall or other support. Floor stands shall be full-depth and shall have a minimum height of 300 mm. Floor stand material and finish shall match the cabinet. All wall-mounted cabinets shall meet the requirements of the panel fabrication paragraph of this section.

Outdoor cabinets shall be provided with sunshades as indicated on the Drawings.

14.2.5 Wall Mounted Instrument Subpanels

Instrument subpanels shall be constructed from 3.2 mm thick carbon steel and shall be reinforced and braced to form a rigid assembly. Panels designed for wall mounting shall have 25 mm turned back edges and a minimum 50 mm air space between the panel and the wall surface. All components on wall-mounted panels shall be mounted so as to be

easily removable without requiring rear access to the subpanel. Instrument subpanels used for the free chlorine analyzers shall be as shown on the drawings.

14.3 EXECUTION

14.3.1 General Installation Requirements

Installation requirements are specified in the Instrumentation and Control System section. In addition, equipment furnished under this section shall conform to the following manufacturing stipulations.

14.3.1.1 Piping

All tubing shall be run in horizontal and vertical planes and shall be rigidly supported to withstand handling and shipment. Flexible polyethylene tubing shall be used to connect devices mounted on hinged doors.

14.3.1.2 Wiring

All wiring shall be grouped or cabled and firmly supported inside the panel. Wiring shall be bundled in groups and routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel with removable covers and shall have a space of at least 40 percent of the depth of the duct available for future use after installation is complete and all field wiring installed. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

14.3.1.3 More Than One Panel

Where signal or loop wiring must be routed to more than one panel or device, the required circuit routing shall be as indicated on the one-line diagrams. The panel fabricator shall provide such additional circuits as may be indicated on the electrical schematic Drawings.

End of Section

15 UNINTERRUPTIBLE POWER SUPPLY

15.1 GENERAL

15.1.1 Scope

The Uninterruptible Power Supply section covers the furnishing of a complete on-line uninterruptible power supply (UPS) as indicated on the Drawings.

The system shall convert incoming single phase, 50 Hz, power into dc power, maintain and charge backup batteries and reconvert outgoing power into a sinusoidal single phase, 50 Hz, ac power source (Double Conversion –Online UPS). The system shall consist of a rectifier, battery charger, batteries inverter, integral static bypass switch, and maintenance bypass switch as required.

Additional accessories and appurtenances shall be provided as specified herein to provide a complete and properly operating system.

15.1.1.1 Control System

Where indicated on the Drawings or in the referring equipment specifications, free-standing vertical panels and wall cabinets shall each be provided with an interior-mounted UPS to provide backup power to critical loads upon loss of power supply to the panel. UPS-backed power shall be provided to the programmable logic controller CPU, HMI, Switches, Modems, instrument loops, I/O modules (operating and wetting voltages), all network communications devices, and any other load essential to preventing loss of control system function.

Backup power for panel interior lights, heaters, and convenience receptacles is not required. UPSs for free-standing vertical panels and wall cabinets shall meet the requirements specified below.

15.1.1.2 Control System Loads

The UPS shall supply Control System and other loads located as indicated on the Drawings.

15.1.2 General

Equipment furnished under the Uninterruptible Power Supply section shall be fabricated and assembled in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

15.1.2.1 General Equipment Stipulations

The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

15.1.2.2 Drawings

Supplementing this section, the Drawings indicate locations and arrangement of enclosures and provide one-line diagrams regarding the connection and interaction with other equipment.

15.1.2.3 Nameplates

Each UPS shall be identified with a suitable engraved nameplate mounted on the top front. The nameplates shall be made of laminated black and white plastic. The lettering shall be bold, not less than 6 mm square, engraved by cutting through the black outside layer so that the letters appear white.

15.1.3 Submittals

In addition to the Instrumentation and Control System section, all material and equipment documentation shall be submitted for review as specified in the Submittals section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows:

- a. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which equipment applies.
- b. Sheets or drawings showing items not applicable to this system, or not requiring review, shall contain clear indication as to which section or sections require review.
- c. Functional line diagrams showing all major system components and external connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.
- d. A report certifying that the UPS will provide the required backup time at the specified UPS loading and UPS ambient temperature. The report shall include anticipated continuous electrical load calculations, backup time calculations and shall indicate the battery end-voltage used in the analysis.

15.1.4 Delivery, Storage, And Shipping

Delivery, storage and shipping shall be as specified in the Instrumentation and Control System section.

15.2 PRODUCTS

15.2.1 General

All equipment, enclosures, and accessories shall be designed, assembled and connected in accordance with the requirements of these Specifications and the Drawings. Enclosures shall be NEMA Type 1/IP 20.

15.2.1.1 System Design Requirements

The UPS system(s) have the following capacity and rated for the following voltages:

- a. Tag number: Capacity 2 KVA
- b. Input voltage at 50 Hz: +10 to -15 percent 230
- c. Output voltage at 50 Hz: single phase 230
- d. Minimum Back up time required: 30(minutes)
- e. The UPS system(s) shall ratings and features. Capacity, peak (minimum) :150 percent of continuous power rating for 10 seconds.
- f. Frequency stability, battery mode: + 0.5 percent.
- g. Harmonic distortion (max) :5 percent.
- h. Efficiency, overall on-line: 75 percent minimum.
- i. Operating temperature-humidity: 0 to 40°C; 0 to 95 percent relative humidity, non-condensing.
- j. Recharge time (max):4 hours.

15.2.1.2 Acceptable Manufacturers

All systems supplied under this contract shall be of the same manufacturer. The uninterruptible power supply systems shall be as manufactured by GE, ABB, Eaton, APC “Smart-UPS”, Emerson/Sola “S4K5U-5C”, Toshiba “1000 Series”.

15.2.1.3 Capacity Calculations

As part of the product shop drawing submittals, the System Supplier shall include unit and battery sizing calculations showing that the proposed UPS is capable of providing backup power to 120 percent of the actual connected load for the specified runtime. Calculations shall clearly show the estimated load, evaluation temperature, and assumptions used. The Contractor shall notify the Engineer in writing if the specified UPS is not adequate to

accommodate the calculated loading and shall supply a unit having a higher output rating to meet the project requirements. The System Supplier shall notify the Engineer if externally mounted batteries are required to meet the specified runtime at the required load.

15.2.1.4 Terminal Blocks

Wiring for external circuits, including all alarm contacts, shall be brought to grouped terminal blocks located for convenient connection. Provisions shall include suitable marked terminal blocks for connection of 4 mm² control wiring and for input/output power conductors as sized on the Drawings. Terminal designations shall agree with manufacturer's wiring diagram.

15.2.2 Battery Charger/Rectifier and Batteries

The battery charger and the rectifier shall have the following characteristics:

- a. The rectifier shall convert the incoming ac power to dc power to energize the static inverter.
- b. The battery charger shall supply a float current to the batteries to maintain them at a fully charged state while incoming power is being provided. The charging voltage shall be temperature- compensated over the entire operating temperature range to avoid overcharging or undercharging the batteries. The battery charger shall automatically apply an elevated voltage (equalization charge) to the batteries if and as required by the battery manufacturer.
- c. The battery shall provide backup power for the UPS when incoming commercial power is not available. The battery cells shall be valve-regulated or gelled-electrolyte lead-acid type. The battery shall be integral to the UPS. Battery shall have capacity to supply the dc power to the UPS while operating at full load for a period of not less than as required at 25°C. The battery shall have an expected life of 5 years and shall carry a one-year warranty.

15.2.3 Static Inverter

The solid-state inverter shall employ silicon-controlled rectifiers (SCRs) and other devices for converting direct current power to essentially sinusoidal alternating current power. The static inverter shall conform to the following characteristics and requirements.

- a. Automatic Synchronization: During normal operation, the inverter shall provide power to critical loads. The utility electric system will act as an alternate supply. Inverter equipment shall include stable solid-state devices designed to automatically maintain inverter output in phase with the utility electric system.
- b. Overload, Short Circuit, and Load Loss: The inverter shall have input and output fuses and other equipment necessary to protect from overload, short circuit, and 100

percent loss of load. Current limiting features shall also be provided.

- c. Loss of Supply Voltages: The inverter shall include protective devices to prevent damage resulting from excursion, loss, or restoration of its synchronization voltage and its dc input voltage and any inrush current occurrences associated with such conditions.

15.2.4 Static Transfer Switch

The static transfer switch shall use SCRs and other static devices to automatically transfer loads from the off-line (bypass) to the on-line operating condition and back again. In off-line mode, the static transfer switch shall connect clean filtered power to the load. The primary ac line shall be monitored and the load shall be transferred to the inverter if the voltage drops below 85 percent. During on-line mode operation, any inverter problem shall cause an instantaneous transfer to the bypass mode.

15.2.5 Maintenance Bypass Switch

Manufacturer standard breaker type, mechanically interlocked with terminal blocks for cable connection.

15.2.6 UPS Wall-Mounted Panel

The UPS shall have Small Wall mounted panel as indicated in Drawing that includes AC Breakers for all Inputs and outputs from UPS.

15.2.7 Control, Indication and Alarm

Controls, indicators and alarms shall be provided as a part of the UPS. Control buttons and LED indicators shall be provided on the UPS panel and shall be permanently labeled.

15.2.7.1 Controls

A dc battery circuit breaker, a mode selector switch, and system "ON" and "OFF" buttons shall be provided.

15.2.7.2 Indication

A digital display for selection and indication of input, output, and battery voltages shall be provided.

LED indicators for inverter ready, frequency, battery voltage, overload, over temperature, and impending shutdown conditions shall be provided.

15.2.7.3 Remote Alarms

The UPS shall have the following provisions for remote alarms:

A. General Alarm:

common, isolated, dry, alarm contact rated 3 amperes at 230 volts ac shall be provided with the UPS for indication of general alarm to station PLC. The contact shall close under any UPS fault condition, including when the UPS is operating in bypass mode and when battery depletion is imminent (low battery).

B. Power Failure:

isolated, dry, alarm contact rated 3 amperes at 230 volts ac shall be provided to station PLC with the UPS for remote indication of utility power failure. The contact shall open upon loss of utility power to the UPS.

C. UPS on Battery Alarm:

A common, isolated, dry, alarm contact rated 3 amperes at 230 volts ac shall be provided to station PLC with the UPS for indication that the UPS is operating on battery power. The contact shall close under when the UPS is on battery.

15.3 EXECUTION

15.3.1 Installation Requirements

Installation requirements are specified in the Instrumentation and Control System section.

15.3.2 Owner Training

System Supplier shall provide a qualified representative at the jobsite to train Owner's personnel in operating, maintaining, and repairing the equipment. The training shall consist of one full 4-hour session and the schedule shall be arranged and coordinated with Owner.

End of Section

16 CONDUCTORS, CABLES AND ACCESSORIES

16.1 GENERAL

16.1.1 Scope of Work

- A. This section will cover all miscellaneous equipment and materials required to complete the desired project and shall be supplied, installed and tested by contractor.
- B. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.
- C. Electrical cables shall be new and not more than one-year-old.
- D. Contractor shall verify all cables sizes and lengths that indicated in Drawings that carry Current ampacity for all Motors and Load, and to confirm it by Cable Size Calculation studies before procurement.
- E. Contractor shall provide all power and control cables for all Booster Stations as indicated in drawing schedule and all ANY required Cables for boosters.

16.1.2 Related Sections

- A. The Contractor shall coordinate the work with other trades, and furnish and install the equipment in accordance with the manufacturers' recommendations including all required accessories.
- B. The Related Work can be found in other Divisions of these specifications, such as, but not limited to:
 - General Requirements Equipment Division
 - Instrumentation and Control System Division
 - Mechanical Division
 - Electrical Division

16.1.3 Submittals

- A. Submit manufacturer's data on Electrical Cable and terminations including manufacturing date.
- B. Submit name and experience record of each person to be engaged in medium voltage cable work. Only those persons accepted by the engineer will be permitted to engage in medium voltage cable work.
- C. Submit cable manufacturers' certified test report prior supplying the cables.
- D. Submit certified field test report after installation.

16.2 PRODUCTS

16.2.1 Low Voltage Power Cables

1. All Cables shall have a stranded copper conductors according to IEC 60228-Class2, (Solid conductor or Wires according to IEC 60228-Class1 will be accepted and used only for Site Indoor Lighting and Receptacles of rooms or Facilities), and aluminum conductors will not be accepted except when required by specific project for power transmission purpose only.
2. Special care shall be taken for driven equipment power cable, contractor to coordinate cable type and length with the driver as per driver manufacturer recommendations, letter certifying the cable type and length stamped by driver manufacturer (not assembler or Agent) shall be submitted to engineer. Any impact for updating the cable specifications, size and/or lengths shall be done without any impact on the original contract.
3. Contractor shall refer to cable schedule for cable rated voltage and size required.
4. Low Voltage Cables shall be:
 - A. A copper single wire round, compacted circular stranded or shaped stranded conductor has an extruded cross-linked polyethylene (XLPE) colored insulation applied around the conductor. The cores are twisted together and covered with an extruded inner covering. A PVC outer sheath with printed marking is extruded over all Conforms to IEC 60502-1 Standard.
 - B. Annealed, high conductivity copper single wire round, compacted circular stranded or shaped stranded conductor according to IEC 60228, Class 2.
 - C. Insulation shall be applied directly over the conductor as a homogeneous wall of XLPE insulation. The thickness shall be in accordance with IEC 60502-1 Standard.

16.2.2 Control Discrete Cables

Control cables shall be constructed of bare wire fine copper conductor and PVC insulation rated for 500 Volts and 80C ambient temperature with black numbered core wires, cable shall include yellow green earth conductor.

1. All Discrete Cables shall be flexible cables, For Discrete signals control cables. (Switching system Voltage up to 48VAC/DC).
2. PVC outer sheath, meets DIN VDE 0281 part 1 and HD 21.1 80 C°.
3. Bare copper, Stranded fine wire conductors, according to DIN VDE 0295 cl. 5, BS 6360 cl. 5 and IEC 60228 cl. 5.
4. Black cores with continuous white numbering according to DIN VDE 0293).
5. Green-yellow earth core in the outer layer.

16.2.3 Analogue Signals 0/4-20ma and RTD Cables

1. Analog Cables shall be flexible cables.
2. Instrumentation cable shall be rated at 300 volts minimum.
3. Individual conductors shall be 16AWG/ 1.5 mm² stranded tinned copper. Insulation shall be color coded polyethylene: black-red for 2 conductor cable and black-red-white for 3 conductor cable.
4. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, and 0.90 mm² stranded tinned copper drain wire, and a PVC outer jacket with a thickness of 15 mm.
 - Analogue signals 0/4-20mA cables Single pair, 16AWG/1.5 mm², twisted, shielded.
 - RTD cables shall be Single triad, 1.5 mm², twisted, shielded cable.

16.2.4 Grounding Conductors

1. Equipment: Stranded copper with green/yellow, Type -XLPE or PVC insulation.
2. Direct Buried: Bare stranded copper.

16.2.5 Cables Accessories.

A. Heat Shrinkable Splice Kits (only wherever requested by engineer):

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices that have a current rating equal to, or greater than the cable ampacity, conforming to IEEE 404.
 3. 400V, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined re-jacketing sleeve to provide a waterproof seal.

B. Termination Kits:

1. Capable of terminating a 400V, single-conductor, polymeric-insulated shielded cables Capable of producing a termination with a current rating equal to, or greater than, the cable ampacity, meeting Class 1 requirements of IEEE 48.
2. Capable of accommodating any form of cable shielding or construction without the need for special adapters and/or accessories.

C. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible crosslinked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.

D. Cable Lugs:

1. In accordance with NEMA CC1 long neck tin plated copper confirming DIN 46235.

2. Cable head shall be insulated by colored heat shrinkable tube.

16.3 EXECUTION

16.3.1 Preparation

- A. Examine areas and conditions under which cable terminations are to be installed and notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work.
- B. Do not proceed with the Work until unsatisfactory conditions have been corrected.

16.3.2 Installation

- A. Installation shall meet or exceed all applicable NEC standards.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install cables and terminations as indicated in accordance with the manufacturer's written instructions, the applicable requirements of NEC, and in accordance with recognized industry practices to ensure that products serve the intended functions.
- D. Cable Identification:
 1. Identify cables as to phase and circuit at each accessible location. Identification to be accomplished by means of (PVC tags for indoor locations and Stainless steel for outdoor locations).
 2. Arrange tags such that they can be read without moving cables.
 3. Cable identification shall be installed in all accessible areas such as trenches, inside manhole, inside source equipment and target equipment.
- E. Where cable terminates in a stress cone, wrap exposed insulation with half-lapped layer of self-fusing silicone tape applied without stretch. Secure ends of silicone tape with vinyl plastic tape to prevent ravel.
- F. All cables shall be installed in conduits unless if required for special long feeder lines.
- G. Wherever the underground cable passing near sewer pits or crossing roads or Valley or sewer lines, a reinforced duct bank shall be installed to protect the cable for moisture.
- H. Damaged cable jacket and/or insulation will cause cable rejection. Do not install cable if jacket is damaged in any way. No kinks are permitted and the bends are to be kept in accordance with the minimums recommended by the manufacturer. Pull cables directly into the duct from the coil or reel on which

they are received. Cable shall not be pulled off and laid on the ground prior to installation. Make pulls in one direction.

- I. Splices are not permitted for new pulls. Contractor shall pull all cables in continuous lengths. Splices are permitted only where required and indicated on the Drawings for connections to existing underground medium voltage feeders in manholes. The installer shall be a trained and certified technician for such special installation with appropriate splicing kit and materials as described above.
- J. Provide cable lengths with liberal allowances for slack for terminating. If pulling grips are used, sufficient excess cable shall be allowed so that damage due to the pulling grips can be removed prior to terminating. Use rubber tape to seal cable ends. Cable shall not be pulled with the ends open. Cable ends shall not be allowed to rest on the floor. Cable ends shall be moisture proofed at all times until terminations are installed.
- K. Provide pull-in guides, cable feeders or draw-in protectors to prevent damage to the cable at the duct mouths. Pull cable by grips on the conductors with proper taping to prevent pushback. Short lengths may be pulled with cable grips around the entire group; however, care should be taken to ensure equal distribution of tension and any damaged ends must be cut off and discarded before terminating the cable.
- L. Stop pulling instantly if undue tension occurs. Lubricant shall be used to facilitate pulling and shall be compatible with the type of cable used.
- M. Identify individual phases of each power circuit at points near each end of the cables. Before connections are made at cable terminals, check by ringing out or talking over each conductor by means of a portable hand telephone set. Identify circuits before terminal connections are made by one of the methods specified above.

16.3.3 Primary Cable Testing

- A. The cable manufacturer shall perform non-destructive factory tests on all cable in accordance with ICEA standards and shall furnish three (3) copies of certified test reports to the Engineer.
- B. Cables shall be field-tested prior to energization. Notify the Engineer at the proper time during construction that the cables are ready for field-testing. Cables shall not be energized prior to testing.
- C. Insulation resistance of each cable shall be measured with a 500- volt megohm meter for circuits, feeders and equipment up to
350 Volt and 1000-volt for megohm meter for 350-600 Volt circuits, feeders and equipment. Cable will be rejected if resistance is less than 25 megohms.
- D. Adequate means shall be taken to ensure safety during the tests and all safety instructions of the test operator shall be carried out.

- E. If a cable fails, the fault shall be located, and all cables in the conduit between the nearest pulling points on each side of the failure shall be withdrawn. If, in the opinion of the Engineer, the other cables in the same conduit have not been damaged, they may be reinstated, but the cable that failed shall be replaced by new cable. After the replacement of the faulted cable, and any other damaged cables, all cables of the circuit in that conduit shall be retested.
- F. During the Warranty Period, any failure in primary cable, terminations or splices shall require immediate correction. In the event of a failure creating interruption in electrical service, furnish and install all labor and materials for temporary services to get the electrical system back in service. Work shall begin immediately upon notification of a failure, regardless of time.

End of Section

17 VARIABLE FREQUENCY MOTOR CONTROLLERS' LOW HARMONIC PROCESS VFD

17.1 GENERAL

17.1.1 Description

- This specification describes a complete adjustable speed AC drive (VFD) used to control the speed of induction motors used in areas where low harmonic content is desired or mandated.
- The manufacturer shall supply the VFD assembled with all necessary controls as herein specified.
- The VFD shall be manufactured and assembled by a company with at least Seven (7) years' experience in the production of this type of equipment.

17.1.2 Quality Assurance

- The VFD manufacturing facility shall be ISO 9001 and ISO 14001 certified.
- All printed circuit boards shall be completely tested before being assembled into the complete VFD. The VFD shall be subjected to a functional test and load test. The load test shall be at full rated load, or cycled load.
- The VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component.

17.1.3 Qualifications

A. Applicable Standard:

The AC Drive shall comply with National and International standards and the recommendations for electrical industrial control devices (IEC, EN, UL, NFC, VDE):

- a. ANSI/NFPA 70: National Electrical Code.
- b. EN50178: Electronic equipment for use in power installation.
- c. CSA C22.2 No. 14-M91: Industrial Control Equipment.
- d. IEC 68 Part 2-3: Basis Environmental Testing Procedures Part 2: Tests # Test Ca: Damp Heat.
- e. IEC 146.1: Semiconductor Converters # General Requirements and Line Commutated Converters Part 1-1: Specifications of Basic Requirements.
- f. IEC 664: Insulation Co-ordination for Equipment Within Low-Voltage Systems.

- g. IEC 447: Man-Machine Interface Actuating Principles.
- h. IEC 439 Part 1: Low Voltage Switch gear and Control Gear Components.
- i. IEC 364: Electrical Installation of Buildings.
- j. IEC 204/NFPA 79: Electrical Equipment of Industrial Machines/Industrial Machinery.
- k. IEC 106: Guide for Specifying Environmental Conditions for Equipment Performance Rating.
- l. IEC 529: Degrees of protection Provided by Enclosure.
- m. IEC 1000: Electromagnetic Compatibility.
- n. IEC 1800: Adjustable speed Electrical power drive systems.
- o. IEC 721: Classification of Environmental Conditions.
- p. IEC 255-8: Overload Relays.
- q. IEC 801-2, -3, -4, -5: Immunity Tests.
- r. NEMA ICS Part 4: Overload Relays 3.

B. Acceptable manufacturers:

- Schneider Electric, ABB, Rockwell Automation or approved.
- VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable.

17.1.4 Submittals

- A. The Submittals shall include the following information:
- 1. Outline dimensions and weight, schematic drawings and manuals.
 - 2. Complete internal component data sheet such as but not limited to Circuit breakers, Fuses, flanged disconnect, Relays, Filters, fans, Peripheral devices... with complete selected ordering information.
 - 3. Customer connection power and control wiring diagrams.
 - 4. Complete technical product description, including a complete list of options provided.
 - 5. Harmonic test data for both utility and generator power sources demonstrating harmonic current distortion up to the 30th harmonic at VFD input terminals.
 - 6. Compliance to IEEE 519 - Harmonic analysis for the particular jobsite including total current distortion. In case an alternative low harmonic solution is offered, the VFD manufacturer shall provide calculations, specific to the jobsite, showing that the total harmonic current distortion (TDD) at the Point of Common Coupling (PCC) is at or below THDi limits as recommended by IEEE 519- June 2014.

17.2 DESIGN

17.2.1 Description

- A. The VFD shall be a solid-state, AC-to-AC inverter-controlled device using the latest insulated gate bipolar transistor (IGBT) technology.
- B. The VFD shall be Active Front End (AFE) AC drive with DC Bus Capacitors designed to comply with standard IEEE 519-2014 when installed in a system. VFD shall be used to provide a low harmonic current load to the power system and to avoid introducing additional common mode noise to the motor.

17.2.2 Harmonics

- A. The low harmonic construction of the VFD shall not contribute any significant harmonics at the input terminals of the supply MCC and shall contribute no more than 5% THDi at the input terminals.
- B. All harmonic management devices must be internal to the VFD enclosure and supplied as a complete solution.
- C. The VFD shall have an active line supply unit (Filter) which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.
- D. Each input phase of the VFD shall incorporate a symmetrical inductor- capacitor-inductor (LCL) filter high frequency arranged in a T- configuration. The inductors are to be series power components that carry the full current of the VFD.
- E. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on a power system sized according to IEEE 519-2014, at line voltage unbalance up to 2%, and under all motor load conditions.
- F. The VFD shall operate at a fundamental power factor 96% or higher on the supply side when operating above 20% of rated full load current.
- G. The VFD's design shall not compensate for existing harmonic content in the distribution system.

17.2.3 Ratings

- A. The VFD shall be rated to operate from 3-phase power, 380 Vac to 400 Vac, the overvoltage trip level shall be a minimum of 30% over nominal, and the under-voltage trip level shall be a minimum of 25% under the nominal voltage.
- B. The VFD output KW shall be rated to at least 1.2 times the nameplate kW of the driven motor at the environmental operating conditions, for 24-hour operation.

- C. The VFD shall be rated to operate from input power of 50 Hz.
- D. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard IEC motors.
- E. The normal duty overload current capacity shall be 110% of rated current for one (1) minute out of ten (10) minutes.

17.2.4 Construction

- A. The VFD manufacturer shall provide a VFD as assembled complete package, ready-to-install solution.
- B. The most efficient IGBT power technology shall be used. This technology shall be used for all power and voltage ranges offered by the manufacturer.
- C. The VFD shall offer microprocessor-based control logic that is isolated from power circuitry.
- D. The VFD shall use the same main control board for all ratings.
- E. Control interfaces shall remain consistent for all power ratings.
- F. The VFD shall use active input modules active rectification.
- G. VFDs at all power rating shall be of free standing inside Local Control Panel or MCC built-in construction as per Drawings and shall include the following standard features both passive filter solutions and/or Active Front End systems:
 - I. A circuit breaker with a combination AIC Rating of 85,000 amperes.
 - II. Modular power modules in the cabinet for quick removal and replacement of individual modules. The modular construction also allows for adaptation of the enclosure unit to individual requirements. The modularity and accessibility of the drive components allow for servicing without relocation of the drive enclosure.
 - III. To ensure fast and easy handling, all VFD shall have a modular power modules and heavy power components such as Inverter IGBT Line Filtering and third level bi-directional IGBT.

17.2.5 Operator Interface

- A. Detachable backlit graphical user interface terminal with keypad and capacitive wheel shall be provided for monitoring, Graphical user interface with keypad shall be provided for monitoring annunciation, and configuration. The graphical display shall change to a red backlit color when an alarm occurs. The mechanical mounting for the user interface on the cabinet or MCC door shall be done with a 22 mm hole.
- B. "Simply Start" menu for fast and easy commissioning shall be provided. Parameter setting shall be easily accessible and user friendly with plain text messaging and actual setting range.
- C. The keypad shall be capable of providing password protection.
- D. The user interface shall be capable of saving and downloading configurations of the

- VFDs, as well as importing them to other VFDs.
- E. The user interface shall offer a mini-USB/Ethernet port for mass storage or PC device connection.
 - F. VFD configuration software with all related cables, drivers shall be handed over to each facility owner.
 - G. The VFD shall have self-diagnostic capabilities to display alarms, errors, and warnings as they occur and shall be able to store into memory the last 15 messages, at minimum. These shall be accessible by PC maintenance tools or by web server, with flash record for data logging.
 - H. The VFD shall have a separate dedicated Modbus serial port for the keypad and shall allow for simultaneous use of a remote mounted keypad with RS485 serial communications network.
 - I. The displayed messages shall be in plain text.
 - J. The display of the control unit shall have the following features:
 - I. During normal operation, control unit one line shall display the speed reference, run/stop status, forward/reverse status, and Local/remote status. Other lines of the display shall be Programmable to display the values of any operating parameters.
 - II. The selection shall include at least the following values:
 - Speed/torque in percent (%), RPM, or user-scaled units
 - Output frequency, voltage, current, and torque
 - Input voltage, power, and kilowatt hours
 - Heatsink temperature and DC bus voltage
 - Status of discrete inputs and outputs
 - Values of analog input and output signals
 - Values of PID controller reference, feedback, and error signals

17.2.6 Protective Features

- A. The VFD shall be met to applicable Standards on distribution systems.
- B. Voltage sag immunity per SEMI F47.
- C. Upon power-up, the VFD shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, AC-to-DC power supply, control power, and the precharge circuit.
- D. The VFD shall be protected against short circuits between output phases and ground and the logic and analog outputs.
- E. The VFD shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one (1) second without tripping.
- F. The deceleration mode of the VFD shall be programmable for normal and trip conditions. The stop modes shall include freewheel stop and fast stop.
- G. Upon loss of the analog process follower reference signal, the VFD shall be capable to be configured for one of the following options:

- Trip
 - Operate at a user-defined speed set by a software programmed speed setting.
 - Operate at last speed.
- H. The VFD shall integrate a protection against IGBT and heatsink over temperature.
- I. The VFD shall have solid-state thermal protection is compatible with large motor protection (RTD's provided - two per winding + 2 on bearings)
- J. The VFD shall have a motor thermal memory retention function per IEC requirements.
- K. The VFD shall be able to protect the motor when temperature probes (RTD) are connected.
- L. The VFD shall be able to limit the motor surge limitation to twice the DC bus voltage. This must be accomplished by use of internal software. The VFD shall limit the motor surge limitation to value of not more than twice the DC bus voltage. Special care shall be taken for driven equipment power cable, contractor to coordinate cable type and length with the driver as per driver manufacturer recommendations, letter certifying the cable type and length stamped by driver manufacturer (not assembler or Agent) shall be submitted to engineer. Any impact for updating the cable specifications, size and/or lengths shall be done without any impact on the original contract
- M. The VFD shall provide the following IGBT protection circuits.
- IGBT overcurrent protection
 - IGBT checkup sequence
 - IGBT checkup sequence before PWM enable sequence
 - IGBT overheat protection
- N. The VFD shall have the following Features:
- Motor over-speed input protection
 - Current limitation
 - Power limitation
 - Reverse inhibition
 - Underload protection
 - Overload protection
 - External error management
 - Loss of follower signal
 - Thermal sensor management
 - PID feedback
 - Customer defined input

O. Motor Protection

Current protection	
a.	Phase short circuit protection
b.	Ground protection
c.	Overcurrent protection
Voltage Protection	
a.	Mains overvoltage protection
b.	Mains undervoltage protection
c.	DC Bus overvoltage protection
d.	DC Bus pre-charge protection
	Thermal protection.
a.	VFD overtemperature protection
b.	Fan management
c.	Switching frequency management
	motor protection functions
a.	Motor output phase detection
b.	Motor surge voltage
c.	Motor overload detection
d.	Motor stall protection
	protection functions
a.	Catch on fly function
b.	Mains input phase lost protection

17.2.7 Control Interface

- A. The VFD shall interface with automation systems to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained in the VFD's nonvolatile memory.
- B. The speed command reference shall be selectable from the following sources:
 - 1. I/O terminals
 - 2. Communication network
 - 3. Web server
 - 4. Remote graphic display terminal
- C. A minimum of the following standard inputs/outputs shall be provided to interface with control systems and instrumentation:
 - 1. Analog inputs: 2 programmable 0(4)-20 mA
 - a. Separate 8 (8) analog inputs shall also be available (separate RTD module) for

temperature sensors (PT100).

2. Analog outputs: Two (2) programmable 0(4)-20 mA
3. Discrete inputs: 6 programmable isolated logic inputs as either sink or source
 - a. Two (2) discrete inputs shall also be programmable as 0-30 kHz pulse inputs.
 - b. Two (2) discrete inputs shall be dedicated to the Safe Torque Off safety function in accordance with IEC/EN 61508-1 SIL3
4. Discrete outputs: 6 programmable relay contacts [and 1 open collector output], One (1) discrete output shall be dedicated to product watchdog logic
 - D. Programmable analog inputs shall be able to be assigned the following parameters:
 1. Speed reference
 2. Summing reference
 3. Subtracting reference
 4. Multiplying reference
 5. Torque reference
 6. Torque limitation
 7. PID feedback
 8. Manual PID reference
 9. PID speed reference
 10. Forced local reference
 - E. Programmable analog outputs shall be able to be assigned the following parameters:
 1. Motor current
 2. Motor frequency
 3. Motor torque (signed or unsigned)
 4. Motor power
 5. Motor voltage
 6. Output frequency (signed or unsigned)
 7. PID error
 8. PID feedback
 9. PID output
 10. PID reference
 11. Ramp output
 12. Signed ramp
 13. Drive thermal state
 14. Motor thermal state
 15. Pressure sensor
 16. Flow sensor
 - F. Programmable discrete inputs shall be able to be assigned the following parameters:
 1. Run
 2. Forward

3. Reverse
4. Jog
5. Preset speeds
6. Reference switching
7. Ramp switching
8. Error reset
9. Error inhibition
10. Product reset
11. PID regulation mode (auto)
12. PID speed regulation mode (manual)
13. PID integral reset
14. Preset PID reference
15. Sleep/wake-up
16. Activate sleep mode by flow detection
17. Analogue torque limitation activation
18. Torque reference sign
19. Command switching
20. Parameter sets selection
21. Fast stop
22. DC injection
23. Freewheel stop
24. + Speed
25. - Speed
26. External error
27. Pre-fluxing
28. Forced local control
29. Current limitation activation
30. Output contactor feedback
31. Reference memorization
32. Auto-tuning
33. Forced operation
34. Underload detection
35. Overload detection
36. Limiting low speed operating time
37. Switching frequency, noise reduction
38. Drive lock assignment
39. Outlet pressure switch select
40. Pipe fill
41. External anti-jam trigger
42. Dry running / no flow switch select
43. Pump low flow / no flow switch select

G. Programmable discrete outputs shall be able to be assigned the following

parameters:

1. Ready
2. Drive running
3. Frequency reference attained
4. Current attained
5. High speed attained
6. Drive error
7. Frequency threshold attained
8. Torque sign
9. Motor thermal state attained
10. Drive thermal state attained
11. Torque or current limitation attained
12. Output contactor command
13. Input contactor command
14. Current present
15. Power removed
16. Alarm groups
17. Alarms: load slipping, 4-20 mA loss, external error, PTC, PID error, PID feedback, IGBT temperature, under voltage, torque control, drive temperature, fan counter, fan feedback, customer warning, power threshold, electrical power drift
18. Active configuration
19. Active parameter set
20. Active channel
21. DC bus charged
22. DC bus charging
23. Water Command: jockey pump, priming pump
24. Water running: anti-jam, pipe fill, priming pump, jockey pump
25. Water warning: dry running, flow, inlet pressure, outlet pressure, pump cycling, anti-jam, outlet pressure switch

17.2.8 Communications

- A. The VFD shall provide at minimum one (1) Serial Modbus and one (1) Ethernet Modbus TCP communication port. In addition, refer to communication requirements specified elsewhere within the Contract Documents for other communication requirements.
- B. VFD Ethernet ports shall be IPv4 compliant, allow for web server access, and provide network management via Simple Network Management Protocol, and clock synchronization.
- C. The VFD shall provide an embedded web server for enhanced diagnostic, configuration, parameter access, and energy management. It shall be possible to

create a user-defined custom dashboard for viewing VFD and process status through tables, charts, and graphical views. It shall be possible to export data in standard table format using the web server, for information about energy consumption as well as error and warning history.

- D. VFD communications modules shall be [capable of being] remotely powered by a separate external 24Vdc to allow for continued communications when the VFD power supply is off.
- E. The VFD shall provide integration connectivity via:
 - 1. DHCP protocol for Fast Device Replacement
 - 2. DTM library in compliance with standard FDT technology

17.2.9 Control Functions and Configurations

- A. The VFD shall be capable of accepting independent command and speed reference signals from:
 - 1. Terminals
 - 2. Modbus port
 - 3. Ethernet port
 - 4. Keypad display.
- B. The VFD shall provide a speed set-point function capable of:
 - 1. Maximum output frequency function
 - 2. Low and high-speed scaling and limitation function
 - 3. Jump frequency
 - 4. Speed summing reference's function
 - 5. Preset speed reference's function
 - 6. Jog function
 - 7. Up-Down speed references
- C. The VFD shall provide a Stop function capable of:
 - 1. Deceleration ramp on power loss
 - 2. Freewheel stop
- D. The VFD shall have an acceleration/deceleration, time-adjustable ramp function capable of:
 - 1. Ramp type: linear ramp, S shape ramp, with U or customized profile
 - 2. Ramp deceleration adaptation with adjusting time
 - 3. 4 points frequencies jumping
- E. Application programming dedicated to pumps
 - 1. The VFD shall provide pump control and monitoring functions:
 - a. Centrifugal pump characteristics and configurations
 - b. Pump monitoring function in order to define the data relevant for the pump (for example, acceleration, low speed, and high speed)
 - c. Application units function in order to define the units used in applications
 - d. Pump cyclic start protection in order to protect the pump against too many

- restarts in a dedicated time period
- e. Multi-pump functions
- 2. The VFD shall provide pump protection functions:
 - a. Anti-jam function in order to remove automatically clogging substances from the pump impellers
 - b. Pipe cleaning function in order to start the pump regularly to avoid sedimentation in pump impeller
 - c. Cavitation pump protection
 - d. Inlet protection in order to avoid system dry running
- 3. The VFD shall provide application control functions:
 - a. Stop and Go function in order to reduce consumption of the VFD in case the pump does not work.
 - b. Pulse input for connection to flow meter feedback.
 - c. Process control (PID) function in order to maintain a process at a given pressure or flow reference.
 - d. Flow limitation function in order to allow limiting the consumption of water.
 - e. Friction loss compensation function in order to compensate pressure losses in pipes due to friction.
 - f. Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the effects of water hammer.
 - g. Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed.
 - h. Low demand function in order to define periods of the application when process demand is low in order to save energy.
 - i. Jockey pump control function in order to start a jockey pump, during sleep period, to maintain emergency service pressure or demand, such as low water.
 - j. Sensor management in order to define how VFD inputs will be used to manage the pressure sensor or flow sensor.
- 4. The VFD shall provide application protection functions:
 - a. High flow protection function in order to detect pipe burst or detect running outside normal working area.
 - b. Outlet pressure protection function in order to fix minimum and maximum pressure.
- 5. The VFD shall provide pump curve input to help optimize pump performance.
 - a. Input and storage of the pump characteristics including five (5) points of the pump curve.
 - b. A best efficiency point (BEP) function in order to operate at maximum system efficiency and alarms to indicate deviation from BEP.
- F. The VFD Supplier shall have Windows-based PC software for configuring and diagnosing the VFD. It shall be possible to set and modify parameters, control the

- VFD, read actual values, and make trend analysis using the software. The PC tools to be connected to the VFD by utilizing wired connection.
- G. The VFD shall display all faults in plain text and help screens shall be available to guide the user in troubleshooting. Codes are not acceptable.
 - H. The VFD shall provide a real time clock for time stamping detected errors.
 - I. The VFD shall display detected errors with QR codes to guide the user in the troubleshooting.
 - J. The VFD must provide LED lights to indicate its status such as Power On, Run, Fault condition, active communications, other project- customized requirements.
 - K. The VFD must have the ability to dynamically display I/O status.
 - L. VFD shall include Thermomagnetic input circuit breaker with LSI Electronic trip unit.
 - M. VFD should include input surge power protection AC line, phase-to- phase transient voltage surge suppression utilizing metal oxide varistors. Drive shall meet the requirements of IEEE C62.41.
 - N. VFD shall include below:
 - a. Control switches and pilot lights shall be provided as indicated on the schematic diagrams. Manual-0-automatic selector switches and start-stop and reset controls.
 - b. Input thermal-magnetic molded-case circuit breaker disconnect with interrupting capacity rated in RMS symmetrical amperes as required with LSI Electronic trip unit. The disconnect shall be mounted inside the controller enclosure and shall have door interlocks and a handle with provisions for padlocking in the "Off" position.
 - c. The VFD shall be installed in Local Control Panel or MCC as indicated in Drawing with all Control Function as specified in P&ID Drawings.
 - d. Thermal protection for motor as follows:
 - Thermistor relay (three phase) for motors smaller than 75kW, relay equal to SIEMENS Sirius 3RN 10 - 62.
 - RTD interface module (8 inputs minimum) with trip output and temperature indication for motors equal and larger than 75kW (See “s” below).
 - The RTDs or Temperature Protection Relay shall be connected through Modbus (Serial or TCP) Connection to PLC for Displaying Analog Reading for Temperature Elements.
 - e. Manual speed adjustment.
 - f. Indications of power "On", drive "Run", and drive "Fault". Indication of these parameters shall be provided by full voltage type LED pilot lights with output alarm contacts. Lamps shall be easily replaceable from the front of the indicating light.
 - g. Elapsed time meter.
 - h. Speed indication - calibrated in percent rpm.
 - i. Control circuits supplied by internal control power transformers. Control power transformers shall have additional capacity as required by external devices indicated on the Drawings. Control power transformers 400-to-24 AC, 230-24V transformers will not be acceptable shall be equipped with two primary leads fused, one

- secondary lead fused, and one secondary lead grounded.
- j. Automatic controller shutdown on overcurrent, overvoltage, undervoltage, motor over-temperature and other drive fault conditions. Controller shutdown shall be manually reset type. Terminals shall be provided for control wiring from motor temperature switches, or a motor protection relay located in the drive enclosure.
 - k. Diagnostic indicators that pinpoint failure and fault conditions. Indicators shall be manually reset to restore operation after abnormal shutdown.
 - l. Accept a remote 4-20 mA speed control signal while in automatic mode.
 - m. Process control output for remote 4-20 mA speed indication, rated 0 to 100 percent speed.
 - n. Spare interlock contacts rated 5 amperes at 220 volts ac, wired separately to the unit terminal board. One NO and one NC isolated spare interlock shall be furnished with each drive. Additional interlock contacts shall be provided as indicated on the Drawings.
 - o. Drive fault and run status contacts for remote indication, rated 5 amperes at 220 volts ac.
 - p. Speed droop feature, which reduces the speed of the drive on transient overloads. The drive shall return to set speed after the transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive shall automatically compensate to prevent drive trip.
 - q. Individual adjustable speed profile settings for start, stop, entry, slope, and minimum and maximum speed points.
 - r. Coast, controlled ramp, or dc injection selectable modes of stopping.
 - s. AUTO/HAND selection from a remote logic relay or switch.
 - t. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.
 - u. Ethernet communications port. The unit shall be capable of transferring real-time operating information with the facility control system over a 10/100Base-T(X) communication link as shown on the drawings. At a minimum, instantaneous load voltage and current values (for each phase), total power, output frequency, motor temperature alarms and alarm conditions shall be available. The Identities of all points monitored over the link shall be determined in consultation with the Owner.
 - v. Speed Set Potentiometer and Speed indicator shall be mounted on Front Door of The VFD Local Control Panel to use for Local Control Speed functions.

17.3 EXECUTION

17.3.1 Examination

- A. Examine the VFD exterior and interior prior to installation. Report any damage and

- do not install any VFDs that are structurally, moisture, or mildew damaged.
- B. Prior to locating the VFD at the planned installation site, ensure that the location is prepared for the installation and that the storage or operating condition requirements can be maintained. Verify that the installation space requirements are satisfied. Report any conditions that are detrimental to performance of the work. Proceed with installation only after detrimental conditions have been corrected.
 - C. Before, during, and after installation ensure that the VFD is protected from area construction activities and site contaminants.

17.3.2 Installation

- A. VFD shall be installed in Local Control Panel on leveled Surface and to be fastened to the supports by anchor bolts or Built-in MCC.
- B. Installation shall comply with manufacturer's instructions, drawings, and recommendations.

17.3.3 Field Quality Control

- A. Configuration and startup: Provide the services of a qualified factory- trained manufacturer's representative to assist the installing contractor with the installation, configuration, and startup of each VFD. The manufacturer's representative shall inspect the installation of each VFD prior to energizing and configure each VFD for operation under the specified conditions. The manufacturer's representative shall conduct the initial startup and operation of each VFD. The manufacturer's representative shall revisit the project site as often as necessary to ensure that all issues are corrected and that the installation and operation of the VFD are satisfactory.
- B. Certification: The Contractor shall submit a written report certifying that each VFD has been installed, configured, and tested under load in accordance with the manufacturer's recommendations. This report shall be signed by a factory-trained manufacturer's representative and shall include a listing of all modifications and adjustments made on site to include any settings/parameters that are not identified as factory defaults in the equipment's O&M documentation.
- C. Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. The Contractor shall conduct performance verification tests in the presence of a Government representative, observing and documenting complete compliance of the system to the specifications. The Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

17.3.4 Testing and Commissioning

- A. General: VFDs and related equipment shall be tested and commissioned in accordance with Specification.
- B. Field Harmonic Testing: The Contractor shall record and provide in a report the harmonic line distortion for ac voltage and current to include individual harmonic values up to the 30th harmonic as well as the total harmonic distortion (THD) and total demand distortion (TDD) for all VFDs furnished above [30] KW. Testing shall be in accordance with IEEE 519.

End of Section

18 SITE LIGHTING

18.1 SCOPE OF WORK

The item shall consist of furnishing and installing the site lighting system as required by the drawings and as described in this Specifications. The work shall include supply install and test the following as minimum:

- A. Electrical services, including all conduits, junctions' boxes and manholes, KWH meter, fittings, and wiring from the Power Utility Company connection points including any additional poles and excavation and backfilling with related reinstatement to lighting main panel boards.
- B. Lighting panels with concrete protection.
- C. Complete luminaries.
- D. Lighting Standard poles and foundations base.
- E. Photoelectric switches.
- F. Grounding and Bonding of lighting system.
- G. Cable trench, excavation, backfill, reinstatement and Testing.
- H. Contractor shall investigate the site requirements during bidding time to include all other required materials and work to complete the job and put in operation as required.

18.2 MATERIALS

A. Street Lighting Power Cable:

Power cable depends on type of installation, contractor shall refer to project drawings for installation type, one-piece cable, splice in power cables will not be permitted.

Type 1 - Direct Burial installation, for direct burial installation Power Cable shall be armored 0.6/1KV, 3x10mm Multicore with COPPER conductor XLPE insulated and PVC Sheathed Rated for 90°C confirm to IEC 60502. Compacted or shaped stranded copper conductor Confirm to IEC 60228 Class 2. Round wire galvanized steel armor with an additional open counter helix galvanized steel tape on the inner covering in accordance with IEC 60502-1 Standard

Type 2 - Inside Conduit installation, Power Cable shall be 0.6/1KV, 3x10mm Multicore with Copper conductor XLPE insulated with PVC Sheathed Rated for 90°C confirm to IEC 60502. Plain Circular, copper conductor Confirm to IEC 60228.

B. Site Lighting Pole:

Provide Lighting Standard poles designated for wind loading of 130 kilometers per hour determined in accordance with AASHTO LTS-2 while supporting luminaries having effective projected areas indicated. Poles shall be anchor - base type designated for use with underground supply conductors. Galvanizing shall be in accordance with the requirements of ASTM A-120 for the poles and A-153 for the fittings. Effective height shall be 10 m including Arm unless otherwise noted on the drawings.

Lighting Pole shall be one-piece stationary type 8-meter height and 4mm thick with minimum 60-80 Micron thick Hot Dip Galvanize coating, pole shape as per project design drawing and to be coordinated with Authority Having Jurisdiction. Pole Base Plate shall be 60x60x15CM with 4 pieces 15mm thick stiffeners.

Lighting Pole Arm, shall be of semi arc two inches bent type hot dip galvanized, 2-meter height and 1.5-meter width. Arms can be single double or triple type per design drawings.

Fuse box shall be located 50 cm above base plate with anti-theft screw access opening, opening cover shall be chained connected to the pole body and shall include a welded nut for 10mm ground connection conductor.

Lighting Pole base anchor bolts shall be constructed of four 30mm that should be hot dip galvanized; each rod shall be L shape with 1200 mm length including 200 mm down bend. Each rod shall include one Hot Dip Galvanized nuts below the pole base and one above.

Wherever required by drawings or by engineer, lighting Pole base anchoring bolts shall include a broken type extension for High energy absorbing safety (according to EN12767).

Lighting pole shall be new manufactured, not more than 3 months old.

C. Street Lighting fixture:

Fixture type and power as reflected in design drawings, contractor shall refer to project drawings for lighting fixture type and power rating. Lighting fixture shall be as below:

LED lighting fixture:

Led Lighting Fixture shall include patented heat dissipation and 10KV surge protection, design to achieve optimum efficiency, ventilation system designed for managing water resistance & dust proving, Led Lighting Fixture shall be 158 Watt with IP65, IK08.

D. Electrical Panel Enclosure:

All enclosures shall be type tested panels; enclosure is classified per project design drawings to two types:

1. Type 1 Enclosures, Ground-Mount Type IP66 Freestanding Double-Door. Enclosures shall be impact resistant, non-conductive, light-weight hot compression molded fiberglass reinforced polyester, panel shall include below:
 - a. Poured polyurethane seamless gasket provides Twist lock latches
 - b. Integral mounting bosses utilize threaded brass inserts for mounting hardware
 - c. Rounded edges reduce build-up of dust and debris
 - d. Full length stainless steel hinged cover
 - e. Built in padlock hasp locking to be included.
2. Type 2 Enclosures, Enclosure shall be Coated steel 316 /IP66 and 1.5mm thick minimum with key padlock, cables opening shall be done using

water tight flexible conduits as described in conduits sections, all conduits raised from ground shall include a transition from PVC-to-PVC coated RGS for above ground installation.

No PVC conduit shall be exposed.

E. Electrical Panel Concrete Protection:

Street Lighting panels shall be protected by concrete frame with metallic door fabricated by hot dip galvanized material and padlocks, touch paint shall be applied for welding points by special paint material, panel thickness shall not be less than 10cm, contractor shall submit catalogue cut sheets for the protection concrete frame to engineer for approval.

F. Pole Circuit Breaker:

Shall be installed for each lighting fixture inside lighting pole, Circuit Breaker shall be Tow pole quick make quick break and trip free mechanism 10KA Ics, 10 Ampere curve B.

G. Lighting Fixture Cable:

Branch cable shall be one piece and shall be XLPE 1/0.6 volts 3x2.5mm connected to power circuit breaker inside the Termination box from one end and to the lighting fixture from the other end.

H. Earthing Bus and Grounding Rod:

Earth bus shall be 25x5x150mm copper and installed inside pole termination Box, pole body, grounding conductors, galvanized strip shall all be tightened to it by suitable screws and washers. Ground Rod shall be copper clad 1500mm long and 15mm diameter.

I. Lighting Pole Labeling:

Each lighting pole shall be labeled by a unique number followed by feeder number on vertical aluminum or galvanized plate fixed by galvanized screws.

J. Electrical Panel Main Internal component:

1. Power Contactor, Contactors shall have positive locking features and shall be mechanically held in both positions. Main contacts shall be double-break, continuous-duty, and 400 volts ac, for all types of loads. Terminals shall accept up to 50mm conductors. Contactors shall operate in any position and may be manually operated for testing and maintenance.
2. Manual/off/auto Rotary Switch, shall be - Screw door Mounting Laser-printed text and with Versatile high protection degree handles, 25 Ampere rating.

3. Circuit Breakers, Main Circuit breaker shall be molded case thermomagnetic with short circuit rating of 25KA Ics. 3 phase thermal magnetic miniature circuit breaker for Feeder Lines with Ics of 25KA. Main Circuit breakers shall accept up to 200mm copper conductor and feeder circuit breakers shall accept up to 50mm conductors.
4. Astronomical time switch, Street Lighting system shall be derived by astronomical time switch, switch shall be installed and integrated inside the lighting Panel to derive the lighting Contractors, Astronomical time switch shall have an LCD display and shall be 230V and integrated photocell to serve lighting enable during winter low lighting, 16 Ampere rating relay with backup 5 years' internal battery capable to be programmed by Cities names and by geographic coordination's. Astronomical time switch shall recognize the time zone of Jerusalem and Beer Sheva at least. Summer time date configuration shall be available, too. Astronomical time switch shall be AST Lux VE148300 manufacturer by Vemer or equal.
5. Digital Power Meter: Digital Power meter shall be panel mount type, 3 phase, suitable for 400V, 50 Hz system, power meter shall include measuring for L-L and L-N Voltages, Line and Total Current, Frequency, Power, and KWH at least. Power Meter shall be capable to receive the Voltage measure directly without Potential transformers, current transformers shall be manufactured by the same meter manufacturer.
6. Surge suppressor: shall be 3 phase plus neutral with maximum discharge current of 65KA comply with the requirements of EN 61643-11.
7. Lighting panel shall include also but not limited to terminal blocks, lighting unit, two 230v power sockets Contractor shall submit load calculations and material components data sheets with complete schematic drawings for Engineer approval.

18.3 INSTALLATION

1. Underground Cable:
Refer to drawings for cable installation type, installation types as below:
 - a. Direct Burial cables shall be installed at 750mm below grade level with 150mm sea sand bedding and 150mm sea sand cover, 15Cm PVC warning tape shall be installed at 30CM below grade level, use compacted Base course and per site reinstatement material for final finish. 25mm Bare Copper conductor shall be installed along with the power cable or conduits and connected to each pole grounding bus.
 - b. Conduit installation cable to be installed at 750mm below grade level inside 75mm PVC conduit with 150mm bedding sand and 150mm sand cover, 15Cm PVC warning tape shall be installed at 30CM below grade level, use compacted Base course and per site reinstatement material for final finish. 25mm Bare Copper conductor shall be installed along with the power cable outside conduits and connected to each pole.

For either direct burial and conduit installation, where cable crossing roads, or installed under Pavement,

Contractor to use conduit with reinforcement concrete duct bank as in detail Drawing.

Contractor to submit voltage drop calculations confirms that voltage will not exceed 3 Percent for each feeder; if not then contractor shall use larger feeder cable to achieve requirements without additional Cost.

2. Lighting Pole

- a. Lighting Pole Foundation Base: Pole foundation base shall be 1000x1000x1200mm and shall include reinforcement Steel Bars per drawings, concrete shall be class B250.
- b. Use torque wrench for screw tighten per manufacturer recommendations if requested by engineer.
- c. Lighting pole termination box to be oriented to be in-line with traffic direction so that a man sight working on that pole directed towarded the incoming traffic. Direction of termination box shall be clear indicated on shop drawings.
- d. Use web fabric slings (not chain or cable) to raise poles. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer. Secure poles with level, plumb and square. Grout void between pole base and foundation. Use no shrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of 13 mm diameter min. pipe to make a drain hole through grout.
- e. Install grease with canvas cover on threaded Exposed part from anchor bolts.
- f. Conduit under Roadway. Installation shall be such as to avoid pocket in the conduit run. All run shall be straight as possible and shall be installed in a neat and workmanlike manner. Conduits under roadway shall be encased with reinforced concrete.

18.4 LIGHTING FIXTURES

Lighting fixtures are scheduled on the Drawings.

18.4.1 LUMINAIRES

- A. General: Additional WORK requirements are indicated in the Luminaire Schedule on the Drawings.
- B. Provide a feed-through type or separate junction box.
- C. Provide minimum 12 AWG (0.90 mm) wire leads.
- D. Provide components that are accessible and replaceable without removing the luminaire from the ceiling.
- E. Soffit Installations
 - Installations shall be as "Suitable for Damp Locations."
 - Provide removable and prewired ballasts.
- F. Exterior Installations
 - Installations shall be as "Suitable for Wet Locations."
 - Provide removable and prewired ballasts.
 - When factory-installed photocells are provided, the entire assembly shall be UL or IEC labeled.

G. Marine Environments

- Installations shall be as "Marine, Outside Type."
- Provide a copper-free aluminum housing in accordance with the requirements of IEC or UL.

H. Emergency Lighting

- General requirements for emergency lighting units.
- Battery: Sealed, maintenance-free, lead-acid type.
- Charger: Fully automatic, solid-state type with sealed transfer relay.
- Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
- Test Push Button: Push-to-test, in unit housing, simulates loss of normal power and demonstrates unit operability.
- LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
- Power Pack
- self-contained
- 230 V
- selectable input transformer
- 6 V (or 12V) sealed nickel-cadmium battery
- indicator switch in accordance with the requirements of UL 924
- lighted, push-to-test pushbutton and indicator
- capability of providing full illumination for 1-1/2 hours in emergency mode
- capability of full recharge in 24 hours, automatically initiated upon resumption of normal line voltage
- capability of protecting against excess charging and discharging
- twin halogen, sealed lighting heads
- solid state charger
- normal and emergency LED indicating lights
- mounting stand
- Provide enclosures suitable for the area classifications in which they are installed.

I. Exit Signs

1. General requirements for exit signs: Comply with applicable IEC and UL standards; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
2. Internally Lighted Signs:
 - a. Lamps on AC Operation: LEDs 50,000 hours minimum rated lamp life.
 - b. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - Battery: Sealed, maintenance-free, nickel-cadmium type.

- Charger: Fully automatic, solid-state type with sealed transfer relay.
 - Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
3. Internally illuminated
 4. universal mounting type
 5. internal 6 V (or 12V) nickel-cadmium battery
 6. battery charger
 7. LED-type emergency and normal indicating lights
 8. press-to-test button
 9. directional arrows
 10. green letters on a white panel

18.4.2 LED LUMINAIRES

A. General: Except as otherwise indicated, provide LED luminaires, of types and sizes indicated on fixture schedules.

B. Material and specifications for each luminaire are as follows:

- Each luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply).
- Each luminaire shall be rated for a minimum operational life of 50,000 hours at an average operating time of 12.0 hours per day. This life rating must be conducted 40°C ambient temperature.
- The rated operating temperature range shall be -10°C to +45°C.
- Each luminaire is capable of operating above 100°F [37°C], but not expected to comply with photometric requirements at elevated temperatures.
- Photometry must be compliant with IESNA LM-79 and shall be conducted at 25°C ambient temperature.
- The individual LEDs shall be constructed such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
- Luminaire shall be constructed such that LED modules may be replaced or repaired without replacement of whole luminaire.
- Each luminaire shall be listed with Underwriters Laboratory, Inc. under UL1598 for luminaires, or an equivalent standard from a nationally recognized testing

laboratory.

C. Drivers: Solid-State Type

- Driver and dimmer shall be designed, tested, and UL listed for specific lighting source/load type.
- Driver output current shall not exceed 150% normal current. Driver Input Watts: May not be reduced.
- 0-10VDC Dimming.
- Continuous, flicker-free dimming control from 100% to 1%. Dimming Range: 100 to 1 percent of rated lamp lumens.
- Compatibility of driver and LED light engine must be tested and ensured by driver manufacturer.
- Control: Coordinate wiring from driver to control device to ensure that driver, controller, and connecting wiring are compatible.

D. Electrical

- Power Consumption: Maximum power consumption allowed for the luminaire shall be determined by application. The luminaire shall not consume power in the off state.
- Operation Voltage: The luminaire shall operate from a 50 HZ \pm 3 HZ 230 VAC to 305 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.
- Power Factor: The luminaire shall have a power factor of 0.95 or greater.
- THD: Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 10 percent.
- Surge Suppression: The luminaire on-board circuitry shall include fused surge protection devices (SPD) to withstand high repetition noise transients as a result of utility line switching, nearby lightning strikes, and other interference. The SPD shall protect the luminaire from damage and failure for common mode transient peak voltages up to 10 kV (minimum) and transient peak currents up to 5 kA (minimum). SPD shall conform to UL 1449 depending of the components used in the design. SPD performance shall be tested per the procedures in ANSI/IEEE C62.41-1992 (or current edition) for category C (standard). The SPD shall fail in such a way as the Luminaire will no longer operate. The SPD shall be field replaceable.
- Each Luminaire shall have support Class II power supplies. Class I power supplies will not be acceptable.
- Operational Performance: The LED circuitry shall prevent visible flicker to the unaided eye over the voltage range specified above.

18.5 RECEPTACLES

Single phase Receptacles shall be Duplex or single receptacles that are rated at 250V, 16 amperes as shown drawings, shall be specification grade, two-pole, three wire grounding type with crew type wire terminals suitable for 4 mm² and one-piece mounting strap with integral ground contact. Baseplate shall be high strength, thermoplastic with a white color unless noted otherwise. Contact shall be made on two sides of each inserted blade without detent. Receptacles shall be to Israeli standards.

Receptacles types:

- Indoor dry area receptacles shall be **GEWISS cat number GW 20 220 with cloud white plates** and other related accessories.
- **Chemical area outlet shall be** GEWISS cat number GW 20 220 with weatherproof plates.
- Duplex 220V receptacles for outdoor and damp/wet areas shall be installed within a Galvanized cast metal box with aluminum protective cover whose hinge is located above the receptacle opening. Outdoor and process area socket covers shall be **Legrand or Gewiss Brand**.

18.6 SWITCHES\PHOTOCELL\WIRING

Single phase Switches shall one way or two way rated at 250V, 16 amperes as shown drawings, two-pole, two wire with crew type wire terminals suitable for 4 mm². Baseplate shall be high strength, thermoplastic with a white color unless noted otherwise.

- Indoor dry area Switches shall be GEWISS cat number GW 20 571 - 16AX (on way) or GW 20 576 - 16AX (two way) with cloud white plates and other related accessories.
- Chemical area switches shall be **GEWISS cat number GW 20 571 - 16AX with weather proof plates**.

Photocell:

Photocell shall be 24V, IP65 rated for 10Ampere.

Wiring

- Lighting and Power wirings shall be Copper class 1 conductor with PVC insulation rated for 600V per EN 60288, wire size shall as below classifications.
- Lighting conductors shall be 2.5mm
- Outlet conductors shall be 2.5mm for Electrical and control building, Guard House and Chemical buildings.
- Power wiring for heaters such as water heater shall be 4mm unless mentioned otherwise.

Other sizes may be required as reflected on design drawings.

End of Section

19 GROUNDING AND BONDING

19.1 REQUIREMENT

- A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents and per NEC Article 250.
- B. The requirements of Section Electrical General apply to this Section.
- C. Single Manufacturer
Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

19.2 CONTRACTOR SUBMITTALS

- A. Submit Compliance sheet with system component data sheets.
- B. Contractor shall submit of conductor to electrode and conductor to conductor welding shambles.
- C. Shop Drawings
Submit manufacturer's product information for connections, clamps, and grounding system components, showing compliance with the requirements of this Section.

19.3 GENERAL

- A. Components of the grounding electrode system shall be manufactured and conform to the applicable requirements of National Electrical Code Article 250 and local codes.
- B. Electrical System: Electrical systems shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.
- C. Grounding of Electrical Equipment: All non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials, bonding also require for Cable trays, supports, shaker plates, doors and windows.
- D. Bonding of Electrical Equipment: non-current carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.
- E. Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur.
 - F. Raceways and Metal cable trays: metallic conduits and Cable ladders/trays shall be grounded as required for conductor enclosures of Article 250. Metal cable trays

shall be electrically continuous through approved connections or the use of a bonding jumper.

19.4 GROUNDING SYSTEM MATERIALS

A. Grounding loop conductors.

1. Bare annealed copper conductors and shall be (120 mm²) or as indicated in Drawing, thermo-welded to Electrodes and branches feeding equipment unless indicated otherwise.

B. Ground Rods

1. Unless indicated otherwise, provide ground rods minimum of 3/4 inch (19 mm) in diameter, (1.5 m) long, and with a uniform covering of electrolytic copper metallurgically bonded to a rigid steel core the copper coating shall not be less than 0.25 mm thick at any point.
2. Provide corrosion-resistant copper-to-steel bond.

C. COMPRESSION CONNECTORS AND WELDINGS.

1. Compression connectors shall be tinplated Copper type constructed of high-copper alloy according to DIN 46235 or equal with long nick and shall be used for exposed connections only.
2. Make buried and concrete-encased cable-to-cable and cable-to- ground rod connections using exothermic welds by Cadweld, Thermoweld, or other suitable acceptable welding procedure.

D. Use grounding clamps to bond each separately-derived system to the in pit/manholes grounding electrode conductors.

E. Equipment Grounding Circuit Conductors

1. The conductors shall be the same type and insulation as the load circuit conductors and shall be annealed copper conductors.
2. The minimum size shall be as outlined in Table 250.122 of the National Electrical Code, unless indicated otherwise on drawings.

19.5 GROUNDING

- A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.
- B. Provide a separate grounding conductor for each motor along with the power cable and connect at motor box in addition to other conductor connected to the motor body.
- C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.
- D. Effective grounding system should be utilized, grounding conductor shall run with all power cables in the same conduit and connected to source and destination equipment including transformer.
- E. Conductor sizes shall be as indicated on the Conduit Schedule or drawings and in accordance with NEC Article 250.122.
- F. Route the conductors inside the raceway.
- G. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or

panel-board.

- H. Individually bond the raceway to the ground bus in the secondary section.
- I. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor and doors.
- J. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.
- L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system.

Each Building individual related grounding system shall be tested to be less than 5 ohms, if this couldn't be achieved then contractor shall utilize Chemical ground electrodes with manufacturer produced and recommended backfill.

M. LOW VOLTAGE SWITCHGEAR AND MCC GROUNDING

- Service Entrance Grounding-Neutral Connection (Main Incoming Section):
The switchboard (LV Switchgear or MCC) where is used as service entrance equipment. Power to the service section is received from a three Phase four Wires service. The neutral is always grounded in service entrance equipment. The neutral is connected to ground through a neutral to ground connection and ground bus bar. The ground bus bar is connected to the frame of the switchboard, which is connected to the system or earth ground. The neutral disconnect link is left in place to supply downstream loads. Three-phase, four-wire power is then supplied to downstream loads. The Ground-Neutral Point of Transformer shall be connected to Neutral Bus Bar at Service entrance section of switchboard.
- Downstream Equipment (Switchboard Distribution Sections, MCC, MDBs)
The neutral is only connected to ground at the service entrance. When downstream equipment is used the neutral is isolated in that equipment. The neutral is connected to earth ground through the ground bus bar of the service entrance switchboard. A second switchboard sections, MCCs panel and MDBs which are used as downstream of the service entrance switchboard. The enclosure of the downstream switchboard is connected to ground through a grounding conductor back to the service equipment. The neutral is not connected to ground in the downstream switchboard. Also, that the Downstream Switchboard does not have a neutral disconnect link. Neutral disconnect links are not required in switchboards used as non-service entrance equipment.

N. Low Voltage Grounded System (400V or less)

- A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded. The Ground-Neutral Point of

Transformer shall be connected to Neutral Bus Bar at Service entrance section of switchboard.

- Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.
- The grounded circuit conductor shall not be used for grounding noncurrent-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

O. Embedded Ground Connections

1. Underground buried and grounding connections embedded in concrete using mechanical connectors is not permitted, contractor to use thermo-welding or other suitable welding procedure.
2. The connection shall be made in accordance with the manufacturer's instructions.
3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

P. Ground Ring

1. Furnish trenching and materials as necessary to install the ground ring around each building structure.
2. The bonding conductor shall be bare and in direct contact with the earth and of the indicated size.
3. Provide a minimum burial depth of 30 inches (750 cm) or as indicated on the Drawings, whichever is greater.
4. Re-compact disturbed soils to their original density in 6-inch (15 cm) lifts.

Q. Duct Bank Ground

1. Embed a grounding conductor in every duct bank as indicated in drawings.

R. Ground Rods.

1. Provide ground rods at the indicated locations.
2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.
3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.
4. Rods forming an individual ground array shall be equal in length.

S. Instrumentations:

Connect all instruments to grounded system using No. 14 (2.5 mm²) isolated grounding conductor.

Connect all Control Cabinets and field panels to ground system using No. 6 (16 mm²) isolated grounding conductor.

T. Shield Grounding

1. Shielded instrumentation cable shall have its shield grounded at one end only.
2. The grounding point shall be at the control panel or at the receiving end of the signal

carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.
4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 (2.5 mm²) green insulated conductor.
5. Connect the ground bus via a green No. 12 (4 mm²) conductor to the main ground bus for the panel.

End of Section

20 LOW VOLTAGE MOTOR CONTROL CENTERS

20.1 GENERAL

20.1.1 The Requirement

- A. The CONTRACTOR shall provide motor control centers (MCCs), complete and operable, in accordance with the Contract Documents.
- B. The requirements of General Electrical Work Section, apply to the WORK of this Section.
- C. In the event that provided motors are of greater horsepower (kW) than the indicated motors, revise the raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased motor horsepower in accordance with Section of Electric Motors.
- D. This Section describes the General Rules to guarantee Maximum Level of Quality and performance for a MCC including all stages of manufacture, furnish, install and test all Equipment, accessories and materials required for the installation of Design Verified ASSEMBLY for MCC. MCC shall be assembled in compliance with standard IEC 61439-1&2. The Standard IEC 61439-1&2 is for Low Voltage Switchgear and Control Gear ASSEMBLY for a voltage not exceeding 1000V in AC with a frequency not exceeding 1000 Hz, or for 1500 V in DC. This standard also applies to all assemblies intended for use in connection with generation, transmission, distribution and conversion of electrical energy, and for monitoring of equipment electrical energy consumption.
- E. Applicable Codes and Standards
The MCC ASSEMBLY shall be carried out in accordance with this specification, and the contract drawings and the standards listed here under. The following codes and standards provide an acceptable level of quality for materials and products:
 - I. IEC 61439-1&2: Low Voltage Switchgear and Control Gear Assemblies
 - II. IEC 60529: Degrees of protection provided by enclosure (IP Code)
- F. Coordination

1. The equipment provided under this Section shall operate the electric motor driver with the driven equipment as indicated under other equipment Sections.

20.1.2 Contractor Submittals

- A. Furnish submittals in accordance with Section of Electrical Work, General.
- B. Furnish the following equipment information in the Shop Drawings:
 1. IP rating and color of enclosure
 2. horizontal and vertical bus ampacities, voltage rating, interrupting capacity, and materials of construction
 3. ground bus size and material of construction
 4. conduit entrance provisions
 5. main incoming line entry provision (top or bottom)
 6. control unit nameplate schedule
 7. circuit breaker types, frames, and settings
 8. starter sizes, auxiliary contact provisions, and coil voltage
 9. relays, timers, pilot devices, control transformer VA and fuse sizes
 10. MCC Ladder Diagrams:
 - a. Furnish custom elementary schematic ladder diagrams for each compartment.
 - b. The ladder diagrams shall include remote devices.
 - c. Submittals not meeting these requirements will not be reviewed further and will be returned to the CONTRACTOR.
 11. Short circuit rating of the complete assembly
 12. Replacement parts lists and operation and maintenance procedures
 13. time-current curves for protective devices
 14. VFD Equipment Information
 - a. name of drive manufacturer
 - b. type and complete model number
 - c. assembly drawing and nomenclature, including enclosure dimensions, mounting and anchoring details, and internal layout
 - d. detailed schematics, including external wiring connections

- e. maximum heat dissipation capacity in kW
 - f. altitude de-rating information
- C. Furnish an Owner's Manual
- D. Spare Parts List
 - 1. Furnish spare parts information for parts required by this Section as well any otherspare parts recommended by the MCC manufacturer.
- E. Startup and Testing Report
 - 1. Within 10 days after completion of startup and testing, the CONTRACTOR shallsubmit a report for the MCC.
 - 2. The report shall contain the following documentation:
 - a. the device name, serial number, rating, and complete model number of each MCC.
 - b. A complete listing of all tests performed and the results of each test.
 - c. A complete listing of all circuit breaker and overload settings, fuse ratings, settings, set points and configuration information for VFDs and equipment or devices with adjustable settings.
 - d. Documentation for training that was provided to the OWNER's personnel, including topics covered, instructor's name and contact information, and a list ofattendees.

20.2 PRODUCTS

20.2.1 General

- A. The MCC Components shall be from same Manufacture, the Acceptable component shall be **G.E,Siemens, ABB or Equal**.
- B. The Panel Builder of the low-voltage motor control center shall use Derives of Same Manufacturer for the following:
 - 1. Molded case circuit breakers.
 - 2. disconnect switches
 - 3. motor starters
 - 4. control and timing relays rated at 400 volts AC
 - 5. pushbuttons, lights and selector switches, including remote mounted control stations
 - 6. meters, including ammeter, voltmeter, and solid-state metering devices

20.2.2 Design, Construction, and Material Requirements

- A. The motor control centers shall be 400-volt class and suitable for operation on a 3-phase, 50-Hz system.
- B. The system operating voltage and number of wires shall be as indicated.
- C. The Power:
 - 1. The motor control center shall receive power from a 3-phase, wye-connected 230/400-volt transformer with earthed neutral.
 - 2. Power distribution from the MCC shall be 400-volt, 3-phase, 4-wire.
 - 3. The MCC shall include provision for termination of an incoming neutral conductor in conformance to NEC requirements for service entrance.
- D. Enclosure
 - 1. The enclosure shall be of IP 52.
 - 2. Compartment doors shall be interlocked with compartment circuit breakers, fitted with a maintenance override.
 - 3. Compartment doors containing circuit breakers for connection of generators shall be capable of closing with the portable generator cables connected.
- E. Size and Arrangement
 - 1. Motor control centers shall be configured as mechanical groupings of control center units, assembled into a lineup of control center sections.
 - 2. Each control section shall be maximum 90 inches (2300 mm) tall by 23 inches (600mm) inches deep by 27 inches (700 mm) wide unless indicated otherwise.
 - 3. MCCs shall be designed to not exceed the indicated spatial requirements, including spaces, spares, and future compartments.
 - 4. MCCs shall be subject to rejection if they exceed the indicated lengths, where allotted space is critical.
 - 5. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing that the MCC includes the spares, space, and future provisions as indicated.
 - 6. Switches and circuit breakers used as switches shall be located such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6 feet, 7 inches (2 m) above the

floor, including the height of the concrete pad.

F. Components

1. Busses:

a. Provide a continuous copper ground bus, full width of the motor control centerline-up.

b. Horizontal Busses

- 1) The main horizontal bus shall be of tin-plated copper, and located within an isolated compartment.
- 2) The bus shall be rated for 400 amperes minimum, but in no case less than the main lug or main breaker frame size.

c. Vertical Busses

- 1) The vertical bus in each section shall consist of a single tin-plated copper conductor per phase, with a current capacity of not less than 300 amps.
- 2) The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.

d. Provide fully-rated continuous copper neutral bus through the control center, with lugs of appropriate capacity.

e. Power buses shall be braced to withstand 85,000 amperes, minimum.

2. Wire ways

a. Provide a separate vertical wire way adjacent to each vertical unit, covered by a hinged door.

b. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.

c. Full height (72-inch (1.83 m)) compartments or sections are not required to have a separate wireway.

3. Power, control, and signal fuses shall have blown fuse indicators.

4. Control wires shall be color coded in accordance with Wires and Cables-IEC Codes.

G. Cabinets

1. Structural members shall be fabricated of not less than 2.5 mm Steel, and side and top panels and doors shall be fabricated of not less than 2 mm Steel.

2. Spaces designated as SPACE or BLANK shall include blank hinged doors and vertical bus bars.
3. Control units inside compartments shall be clearly identified with tags or stencil markings.
4. Identification
 - a. Each control unit, including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate.
 - b. Identification shall include the indicated circuit number.
 - c. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the IEC Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.
5. Fans, heat exchangers, transformers, capacitors, junction boxes, and other devices shall not be mounted on the outside of the motor control center enclosure.
6. Protective Coating
 - a. The finish for motor control center shall be light grey: ANSI 61 or 49.
 - b. The panels shall be coated with 2 coats of primer inside and out, and 2 coats of enamel finish.

H. Buss Surge Suppressors

1. Surge suppressors shall be designed to provide transient voltage protection for the MCC main power service compartment.
2. Surge suppressors shall comply with UL 845 or IEC Code.
3. Surge suppressors shall be installed with 12 inches (30.5 cm) or less of connecting cable from the bus to the surge suppressor electronics.
4. Surge suppressors shall be rated for 400-volt, 3-phase service at 250kA per phase.
5. Surge suppressors shall have a built-in diagnostic package with flashing troublelight, a display for the status of each phase, and a counter and display to indicate the number of surges that have caused the device to operate.
6. Surge suppressors shall be resettable.
7. Surge suppressors with sacrificial element shall be not be accepted.

8. Surge suppressors shall be a product of the MCC manufacturer.

20.2.3 Main and Feeder Circuit Breakers (400 V)

- A. Circuit breakers having a frame size of 250 amperes or less shall be molded-case typewith thermal magnetic non-interchangeable, trip-free, sealed trip units.
- B. Circuit breakers with a frame size of 300 amperes to 1,200 amperes shall be moldedcase with RMS sensing electronic trip with the following adjustments:
 1. long-time setting (by changing the unit)
 2. long-time delay
 3. short-time setting
 4. short-time delay
 5. instantaneous setting
 6. ground-fault setting
 7. ground-fault delay
- C. The interrupting capacity of the main and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes.
- D. Service disconnects rated 1000 amps or greater shall provide for ground fault protection of the equipment.
- E. Circuit breaker auxiliary contacts shall be furnished where indicated.
- F. Circuit breakers indicated to be for connection of portable generators shall include connection for solid state metering device and lugs for connection of portable generator as indicated on the drawings.

20.2.4 AUTOMATIC TRASFER SWITCH – ATS

- A. The AUTOMATIC TRANSFER SWITCH shall be a product of the same manufacturer as MCC line, ABB Compact ATS, Schneider (Square D) or approved equal.
- B. Automatic transfer switches shall be rated for continuous duty in both normal and emergency positions. The switches shall have four poles (L1, L2, L3 and N) as specified below, and shall be double-throw. Ampere ratings, and 3-cycle closing and withstand ratings shall be as per Drawings.
- C. Equipment Description and Components
The automatic transfer switches shall transfer electric loads from the normal source of electric power to an emergency source of power. The transfer switches shall

automatically transfer the electrical load circuits upon an interruption or a decrease in the voltage of the normal source of power and shall transfer the loads back to the normal source when it becomes available. The transfer switches shall be furnished without integral overcurrent protection. The switches shall be electrically operated but mechanically held in both the normal and emergency positions. The operating mechanism shall be momentarily energized from the source to which the load is being transferred. All main and arcing contacts and control elements shall be removable from the front of the switches without removing the switch from the enclosure and without removing the power cables. The automatic transfer switches shall be so designed that the load circuits cannot be connected to more than one source of power at a time. The automatic transfer switches shall be magnetic contactor type.

1. Automatic Transfer Switch

The AUTOMATIC TRANSFER SWITCH shall be an electrically operated double throw switch or breaker type where amperage rating as indicated in drawings, Main contacts shall be silver composition. Main and arcing contacts shall be visible without major disassembly to facilitate inspection and maintenance. A manual handle shall be provided for maintenance.

Switches composed of molded case breakers, contactors, or similar components not specifically designed for automatic transfer switch applications will not be acceptable.

2. Manual Operation

The transfer switch shall be Equipped with Manual operation for switching power sources in case of Automatic Transfer Fail.

3. Control System

The control system shall consist of all control devices necessary to operate the switch as described. The system shall incorporate a microprocessor control module connected to the power transfer components by a wire harness and keyed disconnect plugs. The control module shall be completely enclosed with a protective cover and shall be mounted separately from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on plug-in circuit boards. All interface relays shall be identical and shall be control grade, plugin type, with dust covers.

4. Performance

The Automatic Transfer Switch shall be designed to function in accordance with the following requirements:

- a. The voltage of each phase of the normal source shall be monitored and the pickup voltage shall be adjustable from 85 percent to 100 percent of nominal, and the dropout voltage shall be adjustable from 75 percent to 98 percent of the pickup value. The transfer to emergency will be initiated upon reduction of the normal source to 85 percent of the normal voltage, and retransfer to normal shall occur when the normal source restores to 90 percent of the normal voltage.
- b. A time delay to override momentary normal source outages to delay all transfer switch and engine starting signals shall be provided. The time delay shall be field adjustable from 0.5 to 10 seconds and shall be factory set at 1 second.

- c. A time delay to transfer back to the normal source shall be provided. The time delay shall be automatically bypassed if the emergency source fails and the normal source is available. The
- d. Time delay shall be field adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.
- e. An in-phase monitor shall be provided to control transfer so motor load inrush currents do not exceed normal starting currents. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and shall permit transfer only at acceptable values of voltage, phase relationship, and frequency differential.
- f. An unloaded running time delay for engine-generator cool-down shall be provided. The time delay shall be field adjustable from 0 to 60 minutes and shall be factory set at 5 minutes.

5. Indication

The Automatic Transfer Switch shall include indication features in accordance with the following requirements:

- A. Detailed step-by-step operating instruction plate shall be provided on the front of the switch.
- B. Indicating lights or microprocessor control display indication shall be provided for, but shall not be limited to, the following:
 - Normal source available.
 - Emergency source available.
- C. One pair auxiliary contact shall be provided that is closed when the Automatic Transfer Switch is connected to the normal source and one pair contact that is closed when the (ATS) is connected to the emergency source.
- D. A contact, which will close when the normal source fails, shall be provided to initiate engine starting. The contact shall be rated 10 amperes, 32 VDC and shall be gold plated for low voltage service.

20.2.5 Motor Starters

- A. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.
- B. Components
 - 1. Each motor starter unit shall consist of a combination magnetic contactor and shortcircuit protective device, mounted in a completely enclosed cubicle.
 - 2. Circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the OPEN position.
 - 3. Resetting of thermal overload elements shall be possible with the unit door closed.

4. Provide 3-phase overload trip units to suit the full load current of the equipment installed, and the trip unit shall be adjusted as required for power factor correction capacitors.
- C. Control Power Transformer
1. Each starter unit shall have its own control power transformer, with a 24-volt grounded secondary.
 2. Provide one secondary fuse and 2 primary fuses.
 3. Control power transformers shall be sized to accommodate the indicated control devices.
 4. Local control devices shall be mounted independently of the cover door.
 5. Starters shall have a local red RUN indicator, and a green OFF indicator to indicate the presence of control power when the motor is not energized.
 6. Starters shall be provided with elapsed time meters, HAND-OFF-AUTO selector switches, and other devices as indicated.
 7. Cubicle control wires shall be terminated at a pull-apart disconnecting terminal block located at the cubicle.
- D. Identification
1. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers.
 2. Each control wire shall be identified at both ends.
- E. IEC Ratings
1. Motor starters shall be designed to IEC ratings.
- F. Variable Frequency Drives
1. Variable frequency drives (VFDs) shall be in accordance with the requirements of Variable Frequency Drives Section.
 2. An externally mounted line reactor, cooling fan, and bypass contactor will not be accepted.
 3. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

20.2.6 Control Devices

- A. Control devices shall be in accordance with the requirements of Section of Local Control Stations and Miscellaneous Electrical Devices.
- B. Metering
 - 1. Provide solid-state metering where indicated.
 - 2. Include CTs and PTs of ratios as indicated or as recommended by the MCC manufacturer.
 - 3. The CT leads shall terminate on shorting type terminal blocks, and the shorting bar shall be grounded to the MCC ground bus.
 - 4. Solid-state metering device shall be capable of communicating to the plant wide SCADA network via Ethernet.
 - 5. Solid-state metering shall be a product of the MCC manufacturer and shall be **GE, Siemens, ABB or Equal**.

20.2.7 Factory Tests

- A. Provide the manufacturer's standard electrical and mechanical production tests and inspections for motor control centers and their components.
- B. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

20.2.8 Spare Parts

- A. The CONTRACTOR shall furnish the following for each MCC:
 - 1. Unit Control Transformer: one of each size furnished in magnetic starters installed
 - 2. Bezels: 3 of each color installed for pilot indicators
 - 3. Panel Lamps: one dozen of each type (form, voltage and current rating) installed
 - 4. Control Fuses: one dozen of each type (form, voltage and current rating) installed
 - 5. Relays: one of each type and size installed
- B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

20.3 EXECUTION

20.3.1 General

- A. The CONTRACTOR shall install motor control centers in accordance with the manufacturer's published instructions.
- B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings such that conduit stub-ups are within the area allotted for conduit.
- C. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

20.3.2 Storage and Handling

- A. If stored at the Site, motor control centers shall be stored in a clean, dry space. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic.
- B. The storage space shall be heated or the MCC space heaters shall be energized.
- C. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish.
- D. Damage shall be repaired before installation.

20.3.3 Manufacturer's Services

- A. Inspection, Startup, Field Adjustment
 - 1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
 - a. inspection, checking, and adjusting of the equipment
 - b. startup and field testing for proper operation
 - c. performance of repairs to correct any discrepancies or problems revealed during startup and testing
 - d. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements
 - e. Preparation and submittal of a report covering startup and testing,

including alisting of equipment settings and parameters at the end of startup and testing.

20.3.4 Installation

- A. Motor control centers shall be installed in accordance with the requirements of Section of Electrical Work, General.
- B. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to support beams.
- C. The CONTRACTOR shall:
 - 1. torque bus bar bolts to manufacturer's recommendations, and tighten sheet metal and structure assembly bolts;
 - 2. adjust motor circuit protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower (kW) and full load amps of the motor;
 - 3. verify that overload devices are proper for equipment installed;
 - 4. make necessary changes in overload devices as required for motors having power factor correcting capacitors;
 - 5. touch up scratches after the equipment has been installed;
 - 6. verify that nameplate, and other identification is accurate;

20.3.5 Field Tests

- A. Provide a visual and mechanical inspection after installation, as follows:
 - 1. Inspect for physical damage, proper anchorage, and grounding.
 - 2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.
 - 3. Check tightness of bolted connections.
- B. Electrical Tests
 - 1. Insulation Tests
 - a. Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.
 - b. The test voltage and minimum acceptable resistance shall be in accordance

- with manufacturer's recommendations.
- c. Measure the insulation resistance of each starter section phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open.
 - d. The test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.
 - e. Measure the insulation resistance of each control circuit with respect to ground.
2. Verify the proper operation of control logic in each mode of control.

End of Section

21 RACEWAY

21.1 SCOPE OF WORK

- A. Furnish and install raceways as required, and as shown on the Plans of Drawings. Materials employed shall be as shown on the Plans of Drawings.

21.2 SUBMITTALS

- A. Submit product literature including manufacturer part number, model number, material, size, and specifications for conduits, cable ladders, trays, Manholes, Boxes and fittings.
- B. Shop drawings shall be submitted for review and acceptance showing routing, conduit size, coordination with other trades and size of wires in each conduit before installation of conduit and any related work.
- C. Include duct banks with accommodated conduit schedule and Identify conduit by tag number of equipment served or by circuit schedule number.
- D. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc.
- E. Proposed location and details of construction for openings in slabs and walls for raceway runs.

21.3 RACEWAYS CLASSIFICATIONS

- A. Exposed conduits in an unclassified or hazardous area shall be galvanized rigid steel (GRS) unless specifically indicated otherwise on the Plans. Exposed Conduits in corrosive, hazardous, or damp areas shall be PVC coated GRS unless otherwise indicated. Underground buried conduits shall be Schedule 40 PVC, concrete encased conduits shall be PVC SN8 unless otherwise indicated on specific project drawings or specifications. Exposed Conduits in Chlorination or chemical areas shall be PVC schedule 80 and PVC Coated GRS for Floor walls Penetrations and Stub-ups. All conduits concealed in block walls and Roof Slabs serves lighting Power outlets, fire alarms, intrusion system shall be Flexible Heavy Duty PVC conduit unless otherwise indicated. Conduits installed along with Vertical or submersible well pumps shall be threaded Schedule 80 PVC conduit including 100 feet slotted type conduits. Set screw type fittings in EMT conduit will not be accepted. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than one inch.
- B. For all conduits utilize Long Radius curved Bends, short curved bends or sharp bends will not be accepted.
- C. Flexible conduit shall be weatherproof, corrosion resistant, and watertight.

- D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout. Conduit systems shall be water tight.
- E. The conduits and fittings shall be supported per NEC requirements as a minimum.
- F. Sealing fittings shall be provided for classified areas per the NEC requirements in hazardous or corrosive areas. Fittings shall be poured after the final walk-thru unless otherwise directed in writing by the engineer.
- G. Duct Banks:
 - 1. Conduits inside or outside Facility Boundary shall be installed with Concrete Encasement duct bank.
 - 2. Where required direct burial cable installation by design drawings, contractor shall install to the depth of minimum 76Cm with concrete block tiles above the cable, however wherever the cable passing next to sewer pits/lines or for road crossing contractor shall use reinforced red concrete duct banks with concrete tiles.
 - 3. Conduits inside duct banks shall be separated by using spacers each 3 feet.

21.4 CABLE LADDER AND TRAYS

Ladders, trays and supports shall be heavy duty, hot dipped galvanized steel with a minimum of 2mm thickness. Where power, signal, control or communication cable is routed in the same tray a grounded divider shall be provided or separate tray shall be used space shall be as required by NEC. Cable tray not installed in a trench shall have hinged cover that clamps to tray. Tray system shall be connected to ground by proper size copper conductor to grounding system. All joints shall be also bypassed by copper conductor for Grounding continuity.

21.5 GALVANIZED RIGID STEEL CONDUITS (GRS)

- A. Conduits and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc.
- B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. A half-lapped rapping of 20 mil PVC based corrosion protection tape shall be used.
- C. GRS conduits shall be properly connected to grounding system.

21.6 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

- A. PVC coated GRS conduit shall be installed where shown on the Plans or

elsewhere specified

- B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing.
- C. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness.
- D. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.
- E. Conduit straps shall be PVC coated Galvanized steel.
- F. PVC-GRS conduits shall be properly connected to grounding system.

21.7 RIGID NONMETALLIC – PVC

- A. Where specifically indicated on the Plans, or elsewhere specified, conduit may be high density Schedule 40 heavy-duty PVC. Where conduit concrete encasement is indicated on the Plans, conduit supports shall be installed at five-foot intervals. PVC conduit shall be SN8 unless otherwise required by project design drawings.

21.8 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Liquid-tight flexible metal conduit shall be liquid and vapor- tight, oil and ultraviolet ray resistant. Liquid-tight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90 degrees Celsius.
- B. For corrosive locations, liquid-tight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors.
- C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1 1/2 " or larger. Flexible conduits and connectors for 1 1/4 " and smaller shall be listed for grounding.
- D. Connectors for liquid-tight flexible conduit shall be Stainless steel, furnished with a sealing ring and locknut, and suitable for wet locations.

21.9 UNDERGROUND CONDUIT SYSTEMS, MANHOLES AND PULL BOXES

- A. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.
- B. Identify manhole and pull boxes covers as "ELECTRIC (CONTROL/POWER)" by providing raised letters cast into the covers. Control manhole shall contain a cable with maximum voltage of 48V.
- C. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 72 cm clear openings.
- D. Bolt the covers and lids to cast-in-place steel frames using corrosion resistant hardware. Covers constructed of cast-iron, and provide pick holes. Manholes shall be provided with pulling irons, opposite and below each ductway entrance.
- E. Provide frames with a 1.5 cm drilled and tapped hole and lug in order to accommodate a 120 mm² bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the manhole. Provide sealing fittings in chlorine areas.

21.10 CONDUIT BOXES AND FITTINGS

- A. Concealed conduit systems shall have flush-mounted switches and convenience outlets. Exposed conduit systems shall have surface-mounted switches and convenience outlets
- B. Outdoor boxes and fittings shall be galvanized or cadmium plated, threaded, malleable iron boxes and fittings as manufactured by Crouse-Hinds, Appleton, or OZ Gedney or approved equal.
- C. In applications utilizing aluminum conduit systems, aluminum boxes and fittings manufactured by Crouse-Hinds, Appleton, O Z Gedney or approved equal shall be installed.
- D. Indoor boxes shall be Rigid PVC device boxes as manufactured by Carlon or Cantex or approved equal.
- E. Sheet steel device boxes shall be manufactured by Appleton, Raco, or Steel City or approved equal.
- F. PVC coated device boxes shall be manufactured by Thomas & Betts or, Robroy Industries or approved equal.
Hub arrangements on threaded fittings shall be the most appropriate for the conduit arrangement to avoid unnecessary bends and fittings.

21.11 INSTALLATION

- 1. Use metallic conduit for all soft starter and VFD's wiring that has a grounding strap on the outside of the conduit, install a bare ground conductor inside the

conduit along with power cable and terminate to VFD and to motor, VFD To Motor Power Cable should be shielded and connected to ground from both ends. Use also shielded power cable to feed the VFD and terminate both shield ends to ground.

2. Do not run control and power wiring in the same conduit.
3. Separate metallic conduits carrying power wiring or low-level control wiring by at least 80 mm (3 in).
4. Separate non-metallic conduits or cable trays used to carry power wiring from metallic conduit carrying low-level control wiring by at least 305 mm (12 in).
5. Always cross power and control wiring at right angles.
6. Keep the control circuits away from the power cables.
7. Don't mix power and control circuits at the same manhole.
8. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the Engineer.
9. Don't install more than 1-inch conduit inside walls and foundation slabs.
10. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.
11. Utilize hot dip galvanize fixing and accessories for all inside conduits and fittings, use 316 stainless steel for outdoor fixing.
12. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be long radius uniform and symmetrical in shape. Changes in direction shall be made with long radius bends, or with fittings of the conduit type if accepted by engineer.
13. Conduit runs in buildings and structures shall be concealed where possible except as specifically noted, or accepted by the Engineer.
14. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.
15. No PVC conduit shall be installed outdoor, all exposed outdoor conduits shall be PVC coated RGS.
16. PVC Conduits stub-up from underground to aboveground shall be converted to PVC-RGS using suitable adapter, the PVC-RGS shall be immersed in concrete to a minimum of 150mm.
17. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to vibrating equipment such as motors, fans, and transformers. The maximum length of flexible conduit shall

- be 3 feet, unless approved in writing by engineer. Flexible conduit shall not be used for electrician's convenience where rigid conduit could be used.
18. Conduit runs on water-bearing walls shall be supported one inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.
 19. Conduit shall be thoroughly reamed to remove burrs. IMC or GRS shall be reamed during the threading process, and Rigid Nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads.
 20. Bushings and lock nuts or hubs shall be used at conduit terminations. Conduit, bushings, locknuts, and enclosures shall be fastened to the conduit system prior to pulling wire. Splitting the bushings for installation will not be accepted. Hubs shall be used in all process areas outside of electrical rooms unless otherwise specified. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the Engineer. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped by metallic cap and shall contain a suitable pull string. Cable splices will not be accepted.
 21. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.
 22. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.
 23. After installation of complete conduit runs 2 inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used. Test results should be submitted to the engineer.
 24. Provide trenching, backfill, and compaction for duck banks.
 25. Bond all metallic conduits, boxes, ladders supports, shaker plates and wireways to grounding system.
 26. Install support brackets for trays and ladders each 70 cm.

End of Section

22 LIGHTNING PROTECTION SYSTEM

22.1 GENERAL

22.1.1 Scope

This section covers furnishing the lightning protection systems and the furnishing and installation of lightning protection equipment to protect all facilities of Site.

Lightning Protection Systems shall be furnished, installed, and tested as specified.

Lightning protection equipment shall meet the requirements specified herein.

Lightning protection systems shall consist of, but not be limited to, Pulsar 60 Air terminals; main bonding, and down conductors; ground terminals; and all required connectors and fittings required to complete the system. Refer to Lightning Protection System Drawings, the proposed Location of Pulsar Air Terminal is Water Tank.

22.1.2 General

Contractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor and obtain all inspections to complete the work as specified, and in compliance with all codes, standards, and regulations.

Contractor shall provide coordination with other contractors and supervision of installation as needed during construction.

The design of the system shall include determination of the overall lightning hazard for the geographic location of the project and for the structures, the selection of Class I and/or Class II materials, the need of corrosion protection for the copper and/or aluminium components used, and consideration of other pertinent factors. The design shall produce a zone of protection from lightning to prevent personal injury, structural damage, and equipment downtime.

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, and instructions.

The system shall be designed and installed by an installer who is certified by the Lightning Protection Institute (LPI).

22.1.2.1 General Equipment Stipulations

Section 8 applies for this section.

22.1.2.2 Governing Standards

All system components furnished under this section shall be designed in accordance with:

- NFC 17-102 (September 2011 edition), Lightning Protection System Standard.
- BS EN 62-305, 1-4, Lightning Protection System Standards.
- BS EN 62561, 1-7, Lightning protection System Components.
- NFPA 780, lightning Protection System Installation Requirements.
- NEC 250, Lightning protection systems shall be bonded to grounding electrode systems in accordance with the National Electrical Code.

22.1.2.3 *Workmanship and Materials*

Contractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, unless required by tests.

22.1.3 Submittals

Complete certification of design calculations; assembly, and installation drawings; together with complete engineering data covering the materials used and the parts, devices, and accessories forming the system, shall be submitted in accordance with the Submittals Procedures section. In addition, submittals shall include drawings that show location of air terminals, routing of conductors, connections to the grounding system and material information. Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

In Summary, the Lightning Protection System Design shall include:

1. Protected Area of Each Booster Station, shall protect all Structures.
2. Lightning Air Terminals Positioning, Height and Quantity, Proposed Location and Quantity of Air Terminals in Electrical Drawings May be Changed based to Design.
3. Complete List of Materials.
4. Detailed Materials List per Structures.
5. Test Certificate.

The Quantity and Size of down Conductors and Number of Ground rods shall be as indicated in LPS drawings.

All Materials of Protection System shall be from Same Manufacture such as Air terminals and Bonding.

22.1.4 Quality Assurance

The lightning protection system shall be inspected and tested after installation by conducting continuity and ground resistance tests as well as a visual inspection. Inspection results and test data shall be submitted in accordance with the Submittals Procedures section.

22.2 PRODUCTS

22.2.1 Acceptable Manufacturers

The system components shall be manufactured by a company that has been specializing in the design and manufacture of lightning protection equipment for at least 10 years. Acceptable Products are ABB Helita or Approved Equal.

MATERIALS.

All manufactured and fabricated components shall be:

Conductors Air	Copper.
Terminals Grounding	Copper or bronze.
Electrodes Fasteners	Copper clad steel.
Bimetallic Fasteners	Copper or bronze.

22.3 EXECUTION

22.3.1 Installation

The lightning protection system shall be installed in a neat and inconspicuous manner so all components will blend in with the appearance of the building. All conductors shall be concealed or semi-concealed during construction using methods recommended in BS EN 62-305, 1-4, BS EN 62561, 1-7 and NFPA 780.

Air terminals shall have base supports designed for the surface on which they are used and shall be securely anchored. All exposed metal eave troughs, roof vents, guy wires, antennas, and air handling equipment shall be bonded to the lightning protection system in such a way that two paths to ground are provided.

The lightning protection system shall be bonded to structure/building electrical ground rings wherever they are available.

Metal bodies within 1.83 m of the conductor shall be bonded to the system with approved fittings and conductor. Bonding of metallic objects and systems at roof levels and elsewhere on the structure shall be complete. This includes items such as, roof exhaust fans, HVAC units with related piping ductwork, metal plumbing stacks, poles or masts Exterior architectural metal fascia, curtain walls, or mullions, which extend the full height of the structure, shall be bonded, if not inherently bonded through the building frame.

In general, there shall be no roof penetrations if roof penetrations are necessary the contractor shall coordinate with the ENGINEER for specific roof penetration requirements.

22.3.2 Inspection.

The lightning protection system shall be inspected, tested and certified by the contractor provided independent inspector.

End of Section

23 FIRE DETECTION, ALARM SYSTEM CLEAN AGENT FIRE SUPPRESSION

23.1 SCOPE

Contractor shall be responsible for the DESIGN, furnishing, and installation of a fire detection, alarm system and FM-200 Clean Agent Fire Suppression System based on Basic design in Indicated Drawings, The Contractor shall Prepare Complete design for a fire detection, alarm system and FM-200 Clean Agent Fire Suppression in JAIP Well Site as specified herein. All associated equipment, devices, and controls necessary for proper operation, automatic detection and control shall be included.

Peripheral components as specified shall be located as indicated on the Drawings and provided in sufficient number and located as needed to meet all applicable codes.

Area covered by the Clean Agent Fire Suppression System is Electrical room in JAIP Well Site.

23.2 GENERAL

Contractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor to complete the work as specified, and in compliance with the codes, standards, and regulations listed below.

1. Contractor's Qualifications

The system design, equipment, installation, and installation supervision furnished under this section shall be provided by a single manufacturer or supplier who has been engaged in the business of supplying fire alarm systems of this type for at least 6 years.

2. General Equipment Stipulations

The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

3. Governing Standards

Governing Standards for the Fire alarm Control Panel (FACP) and system components:

BS EN 54-1:2011 – Introduction.

BS EN 54-2:1997+A1:2006 - Control and Indicating Equipment.

BS EN 54-3:2001 - Fire alarm devices: sounders.

BS EN 54-4:1998 - Power supply equipment.

BS EN 54-5:2001 - Heat detectors: Point detectors.

BS EN 54-7:2001 - Smoke detectors: point detectors using scattered light, transmitted light or ionization.
BS EN 54-10:2002 - Flame detectors: point detectors.
BS EN 54-11:2001 - Manual call points.
BS EN 54-12:2002 - Smoke detectors: line detectors using an optical light beam.
BS EN 54-13:2005 - Compatibility assessment of system components.
BS EN 54-16:2008 - Voice alarm control and indicating equipment.
BS EN 54-17:2005 - Short-circuit isolators.
BS EN 54-18:2005 - Input/output devices.
BS EN 54-20:2006 - Aspirating smoke detectors.
BS EN 54-21:2006 - Alarm transmission and fault warning routing equipment.
BS EN 54-22:2015 - Resettable line-type heat detectors.
BS EN 54-23:2010 - Fire alarm devices. Visual alarm devices.
BS EN 54-24:2008 - Components of voice alarm systems: Loudspeakers.
BS EN 54-25:2008 - Components using radio links.
BS EN 54-26:2015 - Point fire detectors using carbon monoxide sensors.
BS EN 54-29:2015 - Multi-sensor fire detectors – Point detectors using a combination of smoke and heat sensors.
BS EN 54-30:2015 - Multi-sensor fire detectors – Point detectors using a combination of carbon monoxide and optionally heat detectors.
NFPA 72: National Fire Alarm Code
NEC: National Electrical code

4. Nameplates

Major components of equipment shall be identified with a permanently affixed nameplate bearing the manufacturer's name and address, and type or style and catalog number of the item.

5. Tags

Keys and locks shall be furnished with tags bearing stamped identification numbers. Cable and conduit run, wiring circuits, and all spare parts supplied to maintain the system shall be furnished with hard phenolic or stainless-steel tags.

6. Power Requirements

Power supply to the fire alarm control panel (FACP) will be 230 volts, 50 Hz, single phase. The alarm system shall include an automatically recharged backup power supply with sufficient battery capacity to operate the entire system in the normal supervisory mode for 24 hours and then sound all alarms for 5 minutes. In the event of power failure, the system shall automatically transfer to the standby batteries. All external circuits requiring system-operating

power shall be suitable for 24-volt dc service and shall be individually fused at the control panel.

23.3 SUBMITTALS

Complete Design, electrical wiring diagrams; assembly and installation drawings; detailed specifications; and data covering the materials used and the parts, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with the Submittals Procedures section.

23.4 SYSTEM DESCRIPTION AND OPERATION

- A. The system shall be a Total Flood FM-200 Fire Suppression System.
- B. The system shall provide the FM-200 fire extinguishant minimum design concentration of 6.7% or 7.17% (FM) by volume for Class A hazards and a minimum of 8.97% by volume for Class B hazards, in all areas and/or protected spaces, at the minimum anticipated temperature within the protected area.
- C. The system shall be complete in all ways. It shall include all mechanical and electrical installation, all detection and control equipment, agent storage containers, FM-200 agent, discharge nozzles, pipe and fittings, manual release and abort stations, audible and visual alarm devices, auxiliary devices and controls, shutdowns, alarm interface, caution/advisory signs, functional checkout and testing, training and all other operations necessary for a functional, FM Approved FM-200 Clean Agent Fire Suppression System.
- D. The FM-200 system shall be automatically actuated by either counting zone detection or cross-zoned detection methodology. Smoke sensors / detectors shall utilize photoelectric technology and/or Aspiration Smoke Detectors (ASD) for very early warning smoke detection. Smoke detectors and ASD sample points shall be installed at no more than 250 ft² (23.2 m²) of coverage per detector. When using analog addressable sensors or ASD detectors offering pre-alarm thresholds, further system design consideration is suggested for providing very early warning detection which can offer extended investigation time prior to suppression agent release. In all cases, the compatibility listings of the detectors for use with the control unit should be observed. The system shall require two detectors in alarm prior to automatic agent release.
- E. SEQUENCE OF OPERATION
 - 1. Activation of a single detector in the detection zone shall:
 - a. Cause a first-stage alarm.
 - b. Energize a lamp on the activated detector and identify detector on the display of the control panel (and remote annunciator, if included).
 - c. Note: The shutdown of electrical equipment will be optional based on requirements of the local AHJ or applicable standards.

2. Activation of a second smoke detector shall:
 - a. Transmit an alarm signal to remote monitoring or building alarm panel.
 - b. Cause a second-stage (pre-discharge) Audio/Visual alarm to operate.
 - c. Operate auxiliary contacts for air conditioning shutdowns and automatic dampers.
 - d. Initiate a programmable pre-discharge time delay (FM-200 agent release).
3. Upon completion of the time delay the FM-200 system shall:
 - a. Cause a discharge alarm to be activated.
 - b. Operate auxiliary contacts for emergency power off of all electrical equipment (excluding lighting and emergency circuits for life safety).
 - c. Activate visual alarms (strobe) at protected area entrance.
 - d. Energize control solenoid for FM-200 container, releasing gaseous agent into the protected area.

F. AUXILIARY COMPONENTS

1. Double action manual releasing stations shall be provided at each exit of the protected area, and shall, when activated, release the FM-200 agent and cause all audible / visual alarms to activate. In addition, activation of the manual releasing stations shall cause immediate shutdown of air and power circuits.
2. Abort station shall be provided at each exit of the protected area, and shall, when operated, interrupt the pre-discharge time delay of the FM-200 agent and emergency power-off functions. The abort station shall be momentary devices (dead- man) requiring constant pressure to maintain contact closure.

Note: Manual Releasing Station activation shall override any Abort station. Abort station operation shall be per IRI and FM guidelines.

23.5 PRODUCTS

A. GENERAL REQUIREMENTS:

1. The FM-200 Clean Agent System materials and equipment shall be standard products of the supplier's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same function(s), they shall be duplicates produced by one manufacturer.
2. All devices and equipment shall be FM Approved.

B. FM-200 AGENT STORAGE AND DISTRIBUTION:

1. Each system shall have its own supply of clean agent.
2. The system design can be modular, central storage, or a combination of both design criteria.

3. Systems shall be designed in accordance with the manufacturer's guidelines.
4. Each supply shall be located within the Electrical Room to reduce the amount of pipe and fittings required to install the system.
5. The clean agent shall be stored in ANSUL® agent storage containers. Containers shall be super-pressurized with dry nitrogen to an operating pressure of 360 psi at 70 °F (24.8 bar at 21 °C).
6. Containers shall be actuated by a resettable electric actuator with mechanical override located at each agent container or connected bank of cylinders. Non-resettable or explosive devices shall not be permitted.
7. Each container shall have a pressure relief provision that automatically operates before the internal pressure exceeds 774.5 psi (53.4 bar) \pm 5%.
8. Engineered discharge nozzles shall be provided within the manufacturer's guidelines to distribute the FM-200 agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.
9. Distribution piping and fittings shall be installed in accordance with the manufacturer's requirements, NFPA 2001 and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations:
 - a. Before assembly, all piping shall be reamed, blown clear, and swabbed with suitable solvents to remove burrs, mill varnish, and cutting oils.
 - b. All pipe threads shall be sealed with Teflon tape pipe sealant applied to the male thread only.

C. CONTROL SYSTEMS - GENERAL

1. All control systems shall be FM Approved, and shall be utilized with listed or approved compatible operating devices, and shall be capable of the following features:
 - a. Ground fault indication
 - b. Supervised detection circuit(s)
 - c. Supervised alarm circuit(s)
 - d. Supervised release circuit(s)
 - e. Supervised manual release circuit (if applicable)
 - f. Supervised primary power circuit
 - g. Battery standby
 - h. 4.3" color touchscreen LCD operator interface and LED indicating lamps
 - i. Key lock steel enclosure
 - j. Programmable time delay
 - k. Microprocessor based logic
 - l. History buffer

D. CONTROL PANEL -AGENT RELEASING CONTROL PANEL

1. The panel shall contain a Central Processing Unit (CPU) with integral 8-amp power supply which is rated to provide 8 Amp for "Special Application" appliances including suppression release peripherals such as horns, strobes and horn/strobes and rated to 6 Amp for "regulated 24 VDC" appliance power. The CPU shall communicate with and control the following types of equipment used to make up the system: addressable and conventional initiating devices, addressable modules, annunciators, and other system-controlled devices.
2. System Capacity and General Operation:
 - a. The control panel shall provide up to a 100 addressable point capacity with the capability of expansion to 2 loops.
 - b. The system shall include 4 Class B programmable notification appliance circuits rated at 3 A each.
 - c. The control panel shall provide the following features:
 1. Drift Compensation to extend detector accuracy over life.
 2. Maintenance Alert to warn of excessive smoke detector dirt or dust accumulation.
 3. System Status Reports to display, export to USB device (or print if optional RS232 module is provided).
 4. Rapid manual station reporting (under 2 seconds).
 5. Non-Alarm points for general (non-fire) control.
 6. Periodic Detector Test conducted automatically by software.
 7. Pre-alarm for advanced fire warning.
 8. Counting/Cross Zoning with the capability of: counting 2 detectors in alarm, 2 software zones in alarm, or 1 smoke detector and 1 thermal detector in alarm.
 9. March time and temporal coding options.
 10. Walk Test
3. Central Microprocessor:
 - a. The microprocessor unit shall communicate with, monitor, and control all external interfaces with the control panel. It shall include system program storage in non-volatile memory for building-specific program storage, and a "watch dog" timer circuit to detect and report microprocessor failure.
 - b. The microprocessor unit shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory and shall not be lost even if system primary and secondary power failure occurs.
 - c. The microprocessor unit shall also provide a real-time clock for time annotation of system displays and history file.
4. Display:

- a. The touch screen display shall provide all the controls and indicators used by the system operator.
 - b. The display shall include status information and custom alphanumeric labels for all addressable and conventional detectors, addressable modules, and software zones.
 - c. The display shall be a 4.3 inch color touch screen display.
5. Signaling Line Circuit (SLC):
- a. The SLC interface called an IDNet+ circuit, shall provide power to and communicate with up to 300 addressable points which can include Photoelectric or Thermal detectors along with all monitoring and control points. This can be accomplished over one to three SLC loops.
 - b. The loop interface board(s) shall receive and process information from all detectors to determine whether normal, alarm, supervisory or trouble conditions exist for each detector. The software shall automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The information shall also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
 - c. The detector software shall allow manual or automatic sensitivity adjustment.
6. Enclosures:
- a. The control panel shall be housed in cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.
 - b. The door shall provide a key lock and include a glass or other transparent opening for viewing of all indicators.
7. All interfaces and associated equipment are to be protected so they will not be affected by voltage surges or line transients consistent.
8. Output relay of IO Module of Control Panel will be connected to plc and and to be used to trip Main MCCB in case of Fire alarm.
9. Power Supply:
- a. The power supply shall operate on 230 VAC, 50Hz, and shall provide all necessary power for the control panel. The power supply shall have a 6 A output rating which provides current for special application devices, IDNet devices, module currents and auxiliary output currents. When NACs are controlling regulated 24 DC appliances, total NAC current available shall be 3 A.
 - b. It shall provide a battery charger for 24 hours of standby using dual-rate charging techniques for fast battery recharge.
 - c. It shall provide an earth detection circuit capable of detecting earth faults on I/O modules field wired circuits connected to power supply.

- d. It shall be power-limited using Positive Temperature Coefficient (PTC) resistors and solid state circuits.

10. Field Wiring Terminal Blocks:

- a. For ease of service, all panel I/O wiring terminal blocks shall have sufficient capacity for 18 to 12 AWG wire.

11. Field Programming:

- a. All programming shall be accomplished through a standard PC laptop.
- b. All field defined programs shall be stored in non-volatile memory.
- c. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Three levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A third level (higher-level) is used for actual change of program information.
- d. A special program check function shall be provided to detect common operator errors.
- e. For flexibility, an off-line programming function with batch upload/download shall also be available.

12. Batteries:

- a. Batteries shall be 12 volt (2 required).
- b. Batteries shall have sufficient capacity to power the fire alarm system for not less than 24 hours in standby plus 5 minutes of alarm upon a normal AC power failure.
- c. Batteries are to be completely maintenance free. No liquids are required. Fluid level checks, refilling, spills and leakage shall not be accepted.

E. PROGRAMMABLE ELECTRONIC SOUNDER

1. Electronic sounders shall be FM Approved and operate on 24 VDC nominal.
2. Electronic sounders shall be field programmable without the use of special tools to choose 1 of 8 tones with an output sound level of at least 90 dBA measured at 10 ft (3.0 m) from the device.
3. Electronic sounders shall be flush or semi-flush mounted as shown on plans.

F. VISUAL NOTIFICATION APPLIANCES

1. Strobe lights shall operate on 24 VDC nominal.
2. Strobe lights shall meet the requirements of IEC and shall meet the following criteria:
 - a. The strobe devices shall be multi-candela 15 cd - 110cd and higher intensity if required by the plans.
 - b. The appliance shall be placed 80 in. (to the bottom of the appliance) to 96

in. (to the top of the appliance) above the finished floor within the space.

G. AUDIBLE/VISUAL COMBINATION DEVICES

1. Audible/visual combination devices shall meet the applicable requirements of listed above for audibility.
2. Audible/visual combination devices shall meet the requirements of visibility.

H. ADDRESSABLE DEVICES – GENERAL

1. Addressable devices shall provide an address-setting means using dip switches.
2. Detectors shall be intelligent and addressable, and shall connect with 2 wires to the fire alarm/release control panel signaling line circuits.
3. Addressable smoke and thermal detectors shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions indicating that the detector is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the control panel indicating that an alarm condition has been detected. If required, the flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED.
4. Smoke detector sensitivity shall be set through the control panel and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.
5. Using software in the control panel, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance.
6. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper-proof feature. An optional base shall be available with a built-in (local) sounder rated at 85 dBA minimum.
7. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel.
Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
8. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (PHOTO or THERMAL).

I. ADDRESSABLE MANUAL PULL STATION

1. Addressable manual pull station shall, on command from the control panel, send data to the panel representing the state of the manual switch. They shall use a key operated test-reset lock and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.

2. All operated stations shall have a positive, visual indication of operation and utilize a key-type reset.
3. Manual stations shall be clearly visible operating instructions provided on the cover. The word AGENT shall appear on the front and both sides of the stations.
4. Stations shall be suitable for surface mounting or semi-flush mounting as shown on the plans, and shall be installed not less than 42 in. (1.1 m), nor more than 48 in. (1.2 m) above the finished floor.
5. Operation shall require 2 actions.

J. ANALOG ADDRESSABLE PHOTOELECTRIC SMOKE DETECTOR

1. The detectors shall use the photoelectric (light-scattering) principle to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

K. ANALOG ADDRESSABLE HEAT DETECTOR

1. Heat detectors shall be analog addressable devices rated at 135 °F (57 °C) and have a rate-of-rise element rated at 15 °F (9.4 °C) per minute. It shall connect via 2 wires to the control panel signaling line circuit. Up to 159 intelligent heat detectors may connect to one SLC loop.
2. The detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.
3. An optional, intelligent heat detector shall be available for applications which do not require a rate- of-rise element.

L. ADDRESSABLE TWO-WIRE DETECTOR MONITOR MODULE

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional two-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
2. The two-wire monitor module shall mount in a 4 in. (102 mm) square, 2 1/8 in. (54 mm) deep electrical box or with an optional surface back box.
3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions indicating that the monitor module is operational and in regular communication with the control panel.
4. Smoke Detectors:
 - a. Smoke detectors shall be 24 VDC and shall be FM approved.
 - b. Each detector shall include a visual status indicator, provide remote LED output, and include a built-in test capability.
 - c. The sensitivity shall be factory set.

- d. The detector cover and screen shall be easily removable for field cleaning.
- e. A special vandal-resistant locking screw shall be provided to lock the head to the base.
- f. The head-to-base connection shall be made by use of bifurcated contacts. Terminal connections to the base shall be of the screw type that are accessible with the base installed on the mounting box.
- g. Where specifically identified on the contract drawings, detector bases shall incorporate a relay with Form C contacts rated at 1 amp at 120 VAC and 2 amps at 28 VDC.
- h. Photoelectric-type smoke detector shall be light reflective type and compatible with the AUTOPULSE control system. The detector shall have an LED in its base which is illuminated in a steady-on mode when in alarm and pulse mode when in standby. Reset of the detector shall be performed by the control unit reset switch.
- i. The design of the photoelectric detector compensating circuits shall provide stable operation with regard to minor changes in temperature, humidity and atmospheric conditions.
- j. Photoelectric-type smoke detector with heat detector shall be light reflective type and compatible with the AUTOPULSE control system. The detector shall have an LED in its base which is illuminated in a steady-on mode when in alarm and pulse mode when in standby. Reset of the detector shall be performed by the control unit reset switch.

M. ABORT SWITCH

- 1. The abort switch shall be used where an investigative delay is desired between detection and actuation of the fire suppression system.
- 2. This switch shall be a momentary contact "dead-man" type switch requiring constant pressure to transfer one set of contacts. Clear operating instructions shall be provided at the abort switch.
- 3. This switch shall be rated for 2 A resistive @ 30 VDC.
- 4. The terminal connections shall be of the screw type.

N. MAINTENANCE LOCK-OUT SWITCH

- 1. The maintenance lock-out switch shall be used where it is desired to disable the fire suppression system during routine maintenance.
- 2. This switch shall be key operated allowing removal of the key only in "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-Out" position. The control unit is used to indicate a supervisory condition when in the "Lock-Out" position.
- 3. The switch shall include 1 set of normally open and 1 set of normally closed control

contacts rated for 2 A resistive @ 30 VDC.

4. The terminal connections shall be of the screw type.

O. TOUCHSCREEN REMOTE LCD ANNUNCIATOR

1. The remote annunciator shall provide a 4.3” color touchscreen LCD display that is identical to the control panel user interface. The annunciator shall be capable of displaying a custom background image when the system status is normal.
2. The annunciator shall provide; a local sounder; discrete status LEDs for Alarm, Priority 2, Supervisory, Trouble, Alarm Silenced and AC power indications; and three programmable LEDs with associated control switches with provisions for custom labels. A lamp test feature shall be available from the display menu.
3. The remote annunciator shall provide access to all system status information, controls, diagnostics, and reports that are available on the control unit user interface. Protected access shall be provided to the following operator control functions and diagnostics; Alarm, Priority 2, Supervisory and Trouble Acknowledge; Alarm Silence; and System Reset; Hardware Reset; Point Disable/Enable; Annunciator Sounder Silence, Clear History Logs; Panel Setup; and System Diagnostics. Protection against unauthorized use shall be provided via a passcode, key switch, or both.

P. CAUTION AND ADVISORY SIGNS:

1. Signs shall be provided to comply with IEC and the recommendations of the FM-200 agent equipment supplier:
2. Entrance sign: 1 required at each entrance to a protected space.
3. Manual discharge sign: 1 required at each manual discharge station.
4. Flashing light sign: 1 required at each flashing light over each exit from a protected space.

Q. SYSTEM AND CONTROL WIRING:

1. All system wiring shall be furnished and installed by the contractor.
2. All wiring shall be installed in electrical metallic tubing (EMT or conduit) and must be installed and kept separate from all other building wiring.
3. All system components shall be securely supported independent of the wiring. Runs of conduit and wiring shall be straight, neatly arranged, properly supported, and installed parallel and perpendicular to walls and partitions.
4. The sizes of the conductors shall be those specified by the manufacturer. Color-coded wire shall be used. All wires shall be tagged at all junction points, and shall be free from shorts, earth connections (unless so noted on the system drawings), and crosses between conductors. Final terminations between the control panel and the system field wiring shall be made under the direct supervision of a factory-

trained representative.

5. All wiring shall be installed by qualified individuals in a neat and work man like manner to conform to the National Electrical Code, Article 725 and Article 760.
6. The complete system electrical installation and all auxiliary Components shall be connected to earth ground in accordance with the National Electrical Code.

23.6 EXECUTION

23.6.1 GENERAL

All work shall be installed as indicated in Drawing as Basic Design, and in accordance with the manufacturer's diagrams and recommendations, except where otherwise indicated.

All junction boxes furnished hereunder shall be painted red and permanently labeled "FIRE ALARM". A consistent wiring color code shall be maintained throughout the installation.

Installation of equipment and devices that connect to equipment furnished under other sections, or furnished by the Owner, shall be closely coordinated with the suppliers of the equipment and with Owner.

After completion of the installation, Contractor shall clean the inside and the outside of the fire alarm equipment and shall remove all dirt and debris from the site.

23.6.2 Device Installation

- a. Whether it's reflected on the drawings or not: Smoke Detectors and Fire Alarm Pull Stations shall be installed in accordance with NFPA 72 in the following facilities:
 1. Electrical, Chlorine and Guard House - Electrical, Chlorine and Guard Room.
 2. One pull station shall be installed under booster pumps shed.
- b. Audiovisual Alarm Units shall be installed in accordance with NFPA 72 in the following facilities:
 1. Electrical Room and Guard Room.
 2. One universal audiovisual Alarm Units shall be installed at Site yard
- c. Fire Alarm Control Panel shall be installed Electrical Room.
- d. The FACP in the Electrical and Control Building/rooms shall control all devices in that particular site.

23.6.3 Cable

Cable shall be shielded and shall be installed as described in the cable installation paragraphs in the Electrical section. The system conductors shall be installed in conduits or junction boxes separate from conductors of other systems. Conduit fill shall meet applicable NEC requirements.

23.6.4 Raceways

Conduit shall be installed as described in the conduit installation paragraphs in the Electrical section.

23.6.5 Testing

The tests shall be performed by, or under the supervision of, a qualified representative of the fire alarm system manufacturer and shall include the following:

- a. Verify that the system is free of grounds or open circuits. The FACP shall indicate when a ground or an open circuit exists.
- b. Verify that all alarm signal devices, stations, transmitters, automatic detectors, and supervisory devices are functioning as specified.
- c. Test each fire alarm device and circuit. Individually activate each manual initiating station and verify correct alarm operation and control panel response. Individually test each automatic initiating device and verify correct alarm operation, control panel response, and remote equipment operation.
- d. Test battery backup systems for specified capacity.
- e. Repeat test to verify correction of any defect found in the initial testing.

End of Section

24 CCTV SPECIFICATIONS

24.1 SCOPE

The scope covers supply, installation, testing and commissioning of IP based CCTV Surveillance system for JAIP Well Site.

The scope of the work includes:

- Supply of all components / constituents required and delivery at JAIP Site.
- Contractor shall prepare a commissioning procedure report for approval by the purchaser along with schedule indicating the dates of commissioning.
- The contractor shall be responsible on Installation of Cameras, Network Switches, NVR, Panels, Ethernet cables and other components connected to the system.
- The contractor shall integrate various components mentioned above and establishing the connectivity among all components of the system
- The contractor shall Commission the integrated system as per the approved commissioning report.
- Handing over the system and warranty for 1 year as per technical specifications.

24.2 QUALIFICATION

- The manufacturer shall have a proven technology for the item such as camera, video management software and equipment.
- Contractor shall have experience in supply installation, testing, commissioning and maintenance of CCTV system. The Contractor shall produce a proof of installation of IP based video surveillance system working elsewhere.

24.3 GENERAL FEATURES & REQUIREMENTS

- The power supply available to the electrical loads of the system is 240V AC $\pm 10\%$, 50 Hz $\pm 3\%$, and sufficient isolation shall be provided from the loads.
- The electronic circuits used in the system shall be of solid state fail-safe design and be provided with proper coating to have resistance to humidity and corrosion which prevents the operation from being impaired by dust and dirt.
- The cameras shall be tamper-proof and shall alarm during tampering, and shall log the event to the main database and shall be plug in type with suitable locking devices.
- The Video Management software shall be user friendly and menu driven with self-checking i.e. all the routines shall be checked periodically for their proper functioning and integrity.
- Diagnostic checks shall be done by the system periodically for the proper functioning of the Video cameras.
- The configuration modifications can be done only from the control room.
- The system shall have flexibility for upgrading and expansion in all respects depending on future requirements.
- All the software manuals, hardware manuals, user manuals, training manuals related to the system shall be supplied in hard copy format [two sets] and 2 nos. in CD format .
- The system shall confirm highest standards of the engineering design and workmanship.

24.4 GENERAL SPECIFICATIONS

24.4.1 Day\Night IP HD Camera

The Camera shall have the followings:

- It shall be positional type as Indicated in Drawings.
- It shall be compatible with encoder integral to IP camera.
- It shall be High Definition (HD) with 720P-Min image quality.
- It shall have Electronic Image Stabilization.
- Has Compass Direction and scene presets 2.

a. Standards

EMC:

EN 55032 Class A, EN 50121-4, IEC 62236-4, EN 61000-3-2, EN 61000-3-3, EN 55024, EN 61000-6-1, EN 61000-6-2, FCC Part 15 Subpart B Class A, ICES-003 Class A, VCCI Class A, RCM AS/NZS CISPR 32 Class A, KCC KN32 Class A, KN35

Safety:

IEC/EN/UL 62368-1, IEC/EN/UL 60950-22, IEC 62471, IS 13252

Environment

IEC/EN 60529 IP66/IP67, NEMA 250 Type 4X, NEMA TS 2 (2.2.7-2.2.9), IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-78, IEC/EN 62262 IK10

Network

NIST SP500–267

b. Power Supply

The Camera shall be equipped by 12–28 V DC Inputs and Power over Ethernet (PoE) Based on IEEE 802.3af/802.3at Type 2 Class 4, max 20.4 W, typical 11.1 W with disabled IR: Power over Ethernet (PoE).

c. Casing and Operating Condition

The Casing of Camera shall be IP66\NEMA 4X rated, IK10 impact-resistant polymer enclosure with aluminum base and intrusion alarm switch Weather shield with black anti-glare coating.

Camera shall be suitable with the following Operation Conditions :

- -40 °C to 60 °C (-40 °F to 140 °F)
- Humidity 10–100% RH (condensing)
- Wind load (sustained): 55 m/s (123 mph)

Features Table:

No.	Feature	Required Parameters
1	Image sensor	1/3” or better type CMOS colour Sensor
2	Effective Pixels	1920*1080 (4MP)
3	Scanning System	Progressive Scan

4	Resolution	1080p Full HD images up to 25/30 fps
5	Signal-to-Noise Ratio	More than 50dB
6	IR Distance	Up to 60 m
7	Lens	2.7 mm – 12 mm
8	Frame Rate	25 FPS/30 FPS for 1920 x 1080p at H.264 Compression or better
9	Ethernet	10Base-T / 100Base-TX, RJ-45 POE Connector IPv4/IPv6, TCP/IP, HTTP, HTTPs , DHCP,
10	Weather protection,	IP66, IK10 or better
11	Surge/Lightening	Required (Internal/External) Industrial grade 500 V protection on POE or 1.5KV protection level on Power adapter

24.4.2 Network Video Recorder (NVR)

- The equipment envisaged is a 16-channel NVR recorder suitable for Megapixel IP cameras with built in POE ports for easy connection to compatible IP cameras.
- It should be equipped with H.264 Video codec encoding.
- The NVR shall support minimum 8 TB hard drives. It should have HDMI and VGA output for high-resolution output to a HD TV or computer monitor.
- Real time: It should record all cameras at 1080p reposition at 25/30 fps per camera without any frame skipping. Further the recording can be motion activated recording or calendar based recording or manual mode. It should accept 4 MP IP cameras. It should have user selectable recording resolutions: 4 MP, 2 MP, 1.3MP, etc.
- It should have adequate input bit rate. It should be possible to easily configure IP cameras on the same network. It should also be possible to have real time viewing in HD for all cameras on NVR. Recording should start on SD card if Network or server fails. The network failure is registered immediately if the failure is longer than 10 seconds. Once the network connection has been restored, gaps in the recording are automatically filled without manual intervention.
- Storage must be programmed for disc management system, which will automatically reap old recordings to overwrite with the new ones when maximum usage is reached. The system shall be able to carry adequate hard disks to achieve at least 8 TB recording storage.
- The system shall support dual gigabit Ethernet ports. The system shall be able to centrally configure all devices and system settings from one interface. The system shall support system status watchdog and automatically restart the system when abnormal event happened.

No.	Features
1	Licenses: 16 IP Camera Station Universal licenses included.
2	Processor: Intel i5-4590S, 3,0GHz, 6MB Cache, 4C/4T, turbo
3	IP Camera Input : Min 16 Channel
4	Memory: UDIMM 8GB (1x8GB) 1600 MHz DDR3, non ECC
5	Storage: 8 TB, (2x4 TB) Surveillance Class HDD SATA 6Gb/s. Boot drive 120 GB mSATA
6	Switch: 16 ports integrated, 277 W total power budget, Power over Ethernet (PoE) IEEE 802.3af/802.3at Type 2 up to Class 4
7	Operating system: Microsoft Windows 10 IoT Enterprise
8	Video streaming: Live view: Capable of 25 camera split views or 1 x 4K camera view. Playback: 4 x 1080p camera split views or 1 x 4K camera view. 2 screens supported.
9	Recording: Qualified for recording with a total recording rate of 256 Mbit per second.
10	Power: Max 500 W, 100 V AC to 240 V AC 277 W PoE dedicated
11	Ports: 16x PoE ports RJ45 10/100 Mbps, 2x RJ45/SFP Uplinks 10/100/1000 Mbps, 2x USB 2.0, 2x USB 3.0, 1x VGA, 1xHDMI 1.4b, 1x eSATA
12	Protocols: EN/IEC/UL 60950-1, FCC part 15 Class A, VCCI Class A, EN 55022 class A, ICES-3(A)/NMB-3(A), RCM AS/NZS CISPR 22 Class A, EN 55024, EN/IEC 61000-3-2, EN/IEC 61000-3-3

24.4.3 LED Display Screen

No.	Feature	Parameters
1	Monitor	Minimum 40" , Full HD
2	Display Resolution	1080p and minimum viewing of 16 cameras
3	Video Signal	480/60i, 480/60p, 1080/60i, 1080/50p (HDMI)
4	Computer Input	HDMI/Audio in, USB 2.0, Ethernet connection, HD15 PC input
5	Power Supply	100V to 240 V AC, 50/60 Hz
6	Remote Control	Remote Control Function Required
7	Mounting	Shall be suitable for rigid support mounting from Wall

24.4.4 Unmanaged Ethernet Switch

No.	Feature	Required Parameters
1	Type	Gigabit Ethernet
2	Operation	Store & forward
3	Memory bandwidth	At least 8 Gbps
4	RJ45 ports	Minimum 8 10/100/1000 BASE-T POE Ethernet Ports. Uplink port should have sufficient speed to avoid network congestion, preferably network should not be loaded more than 70% at any stage, fully IEEE 802.3 compliant

24.4.5 CAT6 Cables

No.	Feature	Required Parametres
1	Type of Cable	Pair-shielded 100 Ohm installation cable with overall braided screen.
2	Conductor	4 pair UTP armoured cable 23 AWG Solid bare Copper
3	Primary	High Density polyethylene
4	Insulation	FR-PVC Insulation thickness 0.2 mm nominal
5	Application	Indoor / outdoor installation

24.4.6 List of Manufactures

- IP Camera: Axis, Pelco, Sony, Bosch, Honeywell, Panasonic or approved equal
- NVR: Axis, Pelco, Sony, Bosch, Honeywell, Panasonic or approved equal
- Monitor :Samsung, Sony, LG or approved equal
- Switch: Cisco, Netgear, Dlink or approved equal

End of Section